State of Oregon
Department of Environmental Quality

Application For Modification of a Solid Waste Disposal Site Permit

Oregon Department of Environmental Quality

(Attach Additional Sheets If Necessary)

DEQ USE ONLY – BUSINESS OFFICE

Date Received: _____

Amount Received: _____

Check No.: _____

Deposit No.: _____

Forward confirmation of fee payment for
Eastern Region applications to:
DEQ – The Dalles
Northwestern Region applications to
DEQ-NWR – Portland
Western Region applications to:
DEQ - Eugene

A. REFERENCE INFORMATION *(Please Print clearly.)*

1. Paul Burns
Legal Name of Registered Applicant (See #22 below.)

2. Ph. (503) 528-0681 FAX (503) 331-2260

3. Riverbend Landfill Company
Legal Name of Business/Facility (May be same as above.)

4. 7227 NE 55th Avenue
Mailing Address of Applicant
Portland OR 97218
City State Zip

5. Riverbend Landfill Company
Legal Name of Property Owner

6. 13469 SW Hwy. 18
Mailing Address of Property Owner
McMinnville OR 97128
City State Zip

7. Ph. (971) 261-4008 FAX (503) 434-9770

8. Riverbend Landfill
Common Name of Facility

9. 13469 SW Hwy. 18
Facility **Physical** Address
McMinnville OR 97128
City State Zip

10. 13469 SW Hwy. 18
Facility's Mailing Address
McMinnville OR 97128
City State Zip
lbrennan@wm.com / Lee Brennan
E-Mail for Facility Operator/Contact

11. Lee Brennan Ph. (971) 261-4008
Name of Facility Operator

12. Yamhill County
County in which Facility is Located

13. Enter Facility Location by LATITUDE and LONGITUDE, SECTION, TOWNSHIP, and RANGE.

Section: 1, 2, 11 & 12 Township: T. 5 S Range: R. 5 W

LATITUDE			LONGITUDE		
Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
45°	9'	123" N	123°	14'	56" W

B. TYPE OF PERMIT REQUESTED

I am applying for the following permit modification (check one): Please call the solid waste permit coordinator at the nearest DEQ office if you have any questions about the permit type or need further information (see map on page 2 for DEQ offices).

- ☐ 14. Closure Permit
- ☐ 15. Composting Facility Permit or Registration (Environmental Screening)
- ☐ 16. Energy Recovery Facility Permit
- ☐ 17. Incineration Facility Permit
- ☒ 18. Land Disposal Site Permit (Landfill)
- ☐ 19. Solid Waste Letter Authorization Permit (short-term projects only)
- ☐ 20. Solid Waste Treatment Facility Permit
- ☐ 21. Transfer Station/Material Recovery Facility Permit

C. SIGNATURE

I hereby certify by my signature below that the information contained in this application, and the documents I have attached, are true and correct to the best of my knowledge and belief.

22. Signature of Legally Authorized Representative | Paul Burns / Director of Disposal Operations | 4/23/2015
Print Name | Title | Date

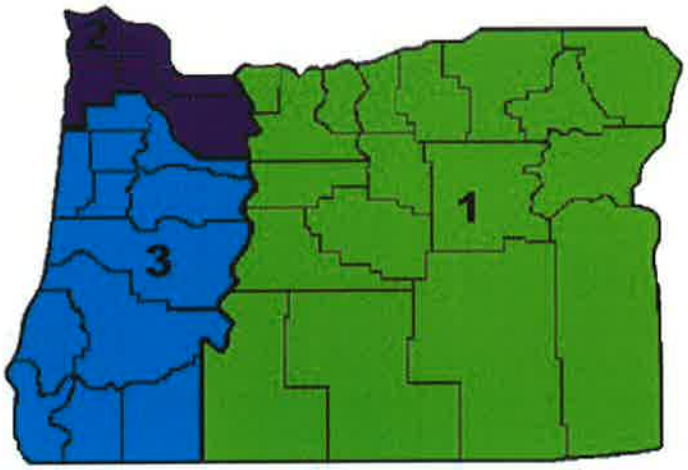
D. FEES – None for Permit Modifications

Please mail the original application and one copy of the completed packet to the appropriate regional office. Note that action will not begin on an application until a complete application packet is received. Incomplete applications may be returned.

1. Eastern Region
   Department of Environmental Quality
   400 E Scenic Drive, Ste 2.307
   The Dalles, OR 97058
   (541) 298-7255 ext. 221

2. Northwest Region
   DEQ Solid Waste Programs
   2020 SW Fourth Ave. Ste 400
   Portland, OR 97201
   (503) 229-5353

3. Western Region
   DEQ Solid Waste Programs
   165 E 7th Ave, Suite 100
   Eugene, OR 97401
   (541) 687-7465



Permit Modification Application
Riverbend Landfill Expansion – Proposed Module 11

McMinnville, Oregon

Prepared for:

RIVERBEND LANDFILL COMPANY
13469 SW Highway 18
McMinnville, Oregon 97128
(503) 472-8788

WASTE MANAGEMENT

REGISTERED
OREGON
DAVID LAMADRID
G1905
GEOLOGIST
Expires 1/31/16

April 24, 2015

Prepared by:

Hari D. Sharma
OREGON
JAN. 20, 1992
HARI DUTT SHARMA
Expires: 6/30/2016

SCS Engineers
14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

Louis Caruso, L.G.
Project Director/Vice President
SCS Engineers

David Lamadrid, R.G.
Senior Project Geologist
SCS Engineers

Geosyntec Consultants
1111 Broadway, 6th Floor
Oakland, CA 94607

Hari Sharma, Ph.D, P.E.
Principal Geotechnical Engineer
Geosyntec Consultants

Fabrizio Settepani
Senior Engineer
Geosyntec Consultants

Table of Contents

Section **Page**

List of Tables iii
List of Figures iii
List of Appendices iii
Acronyms and Abbreviations iv
1.0 GENERAL FACILITY INFORMATION 1
1.1 Introduction 1
1.2 Yamhill County Site Design Review and Floodplain Development Applications .. 2
1.3 Site Description 2
1.4 Land Use Compatibility Statement 3
1.5 Written Recommendation 3
1.6 Site Suitability Criteria 3
1.6.1 Airport Safety 3
1.6.2 Floodplains 3
1.6.3 Wetlands 5
1.6.4 Critical Habitat 5
1.6.5 Seismic Impact Zones 5
1.6.6 Unstable Areas 6
2.0 HYDROGEOLOGIC SITE CHARACTERIZATION 7
2.1 Objective 7
2.2 Physiography 7
2.3 Climate 8
2.4 Site Geology 8
2.4.1 Surficial Soils 8
2.4.2 Quaternary Alluvial Deposits 8
2.4.3 Sand-Gravel Unit 9
2.4.4 Nestucca Formation 9
2.5 Site Hydrogeology 9
2.5.1 Upper (Shallow) Silt-Clay Water-Bearing Zone 10
2.5.2 Lower (Deep) Sand-Gravel Water-Bearing Zone 10
2.5.3 Hydraulic Conductivities 11
2.5.4 Vertical Hydraulic Gradients and Hydraulic Connection Between WBZs 11
2.6 Groundwater Chemistry 12
2.6.1 Upper Silt-Clay Water-Bearing Zone 12
2.6.2 Lower Sand-Gravel Water-Bearing Zone 13
2.7 Water-Use Survey 13
3.0 GEOTECHNICAL INVESTIGATIONS 15
3.1 Field Investigations 15
3.2 Geotechnical Laboratory Testing 16

Table of Contents

Section **Page**

3.3 General Stratigraphy and Summary of Test Results 17
3.4 Additional Field Investigation: CPTs 17
4.0 CONCEPTUAL DEVELOPMENT PLANS AND LANDFILL FACILITIES DESIGN 19
4.1 Preliminary Site Development Plans 19
4.2 ORS 459.055 Requirements 20
4.2.1 Site Rehabilitation 20
4.2.2 Protection of Public Health and Safety and the Environment 21
4.2.3 Minimize Impact of Landfill on Adjacent Property 22
4.2.4 Minimize Traffic 26
4.2.5 Vector Control 27
4.3 Conceptual Landfill Facilities Design 28
4.3.1 Facility Operation and Phased Development 28
4.3.2 Liner Design 29
4.3.3 Leachate Management 29
4.3.4 Stormwater Management 30
4.3.5 Landfill Gas Management 30
4.3.6 Closure and End Use 31
4.4 Detailed Designs 31
4.4.1 Base Grading Plan 31
4.4.2 Liner System 32
4.4.3 Leachate Collection and Removal System 32
4.4.4 Final Cover System 33
5.0 LANDFILL OPERATIONS 34
5.1 Security 34
5.2 Disposal Operations and Waste Handling 34
5.3 Ancillary Operations 35
5.4 Inspection and Maintenance 35
5.5 Environmental Monitoring 35
5.6 Operating Record 36
5.7 Contingency Plan 36
5.8 Incremental Post-Closure Operations 37
5.9 Personnel 37
6.0 ENVIRONMENTAL MONITORING 39
7.0 CLOSURE, POST-CLOSURE, AND FINANCIAL ASSURANCE 40
8.0 REFERENCES 41

List of Tables

Table 1 Submittal Schedule and Description of Components for DEQ Permit Modification Application

List of Figures

Figure 1-1 Site Location Map

Figure 1-2 Overview Map and Aerial Photo

Figure 1-3 Site Plan

Figure 2-1 Soil Survey Map

Figure 4-1 Base Grading Plan

Figure 4-2 Liner System

Figure 4-3 Final Cover System

Attachments

Attachment 1 Land Use Compatibility Statement; Ordinance 887; Board Order 15-115; and Recommendation Letter from Yamhill County

Attachment 2 Preliminary Hydraulic Report (prepared by Waterways Consulting, Inc.)

Attachment 3 Final Site Development Plan Drawings and Photographic Simulations

Attachment 4 Revised Hydrogeologic Site Characterization Work Plan (prepared by SCS Engineers)

Attachment 5 Geomorphic Analysis Memorandum (prepared by Waterways Consulting, Inc.)

Attachment 6 Module 11: Summary of Field Investigation and Laboratory Testing Program (prepared by Geosyntec Consultants)

Attachment 7 Noise Analysis Update Report (prepared by Michael Minor & Associates)

Attachment 8 Traffic Impact Study (prepared by Lancaster Engineering)

Attachment 9 Evaluation of Historical Groundwater Elevations Memorandum (prepared by SCS Engineers)

ACRONYMS AND ABBREVIATIONS

^{o}F	degrees Fahrenheit
1200-Z Permit	Multi Sector General Permit
ADC	alternative daily cover
AEMR	annual environmental monitoring report
Airstrike	Airstrike Bird Control, LLC
AHI	additional hydrogeological investigation
bgs	below ground surface
BMP	best management practice
Board	Yamhill County Board of Commissioners
Ca	calcium
C_s	compression index
CFR	Code of Federal Regulations
Cl	chloride
cm/sec	centimeters per second
County	Yamhill County
CPT	cone penetration test
DEQ	Oregon Department of Environmental Quality
DSL	Oregon Department of State Lands
EFU	Exclusive Farm Use
EMCON	EMCON Northwest, Inc.
EMP	environmental monitoring plan
e_0	void ratios
ESA	Endangered Species Act
FDP	floodplain development permit
Fe	iron
FEMA	Federal Emergency Management Agency
ft/ft	feet per foot
ft/yr	feet per year
Geosyntec	Geosyntec Consultants
GCCS	gas collection and control system
GCL	geosynthetic clay liner
gpm	gallons per minute
HCO_3	bicarbonate alkalinity
HDPE	high density polyethylene
HSC	hydrogeologic site characterization
LCRS	leachate collection and removal system
LDS	leak detection system
LFG	landfill gas
LFGTEF	landfill gas to energy facility
LLDPE	linear low density polyethylene
LL	liquid limit
LUCS	Land Use Compatibility Statement

ACRONYMS AND ABBREVIATIONS (CONTINUED)

MASW	multichannel analysis of surface waves
Mg	magnesium
mg/L	milligrams per liter
Mn	manganese
MSE berm	mechanically stabilized earthen berm
msl	mean sea level
MSW	municipal solid waste
MSWLF	Municipal Solid Waste Landfill
NMFS	National Marine Fisheries Service
NSHMP	National Seismic Hazard Mapping Program
OAR	Oregon Administrative Rule
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
Ops Plan	Operations Plan
ORS	Oregon Revised Statute
PI	plasticity index
PMA	permit modification application
PMS	Public Works/Safety
RCRA	Resource Conservation and Recovery Act
Riverbend	Riverbend Landfill Company
SCS	SCS Engineers
SDR	site design review
SPT	standard penetration test
SSL	site-specific limit
SWDSP No. 345	Solid Waste Disposal Site Permit No. 345
TDS	total dissolved solids
TSP	Transportation System Plan
UGB	Urban Growth Boundary
UU	unconsolidated undrained
USACE	U.S. Army Corps of Engineers
USDAWS	U.S. Department of Agriculture Wildlife Services
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WBZ	water-bearing zone
YCZO	Yamhill County Zoning Ordinance
Zn	zinc

1.0 GENERAL FACILITY INFORMATION

1.1 INTRODUCTION

This document, prepared on behalf of Riverbend Landfill Company (Riverbend), provides information in support of a Permit Modification Application (PMA) for enhancement and expansion of Riverbend Landfill located in McMinnville, Oregon (Figure 1-1). Riverbend Landfill operates under Solid Waste Disposal Site Permit No. 345 (SWDSP No. 345), issued by the Oregon Department of Environmental Quality (DEQ) on December 3, 1999. The proposed enhancement and expansion area is identified as Module 11 (referred to herein as "Module 11"). The proposed Module 11 includes (1) a 29-acre group of disposal cells to be located west of the existing landfill and adjacent to Highway 18, and (2) reconfiguration of the existing berm on the south side of the landfill (see Figure 1-2). Module 11 will be constructed in multiple phases and will also be a contiguous extension of the existing landfill adjacent to Highway 18 with tree plantings and other landscape features to provide a year-round visual screen.

This PMA is being submitted to the DEQ in accordance with Oregon Administrative Rule (OAR) 340-093-0070(6)(a)(B) that states:

> *(6) Permit modifications:*
>
> *(a) An application for a permit modification is required for:*
>
> *(B) Any change in the nature of the activities or operations from those of the last application including modification or expansion of the disposal site or a change in the method or type of disposal.*

Consistent with OAR 340-093-0070(6)(b)(A,B, and C), this PMA provides the following components:

- Completed DEQ application form (Application for Modification of a Solid Waste Disposal Site Permit) that is signed by the person in control of the facility (Mr. Paul Burns, Waste Management's Director of Disposal Operations, Pacific Northwest Region).
- Statement of compatibility with the acknowledged local (i.e., Yamhill County [County]) comprehensive plan and zoning requirements (Land Use Compatibility Statement [LUCS] issued by the County).
- Information showing the reason for the Permit Modification and which provides the level of detail necessary for submittal of this PMA.

It is Riverbend's understanding that DEQ can begin processing the application based on the level of detail being provided, but that Riverbend will be required to provide additional technical information, including completion of the site characterization, seismic design analysis, and slope stability analysis, subsequent to submittal of this PMA. A timetable for completing and submitting

this additional technical information, along with the type of information that will be included with each submittal, is provided in Table 1-1.

1.2 YAMHILL COUNTY SITE DESIGN REVIEW AND FLOODPLAIN DEVELOPMENT APPLICATIONS

Riverbend submitted to the County, Department of Planning and Development (Planning Department), a Site Design Review (SDR) Application (Riverbend, 2014), and Floodplain Development Permit (FDP) Application (Latimer Environmental LLC, 2014) in November 2014. The SDR Application and FDP Application included a Preliminary Site Development Plan for the expansion as it was proposed at that time, which included a small expansion area to the north of the existing facility identified as Module 10. The Planning Commission approved the SDR Application and FDP Application in its letter dated January 16, 2015 (Yamhill County, 2015) subject to several conditions of approval. Along with several other changes, one of the Planning Commission's conditions of approval required Riverbend to remove Module 10 from the site plan. Riverbend provided an updated (Final) Site Development Plan to reflect the changes approved by the Planning Commission.

Opponents of the applications appealed the Planning Commission's decision to the County Board of Commissioners (Board). The Board chose to hold a de novo hearing to review the Planning Commission's decision and to allow interested parties to continue commenting on the applications. The Board held its hearing on March 12, 2015, and left the record open until March 31, 2015. On April 2, 2015, the Board reconvened to hear Planning Department Staff's recommendation and to deliberate on Riverbend's applications. By a vote of 2-1, the Board approved Riverbend's Final Site Development Plan, with conditions, as well as the FDP Application. Riverbend's PMA submittal to the DEQ is based on the Final Site Development Plan and FDP approved by the County.

1.3 SITE DESCRIPTION

Riverbend Landfill is located approximately 3 miles southwest of McMinnville, Oregon, in Yamhill County (see Figure 1-1). Riverbend Landfill is owned and operated by Riverbend, and is permitted by the DEQ to receive municipal solid waste and approved special waste.

The Riverbend Landfill property boundary, various site features, and proposed Module 11 are shown in Figure 1-3. The Riverbend Landfill property encompasses approximately 700 acres of which the permitted landfill occupies approximately 85 acres. The property includes the north and south poplar tree farms occupying approximately 43 acres. Proposed Module 11 will occupy the north poplar tree farm area.

An RV park is located between the landfill and south poplar tree farm. The South Yamhill River borders the site to the south, and agricultural land surrounds the site to the north, west, and east.

1.4 LAND USE COMPATIBILITY STATEMENT

A copy of a Land Use Compatibility Statement (LUCS) approved by the County is provided in Attachment 1. The LUCS is based on the County's recent approval of the SDR Application and FDP Application, as well as an earlier decision that rezoned Riverbend's property to allow the expansion.

1.5 WRITTEN RECOMMENDATION

A copy of a recommendation from the County is provided in Attachment 1.

1.6 SITE SUITABILITY CRITERIA

1.6.1 Airport Safety

The McMinnville Municipal Airport is located approximately 5 miles to the northwest of Riverbend Landfill. The airport has a 1,000-foot paved stopway on the departure end of runway 22, providing capacity to handle corporate jet aircraft. Given the considerable distance to the airport, it is not expected that continued operation of the landfill will affect the airport or aircraft in flight (e.g., hazard from birds). Riverbend Landfill has received no complaints concerning birds interfering with aircraft since Riverbend has operated the site.

1.6.2 Floodplains

Riverbend proposes some development within the 100-year floodplain associated with a small, unnamed tributary of the South Yamhill River that parallels the southern edge of proposed Module 11, hereafter referred to as the "southern tributary" (see Figure 1-2). Development in the floodplain is allowed and must satisfy the criteria in Yamhill County Zoning Ordinance (YCZO) Section 901. Riverbend has obtained approval for a FDP from the County for the portion of Module 11 that will be in the floodplain.

In support of the FDP, Riverbend retained the services of a registered professional engineering firm (Waterways Consultants, Inc.) to complete a hydraulic analysis of the proposed project using methods prescribed by the Federal Emergency Management Agency (FEMA). A copy of the report is provided in Attachment 2. The analysis utilizes current FEMA floodplain mapping, which was updated via a Letter of Map Revision issued by FEMA in December 2012. The analysis of the effects of the proposed project indicates no rise of the base flood elevation, which means Riverbend's development proposal is well within the regulatory limits for floodplain development in the YCZO. The relevant approval standards for obtaining an FDP are addressed below.

- Pursuant to YCZO 901.05, Riverbend must provide the following in its FDP Application relevant to proposed development: "Specific data regarding the extent to which any watercourse will be altered or relocated as a result of the proposed development." As described in the approved FDP Application, earthwork associated

with the project will result in a net removal of soils from the floodplain and will not cause a rise in the base flood elevation.

- Pursuant to YCZO 901.06, an applicant must demonstrate that the proposed development (1) conforms with the regulations of the underlying zoning district, (2) meets all conditions for development within a floodway, (3) does not increase the base flood elevation by more than one foot, (4) will be contingent on obtain all federal, state or local permits, and (5) is consistent with policies j. and k. of the County's Comprehensive Plan. The County determined Riverbend's development proposal is consistent with the underlying Exclusive Farm Use (EFU) zone and does not include any development within a floodway, nor does it cause more than a one-foot rise in the base flood elevation at any single point. The County also determined the project is consistent with the relevant sections of the County's Comprehensive Plan.

Riverbend will have to obtain multiple permits from federal and state agencies as part of its overall expansion plan, including permits relating to the portions of the development within the floodplain.

With regard to Policy j of the County's Comprehensive Plan, Riverbend's proposed development will require some temporary impacts to existing riparian vegetation. Much of the current riparian corridor that will require removal is composed of non-native Himalayan blackberry (*Rubus armeniacus)*, which will be removed and replaced with native species. Most impacts resulting from a portion of the proposed development will be restored and enhanced, and the size of the riparian zone and its vegetation will be increased. With regard to Policy k, the project has been designed to utilize only non-structural, natural materials to minimize adverse impacts from erosion and flooding.

YCZO 901.07 establishes approval standards for specific types of development within the floodplain. The only standard in that section applicable to Riverbend's development proposal is subsection (F) relating to fills and levees. Specifically, that subsection prohibits fill within the floodway, requires the use of natural materials, requires the fill to be for a beneficial purpose, and requires the fill to be protected against erosion. That provision also requires a demonstration that the fill will not cause additional floodwaters on adjacent land.

Riverbend's proposed development will use fill that includes only those natural materials allowed by the County's floodplain regulations, and that fill will have the beneficial purposes of allowing the enhancement and expansion of Riverbend Landfill. The County has on multiple occasions determined that the continued operation of the landfill is important and beneficial to the citizenry of Yamhill County. All fill will be protected from erosion by vegetation, large wood, rock, or similar erosion control measures per standard engineering practices. Finally, the engineer's hydraulic analysis included with this PMA (see Attachment 2) demonstrates that the proposed fill will not cause additional floodwater on adjacent lands.

YCZO 901.09 addresses any proposed alteration of a watercourse. Within that provision, only subsection (C) applies to Riverbend's development proposal. The proposed project will alter the watercourse of the southern tributary in the stream reach south of Module 11 as a consequence of

channel restoration and enhancement. The project will result in either no-rise or a slight reduction in the base flood elevation. Pursuant to YCZO 901.09(C), Riverbend will assist the County in notification of the State Department of Land Conservation and Development and all other applicable local, state, and federal agencies, including the Federal Insurance Administration.

1.6.3 Wetlands

As shown in the Final Site Development Plan (see Attachment 3, Drawing A-1), wetlands are present near the southern edge of proposed Module 11 and are associated with the riparian area of the southern tributary. Riverbend's proposed design will impact a small area of these wetlands, but only to the extent necessary to allow construction of a crossing of the southern tributary that will provide all-weather access to the leachate pond and proposed Green Technology Area. The existing crossing will be removed as part of the proposed development. The new crossing will also facilitate the aforementioned riparian restoration, which will include removal of an additional, abandoned agricultural crossing. Less than one acre of relatively low quality wetlands will be impacted and the riparian restoration project will mitigate those impacts through restoration, enhancement, and creation of about 3.8 acres of wetlands.

Wetland permits from the U.S. Army Corps of Engineers (USACE) and the Oregon Department of State Lands (DSL) are required to allow impacts to existing wetlands and mitigation for those impacts. USACE and DSL permits will require input and certifications from other state and federal agencies, such as Clean Water Act Section 401 Certification from DEQ and Fish Passage Certification from the Oregon Department of Fish and Wildlife (ODFW).

1.6.4 Critical Habitat

Steelhead and Chinook salmon occurring in the South Yamhill River are listed as *Threatened* under the Endangered Species Act (ESA) and as such both are assumed to be present in the southern tributary. The South Yamhill River is designated as *Critical Habitat* for these two salmonid species. Critical habitat only extends to the ordinary high water line of the river; thus, the southern tributary is not designated as critical habitat.

The USACE will address ESA-listed species as part of their wetland permitting process in consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS). Initial coordination with the USACE, NMFS, USFWS, and ODFW indicates that the proposed southern tributary roadway crossing design and riparian restoration and mitigation project will comply with all applicable requirements of the ESA.

1.6.5 Seismic Impact Zones

Riverbend is required to design and construct the landfill in adherence to modern seismic standards. The seismic design for municipal solid waste landfills is governed in Oregon by the following:

- Solid Waste Landfill Guidance Document (DEQ, 2013).

- U.S. Environmental Protection Agency (USEPA), Resource Conservation and Recovery Act (RCRA) Subtitle D (40 Code of Federal Regulations [CFR] 258).
- Seismic Design Guidance for Municipal Solid Waste Landfill Facilities (USEPA, 1995).

These provisions define the basis for design ground motions with a 10 percent probability of exceedance (i.e., a 90 percent chance of not being exceeded) in 250 years.

On the basis of Riverbend's site-specific seismic hazard analyses, supplemented with the results of the 2008 and 2014 U.S. Geological Survey (USGS) National Seismic Hazard Mapping Program ("NSHMP") with values presented in the 2014 USGS NSHMP United States National Seismic Hazard Maps, Riverbend has determined that for the Riverbend Landfill site, the regional seismic hazard reflects the contribution of three primary sources: (1) crustal earthquakes, (2) intraslab subduction earthquakes, and (3) interface subduction earthquakes.

The contributions of all of these sources to the ground motions, having an average return period of approximately 2,500 years, have been thoroughly evaluated for the proposed Module 11 development, and the ground motions have been characterized for use in engineering analyses. The applicable ground motions from those sources will be selected for the seismic design of the proposed Module 11 development. Furthermore, as outlined in the Oregon Resilience Plan (February, 2013), the likely impacts of a magnitude 9.0 Cascadia Subduction Zone earthquake will also be considered in the seismic design.

1.6.6 Unstable Areas

According to 40 CFR Section 258.15, owners or operators of Municipal Solid Waste Landfill (MSWLF) units located in an unstable area must demonstrate that engineering measures have been incorporated into the design so that the integrity of the MSWLF unit is not disrupted. Unstable areas can include poor foundation conditions, areas susceptible to mass movements, and Karst terrain. Riverbend Landfill is not located in Karst terrain. The subsurface soils that will provide the foundation for proposed Module 11 have been evaluated for these factors and have been determined to be generally stable. As part of engineering design for Module 11, foundation stability and settlement will be evaluated.

2.0 HYDROGEOLOGIC SITE CHARACTERIZATION

This section describes the geology and hydrogeology of the site and proposed Module 11 based on previous and recent site characterizations and investigations performed at Riverbend Landfill. A description of the key reports summarizing hydrogeologic investigations and/or providing groundwater elevation and quality information is presented in a hydrogeologic site characterization (HSC) work plan provided in Attachment 4 (SCS, 2015a). The HSC work plan provided in Attachment 4 also includes the following figures (1) historical monitoring and exploratory locations (Figure 1-2), (2) the existing environmental monitoring networks (i.e., groundwater, leachate management system, and landfill gas monitoring networks) (Figure 3-1), and (3) interpretative groundwater elevation contour maps (Figures 3-2 and 3-3).

2.1 OBJECTIVE

The primary objective of the HSC is to demonstrate that the hydrogeologic conditions within proposed Module 11 are consistent with the conceptual hydrogeologic model previously developed for the site based on the extensive background studies and information. The extensive background information summarized below and presented in the HSC work plan (Attachment 4) was used to develop Riverbend Landfill's current monitoring program which is detailed in the site's approved Environmental Monitoring Plan (EMP) (SCS Engineers [SCS], 2014). The background information also formed the basis for defining the HSC scope of work to address data gaps or augment the existing hydrogeologic information for proposed Module 11. The HSC work plan tasks include (1) surficial soil assessment, (2), aquifer slug testing to further evaluate hydraulic conductivity in the shallow water-bearing (WBZ) zone, (3) aquifer pumping test to evaluate hydraulic connectivity between WBZs, and (4) updated water-use survey. The aquifer pumping test was requested by the DEQ based on its review of a previous version of the HSC work plan (SCS, 2015a), as documented in a DEQ letter dated April 14, 2015 (DEQ, 2015).

The HSC work plan tasks (see Attachment 4) are currently being implemented based on conditional approval of the work plan by the DEQ (DEQ, 2015). After completion of the HSC work plan activities, an updated HSC report will be submitted to the DEQ in accordance with the schedule outlined in Table 1.

2.2 PHYSIOGRAPHY

Riverbend Landfill is situated within the northern Willamette Basin physiographic province north of the South Yamhill River. The basin is characterized by a series of uplands bounded by low-lying plains and valleys. The subbasin between the Eola Amity Hills to the east and the foothills of the Coast Range to the west is known as the West Valley Plain (Price, 1967). The West Valley Plain consists of an undulating surface of bedrock hills that outcrop locally from beneath overlying terrace sediments. The sediments were deposited within the Yamhill Valley downwarp, a structural trough trending eastward and generally coinciding with the South Yamhill River for most of its length.

Foothills of the Coast Range outcrop approximately 1.5 miles to the northwest, along the northwest flank of the Willamette Basin. In the local area near Riverbend Landfill, there are no bedrock outcrops, and the topography is divided into upper and lower river terraces, which differ in elevation by about 20 feet.

The landfill area drains primarily to the South Yamhill River, which flows east and north from the Coast Range and joins the North Yamhill River about 2 miles northeast of McMinnville, Oregon. From that confluence, the Yamhill River flows east and drains into the Willamette River. Near Riverbend Landfill there are various unnamed drainages that originate in uplands to the northeast of landfill, dissect the terraces, and drain into the South Yamhill River. An evaluation of geomorphic conditions of the South Yamhill River in the vicinity of the Riverbend Landfill is provided in Attachment 5.

2.3 CLIMATE

The McMinnville area has a temperate climate, with mild, wet winters and warm, dry summers. Most precipitation falls between October and May, with over 50 percent of the average annual precipitation occurring from November through January. Average rainfall for McMinnville, Oregon, is about 44 inches. The average annual temperature in McMinnville is about 52 degrees Fahrenheit (^{o}F). The hottest month is July, with an average temperature of about 65 ^{o}F, and the coldest month is January, with an average temperature of about 38 ^{o}F.

2.4 SITE GEOLOGY

The geologic units described below, from shallowest to deepest, are important for characterizing the hydrogeologic conditions in proposed Module 11.

2.4.1 Surficial Soils

Figure 2-1 shows the distribution of soil types in the project area and surrounding vicinity. Soil types are predominately Amity silt loam and Woodburn Silty Loam (Map Unit Symbols 2301A and 2310A-D in Figure 2-1), with slopes from 0 to 7 percent and 7 to 12 percent. The Woodburn series consists of moderately well-drained soils that formed in silty alluvium. Woodburn soils are associated with the well-drained Willamette soils and the somewhat poorly drained Aloha and Amity soils. Woodburn soils are used mainly for vegetable crops, berries, orchards, small grains, and hay and pasture. They are also suitable for wildlife habitat, recreation, and rural and urban development.

2.4.2 Quaternary Alluvial Deposits

Two Quaternary alluvial units are present at Riverbend Landfill: early to middle Quaternary Willamette Silt and Late Quaternary silt-clay unit. The materials in both units are similar and consist of bedded silts, clays, clayey silts, silty clays, and minor amounts of silty fine sand. The deposits range in thickness from 17 feet near MW-21A, in the southern portion of the site, to 63 feet near SB-17B, in the extreme southwest part of the site (CH2M Hill, 2000). The unit within

proposed Module 11 ranges in thickness from approximately 30 feet at borehole GT14-07 in the southern portion of Module 11, to approximately 50 feet at borehole GT12-01A in the far northern corner of Module 11.

With the exception of small areas of Class III and IV soils associated with creeks and steeper slopes, soils in the project vicinity are categorized as high value farm lands. Most of the acreage is cultivated and the general capability unit is Class II.

2.4.3 Sand-Gravel Unit

Overlying the Nestucca Formation is a mostly laterally continuous unit consisting of sandy gravels and gravelly sands, with localized interbeds of clayey and silty gravels and clay and silt lenses. The sand-gravel material is generally well-graded, angular to subrounded, and in places, cemented. The gravel consists primarily of fine-grained volcanic and marine sedimentary rocks. Silty and clayey sands and gravels of variable thickness occur near or at the top of the unit.

The elevation of the top of the sand-gravel unit is relatively uniform across Riverbend Landfill, ranging from approximately 87 to 112 feet msl. The overall thickness of the unit, however, varies widely due to variations in the elevation of the underlying bedrock surface. The thickest deposits occur in the northwest part of Riverbend Landfill in proposed Module 11 where the unit was found to be greater than 44 feet thick in borehole GT14-02. The unit's thickness along the southern edge of proposed Module 11 ranges from 34.5 feet in borehole GT14-07 to 5.5 feet in the well MW-18B borehole.

The unit generally thins towards the east to southeast where it was found to be less than 10 feet thick in some boreholes along the eastern and southern edges of the existing landfill, and towards the southwest where it was absent in boreholes GT10-10 and GT10-11.

2.4.4 Nestucca Formation

The Nestucca Formation bedrock underlying Riverbend Landfill is composed mostly of basaltic lava flows, with localized occurrences of marine sediments. Nestucca Formation bedrock units were encountered in several boreholes (EW-1, P-04B, GT10-02, GT10-03, GT12-05A, GT12-06A, and GT14-03 through GT14-07) in the proposed Module 11 area at depths ranging from approximately 46 to 84 feet below ground surface (bgs). The elevation of the top of bedrock ranges from approximately 64.5 to 93.5 feet above mean sea level (msl) in the proposed Module 11 area.

2.5 SITE HYDROGEOLOGY

The upper (shallow) silt-clay alluvial deposits (both the Willamette Silt and the late-Quaternary alluvium) and lower (deep) sand-gravel deposits are significant at Riverbend Landfill because they contain either localized or regionally extensive WBZs. As a result, groundwater monitoring at Riverbend Landfill is performed in the shallow silt-clay WBZ and deep sand-gravel WBZ. This section discusses the hydrogeologic characteristics of these WBZs.

2.5.1 Upper (Shallow) Silt-Clay Water-Bearing Zone

The groundwater flow and gradient conditions in the silt-clay WBZ across proposed Module 11 have been previously determined based on historical water level-data from the existing network of monitoring wells and piezometer. Across most of Riverbend Landfill, the groundwater flow direction and gradient in the upper silt-clay WBZ show minor seasonal and spatial variability, typically in response to variations in seasonal precipitation patterns. The direction of groundwater flow in the upper silt-clay WBZ is predominantly south-southeast, towards the South Yamhill River. In the extreme southwestern portion of the site, groundwater flow is predominantly toward the east. A groundwater potentiometric surface contour map showing the typical groundwater flow directions in the upper silt-clay WBZ across the site, including in the proposed Module 11 area, is provided in Figure 3-2 of the HSC work plan (Attachment 4). The contour map shows that groundwater within proposed Module 11 flows southeasterly.

The historical seasonal range of groundwater gradients is generally from 0.005 to 0.01 foot per foot (ft/ft). Average groundwater flow velocities in the upper silt-clay WBZ range from 0.1 to 16.2 feet per year (ft/yr) using (1) an average seasonal gradient of 0.005 to 0.007 ft/ft, (2) hydraulic conductivity values ranging from 4.68×10^{-4} to 2.08×10^{-6} centimeters per second (cm/sec), as determined from slug tests performed as part of the AHI (EMCON Northwest, Inc. [EMCON], 1994), and (3) an effective porosity of 15 percent.

Historical groundwater-level data for monitoring wells screened in the upper silt-clay WBZ near the South Yamhill River indicate that temporal fluctuations of approximately 10 to 15 feet occur. Generally, groundwater elevations in those wells are higher than the river elevation, indicating that groundwater in the upper silt-clay WBZ discharges to the river. This relationship between the South Yamhill River and groundwater indicates that the South Yamhill River acts as a hydraulic boundary to groundwater flow in the upper silt-clay WBZ (SCS, 2013).

2.5.2 Lower (Deep) Sand-Gravel Water-Bearing Zone

The groundwater flow direction and gradient in the lower sand-gravel WBZ do not vary significantly as a result of seasonal changes in precipitation. In most areas of Riverbend Landfill, groundwater flows toward the southeast, in the direction of the South Yamhill River, and shifts southward as it approaches the river. A groundwater potentiometric surface contour map showing the typical groundwater flow directions in the lower sand-gravel WBZ across the site, including in the proposed Module 11 area, is provided in Figure 3-3 of the HSC work plan (Attachment 4).

The historical seasonal range of groundwater gradients is generally from 0.0088 to 0.012 ft/ft. The average groundwater flow velocity in the lower sand-gravel WBZ is 124 ft/yr, using an average seasonal gradient of 0.01 ft/ft, a hydraulic conductivity value of 3.6×10^{-3} cm/sec, as determined from a variable discharge test performed as part of the AHI (EMCON, 1994), and an effective porosity of 30 percent (SCS, 2014).

Riverbend Landfill has a production well designated as PW-1, located near the facility entrance. The well is completed in and pumps water from the lower sand-gravel WBZ. There are also two

production wells (MB-1 and MB-2) on the former Bernards property on the east side of the Riverbend Landfill entrance. MB-1 is active and MB-2 has been disconnected. During the dry season, when PW-1 and MB-1 are used most frequently, groundwater elevations in the sand-gravel WBZ are affected in the northwest corner of Riverbend Landfill by production well pumping.

2.5.3 Hydraulic Conductivities

Slug testing has previously been performed to evaluate hydraulic conductivities in the shallow and deep WBZs across the site, including wells and piezometers located within or in close proximity to proposed Module 11. These included slug tests performed in wells MW-10A, MW-10B, and P-04A as part of the AHI (EMCON, 1994), and wells MW-18B, MW-20A, and MW-20B (and MW-17A and MW-19A to the south) as part of the expansion of Riverbend Landfill's groundwater monitoring network in the north and south poplar tree farm areas (CH2M Hill, 2000). Table 3-3 in Attachment 4 presents a summary of slug testing results for these and other former or existing wells and piezometers at Riverbend Landfill.

The slug testing results showed somewhat higher than expected hydraulic conductivities in the shallow WBZ in area of proposed Module 11 (mean value of 6.8×10^{-3} cm/sec) (CH2M Hill, 2000). Seams of coarser-grained sediments (i.e., silty sand and very fine sand) were encountered at various depth intervals in the upper silt-clay WBZ, which probably account for the higher hydraulic conductivity values in this area (SCS, 2013). Slug testing of deep WBZ wells MW-18B and MW-20B, located generally upgradient and downgradient, respectively, of proposed Module 11, showed hydraulic conductivity values of 1.68×10^{-2} and 4.66×10^{-2} cm/sec, respectively (CH2M Hill, 2000).

2.5.4 Vertical Hydraulic Gradients and Hydraulic Connection Between WBZs

Trends in groundwater elevations between the upper and lower WBZs (exhibited by adjacent shallow and deep monitoring well pairs) are generally similar, with periods of high and low elevations occurring at the same time of the year. The highest water levels in the upper silt-clay and lower sand-gravel WBZs generally occur in the spring, while the lowest elevations occur in the fall. The fluctuations are directly influenced by precipitation. Although seasonal trends are similar in the two WBZs, the magnitude of the water-level fluctuation varies significantly (SCS, 2013).

The relative degree of hydraulic connection between the upper and lower WBZs was evaluated through a pumping test of well MW-3B (EMCON, 1994). The results of the evaluation indicated that the WBZs have a low degree of hydraulic connection. More indirectly, impacts to groundwater from volatile organic compounds (VOCs) in well MW-5A, located adjacent to the south side of the landfill, have historically not been detected in well MW-5B. This also suggests a low degree of hydraulic connection between the two WBZs.[1]

[1] Results of the remedial investigation performed in 1993 demonstrated that landfill gas is the source of VOCs impacting shallow groundwater in the MW-5A area (EMCON, 1993).

2.6 GROUNDWATER CHEMISTRY

The following information related to the general groundwater chemistry in the target WBZs was obtained from the EMP (SCS, 2014) and recent annual environmental monitoring reports (AEMRs), and is based in part on groundwater chemistry data collected from wells installed near or within the proposed Module 11 area.

2.6.1 Upper Silt-Clay Water-Bearing Zone

Groundwater chemistry in the upper silt-clay WBZ is characterized by the predominance of calcium (Ca), magnesium (Mg), and bicarbonate ions (HCO_3), and a pH generally less than 8.0. Sulfate shows little variability. Groundwater in the upper silt-clay WBZ is generally classified as moderately hard to hard.

Manganese (Mn) is routinely detected above the secondary regulatory standard (0.05 milligrams per liter [mg/L]) in groundwater collected from most upgradient and downgradient monitoring wells screened in the silt-clay WBZ. Iron (Fe) is commonly detected in groundwater samples collected from the upper WBZ; however it is found at concentrations above the secondary standard detected (0.3 mg/L) only in samples collected from a few upgradient and downgradient wells.

While the relative concentrations of inorganic parameters in groundwater samples collected from the silt-clay WBZ are generally consistent among wells, some parameter concentrations vary spatially, with higher concentrations detected in both upgradient and downgradient wells (e.g., Fe). The variability can be attributed to the lithologic heterogeneity of the upper silt-clay WBZ. The spatial variability also reflects potential variations in hydraulic conductivity, which may serve to increase groundwater residence time in localized zones across Riverbend Landfill.

The most common metals detected in groundwater samples from the silt-clay WBZ are arsenic, barium, chromium, copper, and zinc, each of which occurs naturally in the native soil (EMCON, 1994). The metals are widely distributed and have been detected in soils samples collected from the borings of both upgradient and downgradient wells. The correlation between total metals and high levels of total suspended solids indicates that the detected metals represent naturally occurring elements in the fine-grained soils. Higher concentrations that have historically been detected are most likely related to high concentrations of particulates in unfiltered samples.

Analytical results of groundwater samples collected in 2013 from detection monitoring well MW-20A located downgradient of the poplar tree farm area (i.e., the proposed Module 11 area) continued to show concentrations of some inorganic parameters (including sodium, chloride [Cl], Mg, and total dissolved solids [TDS]) above their statistical prediction limits (i.e., site specific limits or SSLs), although the concentrations are below the secondary regulatory standards, except for Cl and TDS (SCS, 2014a). Leachate irrigation of the poplar tree farms was suspended in 2013 in response to these water-quality changes (CH2M Hill, 2013); the poplar trees have been irrigated exclusively by precipitation since 2013.

2.6.2 Lower Sand-Gravel Water-Bearing Zone

Groundwater chemistry in the sand-gravel WBZ is characterized by the predominance of Ca, Mg, and HCO_3 ions. Groundwater in the lower sand-gravel WBZ is generally harder than in the upper silt-clay WBZ, and is classified as hard to very hard (EMCON, 1994).

Groundwater samples collected from upgradient and downgradient monitoring wells screened in the lower sand-gravel WBZ typically contain Mn at concentration above the secondary standard. Fe is commonly detected in groundwater samples collected from the lower WBZ; however, it is detected at concentrations above the secondary standard only in a few upgradient and downgradient wells. In addition, Cl and TDS were detected above their secondary drinking water standards (250 and 500 mg/L, respectively) in groundwater collected from former upgradient well MW-8B and compliance well MW-12B. Additional investigations showed the higher concentrations of inorganic constituents in groundwater samples collected from compliance well MW-12B were representative of natural groundwater conditions influenced by the vertical flow from the underlying bedrock (marine sedimentary rocks). Previous site investigations have also shown that the degree of spatial and temporal variation in groundwater chemistry in the sand-gravel WBZ beneath the site is pronounced.

Eleven metals have previously been detected at low-to-trace concentrations in groundwater samples collected at Riverbend Landfill from the sand-gravel WBZ. The most commonly detected metals are barium, cobalt, copper, nickel, vanadium, and zinc. The presence of these metals in unfiltered samples from upgradient wells demonstrates that they occur naturally in this WBZ.

2.7 WATER-USE SURVEY

Water uses in the vicinity of Riverbend Landfill were assessed as part of a beneficial water-use survey performed in 1993 (EMCON, 1993a). The survey included:

- Reviewing agency files to compile information on water wells on site and within a 1-mile radius of Riverbend Landfill, extending south to the South Yamhill River (i.e., southern extent of survey area).
- Performing a door-to-door survey to identify undocumented groundwater use.
- Identifying groundwater wells and surface water rights on a location map.
- Compiling well construction data from driller's logs and from oral reports provided by well owners.

Additional beneficial water-use information was collected in 1993 and 1994 and summarized in the AHI report (EMCON, 1994). Results of the water-use surveys as presented in the AHI report (EMCON, 1994) are provided below.

Twenty-five active wells were identified within a 1-mile radius of Riverbend Landfill, with pumping principally from the Pliocene sand and gravel deposits and lesser quantities derived from underlying marine sediments and basalts. Drillers' logs indicated that eight wells were screened in the sand-gravel WBZ, and six wells were inferred to be pumping groundwater from this WBZ based on their completion depths. Four wells pumped groundwater from bedrock zones as indicated by drillers' logs, and one well was inferred to be screened in bedrock from its completion depth. Insufficient information was available for six wells to assess what groundwater zone they were screened in.

Regional groundwater studies documented that wells completed in the sand-gravel WBZ can yield up to 75 gallons per minute (gpm). The bedrock aquifer generally yields less than 10 gpm (Price, 1967). Average pumping rates for wells within a 1-mile radius of Riverbend Landfill, estimated from short term pumping tests reported on drillers' logs, were generally within these ranges. Review of four wells screened in the sand-and-gravel WBZ indicated pumping rates ranging from 20 to 40 gpm and averaging 28 gpm. Drawdowns recorded during the tests ranged from 22 to 57 feet. Similar data collected from four wells screened in bedrock showed well yields ranging from 6 to 13 gpm and averaging 9.4 gpm.

Groundwater was reportedly used primarily for domestic purposes; a secondary use of groundwater is for agricultural purposes, including irrigation and livestock watering. A few wells were shared by several residences, and one supplied domestic and irrigation water to trailer park residents. An older water-supply well on the landfill was decommissioned in 1989.

Water quality information was not recorded on drillers' logs. In response to the door-to-door survey, two residences described the water quality from their wells as hard, saline, or having a sulfur smell. The well described as producing hard and saline water appears to penetrate bedrock WBZs based on its depth and location. Such water quality is consistent with regional water quality data from wells that produce groundwater from bedrock WBZs.

3.0 GEOTECHNICAL INVESTIGATIONS

This section summarizes geotechnical investigations applicable to the proposed Module 11 area that were conducted from 2010 to 2014. The information was presented in a summary geotechnical field investigation report by Geosyntec provided in Attachment 6. The purpose of these investigations was to characterize the subsurface soils within proposed Module 11 and to evaluate their engineering properties (i.e., grain size, Atterberg limits, dry density, moisture content, strength, and consolidation).

At the request of the DEQ, an additional field investigation program consisting of cone penetration test (CPT) probes is currently underway to further characterize the subsurface stratigraphy across the Module 11 area. Results of additional geotechnical evaluations will be presented to the DEQ in support of this PMA in accordance with the schedule outlined in Table 1.

3.1 FIELD INVESTIGATIONS

Oregon-licensed drilling contractors performed drilling for the field investigations in coordination with SCS in 2010, 2011, and 2012, and in coordination with Geosyntec in 2013 and 2014. The final boring locations were surveyed by Lee MacDonald and Associates of McMinnville, Oregon. Figure 1 of the summary geotechnical report (Attachment 6) shows the geotechnical boring locations.

To evaluate subsurface conditions, the borings were drilled using mud rotary drilling or hollow-stem auger techniques to depths ranging from 10 to 99 feet bgs. Deep borings were drilled to determine the stratigraphy with depth and the depth to firm/dense materials. The shallower borings were drilled to determine the consistency of shallow soils across the proposed Module 11 area.

The mud rotary drilling method allowed the collection of (1) high quality geotechnical soil samples in the shallow clays and silts using Shelby tubes, and (2) standard penetration test (SPT) information (using driven samples) for performing liquefaction evaluations where cohesionless layers (sands and silts) were encountered below the groundwater level. Sampling of the clays and low- to high-plasticity silts was performed by pushing Shelby tubes or by using a Gregory Undisturbed sampler with a Shelby tube. The Shelby tubes were 3-inch diameter, thin-walled, and 3-foot long.

Where materials were hard and the Shelby tube could not be pushed, a Modified California sampler (3-inch outside diameter, 2.5-inch inside diameter) with brass liners was driven. Each Shelby tube or brass liner was capped and labeled with the boring number and the depth interval. The end caps were taped so loss of moisture was minimal.

Sampling of the cohesionless soils such as sands and nonplastic silts was performed using SPT sampling (ASTM D1586) without liners in the barrel. Soil samples collected from SPT samplers were contained in plastic bags. The plastic bags were labeled with the boring number and the interval sampled. Sampling recovery and blowcount per 6 inches were recorded on the boring log. NWJ-rods were used regardless of depth.

To drive the split spoon samplers, a 140-pound above-ground automatic hammer falling 30 inches was used. A 300-pound above-ground slide hammer falling 30 inches was also used with a Modified California sampler with brass liners to obtain samples where gravelly soils were encountered. Bulk soil samples were also collected at some boring locations. Bulk samples were contained in plastic buckets and labeled with their location and sampling interval. The energy of the sampling setups used was measured by Robert Miner and Associates of Manchester, Washington, for the various field investigations. After drilling and sampling was completed at each boring, the drilling contractor grouted the boreholes as in accordance with OAR 690-240, except at boring GT-10-01, which was converted to a piezometer.

The boring logs and the energy measurement reports for the various field investigations applicable to proposed Module 11 were included in the summary field investigation report (Geosyntec, 2015) as follows:

- 2010 boring logs GT10-01 through GT10-05, and energy measurement report applicable to these borings.
- 2011 boring logs GT11-01, GT11-02, GT11-03, and the energy measurement report applicable to these borings.
- 2012 boring logs GT12-01A through GT12-06A, GT12-01B through GT12-06B, and GT12-07 through GT12-13, and the energy measurement report applicable to these borings.
- 2013 boring logs GT13-01 through GT13-06, GT13-16, and GT13-17, and the energy measurement report applicable to these borings.
- 2014 boring logs GT14-01 through GT14-14, and the energy measurement report applicable to these borings.

Site-specific shear wave velocity surveys were performed in 2012 and 2013 by Zonge International using multichannel analysis of surface waves (MASW) surveys. Copies of the survey reports are included with the summary field investigation report (Geosyntec, 2015a) in Attachment 6.

3.2 GEOTECHNICAL LABORATORY TESTING

To characterize subsurface soils and determine their strength and deformation characteristics for permit-level design, the following geotechnical soils laboratory tests were performed on soil samples collected during the geotechnical field investigations:

- Grain size distribution (including hydrometer) (ASTM D422), for subsurface characterization and liquefaction analyses.
- Atterberg limits (ASTM D4318), for subsurface characterization, liquefaction analyses, and consolidation settlement.

- Moisture content/dry density (ASTM D2937), for subsurface characterization and slope stability analyses.
- Consolidation (ASTM D2435), for consolidation settlement.
- Unconsolidated undrained (UU) triaxial tests (ASTM D2850), for strength of natural subsurface cohesive soils, slope stability analyses, and foundation design.

3.3 GENERAL STRATIGRAPHY AND SUMMARY OF TEST RESULTS

Field investigation results indicated that generally, cohesive silts and clays were encountered to various depths underlain by sands and gravels over bedrock encountered at various depths. The laboratory test results performed to date on the cohesive soils indicated the following:

- Soils are low to high plasticity silts and clays (i.e., Unified Soil Classification System [USCS] classification ML, MH, CL, and CH), the liquid limits (LL) range between 22 and 106 and the plasticity indices (PI) range between 3 and 72. The dry unit weights range between 60 and 102 pounds per cubic foot approximately.
- Soils have an estimated compression index (C_c) ranging from 0.21 to 0.59; the void ratios (e_0) ranged between 0.65 and 1.41, and the average estimated compression ratio ($C_c/1+e_0$) of 0.18.
- Soils have an estimated recompression index (C_s) ranging from 0.03 to 0.11 and the average estimated recompression ratio ($C_s/1+e_0$) of 0.03.

Attachment 6 provides further information on the subsurface stratigraphy and a summary of laboratory test results.

3.4 ADDITIONAL FIELD INVESTIGATION: CPTs

The DEQ reviewed a previous version of the report entitled *Module 11: Summary of Field Investigation and Laboratory Testing Programs*, prepared by Geosyntec dated March 17, 2015 (Geosyntec, 2015). The DEQ requested that CPT probes be advanced at various locations across the Module 11 area to further characterize the subsurface stratigraphy across the Module 11 area. A revised summary report dated April 22, 2015, is included in Attachment 6 that addresses the DEQ's comments. Results of additional geotechnical evaluations will be presented to the DEQ in support of this PMA at a later date in accordance with the schedule outlined in Table 1.

The maximum depth of exploration of the CPTs would be to a firm and/or dense stratum, such as, the sands and gravels. Accordingly, nine CPTs will be conducted for this work. Figure 1 in Attachment 6 shows the proposed CPT locations. These locations may need to be adjusted depending on access or wetland impact issues if encountered in the field.

Of the nine CPTs, four CPTs will collect information such as friction ratio and tip resistance which will then be interpreted, using industry-accepted methodologies; the remaining five CPTs will be seismic CPTs where shear wave velocities will also be measured. At three CPT locations pore water pressure dissipation (dissipation) tests will also be performed. At these three locations, one dissipation test will be conducted in the silt zone and the second dissipation test will be conducted in the clay zone, if encountered. The purpose of each CPT is summarized below:

- CPT14-01 through CPT14-04: tip resistance, friction ratio, and stratigraphy.
- CPT14-05S and CPT14-07S: tip resistance, friction ratio, stratigraphy, and shear wave velocity.
- CPT14-06S, CPT14-08S, and CPT14-09S: tip resistance, friction ratio, stratigraphy, shear wave velocity, and pore pressure dissipation.

4.0 CONCEPTUAL DEVELOPMENT PLANS AND LANDFILL FACILITIES DESIGN

4.1 PRELIMINARY SITE DEVELOPMENT PLANS

Proposed Module 11 is a 29-acre group of disposal cells to be located west of the existing landfill and adjacent to Highway 18, and includes a reconfiguration of the existing berm on the south side of the landfill. This module will be constructed in multiple phases and will also be tied into the existing landfill. The western side of Module 11 will include tree plantings and other landscape features will be installed along the newly constructed berms to provide a year-round visual screen.

The proposed development includes a perimeter berm with a traditional earth fill design. The proposed development does not use a mechanically stabilized earthen (MSE) berm as Riverbend used for its most recent approved modification. As proposed, the height of the landfill will not increase from the current permitted maximum height, and the County's approval includes a condition that limits the height of the landfill to below 286 feet msl. Other than the additional landfill area and a reconfiguration of portions of the existing berm, the only other change being proposed to the Riverbend Landfill site is an access road on the southwest corner of Module 11 that will allow personnel all-weather access to the leachate pond, an operations and support area, and the future Green Technology facility.

The application does not propose any new ancillary facilities or structures. The recent addition of some facilities and structures on the site, such as the Renewable Energy Facility and the Recycling/Public Tipping area facilities, received approval through prior SDR applications and are already part of the existing DEQ permit. Future facilities, such as additional stormwater retention basins in the former Module 10 area and west of the leachate pond and the Green Technology Facility that is required as a condition of approval for the Zone Change approved by the County, must be approved as part of separate applications to the County when any new facility is proposed.

The following Final Site Development Plan drawings were provided to and approved by the County in support of the approved SDR application and are included in Attachment 3 for reference:

- Existing Site Conditions (Drawing A-1).
- Existing Site Conditions for Entrance Facilities (Drawing A-2).
- Subgrade Plan (Drawing A-3).
- Proposed Site Improvements at Completion ((Drawing A-4).
- Berm Buffer Plan and Narrative (Drawing A-5).
- Berm Buffer Planting Layout (Drawing A-6).
- Photo Simulations.

4.2 ORS 459.055 REQUIREMENTS

This section provides information demonstrating how the proposed Module 11 expansion meets requirements specified in Oregon Revised Statue (ORS) 459.055 (1) related to development of a landfill in an EFU zone. Now that Riverbend is within the EFU, DEQ has indicated that ORS 459.055 will apply to DEQ's permitting process for Riverbend Landfill.

4.2.1 Site Rehabilitation

ORS 459.055 requires certain rehabilitation standards for landfills in the EFU zone. In essence, the current EFU zone, in conjunction with ORS 459.055, recognizes that the landfill will be an interim use and that, as part of the ultimate closure of the landfill, Riverbend will have to work with DEQ to determine how the site will be rehabilitated to a condition comparable to its original use.

ORS 459.055 does not require any specific farm use or farm practice to occur following closure of a landfill. Instead, the statute requires the site to be restored to a "condition comparable to its original use." The County has acknowledged that the original uses on Riverbend's property that existed before it was developed as a landfill were grazing, turkey farming, and other general farm uses. The County also concluded that it is possible for Riverbend to restore the site to a condition that is comparable to those original uses. The County's discussion of the original uses and a future comparable condition is contained in Yamhill County Ordinance 887 included with the LUCS.

Riverbend has developed a conceptual post-closure plan that describes some of the possible post-closure uses that would be suitable for future conditions that are comparable to the site's original use. That conceptual post-closure plan include general farm uses such as hay or seed production, pollinator gardens, apiculture, plantings for wildlife habitat, grazing, and the creation, restoration and enhancement of wetlands that are among uses comparable to the original use of the landfill property. These are also uses that currently exist on surrounding lands devoted to farm uses. Regardless of what specific activities occur on site, the requirement to restore Riverbend Landfill to a condition comparable to its original use will help ensure the site's long-term compatibility with the surrounding agricultural area.

Another characteristic of the areas surrounding Riverbend Landfill is the open space provided by agricultural uses (also, a nearby area was approved by the County for use as a park). As part of the Zone Change approved by Yamhill County Ordinance 887, Yamhill County concluded that the its Parks Master Plan recognizes the unique characteristics of landfills that allow development of passive open space once closed, and that the continued operation of the landfill would be consistent with those open space characteristics. This would hold true for the landfill once it reaches closure as well.

4.2.2 Protection of Public Health and Safety and the Environment

The starting point for understanding environmental protection relating to landfills is the EPA rules implementing RCRA. In 1992, before Riverbend Landfill became a regional landfill, EPA promulgated rules commonly referred to as RCRA's Subtitle D rules, which established major new environmental protections for landfills. The DEQ implements and enforces Subtitle D requirements through its solid waste permitting system.

One of the primary Subtitle D requirements is that landfills must have an engineered liner system in place to prevent migration of contaminants into the environment. Current EPA and DEQ regulations require a composite liner system made up of a multilayer geosynthetic membrane liner above a natural clay liner. As leachate drains to the bottom of the landfill, it encounters the first liner, where it is then directed to a collection point for proper disposal. Should leachate pass through the liner for some reason, it would encounter the second liner layer, where it would also be directed to a collection point. The clay liner acts as a third layer in the extremely unlikely event leachate is able to pass through the two synthetic membrane liners.

The landfill liner system primarily protects against contamination of groundwater. In addition to the landfill liner system, federal and state regulations require Riverbend to collect and properly dispose of stormwater. The vast majority of Riverbend's property consists of clean soils and vegetated cover. These conditions have either been created as a result of a portion of the landfill being closed, as a temporary measure, or because an area remains in its natural state. Stormwater runoff from these areas does not pass through the landfill or ever come into contact with waste. It is no different than runoff from a non-landfill property and is discharged into the unnamed tributaries on site. Some stormwater does come into contact with waste and is treated as if it were contaminated regardless of the actual quality of that water. That stormwater is collected, managed, and discharged through the use of swales, sumps, and other best management practices (BMPs). Once collected and managed, that stormwater is primarily managed as leachate.

The physical protections built into the site are enhanced by a complex water quality protection monitoring and reporting systems. Riverbend Landfill's systems have been in place since the early 1980s and have been continuously enhanced since that time under DEQ's guidance. The groundwater monitoring network consists of groundwater elevation monitoring, detection wells, and compliance wells. The detection wells provide a sort of early warning system to detect potential contaminants before they move too far from the source. The compliance wells are located further out and serve as the point where Riverbend must ensure that no contaminants are flowing in groundwater leaving the area.

Additionally, Riverbend has a comprehensive stormwater monitoring plan. That plan uses a combination of water sampling and operational measures to determine compliance with established benchmarks and effluent limits. The distinction between a "benchmark" and an "effluent limit" is a meaningful one. An effluent limit establishes an upper limit for a particular contaminant and an exceedance of that limit is a permit violation. A benchmark, on the other hand, is a concentration guideline used to identify potential problems. If stormwater sampling exceeds a benchmark,

additional investigation is triggered and, if necessary, corrective action is taken. In other words, the mere exceedance of a benchmark does not result in a permit violation or even indicate water quality has been compromised by the landfill.

The effectiveness of the landfill liner system, the groundwater monitoring system, and the stormwater monitoring plan are borne out by the results of the actual water quality in and around the Riverbend Landfill site. The analytical results for groundwater samples historically collected from the compliance monitoring wells indicate that no contaminant releases from the landfill have occurred. DEQ concurred with that conclusion in a recent review of Riverbend Landfill's AEMR. The AEMR is an annual submittal to DEQ required by Riverbend Landfill's SWDSP. Stormwater monitoring results similarly indicate that BMPs utilized on site are effective at minimizing or preventing impacts to on-site stormwater discharges.

The ultimate demonstration of the absence of water quality impacts is the surface water quality of the South Yamhill River. Riverbend maintains monitoring points on the river upstream and downstream from the landfill. The surface water sample analytical results, including those for E. coli, show a general uniformity in the concentrations of water quality parameters between the upstream and downstream samples. In fact, E. coli has been shown to be at higher concentrations upstream, which is understandable because of the density of agricultural operations that exist upstream. No incremental impacts from Riverbend Landfill are associated with any of the various pollutants that cause the South Yamhill River to be water-quality limited.

4.2.3 Minimize Impact of Landfill on Adjacent Property

4.2.3.1 *Visual Screening*

Riverbend will continue to develop Riverbend Landfill to limit the largest potential visual impact, which is to automobile traffic along Highway 18. Riverbend recognizes that Highway 18 is an important linkage between the Portland area and portions of the Oregon coast. Riverbend's proposed design will retain the approximately 50-foot wide existing corridor of mature trees and shrubs adjacent to Highway 18 and at the toe of the proposed landfill berm to maintain effective visual screening for travelers on Highway 18. The landfill berm along Highway 18 will also be planted with trees and shrubs to provide additional screening. The landscape plan for the proposed improvements is provided in Attachment 3 (see Drawings A-5 and A-6). Proposed Module 11 will require removal of approximately 22 mature trees. Riverbend will consult with a certified arborist to assess tree health and positon in relation to proposed construction and buffer development to retain as many trees as is practicable. The County's approval of the Final Site Development Plan concluded the visual screening is adequate to minimize impacts on adjacent properties.

4.2.3.2 *Noise Control*

Riverbend Landfill is located in a rural area and next to a busy state highway. Background (ambient) noise is dominated by highway traffic. The noise characteristics associated with the continued operation of Riverbend Landfill should not change relative to existing conditions because Riverbend will not be increasing activities at the site. Riverbend also owns several large surrounding parcels which serve as a substantial buffer around portions of the active landfill,

including the expansion area. Additionally, the density of houses within a 1-mile radius of the landfill is very low (see Figure 1-2). Therefore, it is reasonable to conclude that Riverbend Landfill will continue to comply with DEQ noise regulations.

Riverbend acknowledges that it has received complaints from neighbors in the past regarding noise levels at the site. Although Riverbend's investigation of noise levels revealed that state standards were being met, Riverbend implemented a change in operating hours at the landfill. These changes also addressed neighbors' concerns regarding the amount of light emanating from the site. Historically, Riverbend Landfill was open to the public from 5 am to 5 pm, Monday through Friday, and 6 am to 4 pm on Saturday. In June 2012, the public hours were reduced to 6 am to 4:30 pm, Monday through Friday, and 7 am to 3:00 pm on Saturday, and closed on Sunday. This change in operating hours required numerous conversations and coordination with customers, who in turn agreed to adjust their haul schedules to fit the new schedule. Riverbend made other changes such as replacing a large Caterpillar dozer with a smaller dozer and reducing the size of the compactor on site. Riverbend also relocated its maintenance shop to a location closer to the office and highway.

To demonstrate that the proposed Module 11 expansion would not increase noise levels above DEQ noise level criteria, Riverbend updated the noise analysis originally performed in November 2009. A memorandum presenting the updated noise analysis for the Riverbend Landfill performed by Michael Minor and Associates (MM&A), which includes a copy of the completed November 2009 noise analysis report, is provided in Attachment 7. The updated noise study was performed because some of the operational characteristics at the site have changed since the initial study was performed in 2009. Changes include relocation of the maintenance shop, reduced operational hours, modified expansion plans, and updated list of landfill-related equipment.

The key conclusion of the updated noise analysis (see Attachment 7) is that noise from landfill operations does not currently and is not projected to meet or exceed the DEQ noise level criteria as a result of the proposed expansion at properties near the landfill. For all noise sensitive properties west, south and north of the site, noise from landfill operations was determined to be below the existing ambient noise levels. For three residences east of the landfill where operational noise levels sometimes exceed existing ambient noise levels, the maximum noise level increase is well below the DEQ criteria of 10 decibels.

The County's approval of the Final Site Development Plan concluded that Riverbend's efforts to control noise impacts are adequate to minimize impacts on adjacent properties. The County also imposed a condition of approval requiring Riverbend to prepare a noise report and submit the report annually to the County.

4.2.3.3 *Odor Control*

As part of its Title V air quality permit, Riverbend has been required to implement a Dust Control Plan and Final Odor Control Compendium. That document outlines measures Riverbend has taken, or can take, to control odor. The DEQ Air Quality Division has approved these plans and agrees that Riverbend is in compliance with the requirements of the plan. As a condition of its land use approval from the County, Riverbend is required to continue such measures. The County's

approval of the Final Site Development Plan concluded that measures are adequate to minimize impacts on adjacent properties.

4.2.3.4 *Riparian Area*

Proposed Module 11 development includes new berms that are set back more than 100 feet from the southern tributary and generally more than 1,000 feet from the South Yamhill River. The proposed development necessitates a small amount of development within the riparian area of the southern tributary to allow for (1) a new crossing of the southern tributary and (2) berm enhancement where the existing landfill has already been developed.

Riverbend is proposing one access road that will cross a riparian area at the southwest corner of proposed Module 11 (see Attachment 3, Drawing A-3). This road will provide access to the existing leachate pond and the future Green Technology area. The new crossing will also allow for removal of two existing crossings in areas to be enhanced as part of a larger stream restoration and enhancement project (mentioned below). The road crossing the stream is exempt from the County's Goal 5 riparian provisions that limit the removal of riparian vegetation, and is being designed in coordination with the applicable regulatory agencies (USACE, DSL, and ODFW) to minimize impacts to natural resources as part of the wetland permitting process.

The reconfigured berm that is part of proposed Module 11 extends less than 50 percent into the riparian corridor along that creek and does not impact existing riparian vegetation. Such intrusions are allowed if they are done in conjunction with a proposal that provides equal or better protection of the riparian resources being impacted. Riverbend's proposal provides such better protections, and Riverbend has obtained approval from the County to restore and enhance approximately 3.8 acres of riparian habitat of the southern tributary reach south of proposed Module 11. That enhancement project is detailed in the Riverbend South Tributary Channel and Floodplain Enhancement Plan included in the FDP Application narrative submitted to the County.

4.2.3.5 *Compatibility with Adjoining and Surrounding Uses*

The continued operation of Riverbend Landfill will remain compatible with adjoining and surrounding agricultural and open space uses. The long history of landfill operations at this particular site served in part as the basis for the County to conclude during the Zone Change process that the continued operation of a landfill at this site is compatible with adjoining and surrounding uses. The County's approval of the Final Site Development Plan continues to confirm that the landfill is compatible with surrounding uses and is appropriate in the overall context of surrounding uses and the density and pattern of development in the area. The factors contributing to the compatibility with adjoining and surrounding land uses are discussed below.

Riverbend Landfill is located in unincorporated Yamhill County south of the McMinnville Urban Growth Boundary. Topography in the general vicinity is relatively gentle, with productive agricultural fields in the level valley lands abutting Highway 18, transitioning up to hills and mixed agricultural and woodlots to the northwest, and down to the South Yamhill River floodplain to the southeast.

Natural resources define Yamhill County in general and the Riverbend Landfill area specifically. Yamhill County's agricultural sector makes use of fertile soils, readily available irrigation water, and a favorable climate. Forestry lands comprise over half of the Yamhill County land area and provide jobs, clean water, and habitat for many plants and animals. Natural resource-based industries provide a large percentage of total business revenues for Yamhill County.

As previously noted in Section 2, the predominant soils on the broad valley terraces in the vicinity of Riverbend Landfill include Amity silt loam and Woodburn silt loam (see Figure 2-1, Map Unit Symbols 2301A and 2310A-D). With the exception of small areas of Class III and IV soils associated with creeks and steeper slopes, soils in the project vicinity are categorized as high value farm lands. Most of the acreage is cultivated and the general capability unit is Class II. As part of its SDR Application, Riverbend submitted a Farm Impacts Assessment that described the agricultural crops and practices in this area. According to that analysis, typical agricultural crops include grass seed, grain and hay, nut orchards, and vegetable crops.

Even before Riverbend Landfill began operating in the 1980s, the County operated the Whiteson Landfill in the area on the other side of the South Yamhill River from Riverbend beginning in 1973. Riverbend began operating as Whiteson Landfill reached capacity. A landfill use has therefore been a continuous part of the surrounding area for more than forty years.

The only significant exception to the relatively homogenous agricultural zoning pattern in this area was the period of time between 1980, when the County first rezoned Riverbend's property to its Public Works/Safety (PWS) zone, and 2014, when the County rezoned the landfill back to the EFU zone. The re-designation of that land back to the EFU as part of the Zone Change restored the site's original zoning to make it the same as the surrounding parcels, and also put into place more protections for nearby agricultural lands. Specifically, Riverbend's development proposals must now include a Farm Impacts Assessment to meet the statutory requirements in ORS 215.296, ensuring specific development proposals do not cause substantial changes in farm practices or in the costs of farm practices. The County's approval of the Final Site Development Plan concluded Riverbend's proposal will not cause significant impacts to farm practices, or the costs of those practices, in the area surrounding the landfill.

Another characteristic of the areas surrounding Riverbend Landfill is the open space provided by agricultural uses and a nearby park. As part of the Zone Change, the County concluded that Yamhill County's Parks Master Plan recognizes the unique characteristics of landfills that allow the retention of more open space.

Photo Simulations and Interactive PDF

To further illustrate how the landfill, including the existing landfill area and the expansion areas, will look to passersby and neighbors over time, photographic simulations were prepared to depict selected views of the landfill during different phases of development (provided in Attachment 3). The simulations show views from five viewpoints at different stages of the site's development and at closure. The phases are as follows: (1) present day, (2) five years after construction begins for the expansion (2021), and (3) when the expansion areas are closed and planted with grasses and

shrubs (approximately 12 years after construction begins [2027]). The locations of the viewpoints described below are shown in the orientation figure provided with the photographic simulations and closure (see Attachment 3).

- The intersection of Highway 18 and Durham Lane (the view as seen when traveling from McMinnville).
- Two miles southwest of Riverbend on Highway 18 (the view when traveling from Sheridan).
- An elevated area in front of McCabe Chapel approximately one mile east of Riverbend.
- From the Farm John's produce stand, looking northeast.
- From the intersection of Masonville Road, looking south.

An interactive PDF is included with this PMA (provided as an electronic document on the accompanying CD) to augment the photographic simulations. Using the latest version of Adobe®, the viewer can rotate the image, zoom in and out, and change the visible layers in the document to view the grading plan for the currently-permitted landfill (i.e. the landfill if no expansion is approved), the landfill approximately seven years into the expansion, and the landfill at full build-out.

4.2.4 Minimize Traffic

Oregon Highway 18 is under the jurisdiction of the Oregon Department of Transportation (ODOT) and is classified as a Statewide Highway Route. The highway is on the National Highway System, and it is designated as a State Freight Route, a Truck Route, as well as an expressway. It is generally a two-lane roadway with a statutory rural highway speed limit of 55 miles per hour (mph). The facility has wide paved shoulders in the vicinity of the expansion area.

The County has adopted a Transportation System Plan (TSP) that is coordinated with the transportation system plans of the cities within and adjacent to Yamhill County, and the State Transportation System Plan. Riverbend Landfill has an approved direct access point to Highway 18 that includes a left turn pocket for vehicles entering the landfill and a right turn acceleration lane for vehicles leaving the facility. This existing access meets ODOT standards for sight distance and safety.

As part of the Zone Change, Riverbend submitted an updated Traffic Impact Study (prepared by Lancaster Engineering and provided in Attachment 8) to show how the eventual expansion of Riverbend Landfill would be consistent with the TSP specifically, and consistent with the State's Transportation Planning Rule in general. The Traffic Impact Study was based on several assumptions regarding the level of development that would occur on this site, including development that is more intense than what is currently being proposed. The Traffic Impact Study document indicates that Riverbend has provided, and will continue to provide, safe and convenient

access to Riverbend Landfill in compliance with ODOT access, safety, and level of service standards for Highway 18. The proposed future expansion will not significantly affect Highway 18 as defined by the TPR for the following reasons:

- The proposed expansion does not change the functional classification of Highway 18.
- At the end of the 20-year planning period, the proposed expansion does not allow land uses or levels of development that result in types or levels of travel or access that are inconsistent with the functional classification of Highway 18.
- The proposed expansion does not reduce the performance of Highway 18 and is within the minimum acceptable performance standard (v/c ratio of 0.70) identified by ODOT for this facility.

Based on the Traffic Impact Study, the County made a factual finding supporting the Zone Change that "the existing primary access would be retained and can accommodate the [Zone Change] area and contemplated future expansion area and maintain compliance with ODOT access, safety, and level of service standards for Highway 18." The Board also made the following finding:

> *"As documented in the Traffic Study, the trips associated with the landfill constitute a very small portion of overall traffic volumes on the state highway. The [Zone Change] and contemplated future expansion would not result in a significant change in the percentage of trips relative to the overall background traffic on Highway 18."*

The fact that the expansion proposal is consistent with the expansion as contemplated by thel County as part of the Zone Change and Site Design Review processes, and the fact that Riverbend's proposed development is not as intense as the scenarios considered during the Zone Change, the County determined that Riverbend's application maintains traffic safety when it approved the Final Site Development Plan.

4.2.5 Vector Control

Landfills can attract birds and other wildlife, particularly those that are scavengers; mainly seagulls, starlings, crows, and ravens. The strength of that attraction is based mainly on (1) weather-related and/or seasonal issues, and (2) the availability of food in the landfill vicinity.

Riverbend has contracted with the U.S. Department of Agriculture Wildlife Services (USDAWS) in the past to aid in the control of birds to augment the facility's ongoing bird control program. Riverbend Landfill currently controls nuisance bird populations by a combination of measures including a falconry program and operations such as reducing the size of the working face at the landfill.

Riverbend Landfill started its Falconry Program in November 2012 to provide falconry-based bird abatement at the landfill. The objective of the program is to reduce populations of starlings and seagulls by fundamentally changing the birds' flight and foraging patterns to make Riverbend

Landfill and neighboring properties an inhospitable place for birds to frequent. Riverbend contracted Airstrike Bird Control, LLC (Airstrike) to implement this program. Airstrike has 35 years of commercial practice in aviation, solid waste and agricultural settings. The approach is a non-lethal solution with enduring results. A squad of four falcons and other predatory birds began patrolling the landfill on November 8, 2012 as part of the new bird management program. The falcons have become well-known around Yamhill County vineyards, where they have long performed similar duty. In that case, their mission is to keep away fruit-eating birds from grape-laden vines toward harvest time.

Riverbend Landfill deploys falcons at least three days a week to deter seagulls and starlings. This schedule is adjusted on a seasonal basis to address bird populations. Chronic exposure to predatory falcons, which fly high, dive fast and sport razor-sharp beaks and talons, serves to restore them to their natural forage patterns.

When Airstrike started work at the Riverbend Landfill, Airstrike staff counted 500 seagulls and 4,000 starlings. The goal was to cut the population to less than 100 gulls and 300 starlings. Based on recent data collection, only a few gulls currently visit the landfill on a regular basis. Starlings have been reduced from 4,000 to 200. Ravens currently average fewer than 50 during operational hours. An offending population of about 300 invades the landfill after hours.

In management of birds, Riverbend is committed to adaptive management and multiple approaches to assure that continued operation of the landfill will not force significant changes in farm practices or costs.

4.3 CONCEPTUAL LANDFILL FACILITIES DESIGN

The conceptual Module 11 landfill design will be consistent with and incorporated into the existing landfill facilities design as described below.

4.3.1 Facility Operation and Phased Development

Drawings A-1 and A-2 (see Attachment 3) show existing structures, facility improvements, and roadway access affecting Riverbend's property. The property is located in a rural area outside the McMinnville Urban Growth Boundary ("UGB"). Existing utilities are limited to typical "rural" level facilities such as electrical power and telephone lines. There are no "urban" sewer, water or storm water facilities that extend outside of the UGB.

Drawing A-2 (see Attachment 3) shows existing circulation patterns and parking, loading and service areas. The circulation pattern and parking will not change as a result of this proposal. Recent site improvements approved by the County consolidated facilities at the public entry and also upgraded circulation and parking areas to facilitate separation of "commercial" and "public" access to the landfill. The new Recycling/Public Tipping area provides for a more convenient and safe area for public drop off of recycling and small solid waste loads that is separate from the active landfill work area. The location and layout of the scales and driveways have also separated the commercial and public traffic, and reduced vehicle queues and wait times for the commercial and

public vehicles. On other areas of the site, roads will be reconfigured for access and maintenance that will not be for general use by the public.

Proposed Module 11, which is a 29-acre group of disposal cells to be located west of the existing landfill and adjacent to Highway 18, includes a reconfiguration of the existing berm on the south side of the landfill. This module will be constructed in multiple phases and will also be a contiguous extension of the existing landfill with tree plantings and other landscape features along the newly constructed berms to provide a year-round visual screen. A fill sequencing plan will be submitted with the final engineering drawings at a later time in general accordance with the schedule provided in Table 1 as agreed to by the DEQ.

Riverbend's development proposal does not include any new ancillary facilities or structures. Construction activities will be confined to grading and fill activities for the development of the perimeter berm. The recent addition of some facilities and structures on the site, such as the Renewable Energy Facility and the Recycling/Public Drop facilities, received approval through prior applications. Future facilities, such as the Green Technology Facility that is required as a condition of approval for the Zone Change, will have to be approved by the County as part of a separate application to the County when any new facility is proposed.

4.3.2 Liner Design

Riverbend Landfill's current approved landfill cell liner systems are consistent with current USEPA and DEQ liner system requirements promulgated in 40 CFR, Part 258 (Subtitle D). Proposed Module 11 cell design will be consistent with these requirements. One of the primary Subtitle D requirements is that landfills must have an engineered liner system in place to prevent migration of contaminants into the environment. Current EPA and DEQ regulations require a composite liner system made up of a geosynthetic membrane liner above a natural clay liner, or an engineered alternative.

4.3.3 Leachate Management

Leachate is currently managed by collection, storage, evaporation, and truck-haul to offsite permitted wastewater treatment facilities. Riverbend plans to continue this leachate management practice. The Module 11 leachate collection and removal system (LCRS) sump will be equipped with submersible pumps that will pump leachate to a common high density polyethylene (HDPE) header pipe which will, in turn, discharge leachate to the existing, double-lined leachate collection pond for temporary storage before it is trucked offsite. Secondary leak detection systems (LDSs) will be installed to provide containment of potential liquids below the primary LCRSs. Liquids contained in the LDSs, if any, will be managed similar to leachate.

Riverbend is currently evaluating alternative leachate storage options (such as tanks or smaller ponds) as well as alternative management methods such as evaporation, onsite treatment, or new offsite disposal options. This alternative leachate management analysis will be submitted to the DEQ once it is completed.

4.3.4 Stormwater Management

Riverbend Landfill stormwater discharges are regulated by a Multi Sector General Permit (1200-Z Permit). The existing landfill area includes a network of surface water management control structures (e.g., swales, ditches, pipes) that direct stormwater to detention ponds or sedimentation basins. Stormwater is then discharged onsite or transported offsite for disposal, dependent on the classification of the stormwater as described below. Riverbend plans to manage stormwater for proposed Module 11 in accordance with the existing 1200-Z Permit and consistent with existing stormwater management practices.

The 1200-Z Permit identifies two classes of stormwater, each of which is subject to differing stormwater management requirements. The first class of stormwater is non-contaminated stormwater that discharges at the Riverbend Landfill outfalls to unnamed drainage tributaries of the South Yamhill River. The second general class of stormwater is stormwater that comes in direct contact with waste which is defined as contaminated. Contaminated stormwater is collected, managed and discharged separately from uncontaminated flows by actively segregating it using swales, sumps and other BMPs practices. Contaminated stormwater is primarily disposed of offsite at facilities permitted to accept it. Riverbend only discharges contaminated stormwater through the site's non-contaminated stormwater outfalls to the unnamed drainage locations once it meets stormwater effluent limitations.

4.3.5 Landfill Gas Management

Landfill gas (LFG) is currently managed through an active gas collection and control system (GCCS) designed to manage LFG emissions while efficiently collecting methane for electrical energy generation by the onsite landfill gas to energy facility (LFGTEF). The GCCS includes horizontal and vertical gas wells, temporary and intermediate cover over parts of the landfill, the LFGTEF, and a LFG flare. The flare is typically used to destroy excess LFG that is not able to be combusted by the LFGTEF. The flare also serves as a backup device in the event that one or more engines at the LFGTEF shut down.

The GCCS will be modified, constructed and expanded in phases as individual landfill cells in proposed Module 11 are developed. The Module 11 GCCS will be connected to and incorporated into the existing GCCS infrastructure. The Module 11 GCCS will include the following components:

- Vertical LFG wells installed from the surface of the waste and terminating near the base of the waste.
- Horizontal LFG wells installed in a network of gravel-filled trenches.
- Other collection devices as approved by the DEQ.
- LFG header pipe(s) to convey LFG to the LFGTEF.
- Condensate sumps and pumping systems.

4.3.6 Closure and End Use

As previously discussed in more detail in Section 4.3.1, Riverbend Landfill is now within the EFU zone and DEQ intends to apply the provisions of ORS 459.055 during the permitting process. That statute requires certain rehabilitation standards for landfills in the EFU zone. In essence, the current EFU zone, in conjunction with ORS 459.055, recognizes that the landfill will be an interim use and that, as part of the ultimate closure of the landfill, Riverbend will have to work with DEQ to determine how the site will be rehabilitated to a condition comparable to its original use.

Riverbend has developed a conceptual post-closure plan that describes some of the possible post-closure uses that would be suitable for future conditions that are comparable to the site's original use. That conceptual post-closure plan includes general farm uses such as hay or seed production, pollinator gardens, apiculture, plantings for wildlife habitat, grazing, and the creation, restoration and enhancement of wetlands that are among uses comparable to the original use of the landfill property. These are also uses that currently exist on surrounding lands devoted to farm uses. Regardless of what specific activities occur on site, the requirement to restore Riverbend to a condition comparable to its original use will help ensure the site's long-term compatibility with the surrounding agricultural area. The post-closure activities and potential post-closure uses of the landfill will be detailed in an updated and final post-closure plan to be submitted to the DEQ for review and approval of the Permit Modification.

4.4 DETAILED DESIGNS

The design of Module 11 includes a base grading plan, liner system design, LCRS design, and conceptual final cover system design. Furthermore, as previously discussed, additional geotechnical evaluations will be performed that will include seismic hazard evaluation, dynamic response analyses, slope stability evaluation, and submittal of detailed engineering drawings. The results of these evaluations will be presented to the DEQ in support of this PMA in accordance with the schedule outlined in Table 1.

4.4.1 Base Grading Plan

Figure 4-1 presents the landfill base grading plan for Module 11 that includes potentiometric surface elevations for the shallow WBZ. An evaluation of groundwater elevations in the Module 11 area, including groundwater potentiometric levels, based on a review of historical groundwater elevation data is presented in Attachment 9 (SCS, 2015b). Since the surficial soils are weaker, excavation of these soils will be needed to achieve the base grades.

4.4.2 Liner System

Figure 4-2 shows the composite liner system proposed for Module 11. On the floor, the new liner system (from top to bottom) will consist of the following:

- 12-inch thick operations layer
- 8 ounce geotextile separator fabric
- 12-inch thick gravel primary leachate collection layer (LCRS Drainage Layer)
- 8 ounce geotextile cushion fabric
- 60-mil thick HDPE double-sided textured primary geomembrane
- Geosynthetic Clay Liner (GCL)
- Geocomposite (leak detection system)
- 60-mil thick HDPE double-sided textured secondary geomembrane
- Subgrade soil

On the side slope, the new liner system (from top to bottom) will consist of the following:

- 18-inch thick operations layer
- 16 ounce geotextile separator fabric
- 60-mil thick HDPE double-sided textured primary geomembrane
- GCL
- Geocomposite (leak detection system)
- 60-mil thick HDPE double-sided textured secondary geomembrane
- Subgrade soil

4.4.3 Leachate Collection and Removal System

The leachate collection and removal system will consist of a 12-inch thick gravel layer with perforated leachate conveyance pipes. The floor will grade at a minimum two percent after settlement and at a minimum one percent where leachate conveyance pipes are present. The leachate will flow to a composite-lined sump (Figure 4-2) where it will be pumped to the site's leachate pond for subsequent disposal.

4.4.4 Final Cover System

As shown in Figure 4-3, the Riverbend Landfill conceptual final cover system will consist of the following elements (in order from top to bottom):

- Erosion (Vegetative) Layer: an 18-inch-thick soil layer, the top 6 in. of which is capable of supporting vegetation.
- Drainage Layer: an 8 ounce geotextile placed over the studded surface of the LLDPE geomembrane creates a drainage channel between the geomembrane and the geotextile.
- Barrier Layer: a 60-mil thick linear low density polyethylene (LLDPE) geomembrane with ridges or spikes on one side and flat studs on the other.
- Foundation Layer: an 18-inch-thick foundation soil layer.

The erosion layer will be vegetated with native vegetation that is similar to the vegetation that grows in the areas surrounding the landfill. Plants will be selected for their suitability to local climate, percentage of surface coverage, root zone depths, hardiness and low maintenance requirements.

Prior to construction of a final cover system at Riverbend Landfill, construction level plans and specifications will be submitted to the DEQ for review.

5.0 LANDFILL OPERATIONS

Riverbend Landfill is operated under SWDSP No. 345, issued by the DEQ on December 3, 1999, to accept municipal solid waste (MSW) and approved special waste. Landfill operations summarized in this section are detailed in the current Operations Plan (Ops Plan) for Riverbend Landfill (Riverbend, 2014). The Ops Plan describes the general operations and maintenance procedures as required by OAR 340-94-040. Operation of proposed Module 11 is anticipated to be generally consistent with operational elements described in the Ops Plan.

The site Ops Plan will be updated in accordance with a schedule prescribed by the DEQ after the permit modification is approved.

5.1 SECURITY

Various means of security at Riverbend Landfill help to monitor and restrict access to the site. During operating hours, the scale attendant and operators monitor access to the site and notify the management of unauthorized entry. A combination of natural and engineered features restricts access when the landfill is closed. Natural features including surrounding woodland, streams and rivers restrict vehicle access to a single entrance road from Hwy 18. Engineered security features include fencing and steel gates. Gates are closed and locked when the landfill is not operating. Security cameras are located at the scale house and used as needed.

5.2 DISPOSAL OPERATIONS AND WASTE HANDLING

All customer vehicles enter Riverbend Landfill via the main entrance on Highway 18 to ensure that traffic and waste receiving is controlled. The scale attendant performs an initial screening to ensure the waste is acceptable and to determine the materials origin. Based on inbound material type, the driver is directed to the appropriate area for unloading. The general public customers are typically directed to the public tipping and recycling area where they dispose of MSW and are able to recycle certain material. Commercial customers are directed to the active landfill area where they unload waste material. Riverbend Landfill operators and personnel visually inspect loads to ensure appropriate disposal and for any prohibited waste. Modules 4 to 9 are currently available for landfill disposal operations. Standard waste placement methods will be practiced when waste is placed in any module including the MSE berm area(s). After the initial lift has been placed, lifts will be placed in thin layers and compacted. Waste is compacted continuously during the placement process.

The first lift over newly constructed areas consists of municipal solid waste and special waste that is generally devoid of materials (such as demolition material, lumber, re-bar, or other rigid or bulky materials) that could penetrate or puncture the leachate collection system and/or liner. Operating equipment is restricted to travel on the waste layer only, extending the lift out over the prepared liner/collection system at height of roughly 5 feet (loose state). Moderate compaction is applied to only the top portion of the first lift (i.e., compaction should not occur on the sloped face of daily cells constituting the first lift). If a traffic path on the operations layer will be used more heavily,

the operations layer shall be built up to between 2 and 3 feet thick along the traveled way. Heavy point-load equipment (such as compactors or wheel loaders) will have a minimum of 5 feet of uncompacted disposal material above the operations layer before operating on the landfill.

The size of the working face is minimized to the extent possible to reduce or eliminate vectors, odors, litter, and stormwater infiltration. The outer face/finished grade of placed waste will be no steeper than 3.5(H) to 1(V) to ensure the stability of the waste and liner system. Soil or alternative daily cover (ADC) cover is placed on the top surface of each advancing lift and also on the "daylight" face along the outside perimeter of each advancing lift whenever a daily cover surface will remain exposed for an extended period of time (greater than 30 days). Intermediate cover shall be a minimum of 12 inches (including 6 inches daily cover layer) of compacted soil. Daily cover or ADC will be placed on inactive working faces that have not receive fresh waste for more than 6 hours. Approved ADC materials are generally used at Riverbend Landfill in lieu of virgin soils for cover or base layers within the landfill.

Upon approval from the DEQ, final cover activities shall proceed in accordance with the approved closure plan for the facility. Construction of the final cover shall conform to the DEQ requirements specified in the SWDSP or as agreed upon with the DEQ.

5.3 ANCILLARY OPERATIONS

Recent site improvements consolidated facilities at the public entry and also upgraded circulation and parking areas to facilitate separation of "commercial" and "public" access to the landfill (shown in Drawing A-2 of Attachment 3). Ancillary operations include the new Recycling/Public Tipping area for public drop off of recycling and small solid waste loads that is separate from the active landfill work area, the LFGTEF (renewable energy plant), LFG flare station, scale house, maintenance facilities and equipment parking, leachate pond and tanks containment area, office and other storage buildings, construction material laydown/storage areas, employee and contractor parking areas and other similar uses.

5.4 INSPECTION AND MAINTENANCE

Riverbend Landfill personnel periodically inspect the landfill to ensure compliance with the SWDSP and compatibility with the Ops Plan and Operations and Maintenance Manual. These inspections cover the environmental, health, safety, and operational facilities.

5.5 ENVIRONMENTAL MONITORING

Environmental monitoring is performed in accordance with the methods and procedures described in the EMP (SCS, 2014). The SWDSP requires that Riverbend Landfill maintain and periodically update the facility's EMP. Monitoring of various environmental media (e.g., groundwater, LFG, stormwater, surface water, leachate, and lead detection system liquids) is performed to evaluate the performance of engineered environmental control systems (e.g., liners, leachate and gas control systems) and to assess potential environmental impacts and public health and safety risks from any

potential contaminant releases. Monitoring is also performed to protect the public, landfill personnel, and Riverbend assets.

5.6 OPERATING RECORD

In accordance with RCRA Subtitle D, Paret 258.89, Riverbend Landfill maintains an operating record, which is routinely updated and kept on file at the site office. The facility operating record includes the following items as required by Subtitle D

- Demonstration that the site meets all location prohibitions.
- Inspection records and training records.
- LFG monitoring results.
- Documentation of leachate production;
- Groundwater monitoring data.
- Closure and post closure plans.
- Cost estimates and financial assurance documentation.

5.7 CONTINGENCY PLAN

The Ops Plan, Emergency Plan, and Spill Prevent and Containment and Countermeasure Plan guide Riverbend personnel in the event of an emergency situation at the site. Procedures have been outlined for emergency response to fires, explosions, contaminant releases, medical accidents, and natural disasters such as earthquakes and landslides. Emergency contact information, notification procedures, including telephone numbers for emergency response personnel, regulatory agencies and other key contacts are also provided in the contingency plan documents.

No open burning of any material is allowed at Riverbend Landfill. The landfill operating procedures are designed to minimize the potential for fire. If a hot load were inadvertently unloaded at the working face, the burning materials would be excavated, removed from the active fill area, and extinguished. Landfill personnel will extinguish fires that occur on the landfill site promptly if possible. In the vent a fire is determined to be beyond the capabilities of site personnel, the McMinnville fire Department will be called to assist. Fire protection procedures for landfill equipment include equipment internal automatic fire extinguishing systems, frequently removing debris from undercarriages and engine compartments, repairing oil and fuel leaks, and providing portable fire extinguishers in the cab of each vehicle. All facility buildings, including the scale house and recycling buildings are also equipped with fire extinguishers for extinguishing small fires. The site maintains a water truck and fire suppression water storage that may be used to extinguish small fires.

5.8 INCREMENTAL POST-CLOSURE OPERATIONS

The Ops Plan includes a Closure and Post-Closure Plan that identifies procedures and time schedules for closure, post-closure monitoring and maintenance, as well as a cost estimate for the purposes of establishing financial assurance. Post-closure operations are discussed in more detail in Section 7.0 of this document.

5.9 PERSONNEL

Riverbend personnel are trained in the specific tasks that are required to fulfill their job duties. Training is summarized in the Ops Plan. The following staff members are typically onsite during operating hours, with the actual number of employees varying based on operational hours and needs. Supervisory or technical staff is typically onsite on an as-needed basis (e.g., District Manager, Site Engineer, or Environmental Protection Specialist).

- **District Manager:** Provide administrative oversight to all landfill and recycling activities, communications, personnel, operations, construction, compliance and office administration.
- **Operations Manager**: Manage and direct daily landfill operations and supervise field employees, provide training for new employees in operations policies, equipment usage, equipment maintenance and operation, and safety procedures, special waste acceptance, fill sequencing and road construction.
- **Office Manager:** Provide administrative support to manager's, supervise clerical staff and gate attendants, oversee the on-site accounting and computer systems and act as site payroll/benefits administrator.
- **Safety Manager:** Implement health and safety programs and provide oversight during emergency situations.
- **Site Engineer:** Responsible overall engineering for the landfill, including, gas systems, stormwater, fill sequencing and road construction.
- **Environmental Protection Specialist:** Oversees environmental issues and compliance for the landfill, performs site inspections, investigations and permitting, interacts with regulatory agencies.
- **Scale Attendant:** Inspect, weigh/measure incoming loads, direct traffic to appropriate disposal and recycling areas, and collects disposal fees.
- **Mechanic:** Assist in all operational activities. Inspect, maintain and repair landfill equipment.
- **Operator:** Assist in all operational activities, operate light and heavy landfill equipment and monitor waste loads as they are unloaded. Responsible for grading road and tipping area.

- **Technician**: Monitors the leachate and LFG management systems. Performs sampling duties, inspection duties and performs maintenance.
- **Laborer:** Assist in all operational activities, control on-site traffic, check incoming loads, monitor waste disposal operations, conduct routine load inspections, and police recycling and restricted access areas.

6.0 ENVIRONMENTAL MONITORING

Riverbend Landfill's current monitoring program is described in the site's DEQ-approved EMP (SCS, 2014). The EMP describes the environmental monitoring networks (including the groundwater, LFG, and leachate management system monitoring networks) and schedules. The environmental monitoring networks will be expanded or modified in the proposed Module 11 area to evaluate the performance of environmental control systems (e.g., landfill liner, LCRSs, GCCS, and stormwater management system), and to provide early detection of any potential releases from these systems.

After issuance of the Permit Modification for the Module 11 expansion by the DEQ, an updated EMP will be submitted to the DEQ describing specific modifications to the environmental monitoring networks and programs associated with Module 11. The updated EMP may include but will not be limited to the following:

- Description of initial landfill cell(s) construction, including leachate management system monitoring locations.
- Modifications of the groundwater, leachate, LFG monitoring programs and networks.
- Removal and/or installation of groundwater monitoring wells and piezometers and LFG probes to accommodate Module 11 development activities. The schedule for installing new compliance monitoring wells will consider the requirement for collecting the requisite background groundwater quality data (i.e., four quarterly monitoring periods) prior to placement of waste in any new waste cells.

7.0 CLOSURE, POST-CLOSURE, AND FINANCIAL ASSURANCE

The Ops Plan includes a Closure and Post-Closure Plan that identifies procedures and time schedules for closure, post-closure monitoring and maintenance, as well as a cost estimate for the purposes of establishing financial assurance. The Ops Plan describes the final cover soils and capping procedures. Detailed engineering plans, specifications, and a schedule for closure will be submitted to the DEQ at least 6 months prior to final closure of any portion of the landfill.

At least 5 years prior to the anticipated final closure of the landfill, Riverbend will apply for a closure permit. Maps and statement of fact concerning the location will be recorded as part of the deed with the appropriate County agency within 30 days after final closure.

Upon the completion of site closure activities, post-closure monitoring/long term care activities will commence and continue for a period of 30 years after the closure of the site. During that time, Riverbend will maintain the integrity and effectiveness of the final cover, and continue groundwater monitoring, gas monitoring, and leachate management. Records of all post-closure site inspections and monitoring will be kept on file by Riverbend. Records of inspections will address problems found and corrective actions taken. Post-closure activities are outlined in detail in the Closure and Post-Closure Plan.

Financial assurance for closure and post-closure activities has been developed based on DEQ-approved cost estimate and financing mechanisms. Riverbend Landfill's Financial Assurance Plan is also included with the Closure and Post-Closure Plan. The financial assurance and mechanism will be updated annually and submitted to the DEQ by April 8 each calendar year while the landfill is in operation and during the post-closure care period. A certification will accompany the updated financial assurance plan stating that the plan and financial assurance mechanism(s) have been reviewed, updated, and found adequate, and that the update documents have been placed in the operating record.

8.0 REFERENCES

CH2M Hill, 2000, Technical Memorandum (re: Installation of Eight New Monitoring Wells at Riverbend Landfill) to G. Duvendack, Riverbend Landfill, from B. Long, CH2M Hill, Portland, Oregon, November 21.

CH2M Hill, 2013, 2013 Technical Memorandum (re: 2013 Poplar Tree Farm Monitoring, Riverbend Landfill), prepared for Waste Management, by CH2M Hill, Portland, Oregon, December 20.

EMCON Northwest, Inc. (EMCON), 1993a, Beneficial Use Survey for the Riverbend Landfill, McMinnville, Oregon, prepared for Riverbend Landfill, McMinnville, Oregon, by EMCON, Portland, Oregon, May 19.

EMCON, 1993b, Remedial Investigation, Riverbend Landfill Co., Inc., Yamhill County, Oregon, prepared for Riverbend Landfill Co., Inc., McMinnville, Oregon, by EMCON, Portland, Oregon, October 1.

EMCON, 1994, Additional Hydrogeological Investigation, Riverbend Landfill, Yamhill County, Oregon, prepared for Riverbend Landfill Co., Inc., McMinnville, Oregon, by EMCON, Portland, Oregon, July 29.

EMCON, 1995, Letter (re: Riverbend Landfill, Installation of Monitoring Wells MW-12A and MW-12B) to D. Wilson, Riverbend Landfill Company, Inc., McMinnville, Oregon, from L. Caruso and C. Fanshier, EMCON, Portland, Oregon, August 22.

EMCON, 1996, Installation of New Compliance Boundary Monitoring Wells and Decommissioning of Monitoring Wells MW-8A and MW-8B, prepared for Riverbend Landfill Company, Inc., McMinnville, Oregon, by EMCON, Portland, Oregon.

Geosyntec Consultants (Geosyntec), 2012, Phase 1 MSE Berm – Updated Permit Design Report, prepared for Riverbend Landfill Company, Inc., McMinnville, Oregon, by Geosyntec Consultants, Oakland, California, March 22.

Geosyntec Consultants, 2015, Module 11: Summary of Field Investigation and Laboratory Testing Programs, Riverbend Landfill, prepared for Riverbend Landfill Company, McMinnville, Oregon, by Geosyntec, Oakland, California, March 17.

HWA GeoSciences, Inc., 2001, Letter (Re: informal preliminary assessment to address water-quality issues in MW-12B, Riverbend Landfill), to R. North, Waste Management, Inc., Portland, Oregon, from L. Caruso and K. Mathiot, HWA, Lake Oswego, Oregon, April 13.

Latimer Environmental LLC, 2014, Floodplain Development Permit Application Narrative: Riverbend Expansion – Modules 10 and 11, Riverbend Landfill Company, prepared for Riverbend Landfill Company, McMinnville, Oregon, by Latimer Environmental LLC, Portland, Oregon, November 5, 2014.

Oregon Department of Environmental Quality (DEQ), 1998, Letter (Re: Response to preliminary assessment at Riverbend Landfill) to R. North, Riverbend Landfill Co., Inc., USA Waste, from C. Donaldson, DEQ, Salem, Oregon. February 27.

Oregon Department of Environmental Quality, 2014a, Letter (Re: 2013 Riverbend Environmental Monitoring Plan, Yamhill County SWDP #345), to F. Willman, Waste Management, Portland, Oregon, from A. Eldridge, DEQ Eastern Region, The Dalles, Oregon, March 18

Oregon Department of Environmental Quality, 2014b, Letter (re: Update to 2013 Riverbend environmental monitoring plan, Yamhill County SWDP #345), to F. Willman, Waste Management, Portland, Oregon, from A. Eldridge, DEQ Eastern Region, The Dalles, Oregon, October 6.

Oregon Department of Environmental Quality, 2015a, Letter (re: work plan for hydrogeologic site characterization – Module 11 expansion), to F. Willman, Waste Management, Bainbridge Island, Washington, from A. Eldridge, DEQ Northwest Region, Portland, Oregon, April 14, 2015.

Price, D., 1967, Geology and Water Resources in the French Prarie Area, Northern Willamette Valley, Oregon, Washington: U.S. Government Printing Office, Geological Survey Water-Supply Paper 1833, 1967.

Riverbend Landfill Company, 2014, Site Design Review Application, Riverbend Expansion Modules 10 and 11, Riverbend Landfill, McMinnville, Oregon, November 5.

SCS Engineers (SCS), 2011, Report of Drilling and Piezometer/Monitoring Well Installations for Hydrogeologic Site Characterization in Support of Landfill Expansion Permitting, Riverbend Landfill, McMinnville, Oregon, prepared for Riverbend Landfill Company, Inc., McMinnville, Oregon, by SCS, Portland, Oregon, March 8.

SCS, 2013, Environmental Monitoring Plan, Riverbend Landfill, McMinnville, Oregon, prepared for Riverbend Landfill Company, Inc., McMinnville, Oregon, by SCS, Portland, Oregon, July 30.

SCS, 2014a, 2013 Annual Environmental Monitoring Report, prepared for Riverbend Landfill Company, Inc., McMinnville, Oregon, by SCS, Portland, Oregon, April 29.

SCS, 2014b, Letter (Re: Responses to DEQ's review comments of the July 30, 2013, environmental monitoring plan for Riverbend Landfill, McMinville, Oregon, solid waste disposal permit No. 345), to F. Willman, Riverbend Landfill Company, McMinnville, Oregon, from D. Lamadrid and L. Caruso, SCS, Portland, Oregon, June 10.

SCS, 2014c, Environmental Monitoring Plan, Riverbend Landfill, McMinnville, Oregon, prepared for Riverbend Landfill Company, Inc., McMinnville, Oregon, by SCS Engineers, Portland, Oregon, December 2.

SCS, 2015a, Hydrogeologic Site Characterization Work Plan, Riverbend Landfill, McMinnville, Oregon, prepared for Riverbend Landfill Company, Inc., McMinnville, Oregon, by SCS Engineers, Portland, Oregon, February 13.

SCS, 2015b, Memorandum (Evaluation of Historical Groundwater Elevations in the Proposed Module 11 Expansion Area, Riverbend Landfill, McMinnville, Oregon), prepared for Geosyntec Consultants, Oakland, California, by SCS Engineers, Portland, Oregon, April 23.

Shaw Environmental, Inc., 2006, Water-Quality Assessment of the North Poplar Tree Farm, Riverbend Landfill, McMinnville, Oregon, prepared for Waste Management, Inc., Portland, Oregon, by Shaw Environmental, Inc., Portland, Oregon, December 27.

Sweet, Edwards, and Associates, Inc., 1981, Geotechnical Feasibility Report, River Bend Sanitary Landfill, July 27.

Riverbend Landfill Company, 2014, Operations Plan, Riverbend Landfill, 13469 SW Hwy 18, McMinnville, Oregon, November.

USA Waste, Inc. (USAW), 1997, Preliminary Assessment Report, Riverbend Landfill, Yamhill County, Oregon. Prepared for Riverbend Landfill Co., Inc., by USAW, San Rafael, California. December 30.

Waterways Consulting, Inc., 2014, Preliminary Hydraulic Report for Riverbend Expansion – Modules 10 and 11, Riverbend Landfill Company, prepared for Latimer Consulting LLC, Portland, Oregon, by Waterways Consulting, Inc., Portland, Oregon, November 5.

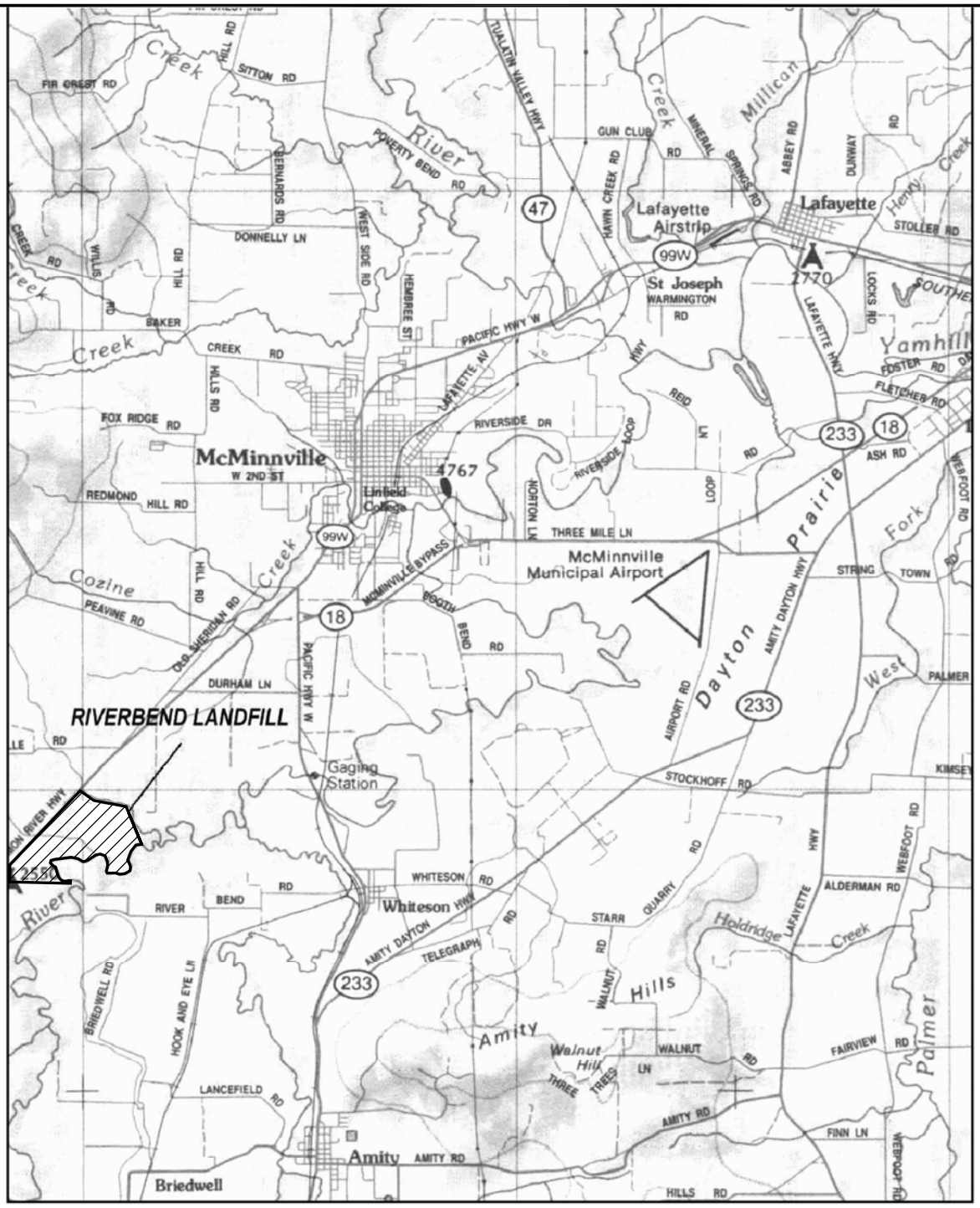
Yamhill County, 2015, Letter (re: Docket No. SDR-16-14/FP-03-14, Tax Lots 5501-101, -200, -400, and -401), to T. Brooks, Cable Huston, Portland, Oregon, from M. Brandt, Yamhill County, Department of Planning and Development, McMinnville, Oregon, January 16.

TABLES

Table 1
Submittal Schedule and Description of Components for DEQ Permit Modification Application
Module 11 Expansion
Riverbend Landfill

Report/Work Plan Submittal	Description of Report/Work Plan Content/Information	Proposed DEQ Submittal Date
Hydrogeologic Site Characterization [HSC] Work Plan (Revised to address DEQ review comments noted in April 13, 2015 letter [DEQ, 2015])	Describes HSC scope of work, field investigations, data evaluation methods, and report content. The revised scope of work based on DEQ's review comments includes an aquifer pumping test using on-site production well PW-1, including construction information for PW-1.	Provided in Attachment 4 of this Application
Geotechnical Investigation Summary Report (Revised to address Hart Crowser and DEQ review comments)	Description of geotechnical field investigation and lab testing investigation methods and results. The revised	Provided in Attachment 4 of this Application
Memorandum: Evaluation of groundwater elevations in Module 11 area	Determination of estimated high groundwater conditions based on review of historical groundwater elevation data that was used in support of Module 11 base grade design.	Provided in Attachment 9 of this Application
Base Grading Plans (text and drawings)	Presents base grade contours relative to high groundwater contours along with conceptual design of primary and secondary leachate collection systems and liner system.	Provided in Figures 4-1, 4-2, and 4-3 of this Application
HSC Report	Lab testing description and results (provided in AEMR; to be summarized in HSC report)	6/15/2015
	Subsurface soil stratigraphy (cross-sections, isopach maps of shallow/deep WBZ, top of bedrock surface), hydrogeologic conditions (GW contour maps, GW gradients/velocity).	
	Hydraulic testing results (pump test and single well slug test	
	Updated water well survey	
	Proposed layout of new groundwater monitoring wells for Module 11	
Seismic Design and Analysis Report	Regulatory requirements	6/15/2015
	Seismic hazard evaluation	
	Dynamic response analyses	
	Response to February 11, 2015 comments by Hart Crowser and April 22, 2015 DOGAMI comments	
Slope Stability Evaluation Report	Static and seismic evaluation	7/15/2015
	Local and global slope stability	
Engineering Design Drawings and Narrative	Site Plan and Existing Topography	8/10/2015
	Base Grading Plans (2)	
	Fill Grading Plan - Final	
	Surface water plan - final	
	Details (6)	
Environmental Monitoring Plan	These existing site plans will be updated to include the Module 11 expansion after issuance of the Permit Modification in accordance with the schedule specified by the DEQ.	After Issuance of Permit Modification
Closure/Postclosure and Financial Assurance Plan		
Operations Plan		

FIGURES



Basemap from Oregon Atlas and Gazetteer (DeLorme)

0 1 2
MILES

WASTE MANAGEMENT

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

PROJECT NO.	DES BY	SITE LOCATION MAP	DATE
04215014.00	D.L.		APRIL 2015
SCALE	CHK BY	RIVERBEND LANDFILL	FIGURE
AS SHOWN	L.C.	McMINNVILLE, OREGON	1-1
CAD FILE	APP BY		
FIGURE 1-1	L.C.		

LEGEND:

Proposed Lateral Expansion Area

Module 11 Berm Enhancement

SOURCE:
1. Satellite image ©2012, Google Earth and Riverbend image ©2014, Waste Management.

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

WASTE MANAGEMENT

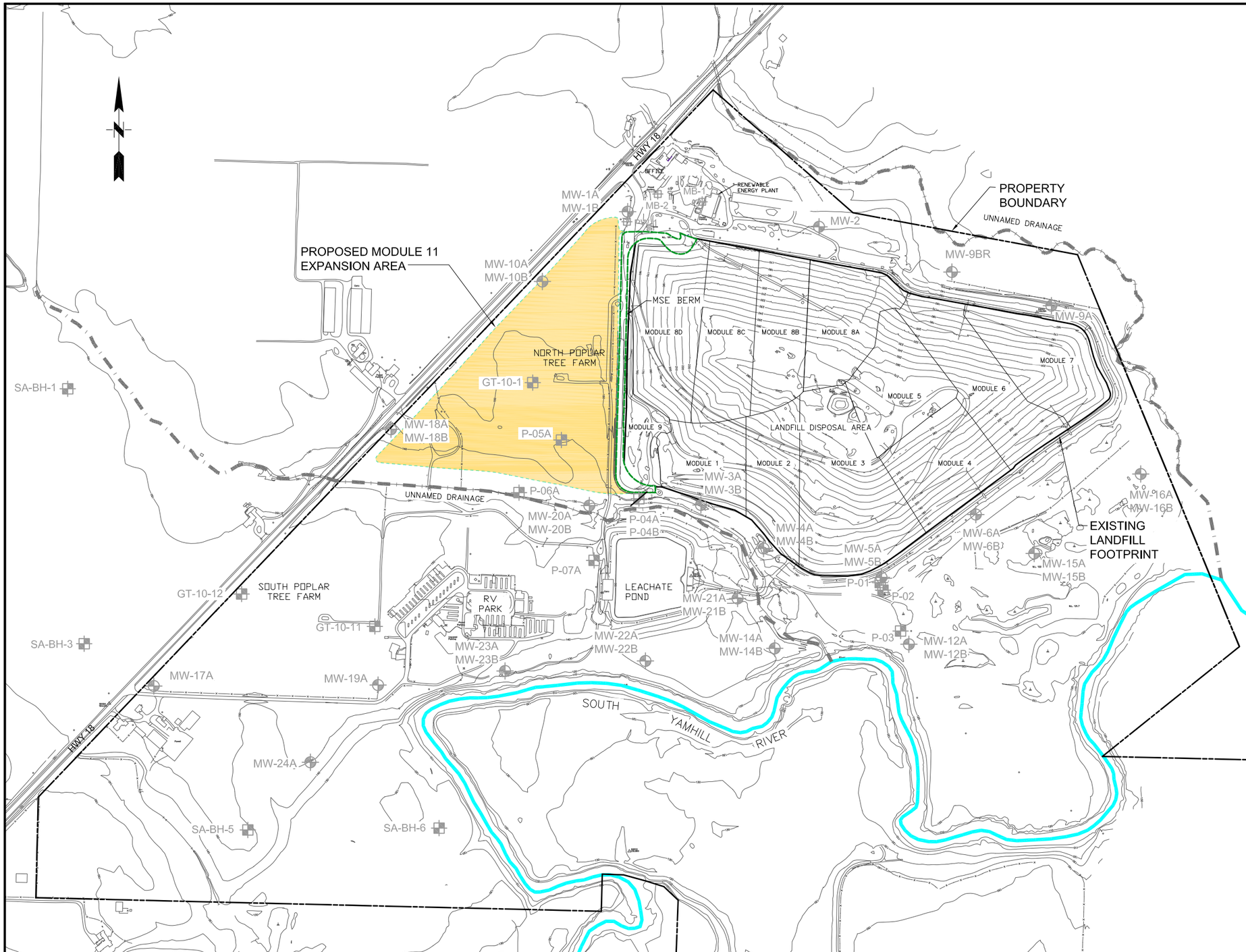
0 600 1200
SCALE IN FEET

PROJECT NO. 04215014.00	DES BY D.L.
SCALE AS SHOWN	CHK BY L.C.
CAD FILE FIGURE 1	APP BY L.C.

OVERVIEW MAP AND AERIAL PHOTO
SITE DESIGN REVIEW APPLICATION
RIVERBEND EXPANSION - MODULES 11
RIVERBEND LANDFILL COMPANY

DATE APRIL 2015

FIGURE 1-2



LEGEND:

- Topographic Contours (Surveyed)
- Topographic Contours (USGS)
- Property Boundary
- Flow Line - Yamhill River
- Flow Line - Unnamed Drainage
- Proposed Expansion Area
- Mechanically Stabilized Earthen (MSE) Berm

EXISTING GROUNDWATER MONITORING LOCATIONS

- MW-19A — Groundwater Monitoring Well
- P-05A — Piezometer
- MB-2 — On-Site Water Well

SOURCE:

1) Topographic base map prepared by Miller Creek Aerial Mapping, using photogrammetric survey methods, date of photograph March 22, 2014.
Contours are based on NAVD 88.

NOTES:

1) Monitoring wells and piezometers with "A" designation are screened in the shallow (Silt-Clay) water-bearing zone, and monitoring wells and piezometers with "B" designation are screened in the deeper (Sand-Gravel) water-bearing zone.

2) Piezometers with "GT" and "SA-BH" designations are screened in the shallow (Silt-Clay) water-bearing zone. .

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

WASTE MANAGEMENT

0 600 1200
SCALE IN FEET

PROJECT NO. 04215014.00	DES BY D.L.
SCALE AS SHOWN	CHK BY L.C.
CAD FILE FIGURE 1-3	APP BY L.C.

SITE PLAN

RIVERBEND LANDFILL
McMINNVILLE, OREGON

DATE APRIL 2015

FIGURE 1-3

LEGEND:

- Soil Boundary
- Proposed Lateral Expansion Area
- Module 11 Berm Enhancement

SOIL MAP LEGEND:

Map Unit Symbol	Map Unit Name
2002A	Chehalis silty clay loam, 0 to 3 percent slopes
2006A	McBee silty clay loam, 0 to 3 percent slopes
2012A	Waldo silty clay loam, 0 to 3 percent slopes
2013A	Wapato silty clay loam, 0 to 3 percent slopes
2015A	Cove silty clay loam, flooded, 0 to 3 percent slopes
2216A	Chehalem silty clay loam, volcanic, 0 to 3 percent slopes
2301A	Amity silty loam, 0 to 3 percent slopes
2304C	Carlton silty loam, 2 to 12 percent slopes
2306A	Dayton silty loam, 0 to 2 percent slopes
2310A	Woodburn silty loam, 0 to 3 percent slopes
2310C	Woodburn silty loam, 3 to 12 percent slopes
2310D	Woodburn silty loam, 12 to 20 percent slopes
2310F	Woodburn silty loam, 20 to 55 percent slopes
2791D	Gellatly silty clay loam, 12 to 20 percent north slopes
2795E	Gellatly-Dixonville complex, 20 to 30 percent south slopes
FILL	Fill land

⊛ Fill area formally consisted of primarily 2310A and 2015A soils.

SOURCE:
1. Natural Resources Conservation Service, Web Soil Survey. Soil Survey Area: Yamhill County, Oregon. Survey Area Data: Version 2, September 24, 2014.
2. Satellite image ©2012, Google Earth and Riverbend image ©2014, Waste Management.

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

WASTE MANAGEMENT

0 600 1200
SCALE IN FEET

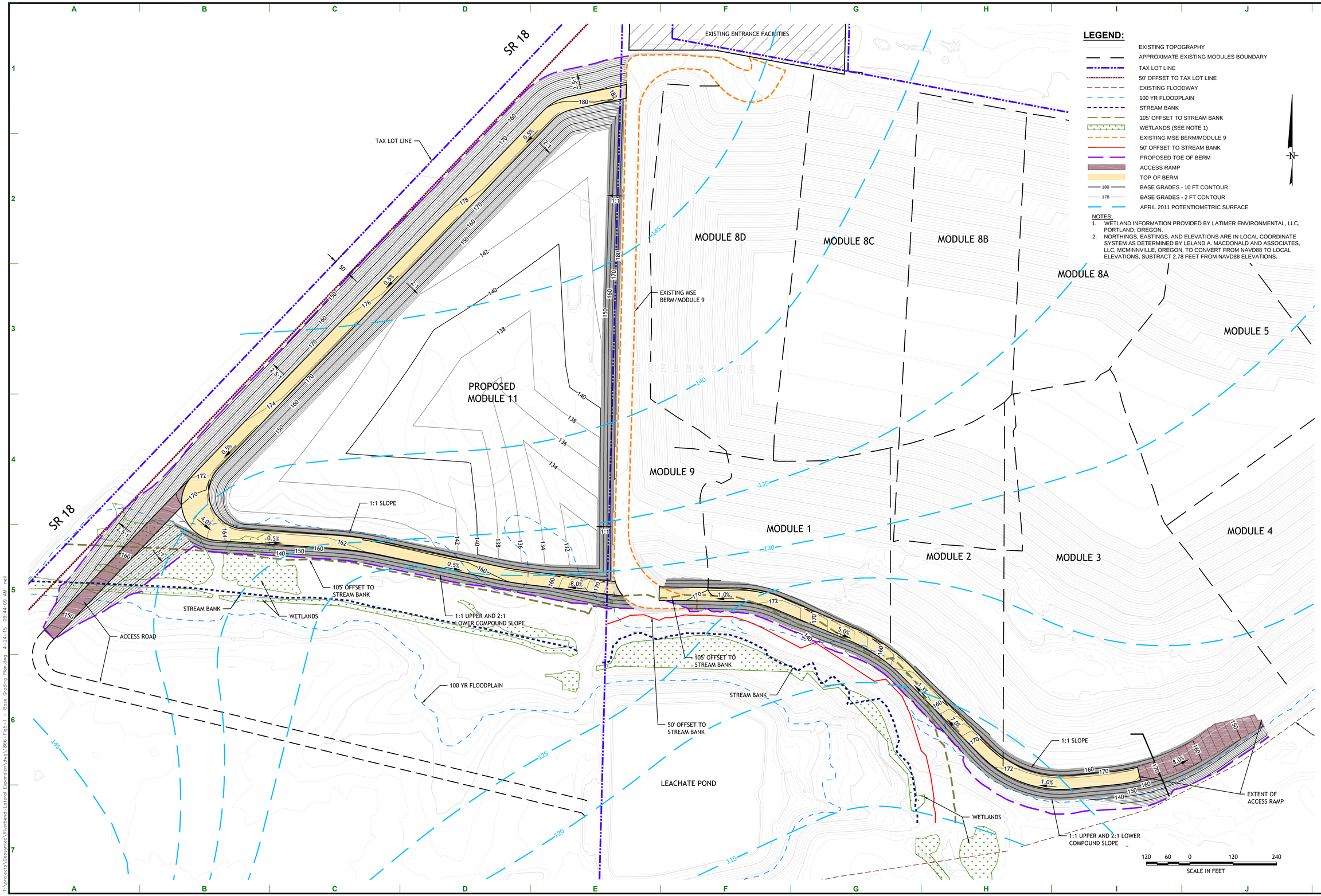
PROJECT NO. 04215014.00	DES BY D.L.		
SCALE AS SHOWN	CHK BY L.C.		
CAD FILE FIGURE 2-1	APP BY L.C.		

SOIL SURVEY MAP

SITE DESIGN REVIEW APPLICATION
RIVERBEND EXPANSION - MODULES 10 AND 11
RIVERBEND LANDFILL COMPANY

DATE APRIL 2015

FIGURE 2-1



LEGEND:

- EXISTING TOPOGRAPHY
- APPROXIMATE EXISTING MODULES BOUNDARY
- TAX LOT LINE
- 50' OFFSET TO TAX LOT LINE
- EXISTING FLOODWAY
- 100 YR FLOODPLAIN
- STREAM BANK
- 105' OFFSET TO STREAM BANK
- WETLANDS (SEE NOTE 1)
- EXISTING MSE BERM/MODULE 9
- 50' OFFSET TO STREAM BANK
- PROPOSED TOE OF BERM
- ACCESS RAMP
- TOP OF BERM
- 180 BASE GRADES - 10 FT CONTOUR
- 178 BASE GRADES - 2 FT CONTOUR
- APRIL 2011 POTENTIOMETRIC SURFACE

NOTES:

1. WETLAND INFORMATION PROVIDED BY LATIMER ENVIRONMENTAL, LLC, PORTLAND, OREGON.
2. NORTHINGS, EASTINGS, AND ELEVATIONS ARE IN LOCAL COORDINATE SYSTEM AS DETERMINED BY LELAND A. MACDONALD AND ASSOCIATES, LLC, MCMINNVILLE, OREGON. TO CONVERT FROM NAVD88 TO LOCAL ELEVATIONS, SUBTRACT 2.78 FEET FROM NAVD88 ELEVATIONS.

NO.	DESCRIPTION	DATE

REVISIONS

SHEET TITLE: BASE GRADING PLAN

PROJECT TITLE: SITE DESIGN REVIEW APPLICATION
RIVERBEND EXPANSION - MODULE 11
RIVERBEND LANDFILL - COMPANY
YAMHILL COUNTY, OREGON

WASTE MANAGEMENT

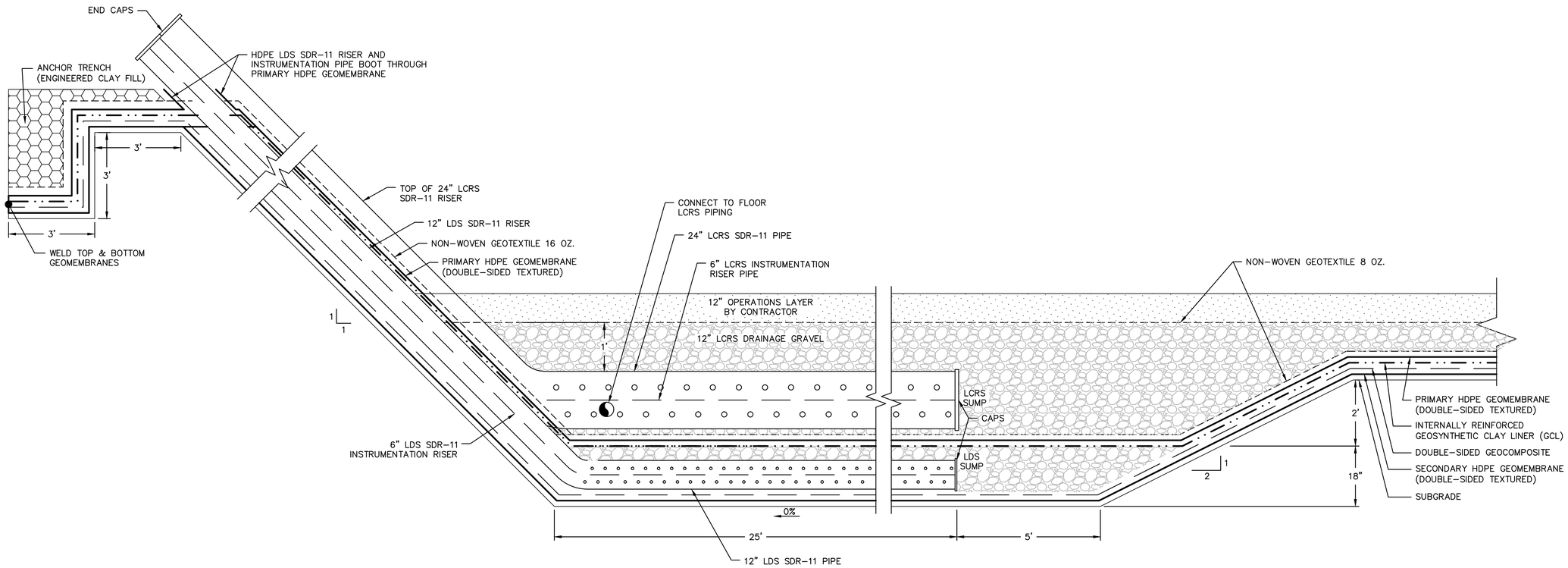
PRELIMINARY DRAWINGS

DES BY:	FWS	DATE:	APRIL 2015
DRN BY:	NTB	SCALE:	AS NOTED
CHK BY:	FWS	PROJECT:	WG1866
REV BY:	FWS	DOCUMENT:	
APP BY:	HDS		
FILE:			

Geosyntec consultants
1111 Broadway
Sixth Floor
Oakland, CA 94607

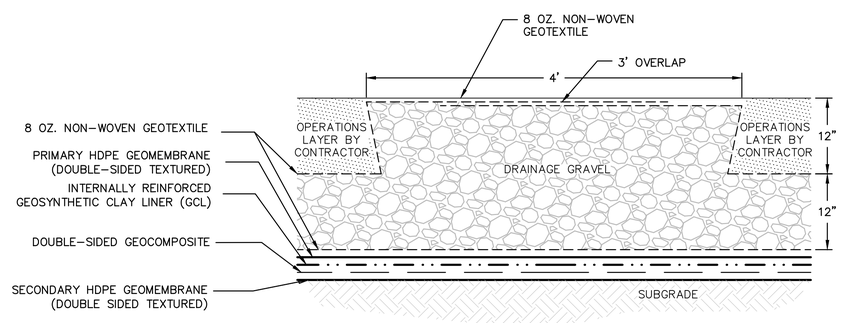
FIGURE NO.
4-1

T:\projects\Geosyntec\Riverbend-Lateral Expansion\dwg\1866-Fig5-1 - Base Grading Plan.dwg 4-24-15 09:44:09 AM neil



SUMP SECTION

NOT TO SCALE



COMPOSITE LINER SYSTEM

NOT TO SCALE

NOTES:

1. ON SIDE SLOPE, OPERATIONS LAYER IS 18" MINIMUM AND NO DRAINAGE GRAVEL IS REQUIRED.
2. ON THE FLOOR, THE 1 FOOT OF SUBGRADE SOIL ADJACENT TO THE COMPOSITE LINER SYSTEM SHALL MEET THE INTERFACE STRENGTH SPECIFICATIONS.
3. INSTALLER TO STAGE DEPLOYMENT OF GEOSYNTHETICS SO THAT EQUIPMENT DOES NOT NEED TO DRIVE DIRECTLY OVER ALREADY DEPLOYED GEOSYNTHETICS. ALLOWED GROUND PRESSURES OVER GEOSYNTHETICS ARE PROVIDED IN THE SPECIFICATIONS AND MUST BE FOLLOWED AT ALL TIMES DURING AND AFTER CONSTRUCTION. CONTRACTOR TO STAGE AND COORDINATE PLACEMENT OF DRAINAGE GRAVEL AND OPERATIONS LAYER SO THAT GCL, GEOMEMBRANES, AND GEOTEXTILES ARE NOT DRIVEN OVER UNLESS MINIMUM MATERIAL THICKNESS LISTED IN THE SPECIFICATIONS ARE MET.

NO.	DESCRIPTION	DATE

REVISIONS

SHEET TITLE: LINER SYSTEM

PROJECT TITLE: SITE DESIGN REVIEW APPLICATION
RIVERBEND EXPANSION - MODULE 11
RIVERBEND LANDFILL - OPERATIONS
YAMHILL COUNTY, OREGON

WASTE MANAGEMENT

PRELIMINARY DRAWINGS

DES BY:	FWS	DATE:	APRIL 2015
DRN BY:	NTB	SCALE:	AS NOTED
CHK BY:	FWS	PROJECT:	WG1597
REV BY:	FWS	DOCUMENT:	
APP BY:	HDS	FILE:	

Geosyntec consultants
1111 Broadway
Sixth Floor
Oakland, CA 94607

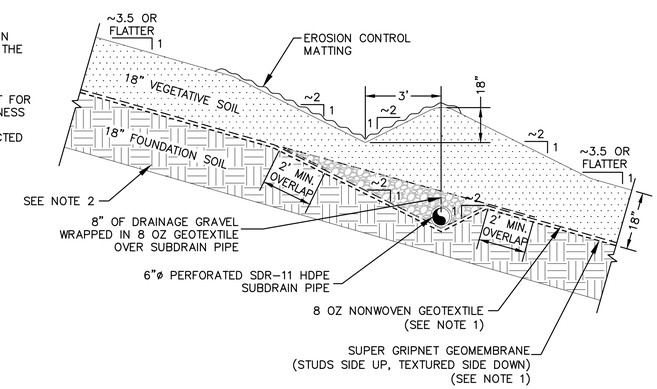
FIGURE NO.
4-2

T:\projects\Geosyntec\Riverbend-Lateral Expansion\dwg\1866-Sump Section.dwg 4-24-15 09:44:50 AM neil

NOTES:

1. A DOUBLE-SIDED TEXTURED GEOMEMBRANE OVERLAIN BY A DOUBLE-SIDED GEOCOMPOSITE MAY REPLACE THE SUPER GRIPNET GEOMEMBRANE OVERLAIN BY NON-WOVEN GEOTEXTILE.

2. EXISTING INTERIM COVER ABOVE MSW MAY ACCOUNT FOR A PORTION OF THE FOUNDATION SOIL LAYER THICKNESS PROVIDED THE INTERIM COVER MATERIAL MEETS REQUIREMENTS IN THE SPECIFICATIONS FOR COMPACTED SOIL (I.E. COMPACTION AND GRADATION).



FINAL COVER SYSTEM WITH DITCH (TYP)

NOT TO SCALE

NO.	DESCRIPTION	DATE

REVISIONS

SHEET TITLE: FINAL COVER SYSTEM

PROJECT TITLE: SITE DESIGN REVIEW APPLICATION
RIVERBEND EXPANSION - MODULE 11
RIVERBEND LANDFILL - COMPLEX 1
YAMHILL COUNTY, OREGON

WASTE MANAGEMENT

PRELIMINARY DRAWINGS

DES BY:	FWS	DATE:	APRIL 2015
DRN BY:	NTB	SCALE:	AS NOTED
CHK BY:	FWS	PROJECT:	WG1597
REV BY:	FWS	DOCUMENT:	
APP BY:	HDS		
FILE:			

Geosyntec consultants
1111 Broadway
Sixth Floor
Oakland, CA 94607

FIGURE NO.

4-3

T:\projects\Geosyntec\Riverbend-Lateral Expansion\dwg\1866-Sump Section.dwg 4-24-15 09:45:20 AM neil

ATTACHMENT 1

Land Use Compatibility Statement
Ordinance 887
Board Order 15-115
Recommendation From Yamhill County

Land Use Compatibility Statement

Oregon Department of Environmental Quality
LAND USE COMPATIBILITY STATEMENT (LUCS)

SECTION 1 - TO BE COMPLETED BY APPLICANT

1A. Applicant Name: Riverbend Landfill Co.	**1B. Project Name:** Riverbend Landfill Expansion
Contact Name: Paul Burns	**Physical Address:** 13469 SW Hwy 18
Mailing Address: 7227 NE 55th Avenue	**City, State, Zip:** McMinnville, OR 97128
City, State, Zip: Portland, Oregon 97218	**Tax Lot #:** 5501 - 101, 200, 400, 401
Telephone: 503-528-0681	**Township:** 55 **Range:** SW **Section:** 1, 2, 11 & 12
Tax Account #: 472722, 209143, 209063, 455448	**Latitude:** 45° 9° 123° N
	Longitude: 123° 14° 56° W

1C. Describe the project, include the type of development, business, or facility and services or products provided (attach additional information if necessary):

The project is an expansion of Riverbend Landfill as proposed to, and approved by, Yamhill County pursuant to dockets SDR-16-14 and FP-03-14. A more full description is included in the Findings attached to Yamhill County Board Order 15-115.

1D. Check the type of DEQ permit(s) or approval(s) being applied for at this time.

- ☐ Air Quality Notice of Construction
- ☐ Air Contaminant Discharge Permit *(excludes portable facility permits)*
- ☐ Air Quality Title V Permit
- ☐ Air Quality Indirect Source Permit
- ☐ Parking/Traffic Circulation Plan
- ☒ Solid Waste Land Disposal Site Permit
- ☐ Solid Waste Treatment Facility Permit
- ☐ Solid Waste Composting Facility Permit (includes Anaerobic Digester)
- ☐ Conversion Technology Facility Permit
- ☐ Solid Waste Letter Authorization Permit
- ☐ Solid Waste Material Recovery Facility Permit
- ☐ Solid Waste Energy Recovery Facility Permit
- ☐ Solid Waste Transfer Station Permit
- ☐ Waste Tire Storage Site Permit
- ☐ Pollution Control Bond Request
- ☐ Hazardous Waste Treatment, Storage, or Disposal Permit
- ☐ Clean Water State Revolving Fund Loan Request
- ☐ Wastewater/Sewer Construction Plan/Specifications *(includes review of plan changes that require use of new land)*
- ☐ Water Quality NPDES Individual Permit
- ☐ Water Quality WPCF Individual Permit *(for onsite construction-installation permits use the DEQ Onsite LUCS form)*
- ☐ Water Quality NPDES Stormwater General Permit *(1200-A, 1200-C, 1200-CA, 1200-COLS, and 1200-Z)*
- ☐ Water Quality General Permit *(all general permits, except 600, 700-PM, 1700-A, and 1700-B when they are mobile.)*
- ☐ Water Quality 401 Certification for federal permit or license

1E. This application is for: ☐ Permit Renewal ☐ New Permit ☒ Permit Modification ☐ Other:

SECTION 2 - TO BE COMPLETED BY CITY OR COUNTY PLANNING OFFICIAL

Instructions: Written findings of fact for all local decisions are required; written findings from previous actions are acceptable. For uses allowed outright by the acknowledged comprehensive plan, DEQ will accept written findings in the form of a reference to the specific plan policies, criteria, or standards that were relied upon in rendering the decision with an indication of why the decision is justified based on the plan policies, criteria, or standards.

2A. The project proposal is located: ☐ Inside city limits ☐ Inside UGB ☒ Outside UGB

2B. Name of the city or county that has land use jurisdiction *(the legal entity responsible for land use decisions for the subject property or land use)*:
Yamhill County

SECTION 2 - TO BE COMPLETED BY CITY OR COUNTY PLANNING OFFICIAL

Applicant Name: Riverbend Landfill Co. | **Project Name:** Riverbend Landfill Expansion

2C. Is the activity allowed under Measure 49 (2007)? ☒ No, Measure 49 is not applicable ☐ Yes; if yes, then check one:

☐ Express; approved by DLCD order #:

☐ Conditional; approved by DLCD order #:

☐ Vested; approved by local government decision or court judgment docket or order #:

2D. Is the activity a composting facility?
☒ No ☐ Yes; Senate Bill 462 (2013) notification requirements have been met.

2E. Is the activity or use compatible with your acknowledged comprehensive plan as required by OAR 660-031?
Please complete this form to address the activity or use for which the applicant is seeking approval (see 1.C on the previous page). If the activity or use is to occur in multiple phases, please ensure that your approval addresses the phases described in 1.C. For example, if the applicant's project is described in 1.C as a subdivision and the LUCS indicates that only clearing and grading are allowed outright but does not indicate whether the subdivision is approved, DEQ will delay permit issuance until approval for the subdivision is obtained from the local planning official.

☐ The activity or use is specifically exempt by the acknowledged comprehensive plan; explain:

☐ **YES**, the activity or use is pre-existing nonconforming use allowed outright by *(provide reference for local ordinance)*:

☐ **YES**, the activity or use is allowed outright by *(provide reference for local ordinance)*:

☐ **YES**, the activity or use received preliminary approval that includes requirements to fully comply with local requirements; findings are attached.

☒ **YES**, the activity or use is allowed; findings are attached.

☐ **NO**, see 2.C above, activity or use allowed under Measure 49; findings are attached.

☐ **NO**, *(complete below or attach findings for noncompliance and identify requirements the applicant must comply with before compatibility can be determined)*:

Relevant specific plan policies, criteria, or standards:

Provide the reasons for the decision:

Additional comments (attach additional information as needed):
Yamhill County has made two recent decisions that address and approve the expansion of Riverbend Landfill. Ordinance 887 re-zoned the landfill property to a zone that allows the expansion. Board Order 15-115 addressed the specific expansion proposal, approving a Final Site Development Plan and Floodplain Development Permit.

Planning Official Signature: [signature] **Title:** Planning Div. Manager

Print Name: Kenneth P. Friday **Telephone #:** 503 434-7516 **Date:** 4/24/2015

If necessary, depending upon city/county agreement on jurisdiction outside city limits but within UGB:

Planning Official Signature: **Title:**

Print Name: **Telephone #:** **Date:**

Ordinance 887

BEFORE THE BOARD OF COMMISSIONERS OF THE STATE OF OREGON

FOR THE COUNTY OF YAMHILL

SITTING FOR THE TRANSACTION OF COUNTY BUSINESS

In the Matter of a Comprehensive Plan Designation Amendment From "Commercial" and "Public" to "Agriculture Forestry Large Holding," a Zoning Map Amendment from "Recreation Commercial" and "Public Works Safety" to "EF-80 Exclusive Farm Use," and Imposition of a Limited Use Overlay, Planning Docket PAZ-02-13, Applicant Riverbend Landfill, and Declaring an Emergency	)	Ordinance 887

THE BOARD OF COMMISSIONERS OF YAMHILL COUNTY, OREGON (the Board) sat for the transaction of county business on February 13, 2014, Commissioners Mary P. Stern, Allen Springer and Kathy George being present.

IT APPEARING TO THE BOARD that Riverbend Landfill applied for a comprehensive plan map designation amendment from "Commercial" and "Public" to "Agriculture Forestry Large Holding" and for a zoning map amendment from "RC-Recreation Commercial" (approximately 25 acres) and "PWS-Public Works Safety" (approximately 227.5 acres) to "EF-80 Exclusive Farm Use," for Tax Lots 5501-101, 5501-200, and 5501-401; and

IT APPEARING TO THE BOARD that this matter came before the Planning Commision for public hearing on November 7, 2013 and that, following a period in which the record remained open for additional written evidence and testimony, on December 5, 2013, the Planning Commission, by a 5-3 vote, recommended denial of the application, but also unanimously recommended that, if the application is approved by the Board, it should be approved in conjunction with a Limited Use Overlay; and

IT APPEARING TO THE BOARD that this matter came before the Board on December 12, 2013 for public hearing and that, following a period in which the record remained open for additional written evidence and testimony, on January 16, 2014, the Board of Commissioners voted 2-0 (Commissioner Stern having recused herself), tentatively, to approve the application and to impose a Limited Use Overlay on the tax lots that were the subject of the application and on other surrounding tax lots owned by the applicant, to limit and condition expansion of the landfill; NOW, THEREFORE

THE BOARD ORDAINS AS FOLLOWS:

Section 1. The findings attached as Exhibit "A" and incorporated herein by reference are hereby adopted in support of this ordinance.

B.O. 14-
ORDINANCE 887

Section 2. The Comprehensive Plan and Zoning Maps of Yamhill County are hereby ameded as specified in the attached Exhibit "B," incorporated herein by this reference, to reflect a plan designation of "Agriculture Forestry Large Holding," and a zoning designation of "EF-80, Exclusive Farm Use" for Tax Lots 5501-101, 5501-200 and 5501-401.

Section 3. A Limited Use Overlay is established for Tax Lots 5501-101, 5501-200, 501-400, 5501-401, 5501-300, 5501-500, 5511-100, 5511-600, 5512-100, 5512-200, 5512-400 and 5512-500, as specified in the attached Exhibit "B." Uses allowed are limited to substantially conform to the plans submitted by the applicant and by the Conditions of Approval in the attached Exhibit "C," incorporated by this reference.

Section 4. The Board adopts the provisions set forth in Exhibit "D" incorporated herein by this reference to implement Goal 5 protections for riparian corridors on the subject property.

Section 5. This Ordinance, being necessary for the health, safety and welfare of the citizens of Yamhill County, and an emergency having been declared to exist, is effective immediately.

DONE this 13th day of February, 2014, at McMinnville, Oregon.

ATTEST:

BRIAN VAN BERGEN
County Clerk

By: Carol Ann White
Deputy CAROL ANN WHITE

APPROVED AS TO FORM:

Todd Sadlo
Assistant County Counsel

YAMHILL COUNTY BOARD OF COMMISSIONERS

(recused)
Chair MARY P. STERN

Allen Springer
Commissioner ALLEN SPRINGER

Kathy George
Commissioner KATHY GEORGE

B.O. 14-

Exhibit A - Ordinance 887

Findings In Support of Approval

I. Introduction, Background and Process

A. Background Information

DOCKET NO.: PAZ-02-13

REQUEST: An application to change the comprehensive plan designation from Commercial and Public to Agriculture Forestry Large Holding. The request is also to change the existing zoning from RC Recreation Commercial (approximately 25 acres) and PWS Public Works, Safety (approximately 227.5 acres) to EF-80 Exclusive Farm Use.

APPLICANT/OWNER: Riverbend Landfill Company, Inc. (RLC)

TAX LOTS: 5501-101, -200, -400 and -401

LOCATION: 13465 SW Highway 18, McMinnville, Oregon
13469 SW Highway 18, McMinnville, Oregon
14325 SW Highway 18, McMinnville, Oregon

ZONE: PWS Public Works Safety and RC Recreation Commercial

CRITERIA: Sections 402, 601, 802 and 1208.02 of the Yamhill County Zoning Ordinance. Comprehensive plan policies may be applicable. Section 904, Limited Use Overlay may be applied. The request is also subject to the Transportation Planning Rule, OAR 660-012-0060.

1. Lot Size: The Yamhill County Assessor's office records show the following acreage for each tax lot: Tax Lot 5501-101 is 25.7 acres. Tax Lot 5501-200, the location of the existing Riverbend Landfill, is 220.4 acres. Tax Lot 5501-401 is 36 acres. Tax Lot 5501-400 is 57.5 acres.

2. Access: State Highway 18.

3. On-site Land Use and Zoning: Pages 15 and 16 of the application contains the existing land uses and zonings for the subject tax lots. These descriptions are incorporated here by reference with one minor correction. Tax Lot 5501-200 is 220.4 acres. Table 6 on page 15 lists

Exhibit "A"
Ordinance 887

only 211.2 acres of this property as being zoned PWS and 9.2 acres as EF-80 (EFU). In actuality the entire 220.4 acres is zoned PWS and none of this tax lot is presently zoned EF-80. The discrepancy is due to the tax lot numbers being converted in the 1980's to a new numbering system. The new numbering system was adopted with maps that "cut off" approximately 9 acres of the 229 acres originally requested to be zoned PWS. This 9-acres is identified as Tax Lot 5512-200 and is already zoned EF-80.

4. Surrounding Land Use and Zoning: RLC owns and manages for farm use many of the adjacent properties. The predominant use within one mile of the existing Riverbend Landfill is agricultural use. The farm uses include grass, grain, hay, nut orchards and vegetable crops. South of the project site, across the South Yamhill River, is the closed Whiteson Landfill with approximately 35.8 acres zoned PWS Public Works, Safety. Uses in the area surrounding Riverbend Landfill also include a church, produce stand, cemetery and cell tower. As for the zoning, land to the south of the South Yamhill River contains approximately 6.2 acres zoned PRO, Parks, Recreation, and Open Space. The remainder of the area bordering the existing landfill and project site is zoned entirely EF-80 Exclusive Farm Use.

5. Water: Provided by an on-site well.

6. Sewage Disposal: Provided by on-site septic systems.

7. Fire Protection: McMinnville Rural Fire Department.

8. Previous Actions: (addressed below)

9. Soils: Because of the large area covered by this application, there are correspondingly, a large number of soil types. The majority of the subject property contains both Class I-IV soils and high-value farmland. The soils include Amity and Woodburn silt loam, and Chehalis silty clay loam, all rated as agricultural Class II, defined as high-value farmland. The nonhigh-value farmland includes Wapato and Cove silty clay loam, agricultural Class III and IV respectively.

10. Taxes: Tax Lot 5501-101 has 25.7 acres at market value. Tax Lot -200 has 220.4 acres at market value. Tax Lot -400 has one acre at market value and 56.5 acres on farm deferral. Tax Lot -401 has 18.5 acres at market value and 17.5 acres on farm deferral.

11. Overlay Districts: Flood Insurance Rate Maps 41071C0395D and 41071C0415D, effective March 2, 2010 and revised by a Letter of Map Revision (LOMR) effective May 9, 2013, shows property along the South Yamhill River and some nearby tributaries as being within the 100-year flood hazard area. It should be noted that the existing landfill and accessory

buildings are located outside of the flood hazard area. The property is not within the Willamette River Greenway or airport overlay district.

12. Fish and Wildlife: The South Yamhill River is identified as fish habitat. The river is shown on the 1979 Natural Resource Conservation Plan as resident trout spawning and rearing area and warm water game fish spawning and rearing as well as an anadromous fish migration route. The property is not located in the big game winter range.

13. Reason for the request: To apply a single zone to the applicant's property. As explained in more detail in other findings, the single zone will provide the applicant with flexibility to operate the existing landfill more efficiently and will also provide the applicant with the opportunity to expand the existing landfill onto adjacent parcels.

B. Applicant's Request

The applicant owns and operates the Riverbend Landfill. The land on which Riverbend Landfill is located is comprised of several tax lots, within three different zones. The tax lots containing the landfill and its ancillary facilities (a portion of Tax Lot 5501-101 and Tax Lot 5501-200) are zoned Public Works/Safety (PWS). Another tax lot (Tax Lot 5501-401) is partially zoned Recreational Commercial (RC). The remaining tax lots on the applicant's property, and the remainder of Tax Lot 5501-101 and Tax Lot 5501-401, are zoned Exclusive Farm Use (EFU).

The applicant proposed to rezone all areas currently designated PWS and RC to the EFU zone, specifically EF-80. The resulting change is a net increase of approximately 245 acres zoned EFU, and the applicant's entire tract containing only one zoning designation – EF-80. Approval of the zone change requires changes to the County's Comprehensive Plan Map. With its application, the applicant did not request any alteration or expansion of the existing Riverbend Landfill. The County will review alterations or expansions of the existing landfill as part of a separate process in the future if the applicant makes an application for such a review.

C. Description of Existing Solid Waste System in Yamhill County

The solid waste system in the County consists of collection, transfer, waste recovery, recycling, composting and disposal facilities and services. The system is operated by private companies that hold franchise agreements with the County and/or cities.

Two private companies provide collection of municipal solid waste from residences and commercial establishments in the County. These companies are franchised by the County to provide garbage and recycling collection throughout the County under authority granted by ORS 459.086 and the Yamhill County Solid Waste Collection and Disposal Ordinance 578.

Western Oregon Waste provides service to the western and northern area of the County, including the cities of Amity, Carlton, Dayton, Lafayette, McMinnville, Sheridan, Willamina, and Yamhill. Waste Management provides collection service to the east side of the County, including the cities of Newberg and Dundee. Solid waste collected by Western Oregon Waste is hauled directly to Riverbend Landfill. Waste Management collects solid waste and hauls it to its transfer station in Newberg where some sorting takes place. Both companies also collect recyclable materials within the boundaries of the 10 incorporated cities and unincorporated County areas where they are franchised.

The Newberg Transfer and Recycling Center is the only transfer station operating in the County. The facility operates under an exclusive franchise from the County. Municipal solid waste received at the transfer station is transferred in waste transfer trailers to Riverbend Landfill. Recyclables brought to the transfer station are separated and sent directly to market.

Landfill facilities are designed and permitted to handle different waste streams. The primary type of landfill is one that is designed to dispose of municipal solid waste (MSW). Riverbend Landfill is the only landfill disposal facility in the County permitted to accept MSW.

In addition to Riverbend Landfill and Newberg Transfer Station, other existing facilities in Yamhill County with DEQ Solid Waste facility permits include: 1) Valley Recovery Zone, a material recovery facility in McMinnville; 2) NW Greenlands yard debris/composting facility in McMinnville; 3) Buck Hollow Industrial/wood facility in Willamina; and 4) Four compost sites in EFU zoned areas registered under DEQ 2009 Rules.

It is within this context that the Board has reviewed RLC's request.

D. Riverbend Landfill History and Future Operations

In 1980, the County approved a plan amendment and zone change from the EFU zone to the PWS zone to allow development of Riverbend Landfill.[1] At the time, although solid waste disposal sites were permissible uses in an EFU zone under state law, the County's 1976 zoning ordinance allowed landfills as an outright permitted use only in the PWS zoning district. The County therefore approved the zone change through an "Exception" to Statewide Planning Goal 3, allowing the conversion of EFU land to PWS.

Riverbend Landfill has operated at this location since 1982 under County land use and license approvals and in accordance with Department of Environmental Quality (DEQ) Solid Waste

[1] Ordinances 236 and 237, adopted May 14, 1980.

Disposal Permit 345. The current DEQ permit authorizes disposal of municipal solid waste on about 88 acres. Under that permit, as modified, the landfill is expected to reach capacity in 2017.

In 2009, the County determined that there was a demonstrated need for the continued presence of a landfill in the County. That determination was made as part of a plan amendment and zone change that authorized the expansion of Riverbend Landfill through another Goal 3 Exception. On appeal of that decision, LUBA reversed the County's decision on the basis that a Goal 3 Exception is not available to allow a use that is already authorized by the statutory EFU zone (ORS Chapter 215). In doing so, LUBA stated, "[i]f the county wishes to allow landfills on agricultural land, it must amend its EFU zone to allow them under the standards set forth in the statutory EFU zone, with any supplementary regulation that the county wishes to adopt."[2] The Court of Appeals upheld that decision based on the same reasoning.[3] Implicit in those decisions is the determination that the County should have originally approved development of Riverbend Landfill in 1980 through the normal zoning process rather than through the Goal Exception process.

In 2011, following the decisions by LUBA and the Court of Appeals, the County amended the Yamhill County Zoning Ordinance (Zoning Ordinance or YCZO) to adopt a text amendment to the EFU zone that mirrors the statutory use in ORS 215.283(2)(k) and allows solid waste sites to be maintained, enhanced or expanded within the EFU zone in some, but not all, of the specific circumstances allowed by state law.

The County's amended EFU zone now allows solid waste disposal sites as a permitted use, consistent with state law. By changing the zoning on the applicant's property back to the EFU zone, the County is restoring the property's original zone designation and putting the applicant in the same position it would have been in if the County had originally permitted the landfill in the manner suggested by LUBA and the Court of Appeals.

Following the zone change, the existing landfill and all ancillary facilities will be maintained wholly within the farm zone. The applicant will then have the opportunity to continue its operations as a permitted use, or to submit an application for a future expansion onto other EFU parcels in the manner identified by LUBA and the Court of Appeals. An expansion onto the tax lots already zoned EFU is not possible prior to this Ordinance 887 because those lots are high-value farmland and, under the County's Zoning Ordinance and state law, such lands can be used for solid waste disposal facilities only to accommodate the maintenance, expansion or enhancement of an existing facility that is wholly within a farm zone. Such expansions and

[2] *Waste Not of Yamhill County v. Yamhill County,* 61 Or LUBA 423 (2010).

[3] *Waste Not of Yamhill County v. Yamhill County,* 240 Or App 285 (2010).

enhancements may include new landfill disposal cells, new ancillary facilities, or even new non-landfill technologies. It is reasonable for RLC to request, and for the County to approve, a zone change that will apply a single zoning designation to RLC's property that will provide the property owner with flexibility to continue or expand the current use that is permitted in that zone.

II. Zone Change Criteria

Approval criteria for a quasi-judicial zone change are set forth in Section 1208 of the Zoning Ordinance. The following findings address those criteria.

A. Section 1301 – Application and Review Procedures

Section 1301 of the Zoning Ordinance outlines application and review procedures. The ordinance sets forth three separate types of procedures (A, B, and C). Because applicant's proposal involves a plan map amendment, the County processed the application under the highest Type C review procedure.

Section 1301.C –The following procedures shall be used when county ordinance requires Type C review of an application.

1. *Prior to or at the time of filing an application, a pre-application conference shall be conducted in which the applicant or the applicant's authorized representative shall meet with the Director or an authorized member of the department to review requirements and concerns about the applicant's request;*
2. *The applicant shall submit an application to the Department of Planning and Development on a form prescribed by the Director;*
3. *Upon receipt of a complete application, a public hearing shall be scheduled and public notice mailed and published according to the public notice requirements contained in Section 1402;*
4. *The appropriate planning advisory committee may hold a public meeting to review the application, and may make a recommendation to the commission or hearings officer;*
5. *At the public hearing the county staff, planning advisory committee, the applicant, and other interested parties may present information relevant to the proposal, and may give reasons why the application should or should not be approved;*
6. *Within 90 days of receipt of a completed application, or such longer period mutually agreed to by both the Director and the applicant, the application shall be approved or denied based on an evaluation of the proposal and applicable criteria as set forth in this ordinance;*
7. *The applicant shall be notified in writing of the decision and of the reasons for the decision; and*

8. *All decisions of the Commission or hearings officer may be appealed to the Board, if the appeal is filed within 15 days from the date of the decision, pursuant to Section 1404 for appeals.*

The requirements of YCZO Section 1301.C have been satisfied.

RLC and its authorized representatives participated in a pre-application conference with the Planning Director and staff on July 8, 2013. At that meeting, the staff provided background information on applicable criteria, standards, and procedures, and highlighted key issues to address in the application.

RLC submitted its application in September, 2013, with the required fee and with the appropriate form for a plan map amendment and zone change.

Staff reviewed the application for completeness following submittal, determining the application was complete, and did not require additional materials or information for the application to be accepted as complete for processing.

The County held public hearings before the Planning Commission (November 7, 2013) and Board of Commissioners (December 12, 2013), following the notification requirements in Section 1402. Interested persons provided testimony in support of and in opposition to the application. Because the application involves a post-acknowledgement plan amendment (PAPA), the County also provided notice of the application to the Department of Land Conservation and Development (DLCD), prior to the first scheduled public hearing.

As a PAPA, this application is not subject to statutory requirements to make a final local decision within 150 days of receiving a complete application. Although this final decision is being made more than 90 days after receipt of the completed application, the Applicant agreed to an extended timeframe during the hearing before the Board on December 12, 2013.

The Applicant is being notified of this decision, including these findings that explain the basis for the decision.

Because approval of a plan amendment and zone change requires a public hearing and final decision by the Board pursuant to YCZO 1208.01.C, no appeal was required to elevate consideration of the application to the Board.

In summary, the applicant has met all of the requirements for the Type C procedure as set forth in Section 1301 of the Yamhill County Zoning Ordinance.

B. Section 1208 – Quasi-Judicial Zone District Boundary Changes

Section 1208 of the Ordinance outlines general requirements and review criteria for quasi-judicial zone district boundary changes. RLC's application proposed two interrelated quasi-judicial map and zoning district boundary changes. The first change rezones 7.1 acres on Tax Lot 5501-101 and 220.4 acres on Tax Lot 5501-200 from the PWS zone to the EFU zone. The second change rezones 25 acres on Tax Lot 5501-401 from the RC zone to the EFU zone.

1. 1208.01 General Requirements

A quasi-judicial zone map change is processed as follows:

(A) An amendment may be initiated by the Board, the Commission, or by application of an owner of land.

The Board finds compliance with this subsection because RLC, as the owner of the land, initiated the amendment.

(B) The application for such a change by an owner of land shall be made in accordance with the Type C application procedure.

The Board finds compliance with this subsection. The County processed the application following the steps outlined for the Type C procedure, as summarized under Section 1300 above.

(C) Such amendments shall be made only by the Board, after review and recommendation by the Commission. When the request includes a Comprehensive Plan map amendment, both the Commission and Board shall hold public hearings, pursuant to Section 1402 of this Ordinance, prior to the Board making a final decision. When the request does not include a Comprehensive Plan map amendment, the Commission shall hold a public hearing to review and make a decision on the proposed zone map amendment. The Board is not required to hold an additional public hearing, but may make a decision based upon the record of the Commission hearing. In either case, the zone map amendment shall not be final until the Board has adopted the amendment by ordinance.

The Board finds compliance with this subsection. Because RLC's application proposed a consolidated amendment to the Comprehensive Plan Map and Zoning Map, public hearings before both the Planning Commission and Board of Commissioners were held before the Board made a final decision. The public hearings were held in accordance with the requirements of Section 1402 of the Zoning Ordinance.

(D) Approval for a boundary change shall include findings satisfying the criteria in 1208.02 or 1208.03, as appropriate, and addressing applicable Comprehensive Plan goals and policies.

The Board makes findings to address the review criteria in Section 1208.02 below. The review criteria in 1208.03 apply only to amendments from EFU to Agriculture/Forestry Zones and are therefore not applicable to RLC's request. The findings to address the zone change criteria also incorporate by reference the related findings addressing the Statewide Planning Goals and findings to address compliance with the Yamhill County Comprehensive Plan.

2. 1208.02 Review Procedures

A quasi-judicial change to a zoning map may be authorized, pursuant to Subsection 1208.01, provided that the request satisfies all applicable requirements of this ordinance, and also provided that the applicant demonstrates compliance with the following criteria, except as provided in Subsection 1208.03:

(A) The proposed change is consistent with the goals, policies and any other applicable provisions of the Comprehensive Plan.

The Board makes specific findings to demonstrate that the proposed zone changes are consistent with the goals, policies, and other applicable provisions of the Yamhill County Comprehensive Plan. Those findings are made in subsequent sections of these findings and are incorporated herein by this reference. Based on those findings, the Board finds that this Zoning Code criterion is satisfied.

(B) There is an existing, demonstrable need for the particular uses allowed by the requested zone, considering the importance of such uses to the citizenry or the economy of the area, the existing market demand which such uses will satisfy, and the availability and location of other lands so zoned and their suitability for the uses allowed by the zone.

The Board finds that this Zoning Code criterion is satisfied. This criterion requires the County to determine whether there is an existing, demonstrable need for the particular use or uses allowed by the zone. In order to make that determination, the Board finds that the County is directed by this criterion to consider multiple need factors, including: (1) the importance of such uses to the citizenry or the economy of the area; (2) the existing market demand which such uses will satisfy; and (3) the availability and location of other lands so zoned and their suitability for the uses allowed by the zone (collectively, the "need factors"). Further, the Board finds that these considerations must be considered on balance and that the Board can weight each factor as it deems appropriate to make a final determination of an "existing, demonstrable" need.

a. The Record Demonstrates an Existing Need for a Local Solid Waste Disposal Option

The record supports a conclusion that there is an existing need for the continued operation of a local disposal option generally and for Riverbend Landfill specifically – a particular use allowed

by the requested EFU zone. The Board bases this conclusion on a combination of all three need factors. As the applicant has indicated, the County has previously determined a market need for the continued operation of Riverbend Landfill. The County arrived at that conclusion as part of RLC's earlier request for a Goal 3 Exception and reconfirmed that conclusion when the County amended the Zoning Ordinance in 2011 to allow landfills in the farm zone through Ordinance 867. Those decisions were based on information similar to the information presented to the County in this proceeding, including an economic and market analysis referred to as the "Zia Report," an update to which appears in this record as the Yamhill County Waste Disposal/Management Alternatives Update 2014 (the "Zia Report Update"). Both the Zia Report and the Zia Report Update were undertaken by the County as independent analyses to augment other information being submitted to the record.

The record demonstrates that a local disposal option is of high importance to the citizenry of the County through the economic benefits that the landfill generates for the community. These benefits are realized through lower disposal costs for individuals and businesses; revenue to the County through the license fee; greater direct and indirect employment income from the construction and operation of the landfill; increased opportunities for local electricity generation; and through a reduction of fuel costs (and air emissions) that would otherwise result from trucking waste to distant sites.

The record also demonstrates that there is a market need for the continued operation of a local disposal option in the County. Specifically, residents and businesses in the County currently generate between 150,000 and 200,000 tons of municipal solid waste every year that require disposal.

Finally, the record demonstrates an existing need for the solid waste use allowed in the EFU zone based on the limited availability and suitability of other lands in the County to accommodate that use. There are only two zones in Yamhill County that allow a sanitary municipal solid waste landfill as a permitted or conditional use—the PWS zone and the EFU zone. The applicant included an inventory of existing tax lots zoned PWS showing the County has a total inventory of 422 acres currently zoned PWS, with more than half of that inventory associated with the PWS zoning at Riverbend Landfill. The balance of the PWS inventory is comprised of smaller sites (with an average size of just over 7 acres) and the majority of the PWS zoned tax lots are committed to existing uses such as cell towers, water storage tanks, and power substations.

The limited availability of lands in the County to accommodate a solid waste use is exacerbated by the fact that the County's EFU zone is more limited than ORS 215.283 allows. YCZO

402.02(V) only permits "the maintenance, expansion or enhancement of an existing site" on EFU land. Riverbend Landfill is the only existing solid waste site in the County that has been granted a permit by DEQ as a municipal solid waste (MSW) landfill. There are eight other sites in Yamhill County with solid waste permits issued by DEQ under ORS 459.245. However, those sites serve very different and specialized roles in the County's solid waste management system, including waste recovery, waste transfer and recycling, yard debris composting and on-site composting associated with farm uses. Only Riverbend Landfill has the long history of operation as an MSW landfill and has in place the necessary infrastructure to continue such operations. Moreover, only Riverbend Landfill is designed to operate as a modern landfill in full compliance with Subtitle D regulations with sufficient area to meet existing and future County disposal needs.

b. Response to Opposition Testimony

The record contains testimony making several arguments that YCZO Section 1208.02(B) has not been satisfied. The Board finds that these arguments do not outweigh or undermine the Board's finding above that there is an existing, demonstrable need for a local disposal option in the County.

- *Need for All Uses Allowed by the Zone*

The record contains comments asserting that YCZO Section 1208.02(B) requires an applicant to demonstrate a need for *all uses* allowed in the farm zone and that a need for just one particular use is insufficient. The Board does not interpret this Zoning Ordinance provision in that manner, and such an interpretation is inconsistent with the County's prior interpretation of this provision. For example, in docket PAZ 05-06, the County approved a zone change from RC to EF-80 to allow for a hazelnut orchard on an abandoned golf course. The County expressly identified the need in that decision as the need for the hazelnut orchard, a very specific kind of agricultural use, and based that need specifically on the suitability of the land to support hazelnut orchards compared to other EF-80 lands in the County. The County did not require the applicant to demonstrate a need for other non-farm uses allowed in the EF-80 zone, or even a need for farm uses in general.

In another example, docket Z-01-98/SU-01-98, the County approved a zoning application changing the zoning of a parcel from the Mineral Resource District (MR-2) to the Heavy Industrial (HI) district. The purpose of that application was to allow aggregate processing and an asphalt batch plant. In approving that application, the County determined that the applicant had demonstrated a market need for an asphalt batch plant – again, a very specific type of industrial use. The HI district allows several other permitted uses such as grain elevators, auto wrecking

yards, slaughter houses, and oil processing facilities. In applying Section 1208.02(B), the County did not require that the applicant show a need for any of these other specific uses listed in the HI district, or even a need for industrial uses in general.

The Board did not receive substantial persuasive evidence or argument that it should abandon its prior interpretation of this Zoning Ordinance provision. This criterion is satisfied because the applicant has shown an existing, demonstrable need for at least one particular use allowed by the requested zone. Even if the Board is required to find that there is a demonstrated need for more than one use allowed by the requested zone, the record in this matter reflects an existing, demonstrable need for multiple particular uses allowed by the requested farm zone, as discussed in more detail below.

First, the record demonstrates an existing need for farm uses in the County – uses allowed by the requested zone. This conclusion is based in part on the importance of such uses to the citizenry and the economy of the area. Several commenters suggested, for example, that the application should be denied because it will eventually allow landfill operations on farm land and that the County needs more, not less farming. Many commenters similarly described the importance of the farming economy and the financial gains it has brought to the area. This finding is also based in part on the market demand that can be served by farm uses. For example, testimony in the record describes the increase in visitors that come to the County for farm-related uses and asserts that such visits will only increase in the future. The Board recognizes that other lands in the County already zoned EFU may be available for farm uses, but that fact relates to only one of the need factors and does not compel the Board to reach the opposite conclusion. The Board finds no substantial evidence or testimony in the record to support a conclusion that there is no need for more land zoned for farm uses in the County.

The County's Comprehensive Plan and the state's policy embedded in Goal 3 demonstrate an existing need for more farm uses. The Comprehensive Plan, for example includes specific policies that encourage more farm uses, including policies that the County should: (1) provide for the protection of farmland in large blocks (Agricultural Lands, Policy B); (2) provide an adequate amount of land, development areas and sites to accommodate those uses which are customarily found in rural areas or require or are better suited to rural locations (Rural Area Development, Goal 1); (3) encourage economic development projects which do not conflict with the predominant timber and agricultural character of the county (Economic Development, Policy B); and (4) ensure the continuance of the open space character that has always existed in the County (Open Space, Goal 1).

Under Oregon's land use laws, agricultural lands are conserved for agricultural uses and certain non-farm uses that are compatible with farming through the application of EFU zones. The record reflects that approximately 15.5 million acres in the state (56% of private lands in Oregon) are included in EFU zones. In the County, about 40% of private lands are zoned EF-80. As the applicant correctly notes, EFU zoning has been instrumental in maintaining working farms in Oregon and the rate of loss of both large (500+ acres) and mid-sized (50-499 acres) farms in Oregon was less than one-third the rate of loss for the nation as a whole. According to an OSU study, what agricultural loss is occurring is primarily in non-EFU zoned areas that are planned for development.

The applicant's proposal to rezone a total of approximately 250 acres from PWS and RC to EF-80 will create a relatively large block of EFU land that, in the long run, offers more protections for farming than the existing "non-agricultural" zoning. The existing PWS and RC zoning, for example, can be developed more intensely and are not subject to ORS 459.055, which imposes certain reclamation standards for landfills in EFU zones. Development in those existing zones can also occur without any consideration of ORS 215.296 (impacts on accepted farm practices and costs) for approval of specific uses in those zones. In contrast, the landfill use in the EFU zone will essentially be an interim use until it reaches the closure stage. At that point, if the site is rezoned to EFU, under ORS 459.055, the site must be restored to a condition comparable to its original use. DEQ has confirmed that this will be a requirement of any future permit it grants to RLC.

Moreover, RLC has submitted evidence establishing that the land can be rehabilitated, at the termination of its use for solid waste disposal, to a condition comparable to its original use. The record reflects that the original use in 1980, when the county approved the first plan amendment and zone change for Riverbend Landfill, was grazing, turkey farming, and general farming. The final contours and cover of the landfill (current and future), and of PWS and RC zoned lands that do not contain landfill uses, will be suitable for those same types of uses.

The new EFU zone will also be more consistent with the established state policies that work in concert to produce large blocks of EFU land: (1) to protect EFU lands as key resources for multiple economic, environmental and open space benefits; and (2) to minimize encroachment of urban uses into agricultural areas. By rezoning the PWS and RC areas to EF-80, the pattern of zoning in this area will be more homogenous with, more consistent with, and more supportive of, the zoning and land use character of the surrounding area.

Second, the record demonstrates an existing need for agri-tourism uses in the County, which are also allowed in the EFU zone. This conclusion is based in part on the importance of agri-tourism

to the citizenry and economy, and in part on the market demand for this use. The importance of agri-tourism, and the fact that there is an agri-tourism market demand to serve, is a fact established by the County's recently-adopted Agri-Business Economic and Community Development Plan. The stated purpose of that plan is to look into the future for the County's agriculture and tourism industries and to identify tourism-related activities and businesses necessary to support local agriculture. The County's agri-tourism plan expressly identifies a need for outdoor adventures, educational opportunities, and "anything that enhances the visitor's experience" as opportunities for the future. Other lands in the County already zoned EFU may be available to serve some of the need for agri-tourism. However, that fact is only one of the need factors the Board has considered and does not compel the opposite conclusion that there is no need for agri-tourism. Further, the Board finds no substantial evidence in the record that there is no need for agri-tourism in the County.

The applicant's request for a zone change would create more land in the County suitable for serving the market demand for agri-tourism opportunities. The applicant's efforts with respect to its Stewardship Plan will utilize RLC property for uses related primarily to farming, outdoor recreation, outdoor environmental education, open space, and wildlife habitat. For example, the applicant's Community Agriculture project is envisioned to allow individuals and non-profit organizations the opportunity to farm on small plots, with some of the food crops to be delivered to local school lunch programs. Recreational opportunities are planned in the form of a trail system that would connect with other area trails for hikers, bicyclists and possibly equestrians. Some of those activities could take place on the portions of RLC's property already zoned EFU, but the zone change is necessary to allow some of those activities on other areas of the property currently zoned PWS or RC.

- *Necessity of the EFU Zone*

The record contains testimony asserting that, even if there is an existing need for a particular use, the proposed zone must be "necessary" to satisfy that need. However, the Board does not interpret YCZO Section 1208.02(B) in that manner, nor is that interpretation supported by the plain language of the Zoning Ordinance. The plain language of this criterion requires the County to determine if there is an existing need for uses allowed by the zone. The Board must still determine if the zone change is "appropriate" under YCZO section 1208(C), but no provision in the Zoning Ordinance, including YCZO Section 1208.02(B), requires that the proposed zone be the only way to satisfy a demonstrated need. That is an inquiry more appropriate for a Goal Exception process, not a zoning decision.

The Board also received comments during the hearing process that, because Riverbend Landfill is already zoned PWS and the PWS zone allows landfills, there is no need for a zone change to continue the existing use. This reasoning is not persuasive. First, the argument ignores the plain language of the criterion, which requires that the County consider, among other factors, whether "other lands" so zoned (in this case, already zoned EFU) are available. By its terms, that inquiry does not relate to the sufficiency of the current zoning of the property. Second, those comments fundamentally misunderstand the purpose of rezoning property, which is to guide future activities and development. If the County could not rezone property where an existing use on the property is already allowed, it would be unable to rezone any property other than property containing non-conforming uses. Third, the applicant has demonstrated that it can make more efficient use of the existing landfill by rezoning the entire legal lot to the EFU zone, for example, by using the RC tax parcel or portions of the EFU-zoned parcels for operations support ancillary to the existing landfill. The applicant has also demonstrated that the remaining undeveloped PWS land is not sufficient to allow the continued operation of Riverbend Landfill. Approximately 75 of the remaining acres extend south of the existing permitted landfill, to and across the South Yamhill River. This area is within the 100-year floodplain and floodway areas. While the existing PWS zoning would theoretically allow landfill operations in that area, natural site constraints and environmental regulations limit its suitability for that use. In general, it is reasonable in this case for the owner of property with split zoning to seek the application of a single zone on that property if doing so creates more flexibility to accommodate existing uses.

- *Critique of Economic Benefits*

The record contains evidence and accompanying arguments that the zone change will cause a negative economic impact or that the applicant has overstated the economic benefits of a local disposal option. In considering the economic benefits of a local disposal option, the Board reviewed economic studies submitted by the applicant, studies submitted by opponents to the application, and an independent study funded by the County (the Zia Report Update). The Board has weighed all of the evidence received, and finds that the economic study submitted by the applicant, and the Zia Report Update, include the more compelling evidence regarding the economic benefits of maintaining a local disposal option.

According to the economic analysis submitted by the applicant, costs of disposal are likely to rise when there is no local disposal option because hauling waste to alternative disposal sites would cause the per-ton cost of disposal to increase for Yamhill County residents and businesses. Specifically, the annual cost of disposal to the entire County would increase by $3.5 to $5.1 million (depending on the alternative site). Additionally, if Riverbend Landfill continues to

operate, RLC would continue to pay license fees to the County that would be greater than the license fees the County would collect from a transfer station that processes only in-county waste.

The economic analysis submitted by the applicant also demonstrates that RLC could invest $25.5 million when it expands Riverbend Landfill in the future. That level of construction activity would generate 202 jobs directly associated with construction activities and $6.1 million in associated personal income in addition to secondary jobs and income. Even before any potential expansion of the existing landfill, operating Riverbend currently requires 17 full-time equivalent jobs, generating $1.6 million in associated personal income per year to operate the facility in addition to secondary jobs, as the Landfill and its employees purchase goods and services in the local economy. Operating Riverbend Landfill generates an estimated 19 secondary jobs and $500,000 per year in personal income, for a total of 36 jobs and $2.1 million per year in personal income. Hauling waste to alternative sites would create about half as many jobs – operating the transfer station and driving the waste to alternative sites would generate between 14 and 19 jobs and between $900,000 and $1.2 million in personal income (depending on the alternative site). Between 11 and 14 of those jobs would be directly employed in transfer station operations and in hauling the waste.

Hauling solid waste from the County to any of the three alternative disposal sites presented in the applicant's economic study generates carbon dioxide (CO2), nitrogen oxides (NOx), carbon monoxide, and particulate matter. According to the applicant's analysis, the economic cost of the CO2 is between $28,000 and $297,000 per year; the cost of the NOx is between $23,000 and $200,000 per year; and the cost of particulate matter is between $28,000 and $242,000 per year.

The update to the Zia Report also included an economic analysis comparing disposal costs if Riverbend Landfill continues operations with costs of using out-of-County sites to meet the County's disposal needs. That report similarly concludes that "[i]f the Riverbend Landfill is not successful in gaining approval for expanding the landfill Yamhill County residences and business will experience an increase in their garbage bill."

In contrast, the economic analysis submitted to the County by opponents of the application concludes that there is an economic detriment to the County if Riverbend Landfill continues to operate. The opponents' alternative analysis contains several flaws that diminish its value as evidence. For example, the analysis overstates the value of possible lost agricultural production by relying on crops that could hypothetically be grown on the site where the applicant plans to expand, but that are not actually grown on the site. The analysis also incorrectly states that 87 acres of farmland will be removed from potential agricultural production, but the correct figure is

37 acres (the size of the anticipated landfill expansion), and does not consider the present value of the economic impacts it identifies.

The record also contains arguments that disposal rates may actually increase if Riverbend Landfill continues to operate, or that there are other ways to reduce solid waste disposal rates in the County without the zone change. If that were true – which the Board finds it is not – the Board nevertheless concludes that reduced disposal rates is only one component of economic benefits, and the market demand for solid waste disposal exists independently of customers' costs of using that service. Even if disposal rates were to increase in the future, that fact alone would not lead to a conclusion that there is no existing need for solid waste disposal, especially in light of the other need factors the Board has considered. Moreover, the Board finds that the zone change will allow RLC to provide solid waste disposal at a lower cost than other available disposal options and that disposal rates are likely to stay lower when there is a local disposal option. The Board finds that these lower rates provide economic benefits important to the citizenry of the County, as evidenced by the testimony received during the hearings from residential, commercial and industrial users of Riverbend Landfill.

c. Conclusion for YCZO Section 1208.02(B)

In summary, YCZO Section 1208.02(B) is satisfied because there is a demonstrable, existing need for the continued operation of a local disposal option generally and Riverbend Landfill specifically, in addition to a need for more farm uses and agri-tourism in the County. Each of these three uses is a use permitted in the requested EFU zone. The solid waste disposal use in particular is important to the citizenry and the economy of the entire County because it provides a local, low cost, environmentally-sound option for solid waste disposal that keeps disposal costs low for all customers and helps businesses and industry to remain profitable. The only zones that permit a landfill are the PWS zone and the EFU zone (with limitations). However, properties in those zones are not available or not as well suited as the applicant's property.

> *(C) The proposed change is appropriate considering the surrounding land uses, the density and pattern of development in the area, any changes which may have occurred in the vicinity to support the proposed amendment and the availability of utilities and services likely to be needed by the anticipated uses in the proposed district.*

This provision in the Zoning Ordinance requires the County to consider if the newly-applied zone is appropriate. To make a determination that the zone change is appropriate, this criterion requires the County to consider: (1) surrounding land uses; (2) the existing density and pattern of development in the area; (3) changes that may have occurred in the vicinity to support the proposed amendment; and (4) the availability of utilities and services needed by the anticipated

use (in this case, the landfill). These factors must be considered on balance, and the Board must weight each factor as it deems appropriate.

The requested zone is appropriate considering surrounding land uses and the existing density and pattern of development. Almost all of the land surrounding the properties being rezoned is already zoned EFU. The uses in those surrounding areas are uses permitted in the farm zone. Other than the parcels that are the subject of this zone change request, the only parcels in the immediate vicinity that are not zoned EFU are the closed Whiteson Landfill and the parcel that houses Munro Landing, a recreational facility. Rather than disrupt the zoning pattern in this area, the zone change will actually make the zoning pattern more homogenous.

The requested zone is appropriate in light of the very few changes that have occurred in the vicinity. In fact, the surrounding area has not changed significantly in the more than three decades that Riverbend Landfill has been in operation. This standard is more appropriately applied when a change in the vicinity is being used to "support" a zone change. The record contains testimony claiming that the area around Riverbend Landfill has changed over the years (for example because of an increase in tourism). That testimony, however, is misplaced, because the applicant is not relying on changes in the vicinity to support the zone change. Even if the County should consider changes in the vicinity to consider denying a request for a zone change, it is not appropriate to do so on this record. It may be true that, as the opposing testimony suggests, more tourists are seeing the benefit of visiting agricultural areas. However, that fact only reinforces a conclusion that the character (farms and open space) and density (large, undeveloped parcels) of the area have remained the same. Many of the changes described in the testimony have occurred in the County generally and not necessarily in the vicinity of RLC's property. The record contains no substantial evidence that any of the identified "changes" have altered the character of the surrounding area or otherwise demonstrate that more EFU-zoned land is not appropriate in light of those changes.

In concluding that the zone change is appropriate, the Board has also considered the fact that additional utilities and services are not likely to be needed to support the anticipated use. Instead, Riverbend Landfill is largely self-sufficient and needed infrastructure such as transportation, electricity, water and sewer are already in place. The continued operation of Riverbend Landfill will therefore not require additional utilities or services, nor will any expansion of the landfill.

In addition to the above considerations, the proposed change is appropriate because it will allow the continuation and future development of uses for which there is an existing, demonstrable need. As explained in other findings, the record demonstrates that the zone change will allow

RLC to more efficiently use its property to operate the existing Riverbend Landfill (even without an expansion) because RLC will be able to make use of the RC-zoned tax parcel and portions of the EFU-zoned parcel for operational support. Similarly, the record demonstrates that the zone change will result in a net increase of land to accommodate farm uses because DEQ will require restoration of the existing landfill to a condition comparable to its original use. Agricultural uses, open space and other uses allowed outright in the EFU zone are anticipated end-uses of the site, and those types of uses are compatible with development on other EFU parcels in the vicinity.

The zone change will cause no change in how the applicant's property will actually be used. Only three uses have occurred on the tract of land owned by the applicant: (1) farm uses; (2) solid waste uses; and (3) recreational uses. These are the only three uses RLC anticipates will occur on its property. Because the zone change does not expand the types of uses that have occurred in the area for decades, the zone change is appropriate.

The record contains other testimony claiming that the *existing* landfill is not compatible with the surrounding area. That testimony, however, is not relevant to this criterion. The Board does not interpret this provision of the Zoning Ordinance to require the County to review development that already exists on the subject property or to consider the compatibility of specific developments that may exist in the future. Rather, the County must determine whether the new zone designation is appropriate in the area to which it is being applied.

(D) Other lands in the County already designated for the proposed uses are either unavailable or not as well-suited for the anticipated uses due to location, size or other factors.

In this case, other lands in the County zoned either EFU or PWS (the only zones designated for the proposed solid waste use) are either unavailable or not as well-suited for the anticipated use. The applicant provided a detailed analysis of all sites in those zoning districts. That analysis primarily concluded that no other EFU sites are available because the County's Zoning Ordinance does not authorize new solid waste disposal sites in EFU zones and, therefore, the only alternative sites are where there is an existing site. Of the existing sites in Yamhill County, only one – Riverbend Landfill – can accommodate the disposal of municipal solid waste.

The zoning analysis provided by the applicant and accepted by the County also concludes that no other PWS sites can accommodate municipal solid waste disposal. Other than the applicant's property, PWS sites in the County are smaller sites averaging just over 7 acres. None of those sites are large enough for a municipal solid waste landfill and a majority of those sites are committed to existing uses such as cell towers, water storage tanks, and power substations.

The record does contain testimony claiming that one other specific site in the County is better suited for the anticipated use. Specifically, that testimony claims that the applicant's tax parcel that is already zoned PWS is the better suited site and, therefore, there is no reason to re-zone the remainder of that lot. This argument ignores the plain language of YCZO Section 1208.02(D). That criterion requires that the County analyze "other lands" in the County, which necessarily refers to lands other than the land that is the subject of the zoning request. Further, as discussed in more detail above, the Board has already found that the existing PWS tax parcel is no longer sufficient to accommodate the continued operation of Riverbend Landfill. Even if the Board concluded that the subject property should be considered under this criterion, the PWS site is therefore not "sufficient" as the opposing testimony claims it is.

Based on location, size, and other factors, the Board finds that no other lands in the County zoned EFU or PWS are as well suited to accommodate the full array of uses RLC anticipates, and that YCZO Section 1208.02(D) has been satisfied.

(E) The amendment is consistent with the current Oregon Administrative Rules (OARs) for exceptions, if applicable.

YCZO Section 1208.02(E) does not apply to RLC's request for a zone change because that request does not involve a Goal Exception.

III. Comprehensive Plan Goals and Policies

YCZO Section 1208.02(A) requires a proposed change to be consistent with the goals, policies and any other applicable provisions of the Comprehensive Plan.

The County's Comprehensive Plan addresses seven broad areas: 1) Urban Growth and Change and Economic Development; 2) Land and Water; 3) Transportation, Communications, and Public Utilities; 4) Public Land, Facilities, and Services; 5) Environmental Quality; 6) Energy Conservation; and 7) Implementation, Evaluation, and Review. The Board finds that no Comprehensive Plan policy serves as an approval standard for RLC's requested zone change. The Comprehensive Plan expressly acknowledges that certain goals and policies may conflict with others and that final decisions require the weighing of the merits in order to achieve a balanced decision. On balance, the Board finds that the requested zone change is consistent with the goals and policies of the Comprehensive Plan. That conclusion is based on the findings below addressing some of the relevant goals and policies in each of the seven areas of the Comprehensive Plan.

A. Section I – Urban Growth and Change and Economic Development

1. Urban Area Development

Goal 1: To encourage the containment of growth within existing urban centers, provide for the orderly, staged, diversified and compatible development of all of the cities of Yamhill County, and assure an efficient transition from rural to urban land use.

Policy C: Yamhill County will recognize the lands within established urban growth boundaries as the appropriate and desired location for urban development.

Approval of the zone change request is consistent with this Comprehensive Plan goal and this policy. The existing Riverbend Landfill is a rural use and has operated under County and DEQ land use and permit approvals for more than 30 years in a rural area. Operation of the landfill does not require urban sewer or water facilities or other urban infrastructure. Landfills typically require large sites and are not dependent on urban infrastructure, such as public sewer and water. The use is more appropriately categorized as a rural use rather than an urban use. Therefore, a location outside of established urban growth boundaries is the more appropriate and desired location for MSW landfills. The record reflects that all of Oregon's larger, active landfills are located outside urban areas. That fact in part reflects the fact that Oregon statutes assign solid waste planning to counties rather than to cities, which is further cemented by ORS Chapter 215, which expressly allows solid waste disposal facilities in the Exclusive Farm Use zone.

Providing a local disposal option in a rural area increases the amount of space available in urban areas for urban uses, reducing the pressure to site those urban uses in rural areas outside urban growth boundaries (UGB) and, therefore, is consistent with Goal 1 and Policy C. The record contains no compelling evidence or testimony that the zone change is inconsistent with this Comprehensive Plan goal or policy.

Goal 2: To encourage the containment of urban services and facilities and other public capital improvements within existing urbanizing areas in order to achieve an orderly pattern of urban growth.

Policy A: Yamhill County will continue to seek full cooperation and coordination among the cities, the school districts, other special-purpose districts of the county and the county itself in jointly planning and programming all land use, urban services and facilities and other public improvements having an impact on the rate and direction of urban growth.

The existing landfill operates with rural services and facilities at a rural location about 2 miles from McMinnville's UGB. The extension of urban services and facilities and other public capital improvements will not be required or allowed to serve the existing facility or any contemplated future expansion. The County has cooperated with the 10 cities in the County and the franchised haulers in the preparation and adoption of the 2004 SWMP. Those cities have deferred the lead role in solid waste planning to the County, and the County has the lead role in the land use

permitting and license agreement for solid waste disposal and all of the urban areas in the County recognize the importance of a centrally located and cost-effective disposal site to accommodate long term disposal of waste. The County has undertaken multiple updates to its Solid Waste Management Plan (SWMP). Based in part on the information developed through the updates to the SWMP, the County found that continued operation of a local landfill was necessary to meet the County's solid waste disposal needs.

The zone change is consistent with Goal 2 and Policy A implementing that goal. The record contains no substantial evidence or testimony that the zone change is inconsistent with this Comprehensive Plan goal or policy.

2. Rural Area Development

Goal 1: To provide an adequate amount of land, development areas and sites to accommodate those uses which are customarily found in rural areas or require or are better suited to rural locations, without compromising the basic goal relating to urban containment and orderly urban development.

As noted in the discussion above, solid waste landfills are recognized under state and county policies and rules as a use that is appropriate and better suited to rural locations. Prior to the opening of Riverbend Landfill in the early 1980s, the Whiteson and Newberg Landfills in the County also operated in rural areas. Further, under Oregon's planning framework, a solid waste disposal facility is a use that is allowed by Goal 3 and the statutory EFU zone and is now also allowed in the County's EFU zone. The zone change does not compromise the basic goal relating to urban containment and orderly urban development embodied in this goal because the landfill is an established rural use at this location and recognized as a permitted nonfarm use in the EFU zone.

3. Economic Development

Goal 1: To maintain a rate and pattern of economic growth sufficient to prevent recurring high levels of unemployment and under-employment in the county, balance the real property tax base of the various cities, and strengthen local economic bases.

Policy A: Yamhill County will, in cooperation with the cities, the local chambers of commerce and affiliated industrial promotion groups, and State agencies concerned with State and regional economic development, encourage a diversified employment base, the strengthening of trade centers, and the attraction of both capital and labor-intensive enterprises, consistent with the needs of each community and the county as a whole.

Policy B: Yamhill County will encourage economic development projects which do not conflict with the predominant timber and agricultural character of the county.

The discussion elsewhere in these findings relating to Goal 3 (Agricultural Land), Goal 6 (Air, Water and Land Resources Quality) and Goal 9 (Economic Development) are relevant to these Comprehensive Plan goal and policies relating to Economic Development. Those findings and discussion are incorporated here by this reference.

Continued operation of Riverbend Landfill as a regional landfill will provide economic benefits to residents, businesses, and public agencies within the County, as expressed by numerous persons who testified at the hearings. The zone change will provide the opportunity for RLC to submit a future application to expand Riverbend.

The existing landfill is an integral part of the overall solid waste management system in the County and the long-term availability of a centrally-located disposal site with competitive rates will help to maintain the stability and encourage the development of the local economy consistent with Goal 1. Specifically, costs of disposal are likely to rise when there is no local disposal option because hauling waste to alternative disposal sites would cause the per-ton cost of disposal to increase for Yamhill County residents and businesses. Lower disposal costs promote the economic vitality of the County.

If Riverbend Landfill continues to operate, RLC would continue to pay licensing and host fees to the County that would be higher than the host fees the County would collect from a transfer station that processes only in-county waste. If RLC expands Riverbend Landfill, RLC would invest $25.5 million in capital improvements. That level of construction activity generates 202 jobs directly associated with construction activities and $6.1 million in associated personal income in addition to secondary jobs and income. Even before any potential expansion of the existing landfill, operating Riverbend currently requires 17 full-time equivalent jobs, generating $1.6 million in associated personal income per year to operate the facility in addition to secondary jobs, as the Landfill and its employees purchase goods and services in the local economy. It is estimated that operating Riverbend Landfill generates 19 secondary jobs and $500,000 in personal income, for a total of 36 jobs and $2.1 million in personal income. Hauling waste to alternative sites would create about half as many jobs – operating the transfer station and driving the waste to alternative sites would generate between 14 and 19 jobs and between $900,000 and $1.2 million in personal income (depending on the alternative site). Between 11 and 14 of those jobs would be directly employed in transfer station operations and hauling the waste.

Hauling solid waste from the County to alternative disposal sites generates carbon dioxide (CO2), nitrogen oxides (NOx), carbon monoxide, and particulate matter. The economic cost of

the CO2 is between $28,000 and $297,000 per year; the cost of the NOx is between $23,000 and $200,000 per year; and the cost of particulate matter is between $28,000 and $242,000 per year.

The predominant timber areas of the County are generally located at higher elevation areas in the westerly portion of the County toward the Coast Range. There are no parcels in the immediate vicinity (1-mile radius) of the existing landfill that are designated and zoned for Commercial Forestry. However, the landfill is located in a productive agricultural area of the County and many properties in the vicinity of the landfill are managed for commercial farm uses.

Riverbend Landfill and Yamhill County's vineyard industry have grown in parallel over the same time period. RLC has demonstrated that it is feasible to balance the economic development benefits associated with continued operation of the landfill while maintaining the predominant agricultural character of the vicinity. The record demonstrates that agricultural tourism has increased over time in the areas near Riverbend Landfill. That fact reinforces the idea that the character (farms and open space) and density (large, undeveloped parcels) of the area have remained the same, and that a landfill can exist without disrupting that agricultural character.

Based on the foregoing, the Board finds that the zone change is consistent with Goal 1 and Policies A and B implementing that goal.

4. Housing

The record contains testimony asserting that the zone change is not consistent with Comprehensive Plan goals and policies relating to housing. That testimony specifically asserts that the planned closure of the Mulkey RV is inconsistent with Goal 1 of the Housing section and Policy C implementing that goal, which provide that the County will assure safe, sanitary and decent housing and provide opportunities for a variety of housing types in different residential environments, including single-family structures, conventional and modular type construction, and mobile homes to serve the housing needs of all components of the county population.

As discussed in other findings, the RV Park is a recreational facility that is not legally allowed to accommodate permanent or even long-term residential use. Testimony was received by the Board that residential use is being made of the RV Park, but that does not make such use legal or desirable from the standpoint of County housing policy. Certainly, the County is not relying on Mulkey RV Park to satisfy its housing needs. To the extent that Mulkey RV Park currently provides recreational opportunities, other RV parks will continue to exist in the County to serve such a need.

Additionally, denial of the zone change would not result in the continued use of the RC-zoned property as an RV park. The record reflects that the use of that tax parcel for an RV park will likely conclude in April of this year, when the current lease terminates.

No testimony in the record asserts that the purpose of the RC-zoned tax parcel is to provide housing, or that any need for housing potentially provided by the park cannot be accommodated elsewhere in the County. Prior to its use as an RV park, this parcel was used as a motor cross facility, and it was zoned RC based on a built-and-committed Goal Exception because of that use. The Board finds that the central character of that tax parcel has been recreational, not residential, and, therefore, there are no housing implications as a result of the zone change that make this decision inconsistent with the County's Housing policies

B. Section II – The Land and Water

1. Agricultural Lands

The findings addressing compliance with Goal 3 are hereby incorporated by this reference to also address goals and policies in the County plan relating to agricultural lands.

Goal 1: To conserve Yamhill County's farm lands for the production of crops and livestock and to ensure that conversion of farm land to urban use where necessary and appropriate occurs in an orderly and economic manner.

Policy A: Yamhill County will provide for the preservation of farm lands through appropriate zoning, recognizing comparative economic returns to agriculture and alternative uses, changing ownership patterns and management practices, changing market conditions for agricultural produce, and various public financial incentives.

Policy B: Yamhill County shall provide for the protection of farmland in large blocks through minimum lot sizes of 20, 40, and 80 acres, as appropriate, on the Comprehensive Plan and official zoning maps. Any proposal to reduce the minimum lot size on a farm or farm/forest parcel shall be shown to be appropriate to maintain the existing commercial agricultural enterprise in the area.

Policy D: Yamhill County will provide for the conservation of farm lands through various plan implementation measures and the review of any public or private land use determinations subject to county jurisdiction, including urban development activity and the location and construction of highways and utility transmission lines which disturb the soil cover and natural drainage pattern, and increase storm runoff, erosion and sedimentation.

Policy H: No proposed rural area development shall substantially impair or conflict with the use of farm or forest land, or be justified solely or even primarily on the argument that the land is unsuitable for farming or forestry or, due to ownership, is not currently part of an economic farming or forestry enterprise.

Approval of the zone change will create a net gain of land available for farm uses in the County. RLC is not proposing to convert farm land to urban use, but instead is proposing the PA/ZC to accommodate a use that, eventually, must be restored to a condition comparable to its original use.

While the Comprehensive Plan limits the amount of farmland conversion that takes place, it nevertheless contemplates that some non-farm rural development will occur. For example, the comprehensive plan has specific policies relating to urban expansion (Section I.D) as well as rural residential uses (Section I.B, policy 2.b). Additionally, because solid waste disposal sites are specifically authorized as a permitted use in the statutory EFU zone, and now the County's EFU zone, the state and local planning framework clearly contemplate that it is appropriate and feasible to balance the need for continued operation of an existing solid waste disposal facility with conservation of Yamhill County's farm lands for the production of crops and livestock. When the County amended its EFU zone to expressly allow solid waste facilities in that zone, it concluded, and LUBA affirmed, that allowing such uses is not inconsistent with the County's Comprehensive Plan provisions relating to agricultural land.

Yamhill County's amended EFU zone allows the maintenance and expansion of *existing* facilities, including Riverbend Landfill, thereby preventing solid waste disposal sites from being sited in all areas of the County's farmland. This fact served as the basis for the County's express finding that the County's Ordinance "minimizes the overall non-farm uses allowed in the EFU zone" as required by Goal 3. The continued use of Riverbend Landfill also makes use of the opportunity to utilize the nearby RC zone, decreasing the total amount of EFU land required for any expansion.

Testimony was received that the viability of commercial farm uses in the general vicinity of the landfill has been diminished by the presence and operation of the landfill. The more compelling testimony and evidence is to the effect that commercial farming in the area has not been significantly impacted by the presence or operation of the landfill. Moreover, changing the zoning back to EFU does not affect the county's policy to preserve farm lands through appropriate zoning, because solid waste disposal sites are listed as a permitted use under the statutory EFU zone and now the County's EFU zone. Nor does the zone change constitute approval of a future expansion. RLC will have to submit a subsequent application for Site Design Review approval, and will have to comply with the criteria in ORS 215.296 relating to impacts on farm practices and costs, and Site Design Review criteria that address compatibility with surrounding uses.

The zone change does not reduce the minimum lot size on a farm or farm/forest parcel. To the contrary, the zone change actually increases the size of the farm parcels located on RLC's property.

DEQ provides a substantial additional layer of regulatory review and oversight of specific operating conditions through its permitting process that protects soil and water quality.

Rezoning the existing landfill from PWS to EFU will not materially change the established patterns of land uses in the immediate vicinity. Solid waste disposal sites are clearly contemplated as an appropriate and permitted non-farm use in the EFU zone. Now that the County's EFU is consistent with the statutory EFU zone, it is appropriate to rezone the PWS and RC-zoned areas back to EFU and "vacate" the exceptions to Goal 3 that Yamhill County previously approved.

The record contains testimony, without explanation, that the zone change is inconsistent with Policy G. That policy states that the County will not permit a subdivision on lands designated by the Comprehensive Plan as EFU. The zone change permits no such subdivision and, therefore, this policy is not relevant to the zone change.

Based on the foregoing, the Board finds that the zone change, on balance, is consistent with Goal 1 and Policies A, B, D, G and H implementing that goal.

The Zoning Ordinance provides other tools for the County to use that will further balance the County's farm land preservation goals with other goals that promote non-farm uses in the farm zone. Specifically, YCZO Section 904.02 allows the Board to apply a Limited Use (LU) overlay to Plan Amendments and Zone Changes for the purpose of limiting specific activities in a specific location. Because RLC has not requested use of its entire landholdings for solid waste purposes, and because portions of RLC's property can continue to be farmed, the Board finds it is appropriate to impose the LU overlay to limit solid waste-related activities in a specific location. The specific limits of the LU overlay are listed in the Conditions of Approval.

The record contains testimony asserting that the LU Overlay cannot be applied in the manner listed in the Conditions of Approval because it identifies which uses cannot occur within the overlay as opposed to the uses that can occur. The Board concludes that YCZO Section 904 should not be interpreted in that manner and that the same purpose can be achieved whether the overlay lists uses that are permitted, or uses that are prohibited. Because there are a large number of uses that could occur in the overlay as proposed by Staff, and only some uses that would not be allowed, it is clearer and more efficient to identify the latter.

Goal 2: To conserve Yamhill County's soil resources in a manner reflecting their suitability for forestry, agriculture and urban development and their sustained use for the purposes designated on the county plan map.

Policy A: Yamhill County will continue to preserve those areas for farm use which exhibit Class I through IV soils as identified in the Capability Classification System of the U.S. Soil Conservation Service.

Riverbend Landfill is located in an area of high-value farm soils, where it was sited in 1980 to replace other landfills in the County that had reached capacity. Riverbend Landfill operates in compliance with an approved DEQ Solid Waste Disposal Permit, and all landfill cells developed since 1993 include a composite liner system which exceeds Subtitle D regulations. State statutes and regulations allow landfills to continue to operate in high-value farmland areas and allow existing facilities to expand into those areas. Because Goal 3 allows landfills as a non-farm use in the EFU zone, even on high-value farmland, the zone change to EFU is appropriate in this case to accommodate the established landfill use.

The zone change area includes a mix of developed areas (including the permitted landfill and ancillary facilities such as the office, gas-to-energy facility, entrance facilities, leachate storage pond, gas monitoring wells, RV park) and undeveloped areas (including floodplain/riparian areas, fields and remnant orchards). As explained in more detail elsewhere in these findings, RLC has not argued, and the County does not find, that the soils under the existing permitted and developed areas meet the definition of "agricultural land" and should be zoned EFU on that basis. However, soils in the undeveloped areas currently zoned PWS and RC exhibit Class I through IV soils and are appropriate to zone EFU on that basis, consistent with the zoning applied to surrounding lands. Policy A does not preclude zoning other areas that no longer exhibit Class I – IV soils to the EFU zone.

While the County's EFU zone now authorizes solid waste disposal sites on EFU land consistent with Goal 3, the County only allows the "maintenance, expansion or enhancement of an *existing* site on the same tract." By applying only to existing solid waste disposal sites, the County's EFU zone minimizes the overall non-farm uses allowed in the EFU Zone and continues to generally preserve areas with Class I – IV soils for farm use.

Based on the foregoing, the Board finds that the zone change is consistent with Goal 2 and Policy A implementing that goal. The record contains no compelling evidence or testimony that the zone change is inconsistent with this Comprehensive Plan goal or policy.

3. Water Resources

Goal 1: To conserve and to manage efficiently our water resources in order to sustain and enhance the quantity and quality of flows for all consumptive and non-consumptive uses and to abate flood, erosion and sedimentation problems.

Policy B: Yamhill County will continue participation in the FEMA National Flood Insurance Program to prevent flood-caused loss of life and property, by identifying and mapping the floodplains and floodways of the county, restricting land uses within the floodplains to those which are open and undeveloped, including forestry, agriculture, wildlife habitat and recreational areas and encouraging improved watershed management practices and the construction of watershed storage projects for flood control.

Policy I: Where conflicting uses are identified or intended, in specific proposals or programs, the economic, social, environmental and energy consequences of the conflicting uses shall be determined and used as a basis for decision-making.

Policy J: It is the policy of Yamhill County to protect riparian vegetation from damage that may result from land use applications for development that is otherwise permitted outright or conditionally under county zoning regulations. To achieve this goal, Yamhill County will review land use applications for development in riparian areas in an effort to mitigate or prevent damage to riparian vegetation that might result from the development. For purposes of this policy, "riparian areas" refers to areas within 100 feet measured horizontally from the ordinary high water line of streams identified as "Fish Habitat" in the comprehensive plan inventory (Natural Resource Conservation Plan, Yamhill County, Oregon, May 1979 – USDA – Soil Conservation Services), that are not regulated under the Forest Practices Act.

The record reflects that RLC has both a permit to withdraw surface water from the South Yamhill River and a domestic groundwater well that provides potable water to the landfill office and a well that serves the RV park. RLC also maintains an extensive system of groundwater monitoring wells around the perimeter of the landfill that are used for environmental monitoring purposes rather than water consumptive uses.

When compared with agricultural irrigation or municipal uses of groundwater and surface water, Riverbend Landfill does not place high volume demands on water resources. Riverbend Landfill also operates under the provisions of DEQ Solid Waste Permit 345. The permit includes operating conditions to address surface water, erosion, and sedimentation control. Additionally, Riverbend maintains existing stormwater outfalls under the provisions and conditions of a NPDES 1200-Z Stormwater Discharge Permit. The Board finds that RLC has documented a good record of compliance with conserving and managing water resources efficiently.

The existing Riverbend Landfill is located outside the floodway of the South Yamhill River. A portion of the landfill was originally constructed within the 100-year floodplain pursuant to a

floodplain development permit the County issued concurrently with the original land use approval for the landfill (Order No. 80-262). The landfill includes a permanent flood protection berm that lies outside the floodway. Future expansions of the landfill located in a floodplain must not restrict the flow of the 100-year flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste to pose a hazard to human health and the environment. The County will rely on FEMA maps as a guide for such future development consistent with County and FEMA regulations.

This zone change approval does not, by itself, result in any conflicting uses because the existing use will remain and any modifications to that use will require additional review by the County. Because Goal 3 and the County's EFU zone expressly authorize a landfill as a permitted non-farm use in the EFU zone, the use is not inherently considered a "conflicting use." Even if future development of RLC's property could be considered a conflicting use, on balance, the positive economic, social, environmental and energy consequences of such a use outweigh any negative consequences.

The economic consequences of temporarily displacing some farmland is outweighed by the construction investment, jobs and payroll, and reduced disposal rates associated with the continued operation of the landfill.

The social consequences such as the removal of the RV Park, potential visual impacts along Highway 18, and temporary noise and odor impacts are outweighed by the social gains achieved by the increase in family-wage jobs, the programs the County can fund with revenue received from the host fee RLC will pay, and the other economic benefits of having a local disposal facility detailed elsewhere in these findings.

The environmental impacts associated with the continued operation of a landfill are only potential impacts, and are unlikely in light of the highly-regulated nature of modern landfills. To the extent that such impacts exist, those impacts are outweighed by environmental gains from reduced carbon emissions associated with maintaining a local disposal option.

The Board finds that the energy consequences of the zone change are a net benefit. The central location of Riverbend Landfill reduces energy needs to transport waste. Further, energy is captured from the disposal of that waste and used locally by McMinnville Water & Light, displacing energy from other resources that is transmitted from farther away.

The Goal 5 findings (below) are relevant to Policy J and are incorporated by this reference. The South Yamhill River is identified as Fish Habitat in the comprehensive plan inventory. Under the existing EFU zoning, farm practices adjacent to streams are not regulated through zoning.

However, several County, state, and federal resource agencies and watershed groups are working cooperatively with farmers to maintain and enhance riparian areas abutting streams for water quality and habitat values.

RLC's property will remain subject to Policy J. As described in the findings addressing Goal 5, the County is imposing Conditions of Approval implementing the "safe harbor" provisions of the Goal 5 rule for protection of riparian corridors. The conditions of approval also ensure that any future expansion will comply with the 100-foot setback specified in Policy J.

Based on the foregoing, the zone change is consistent with Goal 1 and Policies B, I and J implementing that goal.

4. Fish and Wildlife

Goal 1: To conserve the fish and wildlife habitat of Yamhill County with a view to maintaining an optimum ecological balance, enhancing the sport fishing and hunting resource of the county, and protect endangered species.

Policy A: Yamhill County will cooperate with the Oregon Fish and Wildlife Department, the Yamhill County cities, the U.S. Agricultural Stabilization and Conservation Service, the Bureau of Reclamation, and the soil and water conservation districts of the region to identify, conserve, and protect fish and wildlife habitat; determine areas of critical imbalance and threats to particular species; and formulate and implement measures for the improvement of existing habitat and the creation of new habitat where needed.

Policy B: Yamhill County will recognize the need to conserve and protect fish and wildlife habitat in its plan implementation measures, and the following will be considered in any public or private land use determination subject to county review: the impact of harvesting forested areas where there is no forest management plan for regeneration of the forest lands; the filling or drainage of swamps or marshes; the damming of rivers and streams; the location and construction of highways and utility transmission lines; and any other land development activities which significantly interfere with the vegetation or soil cover or drainage patterns in critical habitat areas.

The Board finds that the area of the County in the vicinity of Riverbend Landfill is not designated as a big game winter range area and is not actively managed for sport fishing or hunting. However, the South Yamhill River is identified as Fish Habitat and the open fields and wooded areas in the project vicinity support a wide variety of wildlife.

As discussed in above and in elsewhere in these findings relating to Goal 5, riparian corridors also promote the conservation of fish habitat.

The existing landfill has been, and any future landfill expansion will be, subject to multiple levels of review and permitting by several agencies, including DEQ, DSL, ODFW, and ODOT.

The County is the lead agency for land use and all of the other agencies would coordinate with the County during their permitting processes

Because Riverbend Landfill has operated at this location for many years, the Board finds that substantial landfill related infrastructure is already in place and can be leveraged to accommodate the continued operation and expansion, as opposed to constructing a new landfill in a greenfield setting. The land terrain, soil cover, and vegetation have already been modified with 30 years of landfill activity at this location. However, even with this long land use history, the County and resource agencies have had, and will continue to have, a substantial role in the review and permitting for any future expansion. The Yamhill County Site Design Review process and the state agency permitting would provide the opportunity to review and condition proposed expansion plans to ensure maintenance of adequate setbacks to protect riparian areas and other mitigation measures that might be needed to conserve and protect wildlife habitat as required by Policy B.

Based on the foregoing, the zone change is consistent with Goal 1 and Policies A and B implementing that goal.

5. Open Space

Goal 1: To insure the continuance of the open space character that has always existed in Yamhill County.

The Comprehensive Plan's stated goal to ensure the continuance of the open space character does not imply that no uses or development would be allowed in the rural areas of the County. The Yamhill County Plan Map has reflected a substantial concentration of more than 200 acres of PWS zoning at this location for more than 30 years. The Yamhill County Zoning Ordinance includes 7 rural residential zones, 3 commercial zones, 3 industrial zones, and 3 public facility zones that are available in the unincorporated area. In addition, the resource zones (Farm & Forest) allow the opportunity for up to 50 different non-resource uses in the resource zones.

The County's Parks Master Plan recognizes the unique characteristics of landfills in that they allow the development of passive open space once closed. The County also uses the Site Design Review process as the primary implementation tool to assess the compatibility and character of proposed developments. The Site Design Review process does not apply to development associated with resource uses, but it would be required for any future expansion of Riverbend Landfill.

The Site Design Review process includes public notice and the opportunity for a public hearing. A final grading plan, landscape plan, and design cross sections and elevations are required as

part of the required plan set. In summary, the Riverbend Landfill has a long history of operation and the open space character of this area already includes the existing landfill. Additionally, the subsequent Site Design Review process would provide the opportunity for public and County review of more specific and detailed landscape and buffering proposals for the contemplated Future Expansion Area.

Based on the foregoing, the zone change is consistent with Goal 1.

6. Outstanding Scenic Views and Sites

Goal 1: To protect outstanding scenic views and sites for future generations.
Policy A: Yamhill County will allow uses that may impact scenic resources in the county, subject to the protection offered by the Statewide Land Use Planning Goals, Yamhill County Comprehensive Plan and zoning provisions, particularly site design review, solid waste enforcement, and any other measures as may be adopted to protect the scenic attractiveness of the county.

Outstanding scenic views and sites exist throughout the County. Varied scenic vistas of wooded hillsides, vineyards, productive farm lands, and streams and rivers provide an important component of the livability, attractiveness, and economic health of the County for residents and visitors. Under Goal 5, local governments are not required to amend acknowledged comprehensive plans in order to identify scenic views and sites. Similar to most counties in Oregon, the County has not adopted comprehensive inventories or regulations for protection of scenic views and sites and no sites have been designated in the general vicinity of Riverbend Landfill.

The County approved the existing Riverbend Landfill without placing any limitations on the physical development of the landfill. However, any future development on RLC property will be subject to the County's Site Design Review process. The Site Design Review process provides a framework "to review commercial and industrial development proposals, to insure safe, functional, energy-efficient developments which are compatible with the natural and human-made environment, and to resolve potential conflicts that may arise between proposed developments and adjacent uses." The Site Design Review process will require RLC to take into account impacts to scenic views.

To date, no County strategy has been adopted for establishing a parkway along State Highways 99 and 18. Therefore, there are no plans or programs in place that relate to scenic corridor protection for Highway 18.

Based on the foregoing, the zone change is consistent with Goal 1 and Policy A implementing that goal.

C. Section III – Transportation, Communications and Public Utilities

1. Transportation

Goal 1: To provide and encourage an efficient, safe, convenient and economic transportation and communication system, including road, rail, waterways, public transit and air, to serve the needs of existing and projected urban and rural development within the county, as well as to accommodate the regional movement of people and goods and the transfer of energy, recognizing the economic, social and energy impacts of the various modes of transportation.

The County has adopted a Transportation System Plan (TSP) that is coordinated with the transportation system plans of the cities and the State Transportation System Plan. Riverbend Landfill has an approved direct access point to the state highway system (Highway 18) that includes a left turn pocket for vehicles entering the landfill and a right turn acceleration lane for vehicles leaving the facility. This existing access meets ODOT standards for sight distance and safety.

According to the Traffic Study submitted by the applicant prepared in accordance with ODOT requirements and accepted by the Board, the existing primary access would be retained and can accommodate the PA/ZC area and contemplated future expansion area and maintain compliance with ODOT access, safety, and level of service standards for Highway 18.

As documented in the Traffic Study, the trips associated with the landfill constitute a very small portion of overall traffic volumes on the state highway. The PA/ZC and contemplated future expansion would not result in a significant change in the percentage of trips relative to the overall background traffic on Highway 18.

According to studies from the U.S. EPA, the transportation sector accounts for approximately 34% of our greenhouse gas and CO_2 emissions, followed by electricity consumption at 32%. Landfill release of methane accounts for 2% of the sources of greenhouse gas. Long haul trucking of waste to more distant landfills would require more energy and result in higher air emissions relative to the alternative of expanding Riverbend Landfill as a more centrally located disposal site for the existing service area.

ODOT has adopted access management standards for private accesses to state highways (OAR 734-051). These standards indicate that private accesses along Highway 18 in this area should be spaced 1,320 feet apart. As summarized in the Traffic Analysis, there are two existing private access connections to Highway 18 along the frontage of the parcels included in the PA/ZC or contemplated future expansion area. The existing primary entrance to the landfill would be retained at its existing location. The existing access to the RV park will be a used for a more

limited operations/maintenance access that would have significantly fewer trips than the RV park.

The PA/ZC will not preclude any future expansion of Riverbend Landfill from being set back at least 50 feet from the Highway 18 right-of-way. The zone change and contemplated future expansion would comply with the Comprehensive Plan's goals and policies relating to transportation because RLC would retain the existing approved access points to Highway 18 (a designated arterial) and would maintain more than the required 50 foot frontage setback from the edge of right-of-way.

Additionally, the zone change and contemplated future expansion area can be accommodated with existing transportation facilities and improvements. The primary access point to the landfill would be retained. With the direct access to Highway 18 that only serves the landfill, traffic is concentrated on the state highway (a designated arterial) rather than on the rural County road system, consistent with the functional classification of roadways in the Yamhill County Transportation System Plan. The designated arterials are designed and intended to accommodate higher traffic volumes and freight movement.

Because Highway 18 is under ODOT jurisdiction, a Traffic Impact Study is required for the proposed plan amendment. The Applicant provides an analysis demonstrating that the zone change would not have a significant effect on the state highway system. For these reasons, approval of the requested zone change is consistent with the County's policy to use existing transportation facilities to the full extent possible, consistent with the comprehensive plan and the functional classification of Highway 18.

Based on the foregoing, the zone change is consistent with Goal 1 and the policies implementing that goal.

D. Section IV – Public Land, Facilities, and Services

1. Public Facilities and Services

Goal Statement: To develop a timely, orderly and efficient arrangement of public services and facilities to serve as a framework for urban and rural development, including public lands and buildings, parks and recreation areas and facilities, schools, police and fire protection domestic water supply, sanitary and storm sewerage and other drainage facilities, and power, gas and telephone services.

Policy L: Yamhill County will encourage and cooperate with regional solid waste management programs in scale with the county's needs and subject to equitable cost-sharing arrangements for each of the services and facilities developed on a regional basis.

Policy O: Groundwater supplies will be protected from critical draw-downs or disrupted flows occasioned by surrounding land use development or activities, such as mining and logging where municipal watersheds exist; surface water supplies will be protected from unusual increases in turbidity and sedimentation caused by farming, logging, mining, excavation or grading; and both ground water and surface water supplies will be protected from contamination by subsurface sewage disposal systems, sewage lagoons, sanitary landfill sites and other sources of pollution.

The Public Facilities and Services policies in the Comprehensive Plan underscore the County's long-standing commitment to a regional approach to solid waste management. ORS Chapter 459 instructs counties to establish a solid waste program and a second administrative rule (OAR 340-60-026) requires DEQ to issue solid waste permits only if the permitted facility is compatible with an adopted SWMP.

Ordinance 578 provides the legal authority and policy direction for managing solid waste in Yamhill County. It stipulates that the County will regulate the accumulation, collection and disposal of waste and solid waste, and the creation and operation of disposal sites to accomplish the following:

- Provide for safe and sanitary accumulation, storage, collection, transportation, and disposal of solid waste.
- Prohibit and provide for abatement of accumulation of waste, or solid waste, on private property in a manner that would create a public nuisance, a hazard to health, or a condition of unsightliness.
- Develop a regional long range plan to provide adequate disposal sites and disposal facilities to meet future demands.
- Provide a coordinated countywide program of control of solid waste in cooperation with federal, state, and local agencies responsible for the prevention, control, or abatement of air, water, and ground pollution.
- Provide for and encourage research, studies, surveys, and demonstration projects on developing more sanitary, efficient, and economical solid waste disposal systems and programs.
- Provide for a coordinated solid waste disposal programs with cities within the County and with other counties or cities, should regional programs be developed.
- Provide for cooperation and agreements between the County and other counties involving joint or regional franchising or licensing of solid waste collection or disposal.
- Provide minimum standards for location and operation of disposal sites to protect adjacent or nearby residents.

The SWMP adopted by the County in 2004 reinforces the County's endorsement of a regional approach for providing disposal services. Similarly, the County's updates to the SWMP in 2008 and 2009 through the JR Miller and Zia reports (the conclusions of which were recently supported in the Zia Report Update) acknowledge the many benefits of the continued operation of Riverbend Landfill.

The zone change and RLC's contemplated future expansion of Riverbend Landfill is consistent with Policy L and will provide the opportunity for the County to continue with the approach to solid waste management that has worked well for decades. The zone change will allow County residential, commercial, and industrial customers to retain access to a centrally located, convenient, and cost-effective disposal site for waste generated in the County. Continued operation of Riverbend Landfill as a regional disposal site will maintain economic benefits to the County with ongoing annual payments of licensing and host fees.

The record reflects that the Oregon Department of Water Resources has not identified the zone change area as a sensitive or critical groundwater area. The record also reflects that the existing landfill operates in compliance with DEQ Solid Waste Permit Number 345 and federal Subtitle D regulations. State and federal regulations include stringent requirements to monitor and protect groundwater and surface water supplies from contamination. Groundwater and leachate monitoring are included in the environmental monitoring plan for Riverbend Landfill.

The record contains testimony that the zone change is not consistent with the Comprehensive Plan because it is counter to Policy B of the Public Service and Facilities goal. That policy states that public facilities and services for rural areas will be provided and maintained at levels appropriate for rural use only. This policy does not apply to landfills, which are unique in that a landfill itself is a rural use that must serve all areas of the County. Even if this policy applies to landfills, Riverbend Landfill has been maintained at a level appropriate for rural use and any future development can also be maintained at the same level. Specifically, RLC has demonstrated that modern landfills are highly regulated and, therefore, are capital intensive facilities that must serve a broad customer base to remain financially viable. In other words, only by serving the entire County, and even areas outside the County, can Riverbend Landfill serve rural users as well. This policy is in tension with Policy L, which requires the County to cooperate with cities to provide regional solid waste programs in scale with the County's needs. The Board finds that the continued operation of a local disposal option located in the rural area is appropriate and strikes the right balance between these two policies.

Based on the foregoing, on balance, the zone change is consistent with the Goal statement and the policies implementing that goal.

Although the zone change itself is consistent with the express terms of the Public Facilities goals in the Comprehensive Plan, the summary introducing those goals states "Recycling of solid waste materials conserves natural resources and energy." Conditions of approval attached to this approval require that RLC "add a Green Technology component to minimize landfill expansion," or cease operation, within a specified time frame. Updates to the County's Solid Waste Management Plan have identified the likelihood that other technologies may soon be available to process waste, thereby increasing the efficiency of a landfill. Based on the foregoing, it is appropriate to limit the amount of time RLC uses its property solely as a landfill. The Board is imposing a Condition of Approval that requires RLC to pursue an alternative technology.

2. Parks and Recreation

Goal Statement: To provide adequate recreational opportunities in both the rural and urban environments to meet existing and projected needs.

There is evidence in the record to support a conclusion that recreational opportunities in the rural area will either stay the same or increase following the zone change. Although RLC intends to stop using the RC-zoned tax parcel for the RV Park, it also plans to use other portions of its property as part of Stewardship Lands. Recreational opportunities as part of that effort include a trail system that would connect with other area trails for hikers, bicyclists and possibly equestrians. Such a trail system would provide for recreational connectivity with a footbridge to allow hikers and cyclists to cross the South Fork of the Yamhill River and access an area recently approved for development of a County park. There would also be proximity between the trail system and a wildlife habitat area in development by Ducks Unlimited as part of an existing hunting club that draws participants from outside the County.

Based on the foregoing, the zone change is consistent with the Goal statement and the policies implementing that goal.

E. Section V – Environmental Quality

1. Air, Water and Land Resources Quality

Goal 1: To conserve and to protect natural resources, including air, water, soil and vegetation and wildlife, from pollution or deterioration which would dangerously alter the ecological balance, be detrimental to human health, or compromise the beauty and tranquility of the natural environment.

Policy A: Yamhill County will cooperate with the State Department of Environmental Quality in enforcing state and federal regulations designed to achieve high air quality.

Policy B: Yamhill County will, in making land use decisions relative to industrial or other uses likely to pose a threat to air quality, consider proximity of the proposed use to

residential areas and meteorological factors such as seasonal prevailing wind direction and velocity.

Policy C: Yamhill County will cooperate with the State Department of Environmental Quality in implementing noise control regulations.

Policy E: In order to maintain and improve the quality of the county's air, water and land resources, Yamhill County will seek to minimize irreversible and other long-term impacts in its development of energy resources; support efforts, where feasible, for the appropriate and efficient recovery of energy as a means to reduce waste problems; and encourage a program to recover and recycle used motor oil.

The record demonstrates that Riverbend Landfill has operated at its present location for more than 30 years without 'dangerously altering' the ecological balance of the area. The existing landfill has been operated in compliance with rigorous state and federal environmental regulations that apply to MSW disposal sites. Based on that history, it is reasonable to conclude that the contemplated future expansion allowed by the zone change would also meet those operating standards. RCRA Subtitle D rules for MSW landfills require significant capital investments for providing a robust liner system below landfills, installing groundwater monitoring wells, providing leachate collection and treatment facilities, constructing gas collection and destruction systems, and providing sufficient funds to close and monitor landfills for 30 years after closure. The overall objective of the regulations is to protect environmental and human health.

As part of its application, RLC included information collected from public airports, which post prevailing wind directions by month. According to RLC, most recent reports for the McMinnville airport indicate that prevailing winds blow from the southwest from March through August, and from the north from September through February. In the vicinity of the landfill, wind generally blows to the east or south, and generally never to the west.

RLC owns approximately 700 acres in the vicinity of Riverbend Landfill which provides a substantial buffer between the landfill and most of the surrounding agricultural or other uses. With a location approximately 2 miles from existing urban areas, the existing landfill is surrounded by rural lands and is not near residential areas. Although some farm uses in the area include a residence, there are no established rural residential areas within a 1-mile radius of the landfill. With existing EFU-80 zoning in the general vicinity, the overall density of farm related dwellings is quite low.

Testimony in the record supports a conclusion that the landfill has in the past released odors detectable in the vicinity of the landfill and possibly elsewhere. Odor may be related to air quality, but odor is also subjective and is difficult to quantify and track. The record reflects that RLC has operated the existing landfill to comply with all state and federal standards (specifically

a Title V Air Quality Permit) and has modified facilities and operations to address odor concerns associated with landfill gas. As a result of citizen input and concerns during the last Title V permit renewal, the most recent Title V permit requires Riverbend to submit monthly reports concerning operational information, odor complaints, and odor surveys conducted around the landfill. RLC has made several landfill gas collection system and odor control modifications such as installing more than 120 vertical gas collection wells, adding horizontal landfill gas collectors, installing a new 100hp gas collection system blower, and installing a new enclosed flare and 6 landfill gas-to-energy engines. Under DEQ guidance, RLC will also be implementing new gas collection and odor control measures over the next year such as the addition of a carbon vent system on north leachate tanks, use of Pin Wells for odor mitigation, and application of compost intermediate cover on a 10-acre portion of the landfill.

The zone change is consistent with Policy B because DEQ has confirmed that the existing landfill is operated in compliance with the Title V air quality permit. Any future expansion would be subject to a modification of the Title V permit and on-going facility and operational improvements have enhanced RLC's capabilities to control odor.

The County has not adopted noise control regulations that apply to the landfill, and has received testimony and complaints regarding noise at the landfill affecting nearby residential uses. Riverbend Landfill is located in a rural area and next to a busy state highway. According to RLC, the noise characteristics associated with the contemplated future expansion are not expected to change relative to existing conditions. RLC owns several large surrounding parcels which provide a buffer around portions of the active landfill and proposed expansion area. Additionally, the density of houses within a 1-mile radius of the landfill is very low. Technologies are available to reduce noise production and to shield sensitive uses from noise. Therefore, it is reasonable to conclude that RLC can comply with DEQ noise regulations applicable to a future expansion.

RLC has constructed a gas-to-energy facility at Riverbend Landfill in partnership with McMinnville Water & Light. The landfill gas from Riverbend Landfill creates a generating capacity of 4.8 megawatts, generating about 36,500 megawatt-hours per year of electricity. This is enough capacity to power 2,500 Oregon homes. The electricity generating capacity displaces the need for new electrical turbines powered by natural gas, which generate additional greenhouse gas emissions and other air pollutants. The zone change and any landfill expansion will extend the landfill's ability to generate electricity.

Additionally, the zone change and any landfill expansion will extend the efficient recovery and development of the landfill gas energy resource and will also provide and support expansion of

the County's established solid waste recycling and recovery programs. Notably, the County has implemented a program to recycle motor oil. Several recycling depots in the County accept used motor oil, including the existing recycling depot at Riverbend Landfill.

The record contains testimony asserting that the zone change is not consistent with Policy D implementing Goal 1. That policy provides that the County will consider adopting an ordinance requiring environmental impact review of major development proposals. The Board finds that this policy does not apply to the zone change and is aimed at larger, policy efforts the County could undertake. The record also contains testimony that the zone change is not consistent with Goal 2 under the Air, Water and Land Resources Quality section. That goal is to preserve the charm and amenity values of the County. As described in other findings and testimony in the record, the major amenity value of the County is its rural character. The requested zone change will not, in itself detract from the County's rural character.

Based on the foregoing, the zone change is consistent with Goal 1 and the policies implementing that goal.

F. Section VI – Energy Conservation

Goal 1: To reduce the per capita use of fossil fuels and other non-renewable sources of energy through the efficient and appropriate use of all energy.

Riverbend Landfill currently serves as the only MSW disposal site for the northwest portion of the state, including all of Yamhill, Columbia, Clatsop, and portions of Tillamook and Washington County. Riverbend Landfill is centrally located in the County and is the closest regional landfill to the existing service area.

The record reflects that solid waste disposal in Oregon is increasingly managed by fewer and more widely spaced disposal facilities. Oregon has 27 operating municipal solid waste landfills and one municipal solid waste energy recovery facility. Over 90 landfills have been closed in the past two decades. More MSW is being hauled longer distances for disposal, which has implications for increased use of fossil fuels and related carbon emissions.

Hauling waste to alternative landfills would generate increased emissions of air pollutants as heavy trucks traveled longer distances to those sites. The zone change allows the County to reduce fossil fuel consumption and will minimize carbon impacts relative to the alternatives of hauling solid waste longer distances to out-of-County regional landfills. This approach is consistent with the County's stated goal for energy conservation.

Goal 2: To promote the conservation of existing depletable energy resources and the development of local, renewable resources to ensure that an adequate supply will be available to Yamhill County citizens at a reasonable cost.

Policy C: Yamhill County will support efforts to investigate and establish appropriately scaled units of renewable energy production.

Policy K: Yamhill County will encourage programs for resource recovery and recycling of solid wastes.

The continued availability of a centrally located landfill in the County will provide the opportunity for conserving fossil fuel resources relative to the likely alternative of hauling County solid waste longer distances for disposal at out-of-County landfills. Additionally, RLC has constructed a gas-to-energy facility in partnership with McMinnville Water & Light. That facility captures and combusts landfill gas to generate electricity and provides green energy for customers of the local public utility. The zone change will provide the opportunity for a potential future expansion which will extend the life and capacity of the local gas-to-energy facility.

RLC's application also reserves approximately 25 acres of its property to accommodate a different Green Technology in the future. Preserving the opportunity for a Green Technology at Riverbend Landfill is of paramount importance to the County's solid waste and renewable resource goals, as is the applicant's stated commitment to actually develop a technology or process at the landfill to divert municipal solid waste from landfilling into energy or a useful product or products. Conditions of approval imposed under the Limited Use Overlay will ensure that RLC will develop a Green Technology at the landfill within a specified period of time, or will be required to cease landfilling operations. The zone change will provide the opportunity for RLC to continue to explore its options and will develop additional Green Technology as an enhancement to Riverbend Landfill to conserve resources while developing a marketable energy product.

The County already has several programs in place to encourage resource recovery and recycling of solid waste and the County is exceeding waste recovery goals set by the Oregon Legislature in House Bill 3744. Oregon law requires local governments, or their legally contracted agents, to undertake waste reduction education programs. Solid waste service providers (particularly franchised haulers) must inform their residential and non-residential customers of available waste reduction/recycling options and opportunities.

The revenue the County receives from the host fee RLC pays supports about two-thirds of the County's Solid Waste Fund budgeted expenses, and pays for education and outreach programs, household hazardous waste collection events, and many other programs. If Riverbend Landfill

ceases to operate, continued support of solid waste education, recycling, and other programs would be more heavily dependent on the County general fund. The Board therefore finds that the continued operation of Riverbend Landfill promotes programs for resource recovery.

Based on the foregoing, the zone change is consistent with Goal 2 and the policies implementing that goal.

G. Section VII – Implementation, Evaluation, and Review

1. Citizen Involvement

Policy A: Yamhill County will continue to implement an ongoing citizen involvement program that provides county residents opportunity to be involved in all phases of the planning process.

County residents were involved in all phases of the planning process related to RLC's application. The Yamhill County Planning Commission functions as the County's committee for citizen involvement. County residents are provided with public notices and opportunities to be involved in Planning Commission meetings and public hearings that pertain to legislative and quasi-judicial amendments. The County held two public hearings on this matter, one before the Planning Commission and one before the Board. Between the two hearings, numerous individuals provided written testimony. After each hearing, the record remained open for an extended period for submittal of written testimony, evidence and rebuttal.

In addition to the standard public notice provision required by law, RLC hosted community meetings prior to submitting its application. RLC invited the public to every community meeting with newspaper ads and community calendar notices. Agenda topics at community meetings included groundwater monitoring, landfill gas management, floodplain issues, and other topics.

The review of RLC's application has gone beyond the basic citizen involvement efforts required by this Comprehensive Plan policy.

2. Review and Update

Policy A: Yamhill County will review any development concepts or proposals which conflict with the Plan Map, goals or policies in light of changing needs and conditions and in keeping with established procedures of Plan evaluation, amendment, and update.

Policy C: Yamhill County will encourage federal, state, and regional agencies and special districts to coordinate their planning efforts with those of the county.

The County is not in the periodic review process for review and update of the Comprehensive Plan. However, the County reviewed the proposed plan map amendment for consistency based on established goals and policies in the acknowledged Yamhill County Comprehensive Plan in

light of the policy framework established in the 2004 SWMP and established procedures and criteria for evaluation of plan map amendments. The County also updated the SWMP through analyses of the financial impacts of maintaining a local disposal option and the information in those updates has informed this decision.

Municipal solid waste landfills are one of the most heavily regulated land uses in the state and in the nation. Riverbend Landfill has operated under County land use and franchise approval for more than 30 years and the design and operation of the landfill is heavily regulated and monitored by DEQ for compliance with state and federal environmental rules and regulations.

The Yamhill County SWMP (2004) was prepared under guidance and in coordination with DEQ's solid waste division. The County has the lead role in the land use decision for the proposed landfill expansion. However, other agencies would be involved in subsequent permitting steps and DEQ and other state agencies have established coordination programs in place to assure that state agency rules, programs, and permitting programs that affect land use comply with the statewide goals and are compatible with acknowledged city and County comprehensive plans. The County has and will continue to coordinate solid waste management and permitting decisions with relevant state and federal agencies in compliance with Policy C.

IV. Statewide Planning Goals

Because the zone change also requires an amendment to the Comprehensive Plan Map, the County must demonstrate compliance with applicable Statewide Planning Goals (Goal(s)). Because Oregon's planning framework is based on local comprehensive plans that implement the statewide planning goals, there is quite a bit of overlap between goals and policies articulated in the Yamhill County Comprehensive Plan and the more general statements in the statewide planning goals. The following findings describe why the proposed plan map amendment from PWS and RC to EFU complies with the statewide planning goals.

A. Goal 1 - Citizen Involvement

Goal 1 requires local governments to provide citizens with opportunities to participate in several phases of land use planning, ranging from broad scale public involvement in the development of comprehensive plans and implementing ordinances to more site-specific review of plan and development proposals. Generally, Goal 1 is satisfied when a local government follows the public involvement procedures set out in its acknowledged comprehensive plan and land use regulations.

The County's regulations for comprehensive plan amendments include notice to surrounding property owners and to DLCD, and public hearings before the Yamhill County Planning

Commission and the Yamhill County Board of Commissioners (which makes final decisions on all plan amendments). Opportunities for citizen input and written and oral testimony on the PA/ZC will be provided at public hearings.

The County complied with Goal 1 in its review RLC's application. The County held two public hearings on this matter, one before the Planning Commission and one before the Board. Between the two hearings, numerous individuals provided live or written testimony. Following each hearing, the record remained open for an extended period.

In addition to the standard public notice required by law, RLC hosted community meetings prior to submitting its application. RLC invited the public to every community meeting with newspaper ads and community calendar notices.

The public process in this matter was consistent with the requirements of Goal 1.

B. Goal 2 – Land Use Planning

Goal 2, Part I requires that actions related to land use be consistent with acknowledged comprehensive plans of cities and counties. Consistency of the zone change with goals and policies in the acknowledged Yamhill County Comprehensive Plan is addressed above in these findings.

Goal 2, Part I also requires the County to have an adequate factual base to support the zone change decision. The Board finds that this component of Goal 2 is satisfied based on the large amount of information submitted to the record during this process, which serves as the basis for these findings.

Goal 2, Part II addresses situations in which an exception to another Statewide Planning Goal is being sought. The zone change does not seek a Goal Exception.

Based on the foregoing, the proposed zone change is consistent with Goal 2.

C. Goal 3 – Agricultural Lands

The zone change is consistent with Goal 3. As LUBA stated when it affirmed the County's decision to amend the Zoning Ordinance to allow solid waste disposal activities in the farm zone, Goal 3 allows solid waste disposal facilities in an EFU zone. This authority is set forth in ORS 215.283(2)(k) as refined by OAR 660-033-0120 et seq. ORS 215.283(2) permits the following non-farm use in an EFU zone:

> The following nonfarm uses may be established, subject to the approval of the governing body or its designee in any area zoned for exclusive farm use subject to ORS 215.296:
>
> * * *
>
> (k) A site for the disposal of solid waste approved by the governing body of a city or county or both and for which a permit has been granted under ORS 459.245 by the Department of Environmental Quality together with equipment, facilities or buildings necessary for its operation.

OAR 660-033-0120 and OAR 660-033-0130(18) recognize that solid waste disposal facilities are a permissible non-farm use, but limit such facilities by allowing new facilities only on non-high-value farmland, and by allowing only the maintenance, expansion, or enhancement of existing facilities on high-value farmland. DLCD's Guidelines for Goal 3 also state that "Non-farm uses permitted within farm use zones under ORS 215.213(2) and (3) and 215.283(2) and (3) should be minimized to allow for maximum agricultural productivity."

Because LUBA and the Court of Appeals determined that the County cannot grant an exception to Goal 3 to approve a solid waste disposal facility on farmland for the precise reason that such uses are allowed by Goal 3, and because the zone change is consistent with the associated statute and rules that establish that use under Goal 3, the zone change is consistent with and implements Goal 3.

In amending its EFU zone, Yamhill County took steps to minimize non-farm uses (solid waste disposal sites) to a greater extent than ORS 215.283(2)(k) or OAR 660-033-0130(18). The statute and Goal 3 rule would allow a "new" solid waste disposal site on non-high value farmland zoned EFU. Yamhill County's EFU zone, by contrast, only allows the "maintenance, expansion or enhancement of an <u>existing site</u>...(emphasis added).

RLC's request for a zone change includes other characteristics that serve to minimize non-farm uses:

1. The future expansion area includes a parcel (Tax Lot 401) that has historically been zoned RC.
2. The existing infrastructure and improvements that exist at this location can be leveraged to minimize the area needed for the future expansion and non-farm uses.

In this case, the zone change does not authorize the development of a specific solid waste disposal facility, but provides the opportunity to submit a subsequent application for future expansion. A specific expansion proposal would have to demonstrate that it does not force a significant change in or significantly increase the costs of accepted farm or forest practices on surrounding lands, and would be subject to approval through the county's Site Design Review process, which addresses the compatibility of a specific development with surrounding land uses.

Riverbend Landfill sits in the heart of the County's agricultural region. All of the uses adjacent to the current landfill are agricultural with the exception of the closed Whiteson Landfill and Monroe Landing Park. The Board finds that Riverbend Landfill has a 20-year track record of compatibility with uses adjacent to the existing landfill. Although some owners of agricultural property adjacent to the existing landfill have opposed the future expansion and have complained about impacts from current operations, very little to no real evidence was received to support a conclusion that the actual farming or agricultural operations on farms adjacent to the current landfill have been significantly impacted by the existing landfill. The zone change and contemplated future expansion will not increase existing impacts. Following the zone change, existing operations will continue without significant change. Any subsequent expansion will merely shift the operations to other areas as the existing disposal areas are closed.

1. Authority to Rezone Non-Agricultural Land to the EFU

The record contains testimony asserting that under Goal 3 the County cannot apply the EFU zone to any land other than "agricultural land" as that term is defined in statute and rule. The Board rejects that argument and finds the County is not precluded from re-zoning RLC's non-agricultural land parcels to accommodate a non-farm use.

ORS 215.203(1) establishes a County's ability to zone land for exclusive farm use:

> Zoning ordinances may be adopted to zone designated areas of land within the county as exclusive farm use zones. Land within such zones shall be used exclusively for farm use except as otherwise provided in ORS 215.213 (Uses permitted in exclusive farm use zones in counties that adopted marginal lands system prior to 1993), 215.283 (Uses permitted in exclusive farm use zones in nonmarginal lands counties) or 215.284 (Dwelling not in conjunction with farm use). Farm use zones shall be established only when such zoning is consistent with the comprehensive plan.

Under the express terms of this statute, there are few, but clear requirements for applying the EFU zone. First, a county can "zone designated areas of land." That language does not otherwise refer to any existing uses already on the land being so zoned or the condition of that land. Second, the land, once zoned, can only be used for a "farm use" or for any use listed in ORS 215.213, ORS 215.283, or OES 215.284. Third, the establishment of the exclusive farm use zone on a designated area of land must be consistent with the comprehensive plan.

The County can approve RLC's application consistent with ORS 215.203. The "designated areas of land" are the portions of RLC's tract currently zoned PWS and RC. That land will be used for uses expressly allowed by ORS 215.283. Specifically, some of that land will be used for a solid waste disposal facility as allowed by ORS 215.283(2)(k). Finally, application of the EFU zone is consistent with the County's acknowledged Comprehensive Plan, as discussed in more detail in the above Comprehensive Plan compliance findings.

The focus in opposing testimony that the EFU zone cannot be applied to non-agricultural land is misplaced. Rules promulgated by LCDC define "agricultural land" and require that all inventoried agricultural land must be zoned EFU:

> Except as provided for in section (2) of this rule, counties shall apply zones that qualify as exclusive farm use zones under ORS chapter 215 to "agricultural land" as identified under OAR 660-033-0030, which includes land identified as high-value farmland and land not identified as high-value farmland.

OAR 660-033-0090(1). The rule appears to require that counties apply an EFU zone to agricultural land whenever land is inventoried as such. Individuals opposed to the zone change read the rule as a directive and as a limitation. However, the rule does not state that *only* agricultural land can be zoned EFU and, in fact, lands zoned for exclusive farm use contain at least some land that is not suitable for farming or being farmed. ORS 215.203 allows a county to designate any land as EFU, as consistent with its Comprehensive Plan, and ORS 215.213 and 215.283 limit and allow specific farm and non-farm uses on land zoned EFU.

It is with this understanding that the County has rezoned non-agricultural land to the EFU zone before. In docket PAZ-05-06, for example, the County rezoned two parcels totaling 85 acres from the RC zone to the EFU zone. At the time of the rezoning, those parcels were part of an acknowledged Goal 3 Exception area and were therefore not "agricultural lands" under the definition in OAR 660-033-0010(1)(a). The record also reflects that the County has applied the EFU zone to other non-agricultural lands such as rock quarries.

The only other case law presented to the County on this issue does not control RLC's request because it considered a "determination that a particular parcel of land is 'agricultural land.'" The Board's decision in this matter makes no such determination.

It would be bad policy to prevent counties from re-zoning non-agricultural land to the EFU zone. Applying the EFU zone creates the opportunity for more farm uses in the County, for which there is a demonstrated need. The decision to re-zone such land also adds a layer of protection for surrounding farms by requiring that new development on that land meet the compatibility standards of ORS 215.296.

2. Consistency with Rules Implementing Goal 3

The record contains testimony asserting that the County's decision to rezone RLC's property is not consistent with the intent of OAR 660-033-0130(18), the Goal 3 implementing rule that allows development of a solid waste disposal facility on high-value farmland only if it is related to an existing facility that is "wholly within a farm zone." The implied assertion in that testimony is that the intent of the rule is to limit the expansion of solid waste disposal facilities to those facilities that were wholly within a farm zone when that rule was adopted and that it does not authorize expansions of facilities that may later become wholly within a farm zone by virtue of the rezoning process. The Board rejects this argument; nothing in the rule language limits "existing facilities" to those facilities that were wholly within a farm zone at the time of the rule adoption.

This argument also assumes that the *only* purpose for rezoning RLC's property is to allow an expansion of the existing landfill. While that may be the primary driver behind RLC's request, the record demonstrates that the zone change is appropriate even if Riverbend Landfill never expands. RLC has demonstrated that it can make more efficient use of the property currently zoned PWS by using the RC tax parcel and portions of the EFU tax parcels for operational support. For the opposing testimony's position to prevail, RLC would be unable to rezone its property even if it had no plans to expand the existing landfill. There is nothing in the language of the rule or the testimony in the record that urges such an outcome.

Finally, the position of opponents, if followed, would create an absurdity. LUBA overturned the County's approval of a Goal 3 Exception for RLC in 2009 because Goal 3 and its implementing rules would have allowed the expansion and, therefore, a goal exception was not available. If the County were to now conclude that Goal 3 and its implementing rules did not allow an expansion, a Goal 3 Exception would be necessary, but that goal exception would be unavailable. LUBA and the Court of Appeals could not possibly have intended there to be *no* process available for considering the merits of RLC's proposal.

3. ORS 215.296 Criteria

The record contains testimony asserting that the County must apply the provisions of ORS 215.296 to this decision and that the provisions of that statute have not been satisfied. The Board disagrees and finds that the County is not required to apply the criteria in ORS 215.296 to the request for a zone change, which does not establish or otherwise authorize development of a landfill. However, even if that statute does apply at this stage, the standards in that statute have been satisfied.

As part of its application, RLC has not sought approval from the County to expand Riverbend Landfill. The existing landfill has already been approved and developed under its initial authorization in the early 1980s. Furthermore, before any landfill expansion occurs, RLC will have to come back to the County for additional approval. That approval process will consider whether a specific proposal is consistent with ORS 215.296 (and the identical County Zoning Ordinance provision that incorporates that statute), along with the County's Site Design Review criteria.

Testimony in opposition to the zone change asserts that the County's decision will "establish" a landfill because the landfill does not currently exist in the EFU zone. There can be no dispute that Riverbend Landfill has already been established. Testimony in opposition to the zone change also asserts that the County must review the existing development before applying any new zone to that development. Those arguments ignore the well-established concept that the zoning of property does not "approve" existing development on that property. State law provides that the "lawful use of any building, structure, or land at the time of the enactment or amendment of any zoning ordinance or regulation may be continued." ORS 215.130(5).

Even if the Board were to determine that consideration of the criteria in ORS 215.296 is warranted, the record demonstrates that the requested zone change will not cause a significant change to, or significantly increase the costs of, accepted farm practices in the area. With respect to the existing landfill, the requested zone change will not result in any changes in the nature or intensity of current operations. Therefore the zone change will affect no significant change to, or cost of, accepted farm practices. With respect to potential expansions of the landfill, the record includes a farm impacts analysis. That analysis identifies crops and other farm uses in an area within a radius of approximately one mile around Riverbend Landfill. That analysis also identifies accepted farm practices associated with the production of those crops and other uses. The record does not contain persuasive evidence that the type of farm practices around Riverbend Landfill have changed over the years. The application indicates that if the landfill is expanded in the future, waste disposal volumes will remain relatively constant at approximately current disposal rates. Any subsequent expansion will merely shift the operations to other areas

as the existing disposal areas are closed without significant effect on farm practices or costs. The record also reflects that the applicant investigated the farm practices on its own farm holdings and did not discover any impacts from the landfill on farm practices or costs on those sites adjacent to the landfill. Logically, if no such impacts exist immediately adjacent to the landfill, then they are also not likely to exist farther from the landfill.

Although the record contains some testimony regarding impacts to nearby properties, that evidence does not support a conclusion that "farm practices" have been significantly impacted or will be impacted by the zone change. Most of the impacts identified in that testimony relate to non-farm practices such as tourism or residential property values.

In this case the zone change itself will not allow any new conflicts with farm practices. RLC still must seek approval for a specific development proposal. Future uses that RLC contemplates are the same uses that already exist in this area – solid waste disposal – and those uses have existed in this area for more than three decades without substantially impacting farm practices or costs. The transportation system is more than adequate to accommodate the anticipated use and, therefore, any use of the transportation system for farm activities will not be impacted. To the extent there are potential conflicts between the landfill and nearby farm uses, RLC's property is contained within natural and man-made boundaries that keep the solid waste use separate from surrounding farm uses. Finally, Riverbend Landfill is highly-regulated by DEQ, which imposes several restrictions on activities that prevent harm to air quality or to surface and ground water, thereby maintaining the quality of those resources for other farm uses.

4. Compliance with ORS 459.055

The record contains testimony asserting that the County cannot approve the zone change because RLC cannot comply with ORS 459.055. That statute relates to Goal 3 and requires certain reclamation standards for landfills in the EFU zone. Under ORS 459.055, as part of the ultimate closure of the landfill, RLC will have to work with DEQ to determine how the site will be rehabilitated to a condition comparable to its original use.

ORS 459.055 does not prevent the County from approving the zone change. The record contains a letter from DEQ indicating that DEQ will apply this statute as part of the normal permitting process for the solid waste disposal facility. Despite that letter, opponents argued that the County must determine now what post-closure farm activities will occur. That testimony, however, does not identify what County zone change criterion requires consideration of this statute. The Board finds that no such criterion exists. ORS 459.055 will become applicable only after the zone change to EFU. DEQ has indicated it will enforce the requirement when it applies. If RLC is unable to meet that standard, then it will not receive a solid waste permit from DEQ. It

is also uncertain at this time what specific farm uses DEQ will allow or even require as part of the post-closure process. The County, therefore, cannot require RLC to demonstrate specifically how those requirements will be met.

Even if the Board must consider RLC's ability to meet the standards in ORS 459.055, the record demonstrates that it is possible for RLC to meet DEQ's post-closure standards. DEQ's letter stating that the standards would be enforced suggests that DEQ believes that the standards can be met. The original application for land use approval of Riverbend Landfill identified the current uses as grazing, turkey farming, and other general farm uses. At the termination of the property's use as a landfill for solid waste disposal, ORS 459.055 does not require that the landfill be returned to the same use. Rather, ORS 459.055 requires that DEQ determine the site can and will be reclaimed to a condition comparable to its original use. RLC has developed a conceptual post-closure plan that describes some of the uses it intends to seek approval for from DEQ and those uses would return the site to a condition comparable to the site's original use. For example, the conceptual post-closure plan includes anticipated farm uses such as hay or seed production, pollinator gardens, apiculture, plantings for wildlife habitat, grazing, and the creation, restoration and enhancement of wetlands that are clearly among uses comparable to the original use of the landfill property.

5. Minimum Lot Sizes

One comment in the record asserts that the County cannot re-zone the parcel currently zoned Recreational Commercial (RC) because it is smaller than the 80-acre minimum associated with the County's EF-80 zone. That comment, however, misconstrues the applicable law and also ignores the full ownership of RLC's property.

ORS 215.780 provides that the minimum lot size for non-rangeland farm and forest zones is 80 acres. LUBA, however, has determined that ORS 215.780 applies only to the division of resource land and not to the rezoning of an existing parcel. *LCDC v. Coos County*, 39 Or LUBA 432, 437 (2001). The County's Zoning Ordinance similarly applies the 80-acre minimum size only to newly created lots. Section 402.09(B)(1) expressly states that "new farm parcels proposed to be created shall be a minimum of 80 acres in the EF-80 district." Section 402.09(B)(3) goes on to provide that "any permitted use" in the farm zone "may be established on an existing lot."

The minimum lot size requirement does not apply to this zone change decision. Even if the minimum lot sizes apply to a rezoned parcel instead of a newly-created lot, the record reflects that the legal lot underlying the RC parcel is larger than 80 acres. As RLC explained, several of RLC's tax parcels, including the RC parcel, have been consolidated into one single legal lot

totaling in the hundreds of acres. The minimum lot sizes will therefore not be violated by the County's approval of the zone change.

D. Goal 4 – Forest Lands

None of the parcels included in the zone change, or any contiguous parcels in the vicinity, are designated for Forestry or Agriculture/Forestry in the Yamhill County Comprehensive Plan. Therefore, Goal 4 is not relevant or applicable to the zone change area (from PWS and RC to EFU) or to the future expansion area.

Additionally, the zone change does not have direct or secondary effects on forest lands in the County. The zone change will allow solid waste disposal facilities in the EFU Zone and does not make any changes to forest land zones. The requested zone change is consistent with Goal 4.

E. Goal 5 – Open Spaces, Scenic and Historic Areas, and Natural Resources

Goal 5 requires that local governments adopt programs to protect significant natural resources and conserve significant scenic, historic, and open space resources for present and future generations. The procedures and requirements for complying with Goal 5 are outlined in OAR 660, Division 23.

The County has an acknowledged comprehensive plan and land use regulations. The zone change is therefore a "post-acknowledgement plan amendment" (PAPA) under the Goal 5 rule. OAR 660-023-0250 outlines the applicability of Goal 5 to PAPAs as follows:

(1) The requirements of Goal 5 do not apply to land use decisions made pursuant to acknowledged comprehensive plans and land use regulations.

(2) The requirements of this division are applicable to PAPAs initiated on or after September 1, 1996.

(3) Local governments are not required to apply Goal 5 in consideration of a PAPA unless the PAPA affects a Goal 5 resource. For purposes of this section, a PAPA would affect a Goal 5 resource only if:

(a) The PAPA creates or amends a resource list or a portion of an acknowledged plan or land use regulation adopted in order to protect a significant Goal 5 resource to address specific requirements of Goal 5;

(b) The PAPA allows new uses that could be conflicting uses with a particular significant Goal 5 resource site on an acknowledged resource list; or

(c) The PAPA amends an acknowledged UGB and factual information is submitted demonstrating that a resource site, or the impact areas of such a site, is included in the amended UGB area.

(4) Consideration of a PAPA regarding a specific resource site, or regarding a specific provision of a Goal 5 implementing measure, does not require a local government to revise acknowledged inventories or other implementing measures, for the resource site or for other Goal 5 sites, that are not affected by the PAPA, regardless of whether such inventories or provisions were acknowledged under this rule or under OAR 660, Division 16.

The zone change does not create or amend the County's Goal 5 resource list, create or amend a land use regulation adopted to protect a significant Goal 5 resource, or amend an acknowledged urban growth boundary. Therefore, the only portion of the Goal 5 rule potentially applicable to the zone change is OAR 660-023-0250(3)(b), which requires the County to determine whether the PAPA will allow a new use that could be a conflicting use with a particular significant Goal 5 resource on the County's acknowledged resource list.

The Limited Use Overlay imposes limitations on use of the site and surrounding lands owned by RLC, but does not authorize any new or different uses than the underlying zones. The zone change to EFU applies only to Tax Lots 5501-101, 5501-200, and 5501-401. The record establishes that each of those tax lots is currently developed with a non-farm use, and two of those lots already contain solid waste disposal operations. Because the lots currently zoned PWS are being rezoned to EFU, the Board finds that Riverbend Landfill will be maintained on those existing lots (Tax Lots 101 and 200) and, therefore, the zone change will not have allowed any new use on those lots that does not already exist, and Goal 5 is not triggered for those lots. However, because the lot zoned RC would be rezoned to EFU and allow a new use that is not currently allowed on that lot, the Board finds that Goal 5 is triggered for that lot (Tax Lot 401).

The record contains a Goal 5 Report submitted by the Applicant. That report documents the significant Goal 5 resources that Yamhill County has identified within the areas currently zoned PWS and RC, as well as the areas currently zoned EFU that are within the area contemplated for eventual expansion of the landfill. As documented in the Goal 5 report, the County's acknowledged Goal 5 resource list does not designate any significant Goal 5 resources in the vicinity of RLC's property other than riparian corridors. Although the County's acknowledged Goal 5 resource list does not specifically identify "riparian corridors," it does include provisions for the protection of "riparian zones" of fish bearing streams, e.g., the South Yamhill River.

Because the zone change will provide the opportunity for RLC to apply for a future expansion in proximity to the riparian area around the South Yamhill River, the Board finds that a solid waste disposal site could be a conflicting use with such a resource. However, the County already has

Comprehensive Plan policies in place to guard against such conflicts and, therefore, there is no actual conflicting use allowed. Even so, if the zone change triggers the applicability of Goal 5 under OAR 660-023-0250(3)(b) with respect to riparian corridors because of a new conflicting use, RLC's proposal is sufficient to address that conflict.

Under OAR 660-023-0090 a riparian corridor is a Goal 5 resource that includes the water areas, fish habitat, adjacent riparian areas, and wetlands within the riparian area boundary. During the PAPA process, the County may choose to adopt a safe harbor approach to identify and to protect Goal 5 resources. In the case of significant riparian corridors, the safe harbor approach for identifying significance resources is to adhere to a specific setback:

> The significant riparian corridor area setback is 75 feet from the top of bank of a waterway with an annual average stream flow greater than 1,000 cubic feet per second [e.g., South Yamhill River], and 50 feet for other fish-bearing streams [e.g., unnamed tributaries].

As part of its application, RLC proposed to identify riparian corridors using the safe harbor approach (OAR 660-023-0090(8)), which results in a riparian corridor of 50 feet to either side (from top-of-bank) of each unnamed stream and 75 feet from the South Yamhill River.

The County's Water Resources Policy J addresses significant riparian areas by protecting vegetation within 100-feet of streams identified as "fish habitat" in the comprehensive plan inventory:

> *J. It is the policy of Yamhill County to protect riparian vegetation from damage that may result from land use applications for development that is otherwise permitted outright or conditionally under county zoning regulations. To achieve this goal, Yamhill County will review land use applications for development in riparian areas in an effort to mitigate or prevent damage to riparian vegetation that might result from the development. For purposes of this policy, "riparian areas" refers to areas within 100 feet measured horizontally from the ordinary high water line of streams identified as "Fish Habitat" in the comprehensive plan inventory (Natural Resource Conservation Plan, Yamhill County, Oregon, May 1979 -U.S.D.A. - Soil Conservation Services), that are not regulated under the Forest Practices Act. (Ord 471).*

RLC's application also proposes that the County continue to apply the County's Policy J to the identified riparian corridor associated with all three streams by applying the County's existing policy's 100-foot setback from the ordinary high water line to protect riparian vegetation. RLC also proposed that Yamhill County protect the riparian corridor by adopting provisions in conjunction with the PAPA to protect the significant riparian corridor on RLC's property

consistent with the safe harbor approach set forth in OAR 660-023-0090(8). The Board adopts that approach and has imposed a condition of approval in Ordinance 887 to implement the Goal 5 safe harbor provisions and to continue the application of Policy J to RLC's property (see specific language in Exhibits C and D to this Ordinance).

In summary, the Goal 5 requirements pertaining to significant riparian corridors are satisfied through adoption of the 100-foot setback condition in Exhibit C. No other significant Goal 5 resources exist in the area.

F. Goal 6 – Air, Water and Land Resources Quality

Goal 6 addresses the quality of air, water, and land resources. In the context of comprehensive plan amendments, a local government complies with Goal 6 by explaining why it is reasonable to expect that the proposed uses authorized by the plan amendment would be able to satisfy applicable federal and state environmental standards, including air and water quality standards. Although the record contains testimony from individuals who believe a solid waste disposal facility impacts air, water and land resource quality, no substantial evidence in the record indicates that the continued operation of Riverbend Landfill will not meet established standards. The record reflects that RLC has a long history of successful environmental compliance and the record contains no persuasive evidence that RLC is not meeting established environmental standards. Further, the Board finds that the zone change does not change what activities RLC will engage in and that RLC is therefore likely to be able to continue meeting established environmental standards.

With respect to water quality, RLC utilizes a liner system, leachate collection system and environmental monitoring program that DEQ requires of landfill operations. If Riverbend Landfill expands, the landfill expansion will be designed and operated with environmental control systems comparable, if not more effective, as employed at the existing landfill. The expansion area is in an area where potential impacts to water quality are very predictable and, therefore, more easily avoided or mitigated. Such predictability exists, in part, because of the long history of environmental monitoring that has occurred around the existing landfill and the information that has been gathered from that monitoring.

With respect to air quality, the record reflects that RLC is in compliance with its DEQ-issued air quality permit and DEQ will continue to enforce the same regulations on the expanded portion of the landfill.

Following any future County decision authorizing a solid waste disposal facility in the EFU Zone, DEQ will review and must approve as part of the permitting process the continued

operation, expansion or enhancement of a facility. As part of its permitting process, DEQ will have to review and approve site development plans, including technical information to address DEQ rules and design criteria.

Based on the foregoing, the zone change is consistent with Goal 6.

G. Goal 7 – Areas Subject to Natural Disasters and Hazards

Goal 7 addresses hazards to development and limits development in known areas of natural hazards without appropriate safeguards. The zone change does not authorize development of specific facilities. Rather, the zone change will apply to the existing use on RLC's property and authorizes RLC to seek an expansion of that use in the future. Any specific development proposal after the zone change will require approval by the County and developments in a hazard area will have to demonstrate compliance with all federal, state and local standards that establish safeguards for development in those areas.

The record reflect that federal criteria for MSW landfills (RCRA Subtitle D) took effect beginning October 9, 1993 and that these criteria also restrict landfill siting in certain locations. Two of those criteria potentially apply to future development on RLC's property: floodplains and seismic impact zones.

1. Floodplains

The record demonstrates that Riverbend Landfill is located outside the floodway of the South Yamhill River. A portion of the landfill was originally constructed within the 100-year floodplain pursuant to a floodplain development permit the County issued concurrently with the original land use approval for the landfill (Order No. 80-262). The U.S. Army Corps of Engineers (Corps) assisted the County and RLC with siting the landfill by conducting hydraulic analyses that allowed the County to conclude that the landfill could safely operate in its current location, while also not encroaching on the floodway.

RLC recently worked with Yamhill County in obtaining a Letter of Map Revision from FEMA that resulted in a more accurate depiction of the 100-year floodplain and floodway in the reach of the South Yamhill River associated with Riverbend Landfill. The Map Revision was adopted by FEMA on May 9, 2013. The revision was based on more accurate topographic data than that used in the 1980s: the updated topography accounted for all changes since the 1980s, including the presence of Riverbend Landfill and Whiteson Landfill. The revision also required the use of the Corps' most modern hydraulic modeling methods and software. As a result, the current Flood Insurance Rate Maps now portray the correct locations of the 100-year floodplain and floodway

in the vicinity of the landfills. Those maps will be used to guide future development consistent with County and FEMA regulations.

The record contains testimony that the existing landfill is somehow in violation of the County's floodplain development standards. However, much of that testimony contains information and arguments that were developed prior to the time that FEMA approved the LOMR referenced above. As a result, that information and those arguments do not reflect the actual status of conditions on the ground or the regulatory scheme applicable to RLC's property. The evidence relied upon by the Board is to the effect that the existing landfill is not in violation of the County's floodplain development standards, and will not be in violation as a result of any proposed expansion. The zone change is therefore consistent with Goal 7 in this regard.

2. Seismic Impact Zones

Landfills are allowed in a seismic impact zone if they are designed to withstand the maximum horizontal acceleration at the site. Riverbend Landfill is located in a seismic impact zone. The record reflects that, according to DEQ when Riverbend Landfill was developed, the landfill's slope stability analysis showed that the safety factors against slope failure are adequate for the excavation and final cover of the cells under the current permit. RLC is required to meet Subtitle D seismic resistance requirements for all future waste containment areas. This design standard is similar to seismic design standards (Uniform Building Code) for other facilities in the surrounding area.

DEQ recently completed an extensive review of Riverbend Landfill and approved a proposal for construction of a mechanically stabilized earthen berm (MSE berm) along the west side of Riverbend Landfill. The berm, which is 2,100 feet long and up to 40 feet high, would allow disposal capacity for an additional one million cubic yards of waste within the approved permit area. The DEQ review included a detailed summary of the geotechnical evaluation relying on geotechnical information obtained by drilling 14 borings and excavating seven test pits in the area of the proposed MSE berm. DEQ also required RLC to provide an updated evaluation that takes into account the most recent seismic data, including the recent earthquakes in Chile and Japan. DEQ additionally hired its own consultant to assist in independently reviewing the seismic characterization of RLC's site.

During the DEQ review process for the MSE berm, landfill opponents stated that DEQ should require a design based on a magnitude 9.0 earthquake, noting that other agencies require this. To address this concern, DEQ contacted the Oregon Department of Geology and Mineral Industries (DOGAMI) and requested a written opinion as to whether a 9.0 magnitude earthquake should be considered in the design of Riverbend Landfill. DOGAMI recommended that DEQ "consider in

designs for expansion to this landfill the magnitude 9.0 Cascadia Subduction Zone earthquake." Following that recommendation, DEQ met with DOGAMI twice more to consider earthquakes of such magnitude. Based on those meetings, DOGAMI concluded that the probabilistic seismic-hazard analysis completed for the site used a reasonable approach and that the magnitude 9.0 earthquake was considered and integrated into the probabilistic seismic-hazard analysis.

The DEQ seismic review process is extremely thorough. The Board is satisfied that RLC would have to undergo a similarly rigorous analysis as part of any future permitting process. The zone change is therefore consistent with Goal 7 in this regard.

The record contains testimony expressing concern about the seismic stability of the existing landfill. Such testimony is not relevant to the decision before the County, which relates only to a zone change. The current land use application cannot be used to collaterally attack the approval of the existing facility, and the County is not, in this proceeding, approving permits for any future facility that may be proposed for development in the rezoned areas.

Even if the Board were to determine that the seismic stability of the existing landfill is relevant to the request for a zone change, the arguments presented in opposition to the zone change have been thoroughly addressed – and rejected – by DEQ, the regulatory body charged with actually approving the landfill design. According to DEQ, DEQ and its seismic consultant reviewed the seismic characterization and design thoroughly, considered many issues, including liquefaction, earthquake magnitude, source to site distance, and associated ground motions, and concluded that the design meets the regulations for municipal solid waste landfills. DEQ also noted that the seismic regulations it applied to the most recent permit are more stringent than those used for most other structures. DEQ also concluded that the design of the remainder of the landfill's perimeter berm (i.e. the portions other than MSE Berm) were of sound design.

3. Goal 7 Summary

Given the available information on floodplain and seismic risks and the recent characterization of site conditions through the FEMA Letter of Map Revision and DEQ's review of the MSE berm, it is reasonable to conclude that any future development on RLC's property could be designed to protect people and property from natural hazards and it would is feasible to obtain necessary permits. The zone change is therefore consistent with Goal 7.

H. Goal 8 – Recreational Needs

The zone change does not have direct or secondary effects on recreation areas, facilities or opportunities designated by the County's acknowledged Comprehensive Plan to meet the County's recreational needs.

The Comprehensive Parks and Open Space Master Plan (2003) states that the County currently owns and maintains 17 parks and open space areas totaling 126.4 acres. Ten of the sites are developed, six are undeveloped, and one is leased. The Parks and Open Space Master Plan also describes the two county-owned and decommissioned landfills, one located near Monroe Boat Landing on the South Yamhill River (Whiteson Landfill) and one near Rogers Landing on the Willamette River (Newberg Landfill). The plan indicates that both former landfill sites have potential for passive recreation and open space once reclamation is complete. The zone change will not impact the designated Monroe Landing or new park site south of the river. The extensive floodplain and established riparian corridor along the South Yamhill River provides a substantial buffer between the active landfill and low-intensity park and recreational uses.

As the Board has indicated elsewhere in findings relating to the Comprehensive Plan's Parks and Recreation policies, recreational opportunities in the County will either stay the same or increase following the zone change. The current RC-zoned parcel is developed as a recreational vehicle (RV) park. The County took a "built and committed" exception for the RV Park when the Comprehensive Plan was adopted in 1979. Therefore, the RV Park was not established based on a public need for the use, but rather was grandfathered as an established use. Even so, the record reflects that there are other RV parks available in proximity to Highway 18 to accommodate tourists and visitors to the County, including the Wandering Spirit RV Park near the casino in Grand Ronde (129 spaces) and the Willamette Wine Country RV Park (191 spaces) adjacent to Highway 18 and the South Yamhill River near the City of Dayton. Neither the Yamhill County Plan nor the Parks and Open Space Master Plan have identified a specific "need" for land zoned Recreational Commercial or for overnight facilities, including RV Parks.

Based on the foregoing, the zone change is consistent with Goal 8.

I. Goal 9 – Economic Development

Although the zone change does not involve commercial or industrial lands typically subject to Goal 9, the zone change will contribute to a healthy economy in the County and the larger region. The discussion and findings in Section I.B.2.b and II.A relating to the economic benefits of a local disposal option and the Economic Development policies in the Comprehensive Plan are relevant to Goal 9 and are include here with this reference.

The Board relies on the evidence in the economic study submitted by RLC and the Zia Report Update, and concludes that such evidence is compelling regarding the economic benefits of maintaining a local disposal option. As discussed in more detail elsewhere in these findings, the critique of those economic impacts offered by the opponents is not persuasive. According to the economic analysis submitted by the applicant, costs of disposal are likely to rise when there is not local disposal option because hauling waste to alternative disposal sites would cause the per-ton cost of disposal to increase for Yamhill County residents and businesses. Specifically, the annual cost of disposal to the entire County would increase by $3.5 to $5.1 million (depending on the alternative site). If Riverbend Landfill continues to operate, RLC would continue to pay licensing and host fees to the County that would be higher than the host fees the County would collect from a transfer station that processes only in-county waste.

The economic analysis submitted by the applicant also demonstrates that RLC could invest $25.5 million when it expands Riverbend Landfill in the future. That level of construction activity generates 202 jobs directly associated with construction activities and $6.1 million in associated personal income in addition to secondary jobs and income. Even before any potential expansion of the existing landfill, operating Riverbend currently requires 17 full-time equivalent jobs, generating $1.6 million in associated personal income per year to operate the facility in addition to secondary jobs, as the Landfill and its employees purchase goods and services in the local economy. It is estimated that operating Riverbend Landfill generates 19 secondary jobs and $500,000 in personal income, for a total of 36 jobs and $2.1 million in personal income. Hauling waste to alternative sites would create about half as many jobs – operating the transfer station and driving the waste to alternative sites would generate between 14 and 19 jobs and between $900,000 and $1.2 million in personal income (depending on the alternative site). Between 11 and 14 of those jobs would be directly employed in transfer station operations and hauling the waste.

Hauling solid waste from the County to any of the three alternative disposal sites presented in RLC's economic study generates carbon dioxide (CO2), nitrogen oxides (NOx), carbon monoxide, and particulate matter. According to that analysis, the economic cost of the CO2 is between $28,000 and $297,000 per year; the cost of the NOx is between $23,000 and $200,000 per year; and the cost of particulate matter is between $28,000 and $242,000 per year.

The continued operation of Riverbend Landfill is compatible with other industries in the County. As described in the Economic Impact Report submitted by the Applicant, a review of prior studies on tourism in the County yielded no evidence suggesting Riverbend Landfill negatively impacts tourism in the County. The County is the leading production area for Oregon's wine industry, and several studies have identified wine-related tourism as the main driver of tourism

activities in Yamhill County. Those studies recognize several key factors that could affect the growth of wine-related tourism in Yamhill County, but neither points to Riverbend Landfill nor other waste disposal operations as deterrents of tourism growth. The record demonstrates that Riverbend Landfill has been in operation during the entire time that the wine and tourism industries have developed and continued to thrive in Yamhill County.

In summary, the zone change will support the local and regional economy with the continued availability of good local jobs to operate the landfill, and additional construction jobs associated with the future expansion and required new Green Technology facility. Further economic benefits would include secondary employment and income to local businesses associated with the expansion and operation of the landfill, and cost-effective disposal rates for local businesses and industries when compared with alternative disposal options. Riverbend Landfill is an important and vital part of the County economy and approval of the zone change is consistent with Goal 9.

J. Goal 10 - Housing

Goal 10 requires local governments to do their fair share to provide for a wide variety of housing needs. Under Goal 10, cities must inventory buildable lands for residential use and encourage the availability of adequate numbers of needed housing units at price ranges and rent levels that are commensurate with the financial capabilities of Oregon households.

Buildable lands are defined in Goal 10 as lands *inside* urban growth boundaries that are suitable, available, and necessary for residential use. The Board therefore finds Goal 10 does not apply to the rural lands that are the subject of the zone change. The contemplated future expansion (which will require subsequent Site Design Review approval) would not affect any lands that are zoned for rural residential use or displace any existing housing units.

The record contains testimony asserting the zone change is not consistent with Goal 10. That testimony, however, is based specifically on RLI's plans to use the parcel currently designated RC for operations ancillary to the landfill in the future. The RC parcel is currently used by Mulkey RV Park and testimony in opposition to the zone change asserts there are "housing implications" related to the discontinued use of the RV Park.

An RV Park is a recreational facility that does not allow permanent or even long-term residential use. Pursuant to Section 1003 of the Zoning Ordinance, mobile homes are allowed in an RV park for no longer than a one-month period. The County does not rely on Mulkey RV Park to satisfy its housing needs.

The record also reflects that the continued use of the RC-zoned parcel as an RV park is unrelated to this decision. The record reflects that the use of that tax parcel for an RV park will likely conclude in April of this year, when the current lease terminates. Therefore, the County's denial of RLC's application on a Goal 10 basis would not result in any additional use of that site for residential use even if that use were allowed.

No testimony in the record asserts that the purpose of the RC-zoned tax parcel is to provide housing, or that any need for housing cannot be accommodated elsewhere in the County. Prior to its use as an RV park, this parcel was used as a motor cross facility, and it was zoned RC based on a built-and-committed Goal Exception because of that use. The approved use of that tax parcel has been recreational, not residential, and, therefore, there are no housing implications from the zone change.

K. Goal 11 – Public Facilities and Services

Goal 11 provides that urban and rural development should be guided and supported by types and levels of services appropriate for, but limited to, the needs and requirements of the urban and rural areas to be served. Goal 11 is implemented through the Public Facilities Planning Rule, OAR 660, and Division 11. Under Oregon's land use planning framework, cities have the lead role in preparing and adopting public facility plans for sanitary sewer and water facilities to support planned land uses within urban growth boundaries.

Solid waste disposal facilities serve both rural and urban uses, but that such facilities themselves are more appropriately located in rural areas. In support of this finding, the Board relies in part on the fact that Goal 3 expressly allows these non-farm uses in an EFU Zone and the fact that most regional solid waste disposal facilities in the state are located on rural lands. Neither the existing landfill nor the contemplated future expansion will require city water or sewer service or other urban public facilities.

ORS Chapter 459 gives counties the authority to establish a coordinated solid waste program. Because counties manage rural land uses and a solid waste landfill is identified as a use that may be allowed in rural resource zones, it is reasonable to categorize a landfill as a rural use. The record reflects that all of the regional landfills in Oregon are located in rural zones.

The County has adopted a Solid Waste Management Plan that addresses near and long term disposal requirements as contemplated by Goal 11 and state statutes. Continued operation and potential future expansion of Riverbend Landfill to meet long term disposal needs was clearly identified as an alternative in the adopted SWMP. Because sanitary landfills are identified as a permitted non-farm use in EFU zones – it is also clear that Oregon's land use planning

framework considers rural areas an appropriate location for a solid waste disposal site. The zone change is consistent with Goal 11 and would meet current and long range needs for continued availability of a solid waste disposal site to serve urban and rural development in the County.

L. Goal 12 – Transportation

Pursuant to Goal 12's implementing rules, an amendment to an acknowledged comprehensive plan must put into place measures required by the Transportation Planning Rule to assure that allowed uses are consistent with the identified function, capacity, and performance standards (*e.g.,* level of service, volume to capacity ratio etc.) of the facility.

The applicant submitted a Traffic Impact Study to analyze the potential transportation impacts associated with the zone change and to address the requirements of the Transportation Planning Rule (TPR). That analysis specifically addresses Highway 18, which is under the jurisdiction of the Oregon Department of Transportation (ODOT) and is classified as a Statewide Highway Route. The highway is also on the National Highway System, and it is designated as a State Freight Route, a Truck Route, as well as an expressway.

Riverbend Landfill has one access to Highway 18 located at milepost 41.56. Due to the largely rural location, no major street intersections are present near the zone change area that would require analysis of site impacts. The applicant's Traffic Impact Study includes an analysis of projected traffic impacts during the weekday morning and evening peak hours as well as the Saturday peak for the intersection of the site access and Highway 18.

The traffic impacts associated with the zone change will result in worst case projected traffic volumes in 2030 well below the capacity of Highway 18, and that is otherwise within the acceptable standards set by ODOT. Projected traffic volumes in 2030 (Background Traffic + Site Traffic) would result in a worst case volume-to-capacity ("v/c") ratio of 0.12 for the site peak hour, well below the acceptable V/C ratio of 0.70 set by ODOT.

The zone change does not change the functional classification of Highway 18. Using a 20-year planning period, the zone change does not allow land uses or levels of development that result in types or levels of travel or access that are inconsistent with the functional classification of Highway 18.

Based on the foregoing, the zone change does not "significantly affect" Highway 18. The record does contain testimony opposing the zone change based on transportation concerns, but that testimony is generalized and note not assert that the zone change will significantly affect Highway 18 or any other transportation facility based on the technical standards contained in the Goal 12 implementing rules. Because the zone change does not significantly affect

transportation facilities pursuant to the Goal 12 implementing rules, no special measures are required to assure that the allowed uses are consistent with identified function, capacity, and performance standards.

Based on the foregoing, the zone change is consistent with Goal 12 and the Transportation Planning Rule.

M. Goal 13 – Energy Conservation

Goal 13 directs cities and counties to manage and control land uses to maximize the conservation of all forms of energy, based on sound economic principles. Goal 13 planning and implementation guidelines include two references to solid waste systems:

> *Planning Guideline 5: Plans directed toward energy conservation within the planning area should consider as a major determinant the existing and potential capacity of the renewable energy sources to yield useful energy output. Renewable energy sources include water, sunshine, wind, geothermal heat and municipal, forest and farm waste. Whenever possible, land conservation and development actions provided for under such plans should utilize renewable energy sources.*
>
> *Implementation Guideline: Land use plans should be based on utilization of techniques and implementation devices which can have a material impact on energy efficiency, including systems and incentives for the collection, reuse and recycling of metallic and nonmetallic wastes.*

Solid waste has the potential to be converted into valuable renewable energy that can be both produced and consumed locally.

A local disposal option maximizes energy conservation relative to the alternative of shipping waste to regional sites located outside of the County. Hauling waste to out-of-County landfill sites would require more fuel for transportation and generate increased air emissions as heavy trucks travel the longer distances. Furthermore, the energy potential contained in solid waste will exist no matter where the waste ultimately is disposed, but that potential is off-set in some measure by any energy used to transport the waste. Therefore, the most energy-efficient disposal scenario is the option that keeps the waste as close to its origin as possible.

The Board is also requiring that RLC establish additional "Green Technology" in the future, or cease operation. Potential Green Technologies can extract even more energy from waste than the energy that is captured today from the normal decomposition of waste.

Based on the foregoing, the zone change will provide the greatest opportunity to conserve energy associated with transporting solid waste. Riverbend Landfill is centrally located to sources of waste generation. RLC has already constructed the gas-to-energy facility and is required by conditions of approval to pursue development of a Green Technology facility that will convert waste to an energy product and reduce residual disposal volumes. This integrated approach to managing solid waste and energy resources is consistent with the objective of Goal 13 "to conserve energy."

N. Goal 14 – Urbanization

Goal 14 is a key statewide planning goal in Oregon's overall land use planning framework. Goal 14 requires that each city coordinate with the respective County to adopt an urban growth boundary ("UGB") to meet 20-year land needs for housing, employment, and livability.

Each of the 10 incorporated cities within the County has coordinated with the County to adopt and update urban growth boundaries to meet the requirements of Goal 14. The initial UGBs for the cities in the County were established in the early 1980s to meet population and employment needs to the year 2000. McMinnville and Newberg have pursued major planning projects to update land needs and proposed related UGB expansions.

No city in the County has planned for the location of a solid waste disposal site within its UGB and cities are not required to consider solid waste disposal facilities as part of their urban land needs. Because solid waste disposal sites are a permitted use under state law in the statutory EFU zone, it is clear that the use is considered "rural" instead of "urban." Many components of the solid waste system, such as transfer stations, are appropriately located inside UGBs. However, the franchised haulers for the cities and rural areas of the County (Western Oregon Waste and Waste Management) take all of their residual solid waste to Riverbend Landfill for disposal.

The established solid waste collection, transfer, and disposal system in the County provides an efficient and cost-effective system for residents and businesses in both the urban and rural areas of the County. The zone change will maintain a needed land use at an appropriate location on a large site that can be adequately separated and buffered from surrounding rural and nearby urban uses.

Based on the foregoing, the zone change is consistent with Goal 14.

O. Goal 15 – Willamette River Greenway

The zone change area is not within the Willamette River Greenway boundary. Moreover, no persuasive oral testimony or written comment was presented to the Board indicating that the

legislative amendment itself is inconsistent with Goal 15. The zone change is consistent with Goal 15.

P. Goal 16 through Goal 19

Goal 16 applies to estuarine resources, Goal 17 applies to coastal shorelands, Goal 18 applies to beaches and dunes, and Goal 19 applies to ocean resources. The zone change does not have direct or secondary effects on any lands that are within the areas governed by those Goals. Moreover, the record does not contain any evidence that the zone change is inconsistent with those Goals. The zone change is consistent with Goal 16, Goal 17, Goal 18 and Goal 19.

V. Imposition of a Limited Use Overlay

The applicant has specified that it intends to use the subject property for disposal of municipal solid waste and ancillary facilities including recycling and waste recovery, and has provided the County with an explanation of the proposed use that is adequate to make findings of compliance with all applicable standards. The applicant's plans describe the approximate location and limits of future landfill expansion, and the location of operations support and future green technology areas. Concerns have been raised that uses might occur on the subject property or on surrounding parcels owned by the applicant that have not been described in the application, or that other uses promoted by the applicant and expected by the County to be developed on the site might not be developed. For these reasons, the County is imposing a Limited Use Overlay Zone on the subject property and on surrounding properties owned by the applicant, under YCZO section 904. Imposition of the Limited use Overlay Zone as specified herein, improves the compatibility of the proposed zone change with surrounding land uses and the overall appropriateness of the change, in conformance with the Yamhill County Zoning Ordinance and Comprehensive Plan.

The purpose of the Limited Use Overlay District is stated in YCZO section 904.01, as follows:

> "*The purpose of the Limited use Overlay District is to limit permitted uses(s) and activities in a specific location to only those uses and activities which are justified and approved through Comprehensive Plan Amendments and/or zone changes.*"

It is appropriate in this instance to limit the permitted uses and activities on the subject property to only those uses and activities that the applicant has justified as meeting applicable standards, and to prevent landfill expansion onto portions of the site and other parcels owned by the applicant where such expansion is not anticipated in the application submitted by the applicant. It is also appropriate to limit or prohibit the operation of the site as a landfill if the applicant fails

to establish a new alternative disposal technology on the site as promoted by the applicant and anticipated by the County.

YCZO section 904.02 states as follows:

> *"The LU Overlay District shall apply to that specific area for which a reasons exception has been taken or other area as deemed appropriate to protect Goal 5 resources. The required use of the Limited Use Overlay District is intended to carry out the administrative rule requirement for exceptions pursuant to OAR 660-04-018 and ORS 197.732 and for Goal 5 resource protection pursuant to OAR 660-16-010. The Limited Use Overlay District may also be applied by the Board of Commissioners or Planning Commission to Plan Amendments and/or zone changes."*

The LU Overlay is more restrictive than the underlying zone. It is appropriate in this instance to apply the LU Overlay to promote the goals of the County in ensuring that the land that is subject to the approval and surrounding lands are developed in the manner proposed and as specified in the Conditions of Approval adopted through imposition of the Limited Use Overlay.

Following adoption of the plan amendment and zone change in Ordinance 887, all of the applicant's property will be zoned Exclusive Farm Use, with an 80-acre minimum lot size (EF-80). Farm uses are allowed in the zone, along with numerous uses listed in ORS 215.283 and in the County Zoning Ordinance. YCZO section 904.03 states:

> *"A. When the Limited Use Overlay District is applied, the uses permitted in the underlying zone shall be limited to those specifically referenced in the ordinance adopting the Limited Use Overlay District.*
>
> *B. The Limited Use Overlay District may be used to require conditional use approval for uses normally permitted outright.*
>
> *C. Reasonable conditions may be imposed in the Limited Use Overlay District as are necessary to assure compliance with the provisions of the Comprehensive Plan and this ordinance.*
>
> *D. Until the overlay has been removed or amended, the only permitted uses in an LU district shall be those specifically referenced in the adopting ordinance."*

In conformance with YCZO section 904.03, the County is applying a Limited Use Overlay to the subject property and surrounding properties owned by the applicant, as specified in the Conditions of Approval attached as Exhibit C to Ordinance 887. Under the Limited use Overlay, permitted uses are limited to farm uses and to those uses the applicant has described as being part of its proposal, and as further conditioned and limited by the Conditions of Approval in Exhibit C of Ordinance 887. The Conditions of approval are being adopted pursuant to YCZO section 904.03.C. The applicant has met the requirements for imposition of a Limited Use Overlay.

YCZO section 904.04, "Procedures" states:

> *"A. The Limited use Overlay District is to be applied through a zone amendment application utilizing the Type C process at the time the underlying zone is being changed in the case of an exception.*
>
> *B. It shall not be necessary to disclose in the public hearing notice of a zone change that a Limited use Overlay may be applied.*
>
> *C. The ordinance adopting overlay zone shall, by section reference or by name, identify those permitted uses in the zone that will remain permitted uses or become conditional uses. The description of the permitted or conditional uses may be qualified as necessary to achieve the intent of the LU overlay zone."*

The Limited Use Overlay is being applied to the subject property and surrounding parcels owned by the applicant following a Type C process that included full evidentiary hearings before both the Planning Commission and Board of Commissioners. Staff reports issued during the review proceedings indicated that the Conditions of Approval would be applied by way of a Limited Use Overlay. In this case, the Limited Use Overlay is not employed for the purpose of changing permitted uses into conditional uses, but to provide community assurance that development of the site will proceed substantially in the manner proposed by the applicant, as limited by the Conditions of Approval.

YCZO section 904.05, entitled "Map Amendment," states:

> *"The Official County Zoning Map shall be amended to show an LU on any parcel where the Limited Use Overlay District has been approved."*

The location of the Limited Use Overlay imposed through Ordinance 887 is identified on a map included in Exhibit B of Ordinance 887 and incorporated therein by reference.

YCZO section 904.06, entitled "Site Plan Review" states:

"Uses approved in an LU District may be subject to Section 1101, Site Design Review. The LU Ordinance may indicate any special concerns or location requirements that msut be addressed in the site plan. All other specifications and standards of the underlying zone remain in effect unless specifically altered by the site plan approval or adoption ordinance."

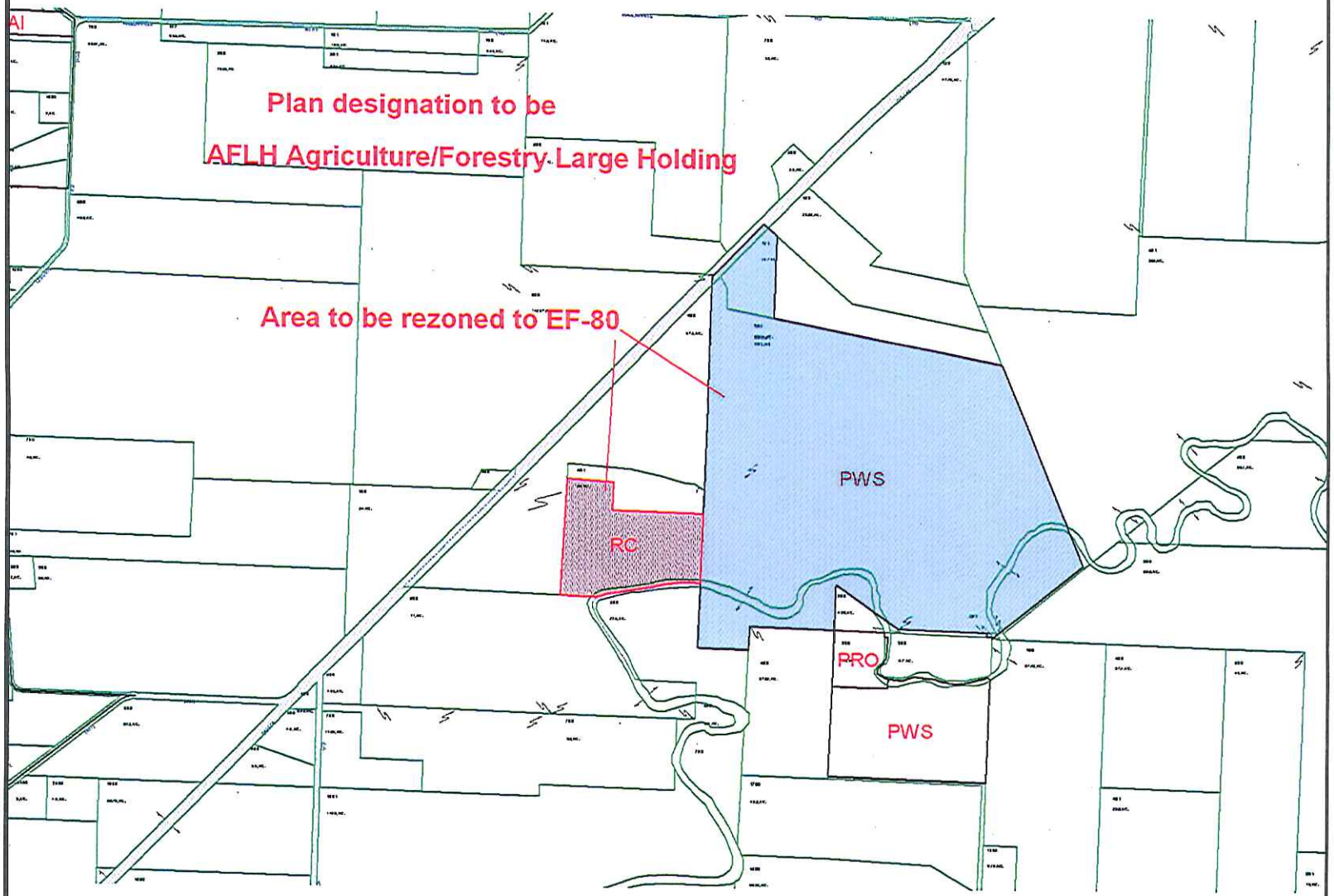
The applicant has provided sufficiently detailed information regarding the nature of its anticipated future uses to establish that it has carried its burden to demonstrate that it meets County standards for a plan amendment and zone change. To develop the site as anticipated, under YCZO section 402.02.V. (Ordinance 867), the applicant must first apply for site design review and meet the standards in YCZO section 1101.

VI. Conclusion

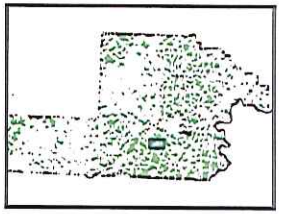
Having accepted and weighed all of the evidence submitted into the record, the Board concludes that all applicable standards have been met. The applicant's request to rezone the existing landfill PWS parcel to Exclusive Farm Use satisfies the County's zone change standards and is consistent with state law and the Yamhill County Zoning Ordinance. A solid waste disposal site is a permitted non-farm use under Oregon's planning framework and the applicant has operated Riverbend Landfill in compliance with County land use and license approvals and DEQ permits. Rezoning approximately 25 acres from RC to Exclusive Farm Use also satisfies the County's zone change criteria and is appropriate because the new zoning will allow the applicant to maintain its existing facility ownership within a single zone, and will provide the applicant with the opportunity to submit a subsequent Site Design Review application for a future expansion onto the same tract. Based upon the information provided in the application and as presented by the applicant and others during the proceedings, the County hereby approves the applicant's request for a Post-Acknowledgement Plan Amendment and zone change.

Plan/Zone Change

Exhibit B Maps - Ordinance 887
Plan Amendment/Zone Change
Limited Use Overlay Zone



Taxlots
Cartographic Arrows
right of ways
taxlot lines
taxlot polygons
Zoning



N

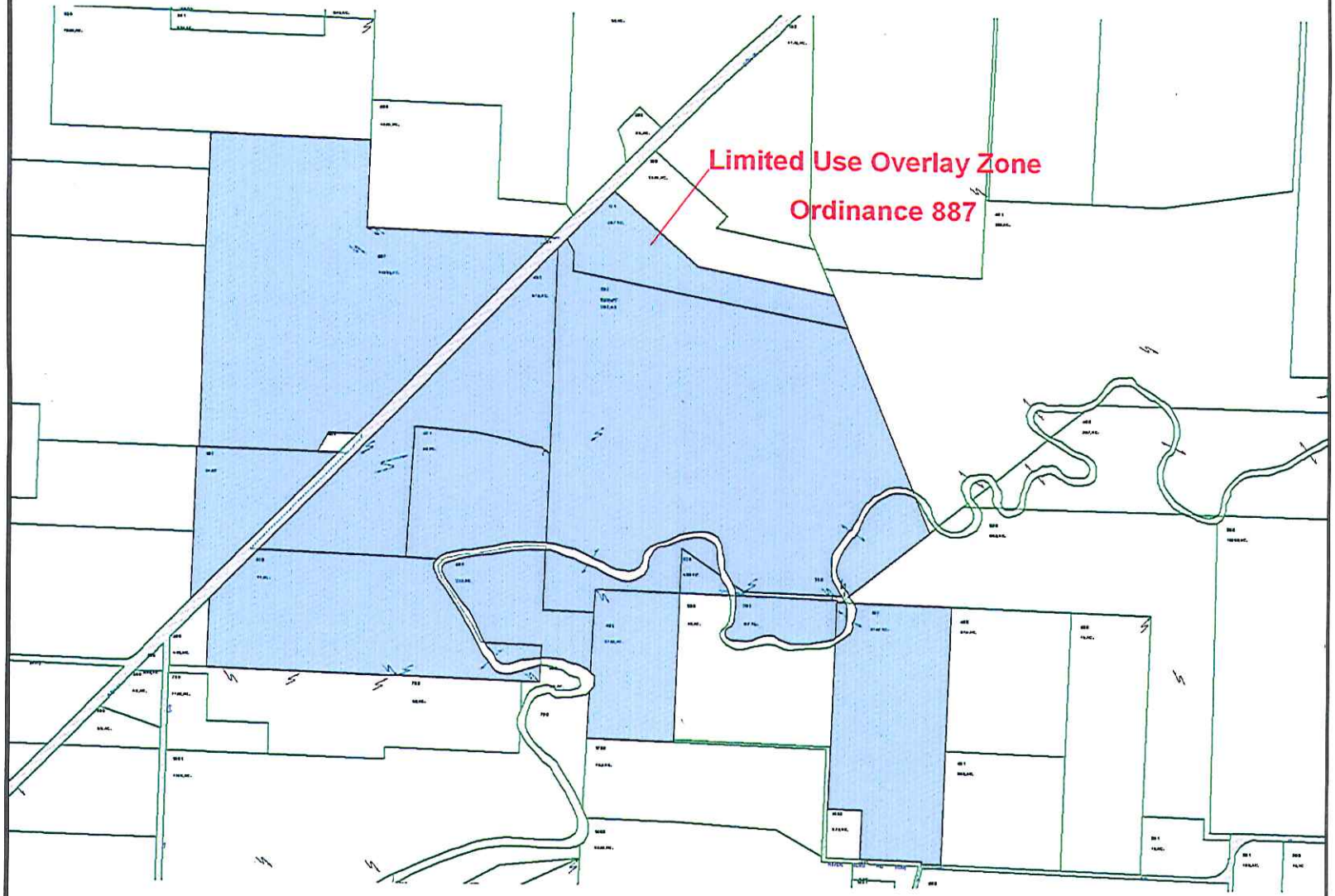
2/13/2014

YAMHILL COUNTY

1in. = 1500 ft.

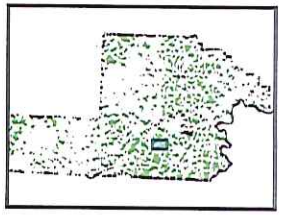
This map was produced using the Yamhill County GIS data. The GIS data is maintained by the county to support its governmental activities. The county is not reponsible for map errors, omissions, misuse or misinterpretation.

Exhibit B Map



City UGB
Exception Areas
N
Taxlots
Cartographic Arrows
right of ways
taxlot lines
taxlot polygons

Exhibit B Maps - Ordinance 887
Plan Amendment/Zone Change
Limited Use Overlay Zone



N

2/13/2014

YAMHILL COUNTY

1in. = 1500 ft.

This map was produced using the Yamhill County GIS data. The GIS data is maintained by the county to support its governmental activities. The county is not reponsible for map errors, omissions, misuse or misinterpretation.

Exhibit C – Ordinance 887

Conditions of Approval
Imposed Through Limited Use Overlay

1. Binding Nature of These Conditions. These conditions are binding on the applicant and the landowner, and shall inure to the benefit of, and are binding upon, all successors in interest to the applicant and the landowner.

2. Area Affected. The Limited Use Overlay Zone ("Overlay"), imposed by the County under Ordinance 887, includes all areas within the following Tax Lots: 5501-101, 5501-200, 5501-300, 5501-400, 5501-401, 5501-500, 5511-100, 5511-600, 5512-100, 5512-200, 5512-400 and 5512-500.

3. Areas Where Landfilling Prohibited. No landfill disposal of solid waste shall occur on the following Tax Lots: 5501-300, 5501-401, 5501-500, 5511-100, 5511-600, 5512-100, 5512-200, 5512-400 and 5512-500. Furthermore, no landfill disposal of solid waste shall occur on the southern portion of Tax Lot 5501-400 as further described below, the eastern portion of Tax Lot 5501-101 as further described below, or any portion of Tax Lot 5501-200 that lies south of the South Yamhill River.

(a) The southern portion of tax lot 5501-400 is described as follows:
Beginning at an iron rod marking the northwest corner of that tract of land described in deed from JOHN G. BERNARDS and MARY BETH BERNARDS to RIVERBEND LANDFILL CO., recorded December 12, 2006 as Instrument No. 200629179, Deed Records of Yamhill County, Oregon; thence South 88°05'26" East 1441.51 feet to a point on the north line of said tract being the southwest corner of Parcel 6 of that tract of land described in deed from Riverbend Landfill CO., to Riverbend Landfill CO., recorded December 6, 1991 in Film Volume 262, Page 1269, Deed Records of Yamhill County, Oregon; thence North 02°321'11" East 1129.76 feet to a point on the west line of said Parcel 6; thence North 87°37'05" West 439.32 feet to an iron rod marking a point on the southeasterly margin of Oregon State Highway 18; thence South 43°38'33" West 1518.72 feet to the POINT OF BEGINNING.

(b) The eastern portion of tax lot 5501-101 is described as follows:
Beginning at an iron rod marking the northeast corner of that tract of land described in deed from MICHAEL J. BERNARDS, et.al., to RIVERBEND LANDFILL COMPANY, INC., recorded April 16, 1999 as Instrument No. 199907961, Deed Records of Yamhill County, Oregon; thence South 22°27'46" East 345.15 feet to an iron rod marking the southeast corner of said RIVERBEND tract; thence North 79°26'19" West 1103.51 feet to a point on the south line of said tract; thence North 07°04'39" West 303.67 feet to a point on the north line of said tract; thence South 79°26'19" East 1007.42 feet to the POINT OF BEGINNING.

4. Area Reserved for Alternative Disposal Technology. Within the southern portion of Tax Lot 5501-400 as described above, no solid waste disposal activities shall occur that would prevent the siting and construction of an alternative solid waste disposal technology.

5. Riparian Corridor Protections. Within the Overlay, any future landfill disposal of solid waste must comply with the 100-foot setback from the Ordinary High Water Mark of the South Yamhill River specified in Section II. C, Goal 1, Policy J of the Yamhill County Comprehensive Plan and must comply with the provisions of Exhibit "D" to Ordinance 887.

6. Mandatory Community Meeting. Prior to final approval of an application for Site Design Review for landfill expansion within the Overlay, the applicant shall hold at least one community meeting to present the expansion plan, and to collect public comments. The community meeting shall be facilitated by the Yamhill County Planning Department or an independent facilitator approved by the Planning Director. The comments collected shall be submitted into the record of the Site Design Review proceedings for consideration by the County with the final design approval. Site Design Review shall be required for any new facility proposed within the Limited Use Overlay.

7. Alternative Disposal Technology. The applicant has stated its intent, to the extent feasible, to "add a Green Technology component to minimize landfill expansion" (an alternative solid waste disposal technology). The County recognizes, as stated in the application, that: "the construction of any particular facility depends on many factors including; proven commercialization of the technology, financial viability for the project, and ability to receive all necessary permits within the current regulatory structure." As such, it will take time to develop a Green Technology facility, as follows, in accordance with this condition:

(a) The applicant shall establish, on-site, a process or procedure to divert municipal solid waste from Riverbend Landfill to a Green Technology Facility.

(b) The process to be employed in meeting this condition shall be at the discretion of the applicant, consistent with applicable law, and may include, but shall not be limited to, the following processes or general classes of processes:

(1) Advanced Thermal Recycling (also referred to as Mass Burn or Waste - to Energy incineration)
(2) Gasification (also referred to as Plasma Arc)
(3) Anaerobic Digestion
(4) Thermal Depolymerization
(5) Pyrolysis
(6) Refuse-Derived Fuel (also referred to as RDF)

(c) Construction of a DEQ-approved facility to satisfy this condition shall commence no later than seven (7) years after the earlier of:

(1) The date a DEQ permit for solid waste disposal outside the former PWS zone becomes final (i.e., no further DEQ action is required and all appeals have been

exhausted or the time for filing an appeal has run with no appeal having been filed) and Riverbend has all DEQ authority necessary to commence disposal of waste on the site; or

(2) The date the 3.6 millionth ton of waste is deposited at the expansion site.

(d) The alternative disposal technology facility shall be operational within 18 months after commencement of construction and shall, when fully operational, significantly decrease the current deposit of 510,000 tons per year of municipal solid waste in the landfill. The facility must be designed to function for the duration of the life of the landfill. The 18 month construction window may be extended as a result of unforeseen weather or other natural events, upon written approval by the Planning Director.

(e) Failure to construct and/or operate an on-site alternative disposal technology facility consistent with this condition shall require the landfill to cease operations.

Exhibit D – Ordinance 887

Goal 5 Provisions to Protect Riparian Corridors

Section 1 –For purposes of this Exhibit "D" to Ordinance 887, the "Zone Change Area" consists of Tax Lots 101, 200, 400 and 401 on Tax Map 5501. "Riparian Area" shall mean the riparian corridor established through the safe harbor method currently set forth in OAR 660-023-0090(1)(b), except that the setback along all streams shall be 100 feet.

Section 2 – Within the Zone Change Area, no permanent alteration of the Riparian Area shall be allowed by grading or by the placement of structures or impervious surfaces, except for the following uses, provided they are designed and constructed to minimize intrusion into the Riparian Area:

(A) Streets, roads, and paths;

(B) Drainage facilities, utilities, and irrigation pumps;

(C) Water-related and water-dependent uses; and

(D) Replacement of existing structures with structures in the same location that do not disturb additional riparian surface area.

Section 3 – Within the Zone Change Area, the removal of riparian vegetation within the Riparian Area is limited to the following activities:

(A) Removal of non-native vegetation when replaced with native plant species; and

(B) Removal of vegetation necessary for the development of water-related or water-dependent uses;

Section 4 – The property owner may seek reduction or removal of the restrictions in sections 2 and 3 upon demonstration of a hardship or map error, or upon a showing that a lot or parcel has been rendered not buildable by application of those restrictions.

(A) An application for reduction or removal of the restrictions in sections 2 and 3 shall be made to the County following the Type B process set forth in YCZO Section 1301.

(B) An application for reduction or removal of the restrictions in sections 2 and 3 shall be subject to the approval standards in YCZO Section 1200.

Section 5 – Notwithstanding the provisions in sections 2 through 4, permanent alteration of the Riparian Area within the Zone Change Area by placement of structures or impervious surfaces shall be allowed upon a demonstration that equal or better protection for identified resources will be ensured through restoration of Riparian Areas, enhanced buffer treatment, or similar measures. In no case shall such alterations occupy more than 50 percent of the width of the Riparian Area measured from the upland edge of the area. Nothing in this section shall be interpreted as allowing new landfill related facilities or development within 100 feet of the Ordinary High Water Mark of the South Yamhill River.

Exhibit "D"
Ordinance 887

Board Order 15-115

BEFORE THE BOARD OF COMMISSIONERS OF THE STATE OF OREGON

FOR THE COUNTY OF YAMHILL

SITTING FOR THE TRANSACTION OF COUNTY BUSINESS

In the Matter of an Order Affirming Approval By the Planning Commission of Planning Dockets SDR-16-14 and FP-03-14, Site Design Review and Floodplain Development Permits for Riverbend Landfill Expansion, Including Findings and Conditions of Approval	))))))	Board Order 15-115

THE BOARD OF COMMISSIONERS OF YAMHILL COUNTY, OREGON (the Board) sat for the transaction of county business on April 23, 2015, Commissioners Allen Springer, Mary Starrett and Stan Primozich being present.

IT APPEARING TO THE BOARD as follows:

A. By application dated November 5, 2014, Riverbend Landfill Company applied for Site Design Review and for a Floodplain Development Permit for limited expansion of the existing Riverbend Landfill;

B. This matter came before the Planning Commission for public hearing on December 4, 2014 and, following a period in which the record remained open for additional written evidence and testimony, on January 15, 2015, the Planning Commission, by a 3-2 vote, approved the applications, with conditions;

C. This matter was heard *de novo* by the Board on March 12, 2015 and, following a period in which the record remained open for additional written evidence and testimony, on April 2, 2015, the Board of Commissioners voted 2-1, to approve the application with conditions as recommended by staff and as modified by the Board; and

D. This matter was continued to April 23, 2015 for adoption of written findings for approval and final conditions of approval, NOW, THEREFORE

IT IS HEREBY ORDERED BY THE BOARD AS FOLLOWS:

Section 1. The findings attached as Exhibit "A" and incorporated herein by reference are hereby adopted in support of this Order.

Accepted by Yamhill County Board of Commissioners on 4-23-15 by Board Order # 15-115

Section 2. The conditions attached as Exhibit "B" and incorporated herein by reference are hereby adopted in support of this Order, inuring to the benefit of Yamhill County, and binding upon the applicant and the landowner and all successors in interest to the applicant and the landowner until modified or removed in accordance with law.

DONE this 23rd day of April, 2015, at McMinnville, Oregon.

ATTEST: YAMHILL COUNTY BOARD OF COMMISSIONERS

BRIAN VAN BERGEN
County Clerk

Allen Springer - approved
Chair ALLEN SPRINGER

By:
Deputy Lucy Mendez Flores

Commissioner MARY STARRETT

APPROVED AS TO FORM:

Commissioner STAN PRIMOZICH

Timothy S. Sadlo
Assistant County Counsel

Accepted by Yamhill County
Board of Commissioners on
4-23-15 by Board Order
15-115

Exhibit A - Board Order 15-115

Findings in Support of Approval

Docket No.:	SDR-16-14 and FP-03-14
Request:	Site Design Review for the enhancement and expansion of an existing solid waste disposal facility, together with a Floodplain Development Permit to accommodate those portions of the development within the 100-year floodplain.
Applicant:	Riverbend Landfill Company 13469 SW Highway 18 McMinnville, OR 97128 Contact: Paul Burns, Director of Disposal Operations, Pacific Northwest
Tax Lots:	Map 5501, Tax Lots 101, 200, 400, and 401
Location:	13469 SW Highway 18
Zone:	Exclusive Farm Use District – EF-80

I. Introduction and Background

1. Riverbend Landfill Co. ("Applicant" or "Riverbend") owns and operates the Riverbend Landfill approximately three miles southwest of the city of McMinnville. Riverbend submitted two applications for the enhancement and expansion of Riverbend Landfill. The first application is for Site Design Review pursuant to Yamhill County Zoning Ordinance ("YCZO" or "Code") Section 1101, and the second application is for a Floodplain Development Permit pursuant to YCZO Section 901. The stated purpose of the applications is to allow Riverbend Landfill to continue operating by reconfiguring portions of the existing landfill, and by expanding operations to adjacent land as other areas of the existing landfill go into final closure. The County is processing both applications together.

2. As originally proposed, Riverbend's applications sought approval for a total of 37 new acres of landfill area to be directly incorporated into the existing landfill. The proposed design included a perimeter berm with a traditional earth fill design containing shallow outside slopes. As proposed, the height of the landfill would not increase from the current permitted height of 286 feet above mean sea level. Other than the additional landfill area and a reconfiguration of portions of the existing berm, Riverbend proposed no other major changes to its current site plan.

3. The proposed expansion and enhancement areas are defined by the development of two new modules:

    1. Riverbend proposed Module 10 as an eight-acre disposal cell adjacent to the north slope of the existing landfill and just east of the existing Renewable Energy Facility.

2. Riverbend proposed Module 11 as a 29-acre group of disposal cells to be located west of the existing landfill and adjacent to Highway 18, including an enhancement of the existing berm on the south side of the existing landfill.

4. The Planning Commission reviewed and approved Riverbend's proposal with several conditions. Along with several other changes, one of the Planning Commission's conditions of approval required Riverbend to remove Module 10 from the site plan. Riverbend provided an updated site plan to reflect all of the changes approved by the Planning Commission, and those figures are now in the record.

5. Opponents of the application appealed the Planning Commission's decision to the County Board of Commissioners ("Board"). The Board held a *de novo* hearing in this matter and has reviewed both Riverbend's Preliminary Site Development Plan and the Final Site Development Plan reflecting the Planning Commission's approval. For the reasons set forth in these Findings, the Board approves the Final Site Development Plan and the Floodplain Development Permit subject to the conditions of approval set forth in these Findings.

A. History

6. The County initially approved the siting and development of Riverbend Landfill in 1980 as part of a Comprehensive Plan Amendment and Zone Change ("PA/ZC"). The result of the 1980 PA/ZC was to rezone Riverbend's property from the Exclusive Farm Use ("EFU") zone to the Public Works/Safety ("PWS") zone. At the time, although solid waste disposal sites were permissible uses in an EFU zone under state law, the County's 1976 zoning ordinance allowed landfills only in the PWS zoning district as an outright permitted use.

7. Riverbend began operating at its present location in 1982 in accordance with Oregon Department of Environmental Quality ("DEQ") Solid Waste Disposal Permit No. 345. In 2009, Riverbend anticipated that the landfill would reach capacity by 2014 and applied for land use approval to expand onto adjacent property. In granting that application, the County determined there was a demonstrated need for the continued presence of a landfill in the County and approved another PA/ZC through an "Exception" to Statewide Planning Goal ("Goal") 3. On appeal, the Land Use Board of Appeals ("LUBA") reversed the County's decision on the basis that an Exception to Goal 3 is not available to allow a use that is already authorized by the statutory EFU zone (Oregon Revised Statute [ORS] Chapter 215). In doing so, LUBA stated, "[i]f the county wishes to allow landfills on agricultural land, it must amend its EFU zone to allow them under the standards set forth in the statutory EFU zone, with any supplementary regulation that the county wishes to adopt." The Court of Appeals upheld that decision based on the same reasoning.

8. The Board finds that implicit in the decisions from LUBA and the Court of Appeals was that the County should have originally approved development of Riverbend in 1980 through the normal zoning process on EFU land rather than through the Goal Exception process. In direct response to those decisions, the County amended the Code and adopted a text amendment to the EFU zone district in 2011 that mirrors the statutory use in ORS 215.283(2)(k) and allows solid waste disposal sites to be maintained, enhanced or expanded within the EFU zone in some, but not all, of the specific circumstances allowed by state law. These findings refer to that legislative amendment as the "2011 Code Change."

9. Following the 2011 Code Change, the County in 2014 approved a third PA/ZC and rezoned the PWS portions of Riverbend's property to EF-80 (part of the EFU zoning district) through County Ordinance 887 ("Ordinance 887" or the "2014 Zone Change"). In doing so, the County made a finding that, by changing the zoning on Riverbend's property back to the EFU zone, the County was "restoring the property's original zone designation and putting [Riverbend] in the same position it would have been if the County had permitted the landfill in the manner that LUBA and the Court of Appeals suggested it should have." Those findings also expressly stated that the 2014 Zone Change would "provide the property owner with flexibility to continue or expand the current" landfill use. The Board reconfirms the County's earlier position and finds that the intent of the 2011 Code change and the 2014 Zone Change, collectively, were to restore the original EFU zoning on Riverbend's property and to correct the error identified by LUBA and the Court of Appeals that resulted in rezoning the property to PWS in 1980.

10. Although the landfill and some of its existing equipment and facilities were previously in two separate zones – PWS and EFU – the property and the existing use is now wholly within a farm use zone as a result of the 2014 Zone Change. The enhancement and expansion of Riverbend is therefore permissible under the revised Code and is also consistent with the statutory farm zone. Under those Code and statutory provisions, Riverbend must nevertheless demonstrate that its development proposal satisfies the County's Site Design Review standards, as well as the farm impacts standards set forth in ORS 215.296.

B. County Proceedings

11. Riverbend submitted its applications on November 6, 2014. The County deemed the application complete for review purposes on November 7, 2014. Based on that date, the 150-day review period would have lapsed on or about April 6, 2015. The Applicant subsequently provided a limited waiver to the County extending that deadline to April 24, 2015.

12. A Site Design Review Application is processed as either a Type A or a Type B proceeding under YCZO Section 1301, as determined by the Planning Director. A Floodplain Development Permit is processed as a Type B proceeding. The Planning Director determined that both applications should be processed as a Type B proceeding. However, pursuant to YCZO 1301.01(B)(3), the Planning Director also determined that the applications should follow the Type C process with a hearing before the Planning Commission.

13. The Planning Commission held the initial evidentiary hearing in this matter on December 4, 2014 and was followed by open written record periods. The Applicant was provided with an opportunity to provide a final legal argument on January 8, 2015. No person objected to these timelines. On January 15, 2015, the Planning Commission approved the applications subject to several conditions of approval.

14. Opponents of the applications appealed the Planning Commission's decision to the Board. The Board chose to hold a de novo hearing in this matter to review the Planning Commission's decision and to allow interested parties to continue commenting on the applications. The Board held its hearing on March 12, 2015. The Board left the record open until March 17, 2015 for any interested person to provide new evidence or to provide rebuttal to evidence that was already in the record as of March 12, 2015. The Board then left the record open until March 20, 2015 for

the limited purpose of rebuttal to new evidence provided to the record after March 12, 2015 up until March 17, 2015. No person objected to these timelines.

15. On March 26, 2015, the Board re-opened the record for the limited purpose of allowing Board Commissioners to disclose ex parte contacts. The Board then left the record open until March 31, 2015 for the limited purpose of receiving evidence rebutting the information disclosed as part of the ex parte contacts. The rebuttal period was chosen because it was the same timeframe the Board allowed for rebutting all evidence in the record between March 12, 2015 and March 17, 2015. The record closed on March 31, 2015 and the Board reconvened to hear Staff's recommendation and to deliberate on April 2, 2015. By a vote of 2-1, the Board affirmed the Planning Commission's decision approving Riverbend's applications, with conditions. Commissioners Primozich and Starrett voted to approve. Commissioner Springer voted to deny the applications. The Board then met to adopt these Findings in support of that approval.

II. Permitted Uses in the EFU

16. As described above in Finding 8, the County amended its EFU Code provisions in 2011 for the express purpose of bringing the Code into closer alignment with state law and allowing solid waste disposal sites as a permitted use in the EFU zone. As a result of those amendments, YCZO 402.02(V) now reads as follows:

> *402.02 Permitted Uses*
>
> *In the Exclusive Farm Use District, the following uses shall be permitted subject to the standards and limitations set forth in subsection 402.09 and any other applicable provisions of this ordinance:*
>
> * * *
>
> *V. The maintenance, enhancement or expansion of an existing site on the same tract for the disposal of solid waste for which a permit has been granted under ORS 459.245 by the Department of Environmental Quality, together with equipment, facilities or buildings necessary for its operation. The use must satisfy the standards set forth in ORS 215.296(1)(a) and (b) and the standards set forth in section 1101, Site Design Review. The maintenance, enhancement or expansion of an existing use on the same tract on high-value farmland is permissible only if the existing use is wholly within a farm use zone. No other Yamhill County Zoning Ordinance criteria or Comprehensive plan goal or policy shall apply as an approval standard for this use.*

17. The Board finds that Riverbend's application seeks approval of a permitted use. Specifically, the application seeks to enhance and expand an existing solid waste disposal site. Riverbend Landfill has been in existence since 1982. Along the southwest portion of the existing landfill, Riverbend's proposal for Module 11 seeks to develop an enhanced berm that will increase the amount of waste that can be disposed of on top of the waste that already exists in those areas. To the west of the existing landfill, Riverbend seeks to expand by developing new waste disposal cells as part of Module 11.

18. The Board finds that the existing landfill has been granted a permit under ORS 459.245. The record contains testimony asserting that Riverbend's permit is expired. That testimony, based on the date appearing on the face of Riverbend's permit, is inaccurate. As the Applicant notes,

DEQ may administratively extend a solid waste disposal permit beyond the expiration date that appears on the face of the permit. The record contains a statement by DEQ that Riverbend's permit has been so extended.

19. Even if Riverbend's permit were not current, the Board finds in the alternative that there is no requirement in ORS 215.283(2)(k) that a DEQ permit be granted as a prerequisite to the County's land use approval for a solid waste disposal site in the EFU. The County Code uses identical permitting language and was intended to be aligned with the statutory use described in ORS 215.283(2)(k). The County therefore interprets its code to have the same meaning as the statute rather than in a manner that would impose an additional requirement to obtain a DEQ permit first. Additionally, the County is imposing a condition of approval requiring Riverbend to obtain a DEQ permit before it establishes any of its enhancement or expansion activities.

20. The Board finds that the proposed use satisfies the standards set forth in ORS 215.296(1)(a) and (b). The Board's discussion of the evidence relevant to those standards, and more detailed findings related to that evidence, are set forth below in Section IV.

21. The Board finds that the proposed use satisfies the standards set forth in Section 1101, Site Design Review. The Board's discussion of the evidence relevant to those standards, and more detailed findings related to that evidence, are set forth below in Section III.

22. The expansion portion of Riverbend's proposal will involve development on high-value farmland. Under state statute and the Code, therefore, the expansion is allowed only if it is on the same tract and only if the existing use is wholly within a farm zone. The Board finds that the expansion portion of Riverbend's proposal is on the same tract. For purposes of non-farm uses in the farm zone, state law defines "tract" as "one or more contiguous lots or parcels under the same ownership." Testimony in the record asserts that the expansion area is not part of the same tract because Riverbend's parcels are under different ownership. For example, a letter from Susan Watkins dated December 4, 2014 identifies Tax Lot 101 as being owned by Riverbend Landfill Company, Inc., whereas the other tax lots are owned by Riverbend Landfill Co. That testimony, however, relies on records from the tax assessor's office and does not reflect ownership of the actual legal lot at issue. To the contrary, Riverbend provided deed records clearly demonstrating that each of the tax lots at issue in the proceeding are part of the same legal lot, including Tax Lot 101, the entirety of which is owned by Riverbend Landfill Co. Even if the information from the tax lot records had some significance, which the Board finds it does not, Tax Lot 101 was the site proposed for Module 10. As explained elsewhere in these findings, the County is not approving the development of Module 10 and, therefore, the only tax lots subject to this approval are those listed by the tax assessor's records as belonging to Riverbend Landfill Co. The Board's decision thus applies to only one tract.

23. The Board finds that the existing use is wholly within a farm zone. The record clearly demonstrates that the entirety of Riverbend's property holdings in this area is zoned EF-80 as part of the EFU zone. The Board further finds that it was the stated purpose of the Zone Change to bring Riverbend's existing use wholly within a farm zone and to restore the original EFU

designation.[1] The Record does not contain any assertion that the existing use is not wholly within a farm zone.

24. The record does contain testimony on behalf of Friends of Yamhill County ("FOYC") and the Stop the Dump Coalition ("STDC") asserting that, although the existing landfill is wholly within a farm zone, landfills that were not wholly within a farm zone in 1996 are not eligible to expand onto high-value farmland. For the reasons stated below, the Board rejects FOYC's and STDC's assertion.

25. Notwithstanding the language of ORS 215.283(2)(k), which broadly allows solid waste disposal facilities in the EFU, OAR 660-033-0130(18) allows a solid waste disposal facility on high-value farmland only for the maintenance, enhancement, or expansion of an existing facility that is "wholly within a farm zone." This administrative rule, promulgated by the Land Conservation and Development Commission ("LCDC") and enforced by the Department of Land Conservation and Development ("DLCD"), serves as the basis for the County's Code language. The FOYC and STDC testimony asserts that the intent of the rule, and therefore the Code language, is to limit the expansion of solid waste disposal facilities to those facilities that were wholly within a farm zone when that rule was adopted, and that it does not authorize expansions of facilities that later become wholly within a farm zone by virtue of the rezoning process.

26. The Board finds that the argument the expansion is not allowed under the LCDC rule is without legal merit. Of particular note, DLCD was provided with the opportunity to review Riverbend's application and it did not indicate that the application would be in violation of the rules. Nor is the FOYC and STDC argument supported by the express language of OAR 660-033-0130(18). That rule allows the expansion of an "existing facility" and places only one restriction on such expansions – the "existing facility" must be "wholly within a farm zone." Riverbend Landfill squarely meets those criteria because it is an "existing facility" and it is "wholly within a farm zone." Under the FOYC and STDC argument, the rule would have to read that expansions are permissible for facilities "wholly within a farm zone <u>that exists at the time of this rule's adoption</u>." The underlined language is not in the rule and the County is not allowed to insert language into the rule that does not exist.[2]

27. The Board finds as an independent basis to reject the FOYC and STDC argument the fact that it is not supported by the context in which the rule exists. When interpreting an administrative rule, the County is directed to look to other provisions in the same rule for guidance. It is clear from other language in the rule that when LCDC intends to give relevance to the effective date of a rule, it knows how to craft language for that purpose. For example, OAR 660-033-0140 adopted provisions setting a time limit on the applicability of some permits. That rule applies only to discretionary decisions "made after the effective date of this division…" LCDC could have used similar language in OAR 660-033-0130(18) but chose not to.

28. Similarly, where OAR 660-033-0130 establishes a date that is relevant to the permissibility of a use in the farm zone, it unequivocally provides the relevant date. For example: (1) a dwelling is allowed on a lot of record that was owned continuously "since prior to January 1, 1985" and that

---

[1] Ordinance 887, p.5.

[2] *See Haskins v. Palmateer*, 186 Or App 159, 168 (2003) *rev den*, 335 Or 510 (2003) (principle that courts may not insert language into the text of a provision applies to the construction of administrative rules).

"was part of a tract on November 4, 1993" on which no other dwellings existed (OAR 660-033-0130(3)(a)); (2) personal-use airports "lawfully existing as of September 13, 1975" are allowed with fewer restrictions than those created after that date (OAR 660-033-0130(7)); (3) a community center can provide services to veterans "only in a facility that is in existence on January 1, 2006" (OAR 660-033-0130(36)); and (4) certain non-conforming uses may be expanded if "[t]he use was established on or before January 1, 2009" ((OAR 660-033-0130(18)(c)). LCDC again could have established a date in the rule for when the farm zone had to exist, but it chose not to.

29. The Board finds as an independent basis to reject the FOYC and STDC argument the fact that the rulemaking history cited by FOYC and STDC is not helpful for understanding the meaning of the rule language. It is clear from that rulemaking history that DLCD did not address the issue presented here where an existing use is later rezoned to become wholly within a farm zone. There is testimony in that rulemaking history from DLCD staff that included the word "currently" in a discussion about the purpose of allowing existing uses "wholly within a farm zone" to expand. There is no indication, however, that the word "currently" was being used to modify the timing of when the farm zone had to exist. To the contrary, the rulemaking record contains absolutely no discussion of a situation where the zoning might later change. The Board finds it more reasonable, therefore, to conclude that DLCD staff was using "currently" to refer to the time in which the rule would be applied, not the time that it was being adopted.

30. Whatever significance the staff might have intended with the word "currently," that word was not included in the final version of the rule, which means it must not have carried any significance with the LCDC commissioners. The Board can presume that LCDC knew properties were capable of being rezoned. The FOYC and STDC testimony relies on one interpretation of an ambiguous term that does not even appear in the rule. The Board therefore finds that the rulemaking history cited by opponents to the applications creates an ambiguity rather than resolves one and, therefore, is not helpful for uncovering any meaning to the rule that is different than the meaning provided by the plain language of the rule.

31. The Board additionally finds that recent statements from individuals involved in the rulemaking process should be given no weight. LUBA has recently determined that "[p]ost-enactment recollections of persons participating in legislative proceedings are not probative legislative history."[3] The Board finds that the rules governing the review of legislative history are equally applicable to the review of rulemaking history.

32. The Board finds as an independent basis to reject this argument the fact that it would create an absurdity in light of earlier rulings by LUBA and the Court of Appeals. Those review bodies reversed the County's approval of Riverbend's earlier Goal 3 Exception for the precise reason that Goal 3 allowed the expansion without a Goal Exception if the County would only amend its Code to mirror state law. If the Board were to now determine that the Goal 3 implementing rules did not allow the expansion, a Goal 3 Exception would be necessary, but that Exception would be unavailable. The County already addressed this possibility as part of its Zone Change decision last year when FOYC raised this same issue. The County concluded that LUBA and the Court of Appeals could not have intended such an outcome. No party has offered the Board a

[3] *See Squier v. Multnomah County*, LUBA 2014-074, Final Opinion and Order (Feb. 2, 2015).

reason that it must reconsider this argument that was already decided as part of the Zone Change and which was part of a decision that applied directly to the same parcels of land at issue in this proceeding.

33. The Board further finds that Riverbend Landfill, for all intents and purposes, was wholly within a farm zone in 1996. As the County found during the Zone Change proceeding, the effect of LUBA's and the Court of Appeals' decisions regarding the Goal 3 Exception was that the County should have originally approved development of the landfill in 1980 through the normal zoning process on EFU land rather than through the Goal Exception process. Had it done so, the landfill would have been in the EFU in 1996 when the "wholly within a farm zone" language was added to OAR 660-033-0130(18) rather than in the improperly applied PWS zone. In fact, as part of the Zone Change decision, the Board made an express finding that '[b]y changing the zoning on the applicant's property back to the EFU zone, the County is restoring the property's original zone designation and putting the applicant in the same position it would have been in if the County had originally permitted the landfill in the manner suggested by LUBA and the Court of Appeals." That finding was never challenged and remains applicable to Riverbend's property.

34. The record contains multiple submittals from Susan Watkins asserting that the expansion of a landfill in the EFU is not permitted under the Code and, instead, that Riverbend's proposal should be reviewed as the expansion of a non-conforming use. The Board rejects that assertion for the following reasons.

35. First, the Board finds the assertion that the County would treat the expansion of an existing landfill in the farm zone as a nonconforming use is directly contrary to the 2011 Code Change. That decision expressly acknowledged the effect of the 2011 amendment to the EFU Code provisions and stated "[t]he County's amended EFU zone now allows solid waste disposal sites as a permitted use."

36. Second, the Board finds the assertion that the County would treat the expansion of an existing landfill in the farm zone as a nonconforming use is directly contrary to Code provisions governing non-conforming uses. Specifically, YCZO Section 202 defines a nonconforming use as a use legally established prior to the adoption of a Code provision with which the use does not comply. LUBA has similarly held that a nonconforming use by definition applies where a use is contrary to provisions of local land use regulations. The Board finds that the existing landfill is not a nonconforming use because it is wholly consistent with all subsequently adopted Code provisions. The Board further finds that because Riverbend's applications meet all relevant approval standards, all bases for treating the existing landfill as non-conforming, if any exist, are extinguished.

37. In summary, the Board finds that Riverbend's proposed development is a permitted use in the EF-80 zone as long as it satisfies the County's Site Design Review standards and the standards set forth in ORS 215.296(1).

III. Site Design Review

38. Riverbend seeks approval to enhance and expand Riverbend Landfill through the County's Site Design Review process. YCZO Section 1100 establishes the standards for Site Design Review and provides a two-step process. The first step requires the applicant to submit a preliminary site

development plan for review. The second step requires a final site development plan submittal to reflect any changes to the site plan necessitated by the County's approval.

39. Most of the Site Design Review requirements are procedural in nature and ensure the applicant has provided the County with complete information on which to base its review. The record contains some testimony asserting that Riverbend did not provide the County with complete information on which to base its review. That testimony, however, is based on an assertion that the application must contain designs akin to final, construction-level drawings. The Board finds that the Code contains no such requirement.

40. The purpose of the Site Design Review process is to review the site as a whole, not the construction level detail of the eventual development. Construction-level drawings are typically reviewed by the building authority as part of the building permit process. Riverbend's development proposal, however, does not include any buildings or other structures for which a building permit is required. The construction-level detail of the proposal will be reviewed by DEQ, which has oversight of the actual development of municipal solid waste landfills and reviews the construction-level plans. The Board finds that an applicant is not required to spend large amounts of resources developing construction-level drawings for a proposal that has not yet been approved in concept by the County as part of a site plan. Instead, the Board interprets the Code to require the applicant to provide only that information necessary to allow the County to review the site plans that will then serve as the basis for detailed construction-level drawings.

41. The materials submitted with the application contain all of the elements of a Preliminary Site Development Plan, including existing site conditions, proposed changes and improvements to the site, and a written statement accompanying the site plan describing the present ownership and a schedule of development. The record contains testimony asserting that Riverbend has not demonstrated its ownership of the property within the proposed development area. As explained in Finding 22 above, however, Riverbend has provided deed records and other information demonstrating that the current landfill and the expansion area are comprised of a single legal lot wholly owned by Riverbend.

42. Beyond the procedural Site Design Review requirements, the actual evaluation of the site development plan is governed by YCZO 1101.02(A). Those criteria are addressed individually below.

A. YCZO 1101.02(A) – Site Design Review Factors for Consideration

43. When reviewing a Site Design Review application, YCZO 1101.02(A) requires consideration of the following factors: (1) characteristics of adjoining and surrounding uses; (2) economic factors relating to the proposed use; (3) traffic safety, internal circulation and parking; (4) provisions for adequate noise and/or visual buffering from noncompatible uses; (5) retention of existing natural features on site; 6) problems that may arise due to development within potential hazard areas; and 7) comments and/or recommendations of adjacent and vicinity property owners whose interests may be affected by the proposed use.

44. The Board interprets the Code such that the factors set forth in 1101.02(A) are not to be used as approval or denial criteria. As described in YCZO 1101.01, the factors are used by the County to

resolve potential conflicts that may arise "between proposed developments and adjacent uses." By that express language, the factors are not intended to avoid all conflicts that may arise, nor are they intended to address uses that are not adjacent to the proposed use. Those factors, therefore, cannot be used as a basis for denying an application. Instead, the County's obligation is to use those factors to potentially shape the development proposal by modifying it if necessary as a result of the consideration of those factors. The Board's consideration of each of the factors listed in YCZO 1101.02(A) is set forth below.

1. YCZO 1101.02(A)(1) - Characteristics of Adjoining and Surrounding Uses

45. The subject property is in a rural setting with surrounding parcels generally used for agriculture. The record indicates that the surrounding parcels are relatively large in size, with few dwellings located adjacent to or in close proximity to the landfill.

46. Riverbend owns multiple parcels in the area totaling approximately 680 acres, allowing the opportunity for Riverbend to maintain extensive buffers between the active portions of the landfill and adjacent and surrounding uses. The areas where new landfill cells can be developed are constrained by the County's prior imposition of a Limited Use Overlay that prevents landfill disposal in all but two areas of Riverbend's property. The Board finds that the combination of the buffer areas and the Limited Use Overlay prevents Riverbend's use of its property from disrupting the land use pattern created by adjoining and surrounding uses.

47. Riverbend's proposed development will not increase the intensity of operations at the site. The record demonstrates that waste disposal volumes are projected to remain at current levels during the operational period of the expansion. The record further demonstrates that landfills are developed through the progressive filling of individual disposal cells. As one cell reaches capacity, an adjacent cell is opened. Once it reaches capacity, a disposal cell is closed. This progressive development results in landfill operational levels and equipment use that remain constant over time and the current level of operations simply relocates to a different portion of the site. The development proposal therefore does not result in any increase in potential conflicts with adjacent uses. Further, the County has previously concluded that the long history of landfill operations at this particular site has been compatible with adjoining and surrounding uses. As part of the Zone Change decision, for example, the County expressly found that the character and density of the surrounding area have remained consistent over the time period the current landfill has been developed.[4] Because the application proposes only an expansion of the overall footprint of the landfill rather than an expansion of activities or operations, the Board finds that the proposal will continue to be compatible with adjacent and surrounding uses as it has been for decades.

48. The Board also finds that Riverbend's proposed site plan has been modified in direct response to the County's consideration of surrounding uses. For example, the perimeter berm along Highway 18 has been moved back to allow the retention of existing vegetation in that area. That vegetation serves to screen the landfill from travelers along Highway 18 as well as from more distant viewpoints. Similarly, the site plan will no longer include the development of Module 10.

[4] Ordinance 887 at p.18.

That area of the proposed expansion would have brought landfilling activities closer to the adjacent farms to the north of the existing facility and had the potential for some impacts to those areas.

2. YCZO 1101.02(A)(2) - Economic Factors Relating to the Proposed Use

49. The Board finds that there are multiple economic factors relating to the proposed use reflected in the Preliminary Site Development Plan and the Final Site Development Plan being approved with this decision. From a site-design standpoint, Riverbend's development proposal is economically efficient. By enhancing the existing site and developing the expansion in a manner that ties into the existing facility, the proposal allows Riverbend to achieve the same disposal capacity utilizing a smaller footprint than would be required at a new site. The record also indicates that Riverbend has already reconfigured its entrance facilities, including initiating a major upgrade to its recycling and drop-off facilities, to create efficiencies, and that reconfiguration will not be altered with the new site plan.

50. Testimony from FOYC and others opposing Riverbend's application urge the County to review broader, non-site-specific economic factors, such as potential consequences of any landfill use, rather than the economics of the specific design being proposed. The Board finds that such a broader economic view is not required for purposes of Site Design Review. Broad economic factors are more appropriate when the County is reviewing amendments to the Comprehensive Plan or zoning designations, which was the focus of the County's earlier Zone Change decision for Riverbend. The Zone Change decision, for example, expressly weighed economic impacts to: (1) residential, commercial and industrial landfill customers; (2) other businesses that provide construction or operational services to the landfill; and (3) the citizenry of the entire County. No testimony in the record presents a compelling reason for why the County should reanalyze those broad economic factors as part of the Site Design review process.

51. Even if the Board were required to review broader economic impacts of the proposal, the record does not support FOYC's argument that there are negative economic consequences from a landfill use on the subject property. Riverbend Landfill is situated in an agricultural area where the farm uses are identical to the farm uses in other areas of the County with a similar topography, demonstrating that landfill operations are not hindering nearby farm uses. Further, investments in agriculture in this area have increased over time, as is evident by the increased number of vineyards and other capital-intensive crops like filbert orchards. Even one of the most vocal opponents submitted testimony stating that he has increased the level of farm activities on his farm that lies adjacent to the landfill property. To the extent there is any economic loss resulting from the removal of some of the subject property from agricultural production, the Board finds that loss to be outweighed by the economic gains associated with the landfill. Those gains are realized in the form of lower disposal costs for individuals and businesses, employment income from the development and operation of the landfill, and revenue to the County from license fees and taxes.

3. YCZO 1101.02(A)(3) - Traffic Safety, Internal Circulation and Parking

52. The Board finds that the Final Site Development Plan reflects a strong consideration of traffic safety and internal circulation. The record contains a recent traffic study demonstrating the proposed development will not negatively impact traffic safety. The County previously relied on this traffic study during the Zone Change proceedings because it demonstrated that the proposed expansion would be consistent with the County's Transportation System Plan. The traffic study concludes that trips associated with the landfill constitute a very small portion of overall traffic volumes, and there have been relatively few accidents in the broader area, none of which have been identified as being related to the landfill.

53. The record contains some testimony asserting that landfill-related traffic has the potential to track mud onto the highway, thereby reducing traffic safety. The record also indicates Riverbend actively clears the roadway of debris on a regular basis, and more frequently if necessary. Further, Riverbend works directly with DEQ to ensure that landfill activities do not negatively impact traffic safety along Highway 18.

54. The Final Site Development Plan has also been modified from the original plan in direct response to comments in the record regarding traffic safety. For example, one of the conditions of approval imposed by the Planning Commission, and which the Board is retaining, requires Riverbend to add additional screening along the roadway atop the perimeter berm. This screening will reduce the likelihood that lights from trucks using that roadway will impair the sight of drivers using Highway 18, thereby avoiding potential safety hazards.

55. The Board also finds that the development proposal does not make any changes to the internal circulation and parking plans that have already been approved by the County. Those plans remain sufficient for the proposed expansion, which will not result in any increase in traffic to the site or any need for additional parking. The Board also notes that no testimony in the record asserts that parking on the site is insufficient.

4. YCZO 1101.02(A)(4) - Provisions for Adequate Noise and/or Visual Buffering from Noncompatible Uses

56. The Board finds that the Final Site Development Plan provides adequate noise and visual buffering from non-compatible uses.

57. The County has previously acknowledged that the continued operation of Riverbend Landfill is compatible with development on other EFU parcels in the vicinity. That acknowledgement was made in findings supporting the Zone Change decision. Those findings were not challenged and remain applicable to Riverbend's property. The Board therefore finds that there are no non-compatible uses for which noise and visual buffering are required.

58. As an independent basis for concluding that noise and visual buffering have been considered, the Board finds that the Final Site Development Plan includes noise and visual buffering that is reasonable in light of surrounding uses. The Board specifically finds that landfill operations are very similar to agricultural operations and other nearby uses, and that those uses create similar conditions. For example, farming operations rely on the use of heavy machinery that generate noise and that are visible from distant areas. Similarly, traffic on Highway 18 also generates noise and is visible from distant areas.

59. Riverbend has proposed to develop a berm along Highway 18, planted with trees and shrubs to screen views of the landfill from travelers on Highway 18 and the surrounding area. In the Preliminary Site Development Plan, Riverbend proposed the addition of a 35-foot vegetated buffer between the toe of that berm and Highway 18. The stated intent of that proposal was to retain as much of the existing vegetation in that area as possible, and augment that vegetation with new plantings where needed.

60. In direct response to comments submitted to the Planning Commission, Riverbend then agreed to alter the initial design in a manner that will allow nearly all of the existing, mature vegetation in that area to remain. The revised plan moves the toe of the perimeter berm an additional 15 feet away from the highway right-of-way. The Board finds this modification increases the overall effectiveness of the screening because the buffer between the highway and berm will increase from 35 feet to 50 feet and retain existing vegetation that is already well established and effective.

61. The Board finds that the removal of Module 10 from the Preliminary Site Development Plan will also result in the reduction of potential visual and noise impacts. One result of that modification is that the working face of the landfill, where noise is generated, will move closer to Highway 18 where ambient noise levels are higher. The record contains a noise study that concludes the landfill operates within DEQ's noise standards and that potential noise impacts from the expansion area will also meet those standards. The removal of Module 10 from the site plan will also decrease the amount of active landfilling activities that are visible to travelers along Highway 18.

5. YCZO 1101.02(A)(5) - Retention of Existing Natural Features on Site

62. The Board finds that the Final Site Development Plan considers the retention of existing natural features on the site. The record reveals that the site contains natural features such as the river and tributaries with associated riparian vegetation, floodplains, stands of trees and other vegetation, and open space.

63. The Board finds that Riverbend's development proposal retains and enhances many of the natural features on the site. For example, Module 11 is designed to be set 105 feet back from the southern tributary on the property, which is a greater distance than the maximum amount the County could require under its riparian regulations. Additionally, the stream in that area, which has been degraded to facilitate agricultural practices unrelated to the current landfill use, will be enhanced to restore the natural characteristics of the stream and its floodplain by creating a more meandering stream with native riparian vegetation.

64. Riverbend will also retain existing vegetation on the site, except where removal of the vegetation is necessary to develop the expansion area or conduct the stream enhancements. That vegetation will also be enhanced by additional plantings along the Module 11 berm paralleling Highway 18 and within the buffer area between the berm and the highway.

65. The record contains testimony asserting that the removal of any natural feature (e.g. trees) would be a violation of the Site Design Review provisions concerning the retention of natural features. The Board rejects that interpretation of the Code. Under that interpretation of the Code, no new development would ever be possible because development will invariably disturb some natural

area. To the contrary, the Board finds that the purpose of the Site Design Review provisions is to guide development, not to prevent it.

66. In direct response to comments submitted to the record, the Preliminary Site Development Plan has been modified in a manner that will retain even more of the natural features on site than Riverbend originally proposed. For example, as explained in finding 60, the toe of the Module 11 berm along Highway 18 has been relocated to allow nearly all of the existing, mature vegetation in that area to remain. Similarly, the removal of Module 10 from the site plan will allow trees in that area originally slated for removal to remain.

6. YCZO 1101.02(A)(6) – Problems that May Arise Due to Development Within Potential Hazard Areas

67. The Board finds that the Final Site Development Plan adequately considers problems that may arise within potential hazard areas. The record indicates that Riverbend's development proposal includes development within two potential hazard areas: (1) the 100-year floodplain and (2) a seismic zone.

68. The Board finds that the County imposes a specific mechanism for addressing problems that may otherwise arise due to development within the floodplain though imposition of YCZO Section 901. Pursuant to that Code section, before any development is permitted in the floodplain, it must satisfy the criteria for obtaining a Floodplain Development Permit. Riverbend has applied for, and the Board is approving, a Floodplain Development Permit. The Board discusses the criteria for obtaining the Floodplain Development Permit in section V of these findings. The Board adopts those findings here with this reference as support for its consideration of this Site Design Review factor.

69. In direct response to comments submitted to the record, the Preliminary Site Development Plan has been modified in a manner that will reduce potential floodplain impacts. Specifically, the removal of Module 10 from the site plan results in there being no new development in the floodplain of the northern tributary on the subject property.

70. The record contains testimony urging the County to consider more than what is required by the Floodplain Development Permit criteria. For example, one opponent of the application asked the County to look at impacts to the 500 year floodplain rather than the 100 year floodplain that is part of the County's Floodplain Development permit criteria. The Board finds no basis for using the Site Design Review process as a basis for essentially imposing additional floodplain development criteria. The Board further finds that impacts to the 500 year floodplain are not normally considered when reviewing development. Having considered the request to review impacts to the 500 year floodplain, the Board finds that such a review is unwarranted and that its review of impacts within the 100 year floodplain is sufficient for this Site Design Review factor.

71. Unlike the County's Floodplain Development Permit, the County does not impose its own seismic standards on development. However, the County does require solid waste disposal facilities to be permitted by DEQ, and the DEQ permitting process requires the landfill owner to address seismic issues. As the Applicant notes, seismic design for municipal solid waste landfills is governed in Oregon by the following: (1) DEQ's Solid Waste Landfill Guidance Document; (2) Subtitle D of the Resource Conservation and Recovery Act ("RCRA"); and (3)

the U.S. Environmental Protection Agency's ("EPA") Seismic Design Guidance for Municipal Solid Waste Landfill Facilities. The Board finds that nothing in the site plan would allow Riverbend to avoid these seismic standards and, therefore, the very act of obtaining a DEQ permit ensures that seismicity is considered as part of the overall process. The Board relies on DEQ to ensure DEQ seismic standards will be met. By requiring Riverbend to obtain a DEQ permit as a condition of approval, the Board is ensuring that the County's obligation to consider seismicity also is met.

72. The record contains testimony asserting that DEQ does not adequately address seismic issues as part of the permitting process. The Board has considered that assertion and finds that it is a complaint about DEQ's regulatory process and unrelated to the County's land use process. If a party disputes DEQ's vigilance or seismic methodology, it can raise those concerns during DEQ's permitting process. The Board also finds that assertion to be unsupported by the evidence in the record. Riverbend recently obtained a modification of its solid waste disposal permit for the development of a Mechanically Stabilized Earthen Berm ("MSE Berm"). As part of that process, DEQ considered the analyses from three different seismic experts – one retained by Riverbend, a second retained by landfill opponents, and the third retained by DEQ as an independent third party. The result of that analysis, as demonstrated by DEQ's response to comments in that proceeding, which are in the record here, was a comprehensive review of not only the specific design of the MSE Berm, but also of the entire Riverbend site. Any assertion that DEQ is not vigilant when reviewing seismic issues is inaccurate.

73. In addition to regulatory seismic standards that will apply during the DEQ permitting process, the record indicates the existence of other guidelines that encourage developers to plan for a magnitude 9.0 earthquake. In direct response to comments submitted to the record regarding those guidelines, the County is imposing a condition to require Riverbend to design new perimeter berms to meet seismic design criteria for the magnitude 9.0 earthquake outlined in the Oregon Resilience Plan.

7. YCZO 1101.02(A)(7) – Comments and/or Recommendations of Adjacent and Vicinity Property Owners Whose Interests May Be Affected by the Proposed Use

74. The record in this matter includes significant comments and recommendation from adjacent and vicinity property owners. It also includes comments and recommendations from individuals who work or reside beyond the vicinity of Riverbend Landfill. The Board finds that the Final Site Development Plan reflects many of those comments and recommendations and that the County has sufficiently considered this factor of the Site Design Review process.

75. The Board finds that this Code provision does not require it to list and respond to each comment or recommendation in the record. Indeed, many comments in the record are unrelated to the specific approval standards or the factors to be considered as part of the Site Design Review process. While the Board does not find all relevant comments and recommendations in the record necessitate changes to the site plan, the Board finds some comments and recommendations warrant the changes that were made from the Preliminary Site Development Plan to the Final Site Development Plan, as well as some of the conditions of approval discussed in more detail in section VI. Such changes include those described in the findings relating to the other six Site Design Review factors such as (1) the modification of the perimeter berm to retain

more vegetation, (2) the removal of Module 10 from the site plan, (3) the requirement to include additional screening along the roadway on top of the perimeter berm, and (4) the requirement to design berms in a manner consistent with the seismic guidelines contained in the Oregon Resilience Plan.

B. YCZO 1101.02(B) – Development Standards of the Underlying Zoning District

76. YCZO 1101.02(B) ensures that development subject to Site Design Review satisfies the standards of the underlying zoning district. The Code provision states in full:

> *All development applications for site design review are subject to the development standards of the underlying zoning district and may be modified pursuant to satisfaction of the considerations provided in subsection 1101.02(A). The Director may waive submittal requirements consistent with the scale of the project being reviewed, upon determining that requirements requested to be waived are not necessary for an effective evaluation of the site development plan.*

77. The underlying zoning district applicable to Riverbend Landfill is the EF-80 zone as part of the County's EFU district. Those development standards are set forth in YCZO 402.09. Pursuant to the conditions of approval associated with the Zone Change, other development standards apply as well, such as limits on development within riparian corridors. Additionally, the Zone Change applied a Limited Use Overlay to Riverbend's property that includes limits on some development. The standards in YCZO 402.09, the regulations relating to Riparian Corridors, and the Limited Use Overlay are addressed in this section.

1. EF-80 Development Standards

78. The Board finds that none of the limits on development stated in the development standards set forth in YCZO 402.09 are applicable to Riverbend's application.

79. YCZO 402.09(A) places limits on dwelling density. Riverbend's application, however, does not propose any dwellings. The Board therefore finds this Code provision to be inapplicable. For the same reason, the Board finds that the limit in YCZO 402.09(E) relating to site access does not apply. The record does not contain any testimony asserting that these Code provisions apply.

80. YCZO 402.09(B) places limits on parcel sizes and dimensions. However, the Board finds that this Code provision imposes new limits only where an application seeks (1) to create new parcels, (2) a lot line adjustment, or (3) a land division. For existing lots that will not change, YCZO 402.09(B)(3) provides that any permitted use is allowed. Riverbend's application does not propose changes to any existing lot. The record does not contain any testimony that the application does not satisfy this Code provision. The Board therefore finds that this Code provision places no limits on Riverbend's development proposal.

81. YCZO 402.09(C) establishes minimum setbacks for all yards. A setback, however, is a measure of distance between any property line and the nearest "structure." YCZO 202.00 specifically defines "setback" as follows:

> *The horizontal distance measured perpendicularly from the property line to the nearest point of any structure on any parcel. Ordinary building projections such as eaves, bay windows, and chimneys, and unroofed decks or porches not more than 30 inches above ground level are not subject to setback requirements.*

82. The Board finds that Riverbend's application does not propose any structures and, therefore, the setback requirements do not apply. Even if the setback requirements did apply, Riverbend has not proposed any development within the 30-foot setback required by YCZO 402.09(C). The record shows that the closest new development to any property line is the toe of the perimeter berm along Highway 18, which will be set back 50 feet from the property line.

83. YCZO 402.09(D) places limits on parcel coverage. Those limits apply only for a parcel that is less than one acre in size. The Board finds Riverbend's parcel is greater than one acre in size and, therefore, it is not subject to parcel coverage limits. The record does not contain any testimony asserting that this development standard applies.

84. YCZO 402.09(F) requires maintenance of clear-vision areas. The Board finds, however, that those requirements apply only at intersections of any two of the following: county roads, public roads, private roads serving four or more parcels, and railroads. The only "intersection" at issue in this application is the driveway that serves Riverbend Landfill, but that driveway serves only one parcel. The Board therefore finds this Code provision does not apply. The record does not contain any testimony asserting that this development standard applies to Riverbend's proposal.

85. YCZO 402.09(G) places height limitations on dwellings and structures. The Board finds that Riverbend's development proposal does not seek the development of any dwellings or structures.

86. The record contains testimony asserting the landfill is a "structure" that should be limited to 45 feet in height. The Board rejects that assertion for the following reasons. Section 202.00 of the Code defines a "structure" as "[s]omething constructed or built and having a fixed base on, or fixed construction to the ground or another structure." The Code also defines "Height" as "[t]he vertical distance from the finished grade to the highest point of the structure." "Grade" means "[t]he average elevation of the finished ground elevation at the centers of all walls of a building . . . ."

87. The Board finds that fill is not a "structure" under the Code. This finding applies to both the earthen fill used for the landfill's perimeter berms and the waste fill that goes into the landfill. The fill in a landfill is not "fixed" or "attached" to the ground. Rather, as the Applicant has demonstrated, the fill rests on top of the ground. The only component between the fill and the underlying ground is the landfill liner system. The liner system, however, is an environmental protection measure and does not provide any support for the fill in a way that a foundation provides support for a building. Without the liner, the fill could still be placed on the ground. In contrast, a building requires a foundation for structural support. The Board further finds that the

fill eventually becomes indistinguishable from the original ground, especially when the landfill reaches capacity and soil and vegetation replace waste as the final surface of the fill.

88. As an independent basis for concluding that neither the landfill nor its berms are a "structure," the Board notes that the method for calculating height does not apply to this type of development. For example, YCZO 402.09(G)(3) removes from height limitations "appurtenances" that are "usually required to be placed above the roof level . . . such as spires, belfries, cupolas, antennas, water tanks, ventilators, chimneys and wind generators . . . ." The implication of that Code section is that a height measurement involves structures typical of actual buildings, such as ones that contain a roof, and which are capable of holding appurtenances like spires and belfries. Fill in a landfill does not include a roof or hold any appurtenances potentially rising above that roof.

89. The Board further finds that the Code's definitions of "height" and "grade" demonstrate that the calculation of height does not apply to landfills. "Height" involves measuring elevation from a finished grade to the top of a structure. In the case of a landfill, the finished grade would be the top of the fill. There is no other object, therefore, the top of which can be measured from the height of that finished grade. Similarly, "grade" relates to the elevation of the finished ground at the center of all walls of a building. By using walls of a building as a reference for establishing the finished grade, the Code clearly contemplates height only in terms of an actual building rather than for all things capable of being placed on land.

90. As an independent basis for concluding the landfill is not a "structure," the Board relies on the County's prior consideration of the development of Riverbend Landfill that interpreted the Code in the same manner. As part of the County's approval of the Goal 3 Exception in 2009, the County interpreted this Code provision and specifically indicated that the landfill involves only fill and is not a "building" or "structure." Based on that interpretation, the County determined that Riverbend is not subject to the height limitation for buildings and structures, and the only height considerations were those imposed by the County to make the facility compatible with the surrounding area. Similarly, the County has on multiple occasions concluded that the original 1980 plan amendment and zone change for the landfill did not restrict the elevation of the landfill, even though the PWS zone had height limitations.

91. YCZO 402.09(H) places limits on occupancy of recreational vehicles. Those limits apply in conjunction with a dwelling or construction activities. The Board finds Riverbend's proposal does not seek approval for a recreational vehicle, and any such vehicle needed for construction is allowed by right. The Board therefore finds this Code provision is not applicable. The record does not contain any testimony asserting that this development standard applies.

92. YCZO 402.09(I) places limits on off-street parking. The Board finds Riverbend's proposal does not seek approval for any off-street parking and that this standard applies only to dwellings or to other uses which may generate traffic beyond what is normally expected in the EFU. The Board therefore finds this Code provision is not applicable. The record does not contain any testimony asserting that this development standard applies.

2. Riparian Corridor Development Standards

93. As part of the Zone Change decision in 2014, the County established specific Goal 5 riparian corridor regulations applicable only to Riverbend's property. Those regulations limit the permanent alteration of the "Riparian Area," which is an area defined as a corridor beginning at the top of bank of a fish-bearing stream and extending 100 feet from that top of bank. The County's regulations are based on the Land Conservation and Development's "safe harbor" method for protecting riparian areas set forth in Oregon Administrative Rule (OAR) 660-023-0090. Within that regulated corridor, specifically under subsection (5) of those regulations, Riverbend is permitted to make some permanent alterations of the Riparian Area, but only on a "demonstration that equal or better protection for identified resources will be ensured through restoration of Riparian Areas, enhanced buffer treatment, or similar measures." Such permanent alterations are not permitted, however, if they occupy more than 50% of the width of the Riparian Area. Some activities in the Riparian Area are exempt from these regulations.

94. The Board finds Riverbend's application meets the development standards set forth in the County's Goal 5 regulations applicable to the subject property. Riverbend's application relies primarily on subsection (5) of the County's Goal 5 regulations and presented evidence that its project will provide equal or better protection for the riparian area. The Final Site Development Plan also demonstrates that the permanent alterations do not occupy more than 50% of the width of the Riparian Area. The one exception to that limited encroachment is for the road that crosses the Riparian Area. Roads, however, are exempt from the County's Goal 5 regulations.

95. The Final Site Development Plan includes new berms associated with the development of Module 11 that are set back more than 100 feet from the South Yamhill River and from the two tributary creeks located on the subject property. The Board therefore finds those new berms meet the safe harbor provisions contained in the County's Goal 5 regulations.

96. The Final Site Development Plan includes enhancements to existing berms on the south side of the existing landfill as part of the development of Module 11. These enhancement areas are farther from the southern tributary than the existing berms, but they lie within the Riparian Area because they are closer than 100 feet from the top of the tributary's bank. This enhanced development, however, extends no more than 50 percent into the riparian corridor along that creek and is designed to be no closer than 50 feet at any one point. Such an encroachment is permissible if the development will provide equal or better protection of the resource.

97. The Board finds that Riverbend's development proposal provides equal or better protection of the riparian resource in this area. Riverbend will restore and enhance approximately 3.8 acres of riparian habitat of the southern tributary reach south of Module 11, as detailed in the Riverbend South Tributary Channel and Floodplain Enhancement Plan included with the Floodplain Development Permit Application Narrative.

98. The Final Site Development Plan also includes one access road that crosses a riparian area on the southwest side of Module 11. This road, which replaces two existing crossings, will allow Riverbend to access the existing leachate pond, as well as the future site to be used for an alternative technology for processing solid waste ("Green Technology Facility"). The Board finds that the road is exempt from the riparian vegetation removal limits in the County's Goal 5 riparian provisions. The Board finds that the road minimizes intrusion into the Riparian Area. The location of the road is constrained by the fact that it must tie in to the perimeter berm for

Module 11 and allow trucks to depart the berm to make the crossing. Because the road is located to the extreme west of the stream reach, it is located where the Riparian Area is narrower due to the poplar orchard on the southern side and altering the proposed straight alignment would cause greater riparian intrusion to accommodate more turns in the road. Similarly, departing the berm from a different location would require additional alterations of the riparian area. The proposed location also makes it possible to remove the two existing crossings and restore those areas to enhanced riparian zones, which will be part of the enhancement project. Finally, the location of the crossing allows for the continuation of plantings on the berm, which will improve screening and the overall environmental benefits in that location.

99. The final design of that crossing will not be developed until Riverbend consults further with the Oregon Department of State Lands ("DSL") and the Army Corps of Engineers as part of the wetlands permitting process. The Board's approval of the riparian crossing is therefore based on the figures that comprise the Final Site Development Plan. Although roads are exempt from the County's Goal 5 riparian removal regulations applicable to the subject property, the Board finds that if DSL or the Army Corps of Engineers are unable to permit a crossing with the same or a smaller footprint, Riverbend will have to modify the Final Site Development Plan to allow the County to review any potential additional impacts to the Riparian Area. However, the Board finds that any approval of the riparian crossing that has the same or a smaller footprint than what appears on the Final Site Development Plan will not have to undergo further review by the County because, in that situation, there will be even less intrusion of the Riparian Area.

100. The record contains some testimony that identifies potential concerns related to development within the Riparian Area. However, the Board finds that testimony relies only on general concerns, or relies on subsections (2) and (3) of the County's Goal 5 regulations, and does not assert that the application does not or cannot satisfy subsection (5) of the County's Goal 5 standards applicable to the subject property. For example, a letter from FOYC dated December 4, 2014 requested the County to require Riverbend to modify the site plan so that no crossing of the southern tributary would be required. However, that letter does not state why such a modification would be required, and it was also presented to address YCZO 1101.02(A)(5) relating to the retention of natural features rather than as a requirement of the County's Goal 5 riparian regulations. Similarly, a letter from STDC dated March 12, 2015, relies primarily on the fact that there will be development in the Riparian Area, but does not address subsection (5), which allows such development where equal or better protection of the resource is provided.

101. The letter from STDC does assert that the road across the Riparian Area does not satisfy the County's Goal 5 standards. That assertion, however, is based on STDC's claim that the encroachment has not been minimized. As stated above in Finding 98, the Board finds that the design does minimize disturbance of the Riparian Area because of the chosen location where the Riparian Area is narrower and because of the straight alignment. STDC's letter only speculates that the design should be further minimized and does not present persuasive evidence that it is feasible to do so.

3. Limited Use Overlay Standards

102. In addition to the development standards in YCZO 402.09 and the County's Goal 5 riparian regulations, the County imposed additional standards that apply specifically to the development

of Riverbend's property as conditions of approval for the Zone Change. The conditions of approval that relate to the development of the site are as follows:

> Condition 3 – Areas Where Landfilling Prohibited. Condition of Approval 3 from Ordinance 887 prohibits the landfill disposal of solid waste on certain portions of RLC's property subject to the Zone Change. Those include Tax Lots 5501-300, 5501-401, 5501-500, 5511-100, 5511-600, 5512-100, 5512-200, 5512-400, 5512-500, the southern portion of 5501-400, the eastern portion of 5501-101, and any portion of 5501-200 that lies south of the Yamhill River.
>
> Condition 4 – Area Reserved for Alternative Disposal Technology. In addition to preventing the landfill disposal of solid waste on the southern portion of Tax Lot 5501-400, Condition of Approval 4 from Ordinance 887 prohibits all solid waste disposal activities that would prevent the siting and construction of a Green Technology Facility on that portion of Riverbend's property.
>
> Condition 7 – Alternative Disposal Technology. Condition of Approval 7 from Ordinance 887 requires Riverbend to establish a Green Technology Facility on site. Construction of the Green Technology Facility must commence no later than seven years after Riverbend obtains a DEQ permit for solid waste disposal outside of the former PWS zone. The facility must be operational within 18 months after the commencement of construction unless the County extends that timeline.

103. The Board finds that the Final Site Development Plan is consistent with Condition 3 of the Zone Change because it does not result in the landfill disposal of solid waste in any prohibited areas. The only landfill disposal of solid waste will occur on Tax Lot 5501-200 and the northern portion of Tax Lot 5501-400. Neither of those tax lots appears in the list of prohibited areas set forth in Condition 3.

104. The record contains some testimony asserting that the Final Site Development Plan allows landfilling on the southern portion of Tax Lot 5501-400. The Board finds that testimony to be inaccurate. The development that crosses from the north portion to the south portion of Tax Lot 5501-400 is a road that will be used to access the leachate pond and, eventually, the Green Technology facility. No landfill disposal of solid waste occurs in that area. Moreover, Condition 4 of the Zone Change expressly allows non-landfill disposal activities to take place on the southern portion of Tax Lot 5501-400 such as operational support or other activities that do not prevent the development of the Green Technology Facility. The Board finds that the road does not prevent the development of the Green Technology Facility and, instead, that it will promote the development of such a facility by creating an access way to that site.

105. The record contains additional testimony asserting Riverbend cannot meet the County's development guidelines because it is not proposing a specific Green Technology facility as part of this application. The Board finds that there is no such requirement. As Condition of Approval 7 acknowledges, the construction of any particular facility depends on many factors and will take time to develop. That condition imposes a specific timeframe for when the facility

must be built, but it does not prevent Riverbend from seeking approval of other development that does not include such a facility. The Board finds that Riverbend's development proposal preserves its ability to meet this condition within the applicable time period.

106. The record contains additional testimony asserting Riverbend's Site Design Review application is not consistent with YCZO 1101.01, which is the purpose statement for the Site Design Review Process. The Board finds that YCZO 1101.01 is not an approval standard. Rather, that Code provision describes the "purpose" of the approval standards that appear in other sections of the Site Design Review Code provisions. This provision also describes the types of applications to which the Site Design Review process applies. The Board was presented with no compelling reason to treat YCZO 1101.01 as a stand-alone approval standard and it declines to interpret the Code in that manner.

C. Site Design Review Procedural Requirements

107. YCZO Section 1101.03 contains several procedural requirements governing the Site Design Review Process. The Board finds that these requirements are not approval criteria and that Riverbend's application submittals, Riverbend's supplemental submittals, and the actions taken by the County Planning Department are consistent with these requirements. The Board finds that the record contains no compelling testimony that these requirements have not been met.

108. With respect to YCZO 1101.03(A), Riverbend attended a pre-application conference with County Planning Staff on October 1, 2014. The Board further finds that Riverbend submitted a Preliminary Site Development Plan sufficient for review by the County. As required by YCZO 1101.04, the Preliminary Site Development Plan included: (1) figures showing existing site conditions, including site topography, drainage and other water and soil features, existing structures, and adjacent uses; (2) proposed changes and improvements to the site; and (3) a written statement regarding the present ownership of the subject property, along with a schedule of expected development.

109. The record contains testimony asserting Riverbend's Preliminary Site Development Plan was insufficient for review by the County. However, the Board finds that testimony improperly asserts that Riverbend was required to submit construction-level drawings or include plans for a Green Technology Facility. As just noted, Riverbend's Preliminary Site Development Plan contained all of the elements required by YCZO 1101.03 and YCZO 1101.04. Riverbend also submitted additional information required by the Planning Director pursuant to YCZO 1101.04(B)(1)(e).

110. The Site Design Review provisions allow the Preliminary Site Development Plan to be deemed the Final Site Development Plan if no modifications to the plan are required. In this case, the Planning Commission required several modifications to the Preliminary Site Development Plan. Typically, those changes would be submitted to the County at a later date pursuant to YCZO 1101.05. Because Riverbend's applications were appealed, however, and the record re-opened for this Board's review, Riverbend was able to submit a new site plan to reflect the Planning Commission's required modifications. The Board is not requiring any additional modifications to the site plan and, therefore, finds that the revised site plan provided to the Board on March 4,

2015 as part of the Applicant's Pre-Hearing Submittal shall be deemed the Final Site Development Plan.

111. The Board finds the Final Site Development Plan, in conjunction with other information provided to the record, contains all of the elements required by YCZO 1101.05(A). Specifically, the Final Site Development Plan contains a site analysis (existing conditions), a site plan, a final grading plan, and a landscape plan. No cross sections, elevations or other drawings of proposed structures are necessary because no new structures are being proposed. However, documents in the record do show cross sections and elevations of the perimeter berm and the proposed landfill. Finally, the Board deems the proposed schedule of development to be the same as described in the Preliminary Site Development Plan, only that the schedule will begin with the development of Module 11 rather than Module 10. The record also contains figures depicting what the development will look like in approximately 7 years when the Green Technology condition has been triggered. The Board did not receive any testimony that the figures and information described in this Finding are insufficient for purposes of serving as the Final Site Development Plan.

IV. Farm Impacts Assessment

112. The SDR process requires development applications to demonstrate compliance with the requirements of the underlying zone. The underlying zone for Riverbend's property is the EFU zone governed by YCZO 402. YCZO 402.02(V) specifically requires that the maintenance, enhancement, or expansion of a landfill in the EFU zone must satisfy the criteria set forth in ORS 215.296(1). That requirement implements ORS 215.183(2)(k), the state statute that allows solid waste disposal sites in the EFU. These findings refer to the criteria set forth in ORS 215.296(1) as the "Farm Impacts" criteria.

113. The Farm Impacts criteria require certain proposed uses, including landfills, to demonstrate: (1) that they will not force a significant change in accepted farm or forest practices on surrounding lands devoted to farm or forest uses; and (2) that they will not significantly increase the cost of accepted farm or forest practices on those surrounding lands. These findings will refer to accepted farm and forest practices, and the cost of accepted farm and forest practices, collectively as "Farm Practices."

114. The Applicant provided an initial Farm Impacts Assessment with its applications. The Applicant provided the following supplements to the Farm Impacts Assessment: (1) an updated Farm Impacts Assessment prepared by CSA Planning Ltd., dated December 23, 2014; (2) a letter addressing "Allegations of Impacts to Farm Practices" dated December 31, 2014, prepared by Cable Huston and including Attachments 1-3 relating to the Farm Impacts Assessment; (3) a letter addressing "Farm Impacts Analysis" and "Economics" dated March 17, 2015, prepared by Cable Huston and including Attachments E and G relating to the Farm Impacts Assessment; and a memorandum prepared by CSA Planning Ltd., dated March 19, 2015 regarding "Riverbend's Response to Farm Impacts Assessment Testimony." The initial Farm Impacts Assessment and the supplements described in this Finding are collectively referred to as the "Farm Impacts Assessment" or "FIA." Having weighed all of the evidence in the record, the Board finds that the facts and analysis contained in the FIA are more persuasive and adopts the FIA in its entirety into these findings here by this reference. The Board specifically adopts the methodology, facts,

and conclusions stated in the FIA. In the event of a conflict between these Findings and the FIA, the FIA shall govern.

115. The FIA concludes that Riverbend's proposed development will have no impacts to the low intensity forest practices associated with the relatively few woodlots that exist near the subject property. Further, the Board finds that the record contains no persuasive testimony alleging any impacts to forest practices that have resulted or will result from the continued operation of Riverbend Landfill. The Board therefore finds that the proposed use satisfies the forest practices component of the Farm Impacts criteria and makes no further findings in that regard. The remainder of the Findings in this section focus on the farm practices component of the Farm Impacts criteria.

116. The Board finds that the Farm Impacts criteria do not prevent the County from approving development that may have some impacts on Farm Practices. Rather, a proposed use cannot force a "significant change" in Farm Practices or "significantly increase" the cost of those practices. The Board further finds that the County need only consider "accepted farm practices" and the Farm Impacts criteria do not require consideration of other uses of property such as domestic or commercial uses that are only farm-related. According to state statute, "accepted farming practices" are modes of operation, common to farms of a similar nature, and which are necessary for the operation of such farms to obtain a profit in money. Thus, where a potential farming practice is conducted as a hobby or other personal use, the Board finds that the Farm Impacts criteria do not apply. Further, the Board will not consider evidence of impacts to Farm Practices that are not shown to be common and necessary.

117. The Board has determined that it should adhere to LUBA's well-developed methodology for analyzing the Farm Impacts criteria. Under that methodology, these Findings will first describe the accepted farming practices existing on surrounding lands. The Findings will then determine whether the proposed use will force a significant change in, or significantly increase the cost of, those practices.

118. As a threshold matter, the Board must determine which lands constitute "surrounding lands" for purposes of Riverbend's proposal. The statutes and rules appear to be silent on this matter, and no party in the proceeding identified any authority for what constitutes surrounding lands. The Board finds that surrounding lands for purposes of this application are those lands situated within one mile of the existing landfill and the area proposed for expansion. Beyond that area, potential impacts from the landfill are too difficult to quantify or to isolate from impacts caused by other farm and non-farm uses. For example, testimony in the record addresses potential impacts from litter that may escape the landfill site. However, the record is also clear that litter accumulates along roads that are extremely distant from the landfill, and no party disputed the fact that such litter comes from other sources. Even if landfill litter could travel beyond one mile (which is not supported in the record), it would comingle with litter from other sources and be indistinguishable for purposes of potential impacts.

119. Moving away from the landfill, the land use pattern is broken up by roads, natural features, farm uses, non-farm rural uses, residential uses, and more intense urban development. The Board finds that each of these characteristics limits the spread of potential impacts from the landfill, and some cause impacts of their own. In the absence of compelling evidence that a particular impact

beyond one mile from the landfill is substantially attributable to the landfill, the Board will not consider such distant lands in its primary analysis and findings. The Board will therefore limit its primary analysis and findings to those lands within one mile of the existing facility and the expansion area. However, and only in the alternative, the Board will address some potential impacts to Farm Practices in the broader area reviewed by the Applicant in its Farm Impacts Assessment where there is testimony that those impacts may exist.

120. The Board also finds that its analysis and findings relating to Farm Impacts must be based in large part on quantifiable or verifiable data. Because the Board must determine if a potential impact forces a "significant" change in farm practices or "significantly" increases the costs of farm practices, evidence asserting the proposed use does not meet the Farm Impacts criteria must describe both the alleged impact and the degree to which that impact might reasonably be expected to impact Farm Practices. Without some evidence of the degree of significance, the evidence cannot support a finding that the criteria are not met. And without evidence of the degree of an alleged impact, neither the Board nor the applicant can consider mitigation measures that could reduce a potentially significant impact to an acceptable level. This is especially important in the context of a quasi-judicial proceeding where the sponsor of the evidence may be the only one with access to that information and the procedures do not allow for cross-examination or other compelled discovery to verify the evidence.

A. Accepted Farm Practices on Surrounding Lands

121. The Board is required to identify accepted farming practices on surrounding lands. In order to do so, the Board must first determine what farm crops and other farm uses exist on those lands. The FIA identifies the crops that currently exist within a one-mile radius of the existing and proposed use (the "Study Area"). The record contains testimony criticizing the completeness of the Applicant's initial version of the FIA, but the Board finds those criticisms are unsupported. LUBA has concluded that it is "entirely appropriate" for an applicant to begin the process by visually surveying surrounding lands for purposes of identifying nearby farm and forest uses. Indeed, throughout the Planning Commission process and this Board's review, participants were able to identify areas in the Study Area that were either mis-identified or incomplete in the initial FIA. That testimony was then used to update the initial assessment and the result is that the FIA in the record contains a robust and thorough assessment of crops and other farm uses in the Study Area. To the extent the initial analysis had any deficiencies, those deficiencies were rectified by the remainder of the process.

122. Based on the FIA, in its final version that incorporates testimony presented to the Planning Commission and the Board, farm crops and other farm uses on surrounding lands include the following:

1. Orchards (primarily hazelnuts and walnuts)
2. Grass Seed (including similar uses such as hay production and clover seed)
3. Pastures with Livestock
4. Poultry, Pheasants, and Egg Production
5. Field Crops (such as row crop vegetable production)
6. Plant Nurseries
7. Horse Breeding

123. The record identifies the accepted farming practices associated with the above-listed farm crops and other farm uses. Those accepted farming practices include, but are not limited to, the following:

1. Orchards: orchard establishment, crop growth, chemical and nutrient applications, brush removal, pruning, irrigation, rodent control, bird control, sucker control, flailing and leveling orchard floor, harvest, and nut washing/drying.

2. Grass Seed: chemical and nutrient applications, crop growth, bird control, rodent control, planting, weed control, tilling/disc, sheep grazing, swathing for harvest, combine/thresh, clean and bag seed, and straw bailing or flail.

3. Pastures with Livestock: chemical and nutrient applications, pasture growth, animal growth, birthing, medication, milking, rodent control, livestock medical treatment, feeding and watering, and fence maintenance.

4. Poultry, Pheasants, and Egg Production: feed production, animal growth, incubating/hatching, medication, egg collection, rodent control, feeding and watering, and pen construction/maintenance.

5. Field Crops: chemical and nutrient applications, crop growth, bird control, rodent control, tilling and planting, tilling/disc, and harvest.

6. Plant Nurseries: chemical and nutrient applications, bird control, rodent control, plant starts (in greenhouses), pruning, plant growth, irrigation, soil stockpiling, and on-site composting.

7. Horse Breeding: feeding, cleaning stables, grooming, maintaining fencing, rodent control, providing medication and basic health treatment for resident horses, coordinating veterinary services when appropriate, and activities associated with breeding.

124. Other accepted farming practices may also exist within one mile of the proposed use and are identified in the FIA. Specifically, Section 4.2 of the supplemental Farm Impacts Assessment dated December 23, 2014 includes a full description of farm practices titled “Farm Practice Characterization. Rather than restate that portion of the FIA or all facts and conclusions in the FIA in their entirety, the Board adopts and incorporates the characterization of farm practices in the FIA into these Findings by this reference. The Board further finds that the record does not contain any persuasive evidence of other accepted farming practices not listed in the FIA.

B. Potential Impacts to Accepted Farming Practices

125. In order to complete the second and third steps of the analysis and make findings regarding Farm Impacts, the Board must first identify the source of potential impacts from the landfill use that could force significant changes in accepted farm practices or significantly increase the costs of those practices. The record identifies the following sources of potential impacts from the proposed use:

1. Litter
2. Water quality
3. Air particulates
4. Traffic
5. Nuisance bird attraction
6. Rodent/pest attraction

126. The Board analyzes each of these potential impact sources below. That analysis relies, in part, on the fact that the Board is adopting the Planning Commission's condition of approval denying the portion of Riverbend's original application that included the development of Module 10. Module 10 would have allowed Riverbend to expand the existing facility to the north. That expansion area would be closer to the immediately-adjacent farm to the north. Further, although Module 10 would not have been any closer than the existing landfill is to the farms to the northeast and east and south, it would have brought the working face of the landfill slightly closer to those areas. The record does not contain any testimony from the owner of the farm immediately adjacent to the north of the existing facility, but it does contain such testimony of alleged impacts from the owner of the farm to the northeast and property owners farther to the north. By removing Module 10 from the site plan, the expansion area will not be closer to those areas of alleged impacts and, instead, will move closer only to Highway 18 and the farms to the west and southwest, where there are fewer alleged impacts.

1. Litter

127. The record reveals that litter has the potential to escape from a landfill facility. Such litter in significant volumes could impact Farm Practices if it interferes with combine operations, cleaning and bagging seed, or harvesting operations.

128. The Board finds that the actual litter impact that has resulted from Riverbend's current operations, or that could result from future operations, is not significant and is limited by several factors. Litter is generated where the working face of the landfill is located. Module 11 is predominantly surrounded by a buffer of properties Riverbend owns and for which the record does not indicate there have been any litter impacts. It will be farther from farms to the northeast and east that have alleged litter impacts from the existing facility. The Board also finds that, based on prevailing wind patterns described in the FIA, potential litter impacts will be limited in geography and are not likely to have significant impacts on farms that generally lie to the west.

129. The record also indicates that Riverbend manages litter by the use of litter fences protecting farms to the northeast and east, and by regularly conducting litter patrols around the entire site and along Highway 18. Riverbend is required to conduct litter management as part of its obligations under its DEQ permit. The record reveals that the amount of litter collected as part of the litter patrols is quite small (approximately one to two trash bags collected twice per week, indicating that the actual amount of escaping litter is low). Based on the above facts, the Board finds that the amount of litter actually escaping the landfill is not significant and, therefore, has not and will not cause any impact to Farm Practices, much less significant impacts.

130. The record contains testimony from McPhillips Farms, located to the northeast, that it has a policy to refund customers any time a bale of hay it sells has plastics or other landfill litter in it.

However, that testimony does not indicate that McPhillips Farms has ever had to actually issue such a refund under that policy, which implies that litter has not been a problem for that particular farm. Further, even if such impacts have existed in the past, which the Board finds they have not, the working face of the landfill will be moving farther from that farm and, therefore, those impacts will decline or disappear altogether.

131. The record also demonstrates that the landfill is not the only source of litter that has the potential to reach farms. Other rural areas of the County, where there is no possible connection to the landfill, contain amounts of litter that are no less than those around the landfill, and may in fact be greater. The Board finds Riverbend's litter control measures are effective and create an environment with even less litter than would exist without the landfill. The Board therefore finds that the presence of litter on lands within the Study Area is similar in quantity to other lands in the County and therefore has no impacts on Farm Practices.

2. Water Quality

132. The record contains testimony asserting that an expanded landfill will degrade the quality of groundwater and surface water in the area. The majority of that testimony raises water quality issues as a general environmental concern rather than in relationship to Farm Practices. However, the record does contain some limited testimony that degraded water quality will impact some Farm Practices. For example, a December 4, 2014 letter from FOYC notes that irrigation is an accepted farm practice for many crops. The letter goes on to note that "impacts to either groundwater or surface water from the proposed expansion of the landfill could force significant change in or increase the cost of this accepted farm practice."

133. The record demonstrates that the quality of the water on Riverbend's property is one of the most regulated and intensely monitored site conditions. A map submitted with Riverbend's First Post-Hearing Submittal, for example, identifies the location of multiple compliance and detection wells for monitoring groundwater quality. The record also contains several documents, provided by those opposing the application, containing the results of stormwater monitoring that has occurred on site. These monitoring programs are performed with stringent regulatory oversight by DEQ.

134. The Board finds that the existing landfill has not caused degradation in water quality. The Board further finds that this lack of impacts to water quality means that no impacts to Farm Practices have occurred from the existing facility or will occur from the proposed expansion. Notably absent in any of the testimony opposing the application is a credible assertion that any farmer has changed irrigation practices, incurred higher irrigation costs, or experienced crop losses due to water quality impacts from the landfill. As noted by FOYC, such impacts are only speculative. A more detailed analysis of actual water quality in the area reveals no such impacts.

135. The record reveals that the analytical results for groundwater samples from compliance monitoring wells indicate that no contaminant releases from the landfill have occurred at the permitted point-of-compliance boundary. The Board finds this evidence to be the most credible evidence in the record relating to groundwater quality because comprehensive groundwater monitoring results are provided to and reviewed by DEQ, which has stated its concurrence with the conclusions based on those results.

136. Stormwater monitoring at Riverbend Landfill has shown concentrations of a limited number of constituents to be over statewide benchmarks. Generally these constituents have been iron and E. coli. However, as the applicant noted, exceedance of a benchmark is not indicative of changes in surface water quality. Rather, when concentrations are found above a benchmark, Riverbend is required to take specific corrective actions to manage the facility's stormwater discharges. Such corrective actions have included operational changes, placing additional erosion controls, and investigating potential sources of elevated constituent concentrations.

137. The Board finds that no impacts to surface water can be attributable to the existing landfill and, therefore, are not likely to be caused by the proposed expansion. Other sources of contaminants in the rural area are not regulated in the same rigorous manner as required for Riverbend and, as a result, water quality in the South Yamhill River watershed is already diminished from those activities. The Board finds that this fact is most evident from the figure Riverbend submitted showing the various pollutants which cause the river to be water-quality limited. That figure clearly shows no incremental impact to the quality of the water as it passes by the landfill.

138. Based on the foregoing and the record as a whole, the Board finds that Riverbend's operations have not forced, and will not force, significant changes to farming practices or the cost of farming practices as a result of impacts to water quality.

3. Air Particulates

139. The Applicant initially identified a potential for impacts to Farm Practices resulting from air particulate emissions. Riverbend's existing landfill, and the proposed expansion, is governed by state regulations controlling air emissions, and Riverbend operates under a "Title V" permit for that purpose. However, the record does not contain compelling evidence that any air particulate from the landfill has or will impact Farm Practices.

140. The lack of impacts from the landfill, as the Applicant notes, likely results from the fact that the overall background air quality in the area is determined by existing farm practices surrounding the landfill. Not only is Riverbend limited in what it can emit, many farm uses, especially ones that involve tilling and disc work common to this area, also produce air particulate emissions. Other farm practices, such as slash burning, similarly result in air particulates. The latter can be observed directly in some of the aerial photographs in the record.

141. The Board further finds that the lack of impacts from air particulate emissions is evidenced in part by the increase in farming activities that have taken place near the landfill. A nearby orchard, for example, has been expanding over the last 20 years, clearly indicating that any impacts from air particulate emissions are too slight to significantly impact Farm Practices. Similarly, new orchards downwind from the landfill have been planted in recent years. Such crops require intensive front-end investments that likely would not be made in the face of any significant impacts from the nearby landfill.

142. Based on the foregoing and the record as a whole, the Board finds that Riverbend's operations have not forced, and will not force, significant changes to farming practices or the cost of farming practices as a result of impacts from air particulate emissions.

4. Traffic

143. Riverbend initially analyzed potential Farm Impacts from traffic generated by the landfill. Uses that create significant changes in traffic volumes on roads used by farming operations could conceivably force significant changes in farm practices or the costs of those practices. The record does contain testimony raising concerns with truck traffic accessing the site, but that testimony is presented as a general concern about traffic patterns and is not presented in relationship to Farm Practices.

144. The Board finds that the lack of traffic impacts from Riverbend is due in part to its direct access to Highway 18. That transportation facility is a high-volume state highway, allowing landfill traffic to access the site from distant areas without having to use smaller, more rural roads that would conflict with farm uses. The Applicant submitted a Traffic Impacts Study confirming that the level of road use by the existing landfill and the proposed expansion accounts for a very minor portion of the total peak hour traffic volumes in the area.

145. Based on the foregoing and the record as a whole, the Board finds that Riverbend's operations have not forced, and will not force, significant changes to farming practices or the cost of farming practices as a result of traffic impacts.

5. Nuisance Birds

146. The applicant acknowledges that the existing landfill attracts some nuisance birds. The proposed expansion is therefore likely to be an attractant as well. As explained in more detail in the findings below, the Board finds that the existing landfill and the proposed expansion may cause some impacts to Farm Practices. However, the Board finds that impacts from birds has not been and will not be significant.

147. Birds attracted to the landfill are primarily corvids, gulls, and pigeons. As described in the record, these birds are all mobile and gather where there are available food sources. The landfill is one of those potential food sources because of the working face, an area of temporarily-exposed waste on which birds can feed. There is no persuasive evidence in the record that nuisance birds are attracted to the landfill for any reason other than the food that is sometimes available at the working face.

148. The landfill is not the only bird attractant in the surrounding area. Other crops, such as food crops, filberts, and grain, also attract large populations of nuisance birds. Further out, other attractant food sources exist, such as grapes at vineyards. Urbanized areas are also major attractants of nuisance birds. In fact, the record indicates that there is a documented increase in nuisance birds throughout the entire Willamette Valley because of increased urbanization.

149. The mere attraction of nuisance birds to the landfill does not indicate whether that attraction rises to a level significant enough to force changes in farm practices or to increase the costs of farm practices. To the contrary, it is undisputed in the record that bird control is an accepted farm practice regardless of the presence of a landfill. The Board must therefore determine if birds attracted to the landfill increase the burden on Farm Practices beyond the burden that would occur in the landfill's absence and, if so, determine whether that increase is significant.

150. It is undisputed in the record that Riverbend must implement bird control measures as part of its DEQ permit requirements. Riverbend has apparently controlled birds using different methods

over the years, and it currently relies on a falconry program that uses birds of prey to scare off nuisance birds and to keep them from making the landfill a long-term foraging area.

151. No participant in this proceeding presented a detailed study of bird populations at the landfill throughout the year. DEQ, however, inspects the site regularly and makes note of bird populations. According to DEQ's observations, large increases in bird populations are seasonal and, therefore, it is not a year-round phenomenon. The Board finds that evidence from DEQ to be credible because it comes from a neutral agency that has the opportunity to make year-round observations. Some testimony in the record criticizes the efficacy of Riverbend's falconry program, asserting that the program simply pushes the nuisance birds onto adjacent farms. In contrast, the bird control company that manages the falconry program at Riverbend indicated that the long-term impacts of the falconry program reduce bird populations in a broad area. The Board finds that testimony more credible because it is offered by an individual who has the opportunity to observe bird populations on a regular basis and in different areas of the County.

152. Other testimony in the record asserts that the number of birds in the area has increased as the size of the landfill has increased. The Board gives that assertion little weight, however, because it fails to recognize the operational realities of the landfill. As noted above, the food source for nuisance birds at the landfill is the working face. Although the mass of the landfill has increased over time, the working face of the landfill does not increase as the size of the landfill increases. Indeed, the record reflects that Riverbend has made operational changes to actually reduce the size of the working face over time. The Board therefore finds that if there has been an increase in nuisance birds in the area, that increase is best explained as a result of other, non-landfill factors.

153. The record contains testimony that birds from the landfill have caused grass seed loss from gulls attracted to the landfill. That testimony asserts that gulls leave the landfill to feed on the grass seed on the neighboring McPhillips farm. Other evidence in the record, however, indicates that gulls do not eat grass seeds as a significant food source. That same evidence indicates that the presence of gulls may actually discourage flocks of geese, which may feed on grass seed as a primary food source. Additionally, the evidence asserting impacts from gulls does not attempt to describe the degree of the alleged impact. For example, there is no indication of the frequency the gulls fed on the seeds, if at all. Nor is there any indication that the farm practices for producing grass seed were forced to change as a result. The absence of such details, in conjunction with other evidence in the record that Riverbend must implement bird control measures and that some amount of bird control is a standard farm practice, does not allow the Board to conclude that significant impacts to Farm Practices have occurred, or will occur, as a result of the landfill's operations. The Board finds no persuasive testimony that other birds will be attracted to the landfill in the future that cannot also be controlled.

154. The record contains additional evidence that casts doubt on bird-related impacts caused by the landfill. For example, information provided by a nearby farmer who operates a filbert orchard adjacent to the landfill, another orchard approximately one mile from the landfill, and a third orchard approximately two miles from the landfill, indicates that he has not observed any greater impacts from birds at his orchard that is adjacent to the landfill. Considering the three orchards, the farmer's experience is that impacts from birds are not related to a farm's proximity to the landfill. The presence of nuisance birds at the orchard near the landfill is consistent with bird

populations at the other orchards, and does not require the farmer to alter farming practices as a result. The Board finds this testimony to be the most useful because it allows a comparison to be made of similar uses at different distances from the landfill. In contrast, testimony from other farmers with only one farm is incapable of providing credible comparisons to other farms.

155. The record contains testimony asserting that nuisance birds have specifically caused increases in the occurrence of coccidiosis. That testimony goes on to claim that the increased occurrence of coccidiosis necessitates an increased use of antibiotics in livestock and more costly treatments from a veterinarian. These are presented as evidence that the Farm Impacts criteria cannot be met because of increased costs to farm practices. For the following reasons, the Board finds that this evidence does not compel the Board to conclude that either the existing landfill or the proposed expansion result in significant impacts to Farm Practices.

156. First, the evidence in the record indicates that coccidia, the protozoa that cause coccidiosis, are "host specific" and, therefore, the type of coccidia birds carry are not the same organisms that cause coccidiosis in various livestock. Second, the evidence in the record indicates that coccidia are prevalent in many species and that accepted farm practices include managing for coccidiosis even in the absence of nuisance birds. The mere occurrence of coccidiosis, or even an increase in the number of cases, may therefore be related to several environmental factors unrelated to the landfill. Third, there is evidence in the record indicating that coccidia have a complex lifecycle making it unlikely that birds that digest infected feces from other animals will spread the disease. That evidence was presented by a licensed veterinarian with experience treating various farm animals, including small ruminants. The Board finds that evidence to be the more credible evidence when compared to the anecdotal evidence claiming nuisance birds have caused increased cases of coccidiosis. Fourth, the testimony claiming cases of coccidiosis have increased around the landfill is not supported by quantitative evidence that allows the Board to assess the degree of the alleged impact. For example, the testimony from McPhillips Farms alleges that operation has spent more on antibiotics, but that testimony does not state how much was actually spent, how much was spent before the landfill began its operations, or how much would be expected to be spent in the absence of the landfill.

157. Based on the foregoing, and the record as a whole, the Board finds that Riverbend's operations have not forced, and will not force, significant changes to farming practices or the cost of farming practices as a result of nuisance birds. The Board's conclusion is based on the weight of all the evidence in the record, some of which does indicate that nuisance birds are capable of causing an impact to some Farm Practices. However, as explained above, the Board finds that any such impacts are either contradicted by other evidence in the record, or the impacts do not reflect a level of significance prohibited by the Farm Impacts criteria. To remove any doubt about the degree of those impacts, however, the Board supports the condition imposed by the Planning Commission denying the portion of Riverbend's application that would have allowed the development of Module 10. By only allowing the expansion in the Module 11 area, any potential impacts from nuisance birds will be reduced with respect to the McPhillips farm, the farm for which most of the impacts from nuisance birds are alleged to have occurred.

6. Rodents

158. Riverbend initially analyzed potential Farm Impacts from rodents. As noted in the initial FIA, however, the presence of rodents is not unique to landfills and is common in rural farm areas. Rodent control, therefore, is an accepted farm practice even in the absence of a nearby landfill. Moreover, Riverbend is required by DEQ to implement rodent control measures as part of its permit obligations. As with other potential impacts, the mere potential for rodents, or even the presence of rodents, is not sufficient to determine whether the Farm Impacts criteria have been met. The Board must determine whether the actual presence of rodents has or will force significant changes in farm practices or increase the costs of those practices.

159. The record contains the results of trapping data collected as part of Riverbend's rodent control measures. Those data show a relatively small number of rodents existing on the site. The absence of rodents is further documented in the DEQ inspection reports included in the record. Specifically, DEQ did not discover rodent issues during any of its inspections over the prior year. The Board finds this testimony to be the most credible because it comes from a neutral agency that has the opportunity to make regular observations of the site.

160. The record contains some evidence alleging that farms near the landfill have been overrun with rats coming from the landfill and that these rats have impacted Farm Practices. For example, McPhillips claims that rats coming from the landfill have so overrun his farmhouse that he cannot employ a farm manager. The Board gives little weight to that evidence for the following reasons.

161. First, the Board finds that housing a farm manager is not an "accepted farm practice" required to be analyzed. A farm practice is a mode of operation employed by the person doing the labor, not the laborer itself. Even if hiring farm labor is a "farm practice," the allegation by the owner of McPhillips Farms is that he cannot house his farm manager, not that he cannot hire a farm manager. There is no evidence in the record that housing a farm manager is either common or necessary. No other farmer providing testimony indicated that he or she must house a farm manager. Moreover, McPhillips indicates that he has a farm manager and that his farm has continued to operate. Housing the farm manager is therefore not "necessary."

162. Second, the McPhillips testimony is not credible. Despite the claim that he cannot house a farm manager, other testimony from McPhillips indicates that he indeed has employed a farm manager who lives in the house. The testimony that there is a rodent problem on the McPhillips' side of the landfill appears to be overstated and is severely undermined by other evidence in the record. Specifically, statements by the owner of an RV park immediately adjacent to the landfill, and closer to the working face, indicate that there have been no rat problems. In fact, that testimony and testimony from individuals opposed to the application claim that the adjacent RV park is in an idyllic and pastoral setting.

163. The record contains an assertion that increased rodent populations caused by the landfill have impacted Double G Paints' horse breeding operation. That testimony specifically asserts that rodents dug holes in that farm's pastures and, as a result, caused a horse to be injured. As described in that testimony, however, the Board finds that there is no connection between the rodents and the landfill.

164. The stated connection between the horse injury and the landfill is not rodents from the landfill. Rather, Double G Paints claims that landfill birds caused kestrels and owls to leave their farm, that the kestrels and owls served to reduce rodent populations, and that the result was an increase in rodents that eventually caused the injury. The Board finds that the chain of connections described in this testimony (landfill, nuisance birds, owls/kestrels, rodents, horse injury) severely reduces the likelihood that the landfill caused the horse injury. As the applicant notes, the underlying ecological conditions associated with the landfill have not changed during the period Double G Paints has been in operation in a manner that would establish a causal connection between the landfill and the horse injury. Double G Paints' testimony indicates the owners moved to the area in 2000. The landfill had already been in operation for nearly twenty years at that point. According to scientific literature in the record, the American kestrel is not long-lived and has a lifespan of less than five years. Similarly, owls with the longest lifespan live for only approximately 13 years. Based on those facts, the owls and kestrels that were present when Double G Paints began operating had taken up residence while the landfill was in full operation and the ecological conditions associated with the landfill were already established. The Board finds that the arrival and departure of kestrels and owls on this property is more likely a result of their natural lifecycle and unrelated to the presence of the landfill. The record also indicates that the owners of Double G Paints were not implementing accepted farm practices necessary for rodent control (such as rodent proof food bins), and instead were relying on natural processes that were subject to change. The Board finds that a change in those natural processes (the departure of the kestrels or owls) is not a change in farm practices.

165. The record contains evidence that rodents from the landfill have caused damage to a nearby filbert orchard. However, the record contains additional evidence that a filbert orchard adjacent to the landfill has experienced no increase in rodent problems as a result of the landfill. That latter testimony is the result of an interview with a farmer that has filbert orchards adjacent to the landfill, one mile from the landfill, and approximately two miles from the landfill. The Board finds that evidence to be more credible because it allows a comparison to be made regarding rodent impacts with respect to proximity to the landfill. Given the relatively small range rodents have that is described in the record, the Board finds it reasonable to conclude that if there have been no impacts to an adjacent filbert orchard, there have not been rodent impacts from the landfill to orchards that are more distant. The Board further finds that the lack of impacts from rodents is evidenced in part by the increase in farming activities that have taken place near the landfill. A nearby orchard, for example, has been expanding over the last 20 years, clearly indicating that any impacts from rodents are too slight to significantly impact Farm Practices. Such crops require intensive front-end investments that likely would not be made in the face of any significant impacts from the nearby landfill.

166. The record does not contain any other credible evidence regarding potential impacts to Farm Practices from rodents caused by the landfill. Based on the foregoing, and the record as a whole, the Board finds that Riverbend's operations have not forced, and will not force, significant changes to farming practices or the cost of farming practices as a result of rodents.

7. Other Alleged Impacts

167. In addition to the specific impacts discussed above, the record contains testimony describing other impacts to Farm Practices alleged to be caused by the landfill that either have occurred, or may occur in the future.

a) Impacts to Pheasant Operations

168. The record contains evidence of alleged impacts to a pheasant operation on the adjacent McPhillips Farm. The alleged impacts to the pheasantry stem from the assertion that noise from the landfill is disruptive to the health of the pheasants. For the following reasons, the Board gives limited weight to that testimony.

169. If a pheasantry on the McPhillips farm existed in the past, it has not been operated recently for profit and has been a hobby use of the McPhillips farm outside the scope of the Farm Impacts analysis. During the Planning Commission proceedings, it was demonstrated that the McPhillips farm did not hold a license from the Oregon Department of Fish and Wildlife ("ODF&W"). Such a license is required for anyone who sells game birds or game mammals. While this matter was under review by the Board, Mr. McPhillips provided a copy of a license from ODF&W for game birds. That license, however, was issued on March 3, 2015, one week before the Board's hearing. Similarly, the only receipt for pheasant meat provided as evidence of the pheasantry is dated March 10, 2015, two days before the Board's hearing. The Board finds that the timing of these items seriously undermines the claim that the pheasantry has existed for seventy years. By his own admission, Mr. McPhillips has only recently constructed pens for pheasants, despite his claim that his farm has been using elaborate pens for decades. Finally, even if the Board accepts that there has been a pheasantry on site, Mr. McPhillips' oral testimony to the Board was that his pheasants will be fine as the landfill continues to operate.

170. Finally, the Board has imposed a condition of review that will prevent Riverbend from constructing Module 10, the only area of the proposed expansion that would have been close to the McPhillips farm. By allowing only the construction of Module 11, this decision will ensure that any potential impacts to pheasants on the McPhillips farm will be reduced or eliminated. Based on the foregoing, and the record as a whole, the Board finds that Riverbend's operations have not forced, and will not force, significant changes to farming practices or the cost of farming practices as a result of impacts to pheasants on Mr. McPhillips' farm.

b) Bank Loans

171. The record contains testimony asserting that the presence of Riverbend Landfill has impacted one farmer's ability to get a loan for his farming operations. For the following reasons, the Board finds that testimony does not support a conclusion that the existing or expanded landfill cause significant Farm Impacts.

172. The Board finds that the process of obtaining a bank loan to support farm activities is not an "accepted farming practice." As described above in Finding 116, "accepted farming practices" are modes of operation necessary for the operation of farms to obtain a profit in money. The proceeds of a loan may be used to fund accepted farming practices, but are not farm practices in and of themselves because they are not a mode of operation. Further, a loan is an economic practice that is unique to any debtor. That is, there is no discernible way based on this record for

the Board to determine whether the proceeds of a loan are used directly in a farming operation, or used in a more ancillary manner such as by adding to the source of funds that pay for commercial operations on a farm. The Board therefore finds that although a farm loan may be common, there is no persuasive testimony in the record that farm loans are necessary for farms to make a profit.

173. Even if the process of obtaining a bank loan can be considered an accepted farming practice, the Board finds that such a practice has not been, and will not be, significantly impacted by the existing landfill or the proposed use. The evidence in the record offered as proof of impacts to bank financing relies in part on a property appraisal of the McPhillips Farms property adjacent to the landfill. The appraisal in question, however, was performed on the assumption that the property would be subdivided and developed with six homes on the subdivided parcels. The alleged reduction in property value was based on Mr. McPhillips' potential inability to actually develop the parcels with houses and the appraiser did not opine on any reduction to the property based solely on its use as farmland. Thus, even if the appraisal were valid, the Board finds that any discussion of the property for use as six home sites is not useful for determining what agricultural loans may be obtained for the property in its current state.

174. The Board further finds that the appraisal is not valid because it makes an "extraordinary assumption" that Mr. McPhillips' property has environmental contamination. As noted by additional documents submitted by STDC's attorney, however, no environmental investigation of Mr. McPhillips' property has occurred and any impacts on loan values are purely speculative at this point. The Board further finds that the statements Mr. McPhillips relies on from the bank did not address whether the landfill had reduced Mr. McPhillips' property value, but addressed whether the bank would value the loan based on the lower of two appraisals when two appraisals exist. The Board finds that the record does not indicate Mr. McPhillips ever actually applied for a loan or that he was offered a loan at a higher interest rate solely because of the presence of the landfill.

175. As an independent basis for rejecting this argument, the Board finds that any impacts to bank loans available to farmers, if they exist at all, are not likely to be significant. This conclusion is based on the fact that other farms in the Study Area are apparently able to finance capital-intensive investments such as the establishment of a filbert orchard. Those investments were either made without a loan, which indicates loans are not a necessary part of a farm's operations, or they were made with a loan, which indicates that loans are readily obtainable for farm operations in the Study Area.

c) Potential Impacts to Farms Beyond One Mile

176. As the Board stated in an earlier finding, its analysis of potential Farm Impacts is based on a review of farm uses in the Study Area, comprised of properties devoted to farm uses within one mile of the existing landfill and the expansion area. The record contains testimony asserting that some impacts from the landfill reach beyond that one-mile area. The Board finds that it is not required to review these impacts because there is no persuasive or compelling evidence that any such alleged impacts are a direct result of the landfill. Even so, and solely in the alternative, the Board makes the following findings as the basis to conclude that neither the existing landfill nor the proposed expansion result in Farm Impacts beyond the Study Area.

177. Testimony from Peavine Valley Stables asserts that the existing landfill has impacted its stable operations because of litter, odor, and rodents. The record indicates the stables are 1.75 north of the Riverbend site.

- With respect to litter impacts, the Board adopts the same findings stated above to conclude that the actual impacts from litter are not significant enough to cause impacts to the stables. At that distance, and in light of prevailing wind patterns in conjunction with intervening factors, the small amount of litter that actually escapes the landfill would not cause significant impacts to this stable operation.

- With respect to odor, the Board finds that there is no credible evidence in the record to indicate that odors from the landfill are the odors causing the alleged impacts at the stables. The stables are in a rural area that generates many offensive odors, and the record indicates the presence of other odor generators in the area, including non-farm odors like the composting facility in McMinnville. Even if an offensive odor in this area could be attributed to the landfill, this testimony asserts that the stables lost the business of a single customer as a result. The Board finds that the loss of one customer is not significant, especially in light of the absence of any testimony describing the number of customers that continue to do business with the stables.

- With respect to rodents the Board adopts the same findings stated above to conclude that the actual impacts from rodents at this distance from the landfill are not significant.

178. Testimony from Crescent Farms identified potential impacts to beef cattle, egg production, meat goats, honey production, and general crops. The record indicates Crescent Farms is just over one mile south of the existing landfill and expansion area.

- The Board finds that the Crescent Farms testimony is based on future, undefined plans to expand the farms operations, specifically with respect to beef cattle, egg production, meat goats, and food crops. The Board finds that the County is required to review only potential impacts on current accepted farming practices and that plans for future farming practices that are not well-developed or only speculative in nature, such as those presented in the Crescent Farm testimony, need not be included.

- The Board finds that the Crescent Farms testimony does not describe any Farm Impacts from the existing landfill and, in fact indicates the absence of such impacts. For example, cows are currently raised on that property without the use of any drugs. The development of Module 11 will move the operation of the existing landfill west, and no farther south than the existing landfill. Additionally, the Board finds that there is no credible evidence in the record to conclude that the number of nuisance birds attracted to the existing landfill will increase with the development of Module 11. The Board therefore finds that the expanded landfill will not increase the potential for any impacts to this property.

- With respect to the apiary on this site, the Board finds that the Crescent Farms testimony does not allege any impacts to the apiary from the existing landfill. As with other testimony in the record relating to apiaries, the issue raised is couched in terms that beehives "could" be impacted by American Foulbrood. However, there is no persuasive evidence that any apiary has actually been impacted in this way. As with other potential impacts, the Board further finds that evidence in the record concerning this potential impact is not substantiated by scientific data. The Board agrees with the applicant that if this risk was a major threat to apiaries, one would expect it to be a topic studied by scientists in the field. To the contrary, a review of the Journal of Apicultural Science in the record indicates no such studies have been published. The Board further finds the evidence provided by opponents to the landfill is from Australia as part of a bulletin guide and does not include scientific data sources for its conclusions. Moreover, the bulletin recommends mitigations such as "cover" to minimize impact potential, and daily cover is a requirement for landfills in Oregon. Additionally, the only apiaries identified in the record are to the south, east, or north of the existing landfill, none of which are will be meaningfully closer to the landfill's operations with the development of Module 11.

179. The record contains testimony asserting that the landfill will have negative impacts on wineries in the area because of diminished views. The Board finds that the operation of a winery is not an accepted farm practice. Although directly tied to agriculture because of the connection to vineyards, wineries are commercial uses. Wineries are among the "non-farm uses" listed in ORS 215.283 and would not be allowed to operate in the EFU zone but for their being listed in that statute. The Board also finds it noteworthy that wineries, like landfills, cannot be permitted unless they also meet the Farm Impacts criteria because those standards are imposed on wineries by operation of ORS 215.452(11). That statute requires counties to apply certain standards to wineries "for the sole purpose of limiting demonstrated conflicts with accepted farming or forest practices on adjacent lands." Pursuant to ORS 215.456, wineries may also be permitted as a commercial use in conjunction with agriculture under ORS 215.283(2)(a), in which case the Farm Impacts criteria also apply. The Board finds that it makes little sense to refer to a use as a "farm practice" when that use itself is permissible only where it must avoid significant impacts to farm practices.

180. Even if the Board were to determine a winery is a farm practice – which it does not – the evidence in the record does not support a conclusion that impacts to wineries have resulted or will result from Riverbend's development proposal. Despite the testimony from a representative from the Willamette Valley Wineries Association that there are 20 vineyards or wineries within a three mile radius of Riverbend, the actual number is five vineyards, three of which have wineries. Additionally, those wineries fall within the outer half of that three mile radius and are not within the Study Area the Board adopts for its Farm Impacts analysis. Among those wineries, only one – Youngberg Hill – has a direct view of the landfill. That winery is also approximately 2.5 miles from the landfill. Contrary to the testimony provided to the Planning Commission, and as documented in Riverbend's rebuttal evidence, that winery receives stellar reviews from its customers who rave about the views from the winery, and since 2011 the winery has annually received an award as a best destination for weddings.

181. The record also reflects that the winery industry has increased significantly in recent decades and has grown in the presence of the existing landfill. The Board finds no credible evidence in the record that a winery has been forced to change any of its practices, or incurred additional costs because of the landfill. Based on the foregoing, the Board finds that Riverbend's operations have not forced, and will not force, significant changes to wineries in the area.

C. Summary of Findings Related to Farm Impacts

182. To summarize the Farm Impacts criteria, the Board finds that neither the existing landfill nor the proposed use force significant changes to farm practices, or significantly increase the costs of those practices, on surrounding lands devoted to farm uses. The Board further finds that the existence of alleged significant impacts to Farm Practices is either not significant under the Farm Impacts criteria or undermined by countervailing and more credible or more persuasive evidence in the record. The Board makes the following additional findings as the basis for the other findings in this section:

183. Evidence in the record regarding diminished water quality is based only on perceived concerns, and there is no credible or persuasive evidence in the record that any farmer has changed accepted farming practices or incurred increased costs because of water quality impacts from the landfill. In contrast, evidence regarding the actual water quality in the area around the landfill demonstrates that the existing landfill has not degraded water quality, that water quality is protected in part by regulations enforced by DEQ, and that Riverbend will have to continue adhering to those regulations with the development of Module 11.

184. The Board finds that there is no cumulative effect to Farm Practices from the landfill. The landfill has been and will be developed in phases, and the level of operations will remain constant over time. As older cells are filled, they are closed and the operations move to newer cells. The size of the overall landfill, therefore, is unrelated to the degree of impacts that would be caused by the landfill at any given time. The Board finds in the alternative that if any cumulative impacts do exist, they have not forced significant changes in farm practices or the costs of those practices. The FIA in the record includes a longitudinal study that clearly shows that the level of farming activities adjacent to the landfill have increased over time. The Board finds that an increase in such activities undermines all claims that impacts from the landfill have increased as the size of the landfill has increased, especially in light of other factors that may also serve as the source of impacts. Further, if any cumulative effect did exist, the Board finds that such a cumulative impact would be mitigated to an acceptable (i.e. non-significant) level by the removal of Module 10 from the site plan. The removal of Module 10 from the site plan will reduce the overall life of the landfill. The remaining life of the landfill with the expansion will be less than the amount of time the landfill has already existed.

185. The Board gives great weight to the fact that the farm economy on lands within three miles of Riverbend has intensified over time. The Board specifically adopts and incorporates the longitudinal study contained in the FIA that documents this fact. The Board finds the facts and conclusion in the FIA to be the most compelling evidence that: (1) the amount of land devoted to farm uses has remained stable over time; (2) new, capital-intensive uses such as filberts have been expanded within one mile of the existing landfill and uses such as vineyards have been

added in the foothills farther out; and (3) no land in the Study Area has been taken out of production.

186. The Board also gives great weight to the fact that the landfill expansion will not alter the level of operations at the site. Specifically, the Board finds that the existing landfill has not forced significant changes in accepted farm practices and has not significantly increased the cost of farm practices. The Board therefore finds that the continued operation of the landfill will not significantly impact Farm Practices because: (1) the volume of waste disposal will remain constant at current levels through the useful life of the expansion; and (2) the landfill is developed through the progressive development of individual disposal cells - as one cell reaches capacity, an adjacent cell is opened and the first cell eventually closes. The result is that the "expansion" of a landfill is actually a shift in the same level of operations from one location to another

V. Floodplain Development Permit

187. Portions of Riverbend's proposed development lie within the County's Floodplain Overlay District. YCZO Section 901 governs development within that overlay and establishes the standards for issuing a Floodplain Development Permit.

188. As an initial matter, the Board finds that the floodplain and floodway maps to be used in the review of a Floodplain Development Permit are the most recent versions of any applicable map approved by the Federal Emergency Management Administration ("FEMA") as part of the National Flood Insurance Program ("NFIP"). YCZO 901.15 expressly acknowledges that FEMA will revise those maps, and the Board finds that the Floodplain Development Permit approval standards can be applied in a meaningful manner only if they rely on the most up-to-date data. The Board makes this finding because much of the testimony in opposition to the Floodplain Development Permit focuses on the historic floodplain. The Board finds that testimony to be irrelevant to the current permit application. The record indicates that Riverbend's prior activities in the floodplain were conducted through a previous Floodplain Development Permit. As the Applicant correctly notes, development in the floodplain is not prohibited, and the fact that there has been prior development in the floodplain in this area is irrelevant to Riverbend's current application.

189. The approval standards for a Floodplain Development Permit are straightforward and technical in nature. These Findings address each of the applicable approval standards below. Some provisions in YCZO Section 901 that are procedural in nature are omitted. The Board finds that the record does not contain any relevant or persuasive testimony alleging noncompliance with the omitted provisions.

A. 901.05 - Floodplain Development Permit Application

190. YCZO 901.05 establishes the type of information that must be included with an application for a Floodplain Development Permit. The Board finds that subsections (A) through (C) of YCZO 901.05 are not applicable to Riverbend's application and, therefore, that information required by those sections was not required to be submitted to the County. Those provisions apply to building structures and not to development consisting only of fill. YCZO Section 202 defines "structure" specifically as that term is used in YCZO Section 901 as "a walled and roofed

building including a gas or liquid storage tank that is principally above ground." The Board finds that no such structures are proposed within any floodplain or waterway subject to Riverbend's application. The record does not contain any testimony asserting that such information should have been provided.

191. The Board finds that Riverbend's application provided the information required to be submitted by YCZO 901.05(D). That provision requires submittal of specific data regarding the extent to which any watercourse will be altered or relocated as a result of the proposed development. The record indicates that earthwork associated with Riverbend's development proposal will occur within the 100-year floodplain of the South Yamhill River, and that the earthwork will result in a net removal of soils from the floodplain. The Applicant provided an Engineer's Certification including data regarding the extent those watercourses will be altered as a result of the earthwork activities.

B. 901.06 - Floodplain Development Permit Criteria

192. YCZO 901.06 sets forth the specific approval criteria for obtaining a Floodplain Development Permit:

> *Prior to issuance of a floodplain development permit, the applicant must demonstrate that:*
>
> *A. The proposed development conforms with the permit requirements and conditions of this section and the use provisions, standards and limitations of the underlying zoning district and other overlay district.*
>
> *B. The proposed development, if located within the floodway, satisfies the provisions of subsection 901.09.*
>
> *C. The proposed development will not increase the water surface elevation of the base flood more than one (1) foot at any point.*
>
> *D. All applicable permits have been obtained from federal, state or local governmental agencies, and all applicable National Flood Insurance Program requirements have been satisfied.*
>
> *E. The proposed development is consistent with policies j. and k. of the Comprehensive Plan, as amended by ordinance 471.*

Policies j. and k. of the Comprehensive Plan, as amended by Ordinance 471, read as follows:

> *j. It is the policy of Yamhill County to protect riparian vegetation from damage that may result from land use applications for development that is otherwise permitted outright or conditionally under county zoning regulations. To achieve this goal, Yamhill County will review land use applications for development in riparian areas in an effort to mitigate or prevent damage to riparian vegetation that might result from the development. For*

purposes of this policy, "riparian areas" refers to areas within 100 feet measured horizontally from the ordinary high water line of streams identified as "Fish Habitat" in the comprehensive plan inventory (Natural Resource Conservation Plan, Yamhill County, Oregon, May 1979 -U.S.D.A. - Soil Conservation Services), that are not regulated under the Forest Practices Act. (Ord 471)

k. It is county policy that land use management practices and nonstructural solutions to problems of erosion and flooding are preferred to structural solutions. Water erosion control structures, including riprap and fill, should be reviewed by the appropriate state permitting authority to insure that they are necessary, are designed to incorporate vegetation where possible, and designed to minimize adverse impacts on water currents, erosion, and accretion patterns.

193. The Board finds that Riverbend's development proposal satisfies YCZO 901.06(A). As stated in the discussion and Findings in Section II, the project is an allowed use in the EFU zoning district as part of a solid waste disposal facility under YCZO section 402.02(V). The Board adopts that discussion and those Findings here by this reference.

194. The Board finds that Riverbend's development proposal satisfies YCZO 901.06(B). The project is not located in the floodway. Further, as discussed in more detail below, the project complies with YCZO section 901.09. The Board adopts that discussion and its related Findings here by this reference.

195. The record contains some testimony questioning whether any portion of the proposed development is within the floodway. However, that testimony is based on outdated FEMA maps. For example, the analysis conducted by T.J. Bossard Engineering, sponsored by opponents to the application, relied on a Flood Insurance Rate Map ("FIRM") dated March 2, 2010. However, the record shows that FEMA has since issued new maps for this portion of the floodplain with an effective date of May 9, 2013, which the Applicant relied on. The Board finds that the evidence based on the more recent maps provides substantial evidence on which it should rely.

196. The Board finds that Riverbend's development proposal satisfies YCZO 901.06(C). As noted above, the Applicant provided multiple Engineer's Certifications. Those certifications indicate the proposed project will not increase the water surface elevation of the base flood more than one foot. In fact, those certifications demonstrate that there will be no rise in the BFE. That conclusion is based in part on the fact that the project involves a net removal of soil from the floodplain and that removal is adjacent to the proposed floodplain encroachment where fill will be added as part of the development.

197. Testimony in the record asserts that the Engineer's Certifications are insufficient. That testimony criticizes the first certification because it does not include the "input data" that led to the conclusions. The Board, however, does not find that such input data is required. The input data comes from FEMA and is publicly available. The Engineer's Certification identified the

source of that data, which was available to others. The certification by the engineer as to the data source and the results is sufficient to serve as substantial evidence for the conclusions that appear in the certifications.

198. Other testimony criticizes the second Engineer's Certification because it allegedly relies on an erroneous fact – a statement that Module 10 was not in the 100-year floodplain. The Board agrees that the statement in the certification that Module 10 is not in the floodplain is unclear. However, the Board finds that statement does not undermine the conclusion of the certification.

199. One reading of that statement in the second Engineer's Certification is that Module 10 was not assumed to be in the floodplain for purposes of the initial Engineer's Certification. If that is true, then the removal of Module 10 from the site plan would bring the site plan into alignment with that initial analysis and the conclusions would be the same. A different reading of the statement is that the second Engineer's Certification incorrectly determined that Module 10 was not in the floodplain and, therefore, did not correctly revise its analysis to reflect the removal of Module 10 from the site plan. However, the Board further finds, as a matter of pure logic, that the removal of Module 10 from the site plan would not result in an increase in the BFE. As shown on the figures provided with the applications, the encroachment into the floodplain in that area involves only fill and there are no excavation activities adjacent to that fill. The removal of Module 10 would result in less fill in the floodplain and any impact to the BFE would result in lesser rise. Because the overall impact with Module 10 was less than the one-foot maximum rise allowed by the Code, the smaller increase resulting from the removal of Module 10 would still be within that limit. The Board also notes that no evidence was submitted to the County indicating that the proposed development would cause any increase in the BFE, much less an increase that exceeds the one-foot maximum allowed by this Code provision.

200. The Board finds that Riverbend's development proposal satisfies YCZO 901.06(D). The Planning Commission imposed a condition, which the Board also includes in this decision, requiring Riverbend to obtain all applicable permits from federal, state, and local governmental agencies before the Floodplain Development Permit will issue. That condition also requires Riverbend to document that all NFIP requirements will be satisfied: Wetland permits for impacts to non-wetland waters will be obtained from the Oregon Department of State Lands ("DSL") and the U.S. Army Corps of Engineers; and additional hydrologic and hydraulic analysis of the proposed project will be conducted by a registered professional engineer to ensure all applicable NFIP requirements have been met. The Board finds that it is possible for Riverbend to obtain these permits and approvals because the record indicates it has done so in the past.

201. The Board finds that Riverbend's development proposal satisfies YCZO 901.06(E) because it complies with Policies j and k of the Comprehensive Plan. With regard to Policy j, the proposed project does require some temporary impacts to existing riparian vegetation in order to restore, enhance, and increase the size of the riparian zone and its vegetation. For example, non-native Himalayan blackberry will be removed and replaced with native species. The record indicates that native trees and shrubs that must be removed to facilitate restoration activities will be salvaged and used during site planting and stabilization where possible.

202. With regard to Policy k, the Board finds that the project has been designed to utilize only non-structural, natural materials to minimize adverse impacts from erosion and flooding. In

particular, the grading plan is designed to greatly attenuate flood velocities such that only planting with grasses and staking with shrubs will be needed to stabilize soils.

C. 901.07 - Floodplain Overlay District General Standards

F. Fills and Levees.

Except for approved relocation of a water course, no fill or levee shall extend into a floodway area. Fills or levees in a flood fringe area shall be subject to the following:

1. *Fills shall consist only of natural materials such as earth or soil aggregate and including sand, gravel and rock, concrete and metal.*
2. *Any fill or levee must be shown to have a beneficial purpose and therefore to be no greater than is necessary to achieve that purpose, as demonstrated by a plan submitted by the owner showing the uses to which the filled or diked land will be put and the final dimensions of the proposed fill.*
3. *Such fill or levee shall be protected against erosion by vegetative cover, rip-rap, bulkheading or similar provisions. No fill or levee shall cause additional flood waters on adjacent land.*

203. YCZO 901.07 sets forth general standards applicable to all development within the Floodplain Development Overlay. The Board finds that the Code provisions of subsections 901.07(A), (B), (C), (D) and (E) are not applicable to this project because they apply to manufactured homes, anchoring, construction of new structures or improvements to existing structures, municipal utilities and services, or subdivisions. Riverbend's development proposal does not propose these types of development, and such developments do not currently exist within the area for which the Floodplain Development Permit would apply. Riverbend indicated in its application that these provisions are inapplicable, and the record does not contain any compelling evidence to the contrary.

204. The Board finds that Riverbend's proposal meets the standard in YCZO 901.07(F). That provision prohibits most development within a floodway. As noted above, no fill is proposed to extend into the floodway area. YCZO 901.07(F) also limits the kinds of materials and protections that can be used for fills and levees. Riverbend's proposal is to use fill that will include only those natural materials listed in the Code. The record further indicates that all fill will be protected from erosion by vegetation, rip-rap, or similar erosion control measures per standard engineering practices. The Board finds that the engineer's hydraulic analysis provided by the Applicant demonstrates that the proposed fills will not cause additional floodwater on adjacent lands. The Board further finds that the record does not contain any compelling testimony specifically asserting that these portions of the standards in YCZO 901.07(F) have not or cannot be met.

205. YCZO 901.07(F) also requires a showing that fills or levees will have a beneficial purpose. The Board finds that Riverbend's proposed fill will have the beneficial purposes of allowing the enhancement and expansion of the existing landfill. The Board finds that the County has on multiple occasions determined that the continued operation of the landfill is important and

beneficial to the citizenry of the County, and that the fill activities Riverbend proposes are necessary for that purpose.

D. 901.08 - Specified Standards for Areas Where Base Flood Elevation Data are Available

206. The Board finds that YCZO 901.08 does not apply to the proposed project. That Code provision establishes standards in the FP Overlay District for the development of residential structures, manufactured homes, non-residential structures, or recreational vehicles. Riverbend's proposal does not include any such structures or vehicles. Riverbend indicated in its application that these provisions are inapplicable, and the Board finds that the record does not contain any compelling evidence to the contrary.

E. 901.09 - Floodway or Watercourse Development Provisions

207. YCZO 901.09 sets forth provisions further limiting development in the floodway and additional procedural requirements for the alteration of a watercourse. The Board finds that YCZO 901.09(A) is not applicable. That provision applies only where dwellings or other structures are proposed within the floodway, and Riverbend's proposal does not include either. Riverbend indicated in its application that these provisions are inapplicable, and the Board finds that the record does not contain any compelling evidence to the contrary.

208. The Board finds that YCZO 901.09(B) is not applicable. This provision applies only where development is proposed in the floodway. Although this provision is not applicable, Riverbend provided the County with a hydraulic analysis demonstrating that the proposed project will not result in any increase in flood levels during the occurrence of the base flood discharge.

209. The Board finds Riverbend's development proposal satisfies the approval standard in YCZO 901.09(C). The record indicates the proposed project will alter the un-named tributary in the stream reach south of Module 11 as a consequence of channel restoration and enhancement. Specifically, channel width and sinuosity will be increased. As noted above in Finding 196, however, the project will result in either no-rise or a slight reduction in the BFE.

210. Because of the alteration to that watercourse, YCZO 901.09(C) requires notice by the County to certain entities. Riverbend has indicated it will assist the County in notification of DLCD and all other applicable local, state, and federal agencies, including the Federal Insurance Administration. Further, as required by the conditions of approval, Riverbend must obtain all applicable state and federal permits. The record indicates that Riverbend will maintain the restored and enhanced watercourse such that the base flood elevation will not increase above the existing level.

F. 901.10 - Review of Permits in Generalized Floodplain Areas

211. The Board finds that YCZO 901.10 does not apply to the proposed project. That Code provision applies only where specific flood elevation data are not available. Specific and detailed flood elevation data are available and incorporated into the flood elevation modeling for Riverbend's development proposal. Riverbend indicated in its application that these provisions are

inapplicable, and the Board finds that the record does not contain any compelling evidence to the contrary.

G. 901.12 - General Requirements

212. YCZO 901.12 sets forth specific requirements that apply to a Floodplain Development Permit after it is issued.

213. The Board finds that YCZO 901.12(A) is not an approval standard. Rather, this Code provision states the legal effect of a Floodplain Development Permit.

214. The Board similarly finds that YCZO 901.12(B) is not an approval standard. Rather, this Code provision states the legal effect of a Floodplain Development Permit and states that a Floodplain Development Permit becomes null and void 180 days from the date it is granted unless substantial construction has taken place. Riverbend's proposal involves construction that is anticipated to occur over a period of time to accommodate a phased approach to the development of individual disposal cells. Riverbend has therefore requested that the permit be issued with the understanding that substantial construction of the first disposal cell will constitute substantial construction of the entire project as proposed. The record does not contain any testimony opposing this request or offering a reason why the County cannot approve this request. The Board finds that, given the magnitude of the project, it is likely that Riverbend will not complete all floodplain alterations within 180 days of permit issuance due to additional required permitting processes and the relatively short construction season that exists each year. The Board therefore finds that the floodplain development permit will be valid for 180 days from the time it issues and Riverbend's request to deem development of the first disposal cell as substantial construction of the entire project for purposes of this Code provision.

215. The Board finds that YCZO 901.12(C) and (D) are not applicable to this application. Those provisions apply only to new or substantially improved structures or new or substantially improved floodproofed structures. Riverbend's proposal, however, does not include the development of any structures as that term is defined for YCZO Section 901. Riverbend indicated in its application that these provisions are inapplicable, and the Board finds that the record does not contain any compelling evidence to the contrary.

216. The Board finds that YCZO 901.12(E) is an obligation of the County and not of the Applicant. This Code provision, therefore, is not an approval standard.

VI. Conditions of Approval

217. As part of its approval of Riverbend's applications, the Planning Commission imposed several conditions. The Board has reviewed those conditions in conjunction with the record in this matter. With some modifications, the Board finds that the Planning Commission's conditions of approval should continue to be part of the County's final decision approving Riverbend's applications. Those conditions of approval are set forth below, followed by a brief explanation of their purpose.

> <u>Condition #1</u>: The development shall substantially conform to the revised site maps submitted with this application (see maps dated

March 2015 labeled Figure 1 through Figure 4 (Revised) and Drawing No. A-1 through A-7 (Revised)).

218. As noted above in Finding 110, the Code's Site Design Review provisions allow the County to deem the Preliminary Site Development Plan as the Final Site Development Plan. During these proceedings, the Applicant suggested some modifications to the Preliminary Site Development Plan, such as altering the location of the perimeter berm on Highway 18. Additionally, the Planning Commission imposed a condition of approval that prohibits the development of Module 10 and, therefore, necessitates a modification to the Preliminary Site Development Plan to remove Module 10.

219. Subsequent to the Planning Commission's decision, and before the Board's hearing in this matter, on March 4, 2015 Riverbend submitted a new site plan that reflects all of the changes to the Preliminary Site Development Plan that result from the Planning Commission's approval. Because the Board is approving the Planning Commission's decision without imposing additional conditions that necessitate further modifications to the site plan, the Board finds that the site plan as described in this condition is the Final Site Development Plan pursuant to YCZO 1101.03(B).

> Condition #2: There shall be no disposal of solid waste into proposed Module 10.

220. Riverbend's Preliminary Site Development Plan proposed development of Module 10, a new landfill disposal area that would be developed to the north of the existing facility. As proposed, Module 10 would be closer to the immediately-adjacent farm to the north. Further, although Module 10 would not have been any closer than the existing landfill is to the farms to the northeast, east and south, the working face of the landfill would have been slightly closer to the north and northeast than it currently is.

221. The record does not contain any testimony from the owner of the farm immediately adjacent to the north of the existing facility, but it does contain testimony from the owner of the farm to the northeast and property owners farther to the north alleging impacts that would result from Module 10. Although the Board finds that Module 10 would not force significant changes in farm and forest practices, or significantly increase the cost of those practices, the Board finds that removing Module 10 from the site plan will remove any doubt about the existence or significance of such impacts. With this condition, the expansion area will move closer only to Highway 18 and the farms to the west and southwest, where there are fewer alleged impacts and in the direction where Riverbend owns lands that serve as "buffers" between the landfill and surrounding areas.

> Condition #3: The maximum allowed height of the landfill expansion shall not be greater than 286 feet AMSL. This is the permitted height of the existing landfill.

222. Riverbend's Preliminary Site Development Plan and the Final Site Development Plan incorporate a maximum landfill height of 286 feet above mean sea level. The public's comments on the site plans, and therefore the County's review of the site plans, are therefore based on that

height. The Board therefore imposes this condition to limit the height of the landfill to 286 feet above mean sea level.

> Condition #4: No buildings or structures have been approved through this Site Design Review approval. Any future building or structures will be required to receive approval for a Site Design Review.

223. Neither the Preliminary Site Development Plan nor the Final Site Development Plan proposes new buildings or structures. Testimony in opposition to Riverbend's applications urges the County to require Riverbend to present plans for a Green Technology Facility as part of this process. As noted elsewhere in these findings, Riverbend is not required to develop or otherwise obtain approval for a Green Technology facility except as provided in Condition of Approval #7 of Ordinance 887. This condition clarifies that Riverbend will have to seek Site Design Review approval for any building or structure not shown on the Final Site Development Plan pursuant to YCZO Section 402 and Section 1101.

> Condition #5: Prior to the development of Module 11, and prior to the enhancement of Modules 1, 2, 3, and 9, the applicant shall obtain approval from the Department of Environmental Quality (DEQ). In the event approval by DEQ or other agencies requires a revision or modification to the Final Site Development Plan approved by Yamhill County, the applicant must obtain approval from the County for the revision or modification as provided by Section 1101 of the Yamhill County Zoning Ordinance.

224. As stated elsewhere in these findings, this approval will result in the enhancement and expansion of the existing landfill, an allowed use pursuant to YCZO 402.02(V). The enhancement will occur on the south side of the existing facility where the perimeter berm will be modified to allow additional waste to be placed in the areas currently occupied by Modules 1, 2, 3, and 9. The expansion will occur on the west side of the existing facility where new disposal cells will be created.

225. As further stated in Findings 105, the development of Module 11 is a permitted use only where DEQ has issued a solid waste disposal permit. This condition clarifies that although the County is approving the use pursuant to its land use regulations, Riverbend must obtain a DEQ permit for the use prior to actual development of Module 11. This condition further clarifies that if the permitting process, by DEQ or any other agency, necessitates a change in the Final Site Development Plan, Riverbend will have to return to the County to seek Site Design Review approval for those changes utilizing the Site Design Review process set forth in YCZO Section 1101.

> Condition #6: New Perimeter berms must be designed and constructed to meet the seismic design criteria for the magnitude 9.0 earthquake outlined in the Oregon Resilience Plan. Except as provided in condition 8.d, new perimeter berms must be developed

in phased segments as reflected in a site development plan approved by the Oregon Department of Environmental Quality.

226. As stated in Finding 71, the County does not have its own seismic design standards for the kind of development proposed in Riverbend's applications. However, the Site Design Review Code provisions do require the County to consider potential problems that result from development in hazard areas, including seismic zones. Having taken seismic issues into consideration, the Board finds that DEQ's enforcement of its own seismic regulations will limit potential problems that may result from development in a seismic zone. Further, in Finding 73, the Board concludes that the record indicates the existence of other guidelines, such as the Oregon Resilience Plan, that encourage developers to plan for a magnitude 9.0 earthquake. The Board is therefore imposing this condition to require Riverbend to design new perimeter berms to meet seismic design criteria for the magnitude 9.0 earthquake outlined in the Oregon Resilience Plan.

Condition #7: Roads, fences, lighting, and signage shall be designed and constructed to minimize their visual impact as set forth in this condition. All construction activities shall be screened to the maximum extent practicable from neighbors and travelers on State Highway 18. Prior to placing waste in Module 11, and prior to the enhancement of Modules 1, 2, 3, and 9, the owner shall establish or maintain, as applicable, vegetation and other screening that limits views of solid waste disposal operations in the following manner:

a. The existing landscaping along Highway 18 shall be protected from damage and shall be maintained by the applicant.

b. The existing trees on Tax Lot 5501-101 shall be retained as a visual buffer.

c. To assure the minimum number of trees are removed, the stand of trees that are shown as subject to removal along Highway 18 (where the applicant plans to install a bridge over the creek) shall be marked, inspected and approved by the Planning Director, or his designee, prior to their removal.

d. The 30-foot high Module 11 berm along Highway 18 shall be landscaped within a year of its construction and shall be constructed of material that allows the plants to thrive. The landscaping shall be substantially the same as shown on Revised Drawing No. A-6 of the application in a somewhat random manner to give a natural appearance. Tree species planted for screening shall be sized and selected to achieve an effective visual screen of at least 15 feet in height within 10 years of planting. Trees shall be native, 5 gallon or larger when planted, and spaced appropriately for a natural, filled-in appearance. Trees and landscape plants planted on the berm shall be enhanced with irrigation and regular

maintenance during the first four year establishment period, during which period dying trees or landscape plants shall be promptly replaced with material of like size.

e. Any lighting used for either temporary or permanent illumination shall be placed, shielded or deflected so as not to shine onto adjacent dwellings, or create excessive glare along adjacent roads.

f. The colors of fencing, tarps and other manmade screening materials shall be selected so they blend in with the natural environment.

g. A maintenance agreement shall be signed between the applicant and Yamhill County covering all landscaped areas for the first four year establishment period and subsequent years.

227. As discussed in the Findings in section III, the Code's Site Design Review provisions require the County to consider whether a site plan provides adequate visual buffering. As further discussed in those findings, the Board finds that the Final Site Development Plan provides adequate visual screening. Although these conditions are not necessary to meet any particular approval standard, this condition is imposed as part of the county's consideration of the public comments received to enhance the visual buffering originally proposed as part of the Preliminary Site Development Plan.

Condition #8: The roadway that is proposed to be constructed on the perimeter berm parallel to Highway 18 shall include elements to screen the lights of vehicles using this roadway from view by vehicles driving along Highway 18.

228. As discussed in the Findings in section III, the Code's Site Design Review provisions require the County to consider traffic safety when reviewing a site plan. As further discussed in those Findings, the Board finds that the Final Site Development Plan reflects a strong consideration of that factor. At the request of one commenter, the Planning Commission imposed this condition and the Applicant did not object. Although this condition is not necessary to meet any particular approval standard, it is imposed as part of the county's consideration of the public comments received and will enhance the level of traffic safety originally proposed as part of the Preliminary Site Development Plan.

Condition #9: Prior to use of the expansion area, the owner shall obtain confirmation from the McMinnville Rural Fire Chief that the water supply and site access satisfy minimum safety standards.

229. Although this condition is not necessary to meet any particular approval standard, it is imposed as part of the county's consideration of the internal circulation related to the site plan and will help maintain the adequacy of the internal circulation originally proposed as part of the Preliminary Site Development Plan.

> Condition #10: Five years prior to the landfill reaching capacity, the applicant shall submit a post-closure plan to DEQ consistent with ORS 459.055. The final cover plan shall include contour grading of slopes to give a more natural appearance.

230. As stated in the Findings in section II, the development of Module 11 is a permitted use only where DEQ has issued a solid waste disposal permit. Part of the overall DEQ permitting process includes a requirement for submittal of an application for a closure permit at least five years before the anticipated closure of the landfill consistent with DEQ regulations, including a closure plan and the requirements of ORS 459.055. This condition clarifies that although the County is approving the use pursuant to its land use regulations, Riverbend must continue to obtain the appropriate DEQ permit after the actual development of Module 11.

> Condition #11: The applicant shall comply with DEQ noise standards required in ORS Chapter 467 and administrative rules in OAR 340 Division 35. The applicant shall submit an annual noise report to the Planning Director showing compliance with these standards.

231. As discussed in the Findings in section III, the Code's Site Design Review provisions require the County to consider whether a site plan provides adequate noise buffering. As further discussed in those findings, the Board finds that the Final Site Development Plan provides adequate noise buffering. The applicant demonstrated the adequacy of noise buffering and the feasibility of complying with DEQ noise standards in part by submittal of a noise study that concludes that the noise impacts from the expansion area will meet those standards. Although this condition is not necessary to satisfy any particular approval standard, it will provide a mechanism for the County and the public to determine whether Riverbend is meeting DEQ noise standards.

> Condition #12: The public hours of operation for the landfill shall continue to be limited to Monday through Friday from 6 am to 5 pm, 7 am to 4 pm on Saturday, and closed Sundays.

232. As part of its consideration of whether the Final Site Development Plan contains adequate noise buffers, the Board's findings in section III rely in part on Riverbend's current operating hours. The Board therefore finds that Riverbend should not change its current operating hours and imposes this condition for that purpose.

> Condition #13: The operator shall provide "smart" back-up alarms on all loaders and dozers that operate at the site. ("Smart" back-up alarms are those that only emit backing alarm noises when they sense an object in their path, with the alarm increasing in volume as the distance to the object is reduced.)

233. As discussed in the Findings in section III, the Code's Site Design Review provisions require the County to consider whether a site plan provides adequate noise buffering. As further discussed in those findings, the Board finds that the Final Site Development Plan provides adequate noise buffering. These conditions are not necessary to meet any particular approval standard, but are

imposed to enhance the noise buffering and minimization originally proposed as part of the Preliminary Site Development Plan.

> Condition #14: Prior to issuance of the floodplain develop permit, the applicant shall obtain any required permits from the Corps of Engineers and Oregon Department of State Lands. Copies of these permits shall be submitted to the Planning Director.

234. As discussed in the Findings in section V, the Code's Floodplain Development provisions require the developer to obtain all necessary federal, state, and local permits. Thus, while the Board is approving Riverbend's Floodplain Development Permit, that permit cannot issue until Riverbend obtains other required permits. The Board imposes this condition to ensure that the Floodplain Development Permit is not issued by the Planning Director until the Director has received confirmation that Riverbend has obtained all necessary permits.

> Condition #15: Removal of existing riparian vegetation within the Riparian Corridor shall be the minimum necessary to allow for development of the berm and the enhancement projects. Any disturbed areas outside the footprint of the berm shall be restored with fill and native plants.

235. As discussed in the Findings in section III, the Final Site Development Plan allows Riverbend to develop within the Riparian Area. That development includes the actual footprint of the berms necessary for waste disposal or the access road, but also includes earthwork activities related to the floodplain enhancement project. The purpose of this condition is to clarify that the only removal of riparian vegetation allowed by this decision is where such removal is necessary to develop the berms or the enhancement projects. The Board finds that if any additional areas of riparian vegetation are disturbed from those activities, Riverbend must replace that vegetation to ensure the removal is not permanent.

> Condition #16: All fill used for the construction of the berms proposed in the Floodplain Development Permit Application Narrative shall comply with the requirements of 901.07(F) (1)-(3) of the Yamhill County Zoning Ordinance.

236. As discussed in the Findings in section V, the Code's Floodplain Development Permit provisions allow only certain types of fill to be used in the floodplain. This condition is imposed to provide notice to the Applicant and to the public that only materials specified in the ordinance are allowed to be used as fill in the floodplain.

> Condition #17: To supplement Condition #4 in the Limited Use Overlay applied by Ordinance 887, any activities that would occur on the property identified for future "Green Technology," such as temporary construction support or operational support, shall not prevent the use of that site for future alternative technology.

237. As part of Ordinance 887, the County's ordinance changing the zoning of the site, the County applied a Limited Use Overlay to Riverbend's properties that limits the activities that can occur

on the property that has been identified for the location of a Green Technology facility in the future. As part of the current development proposal, Riverbend will develop a road from the landfill portion of the property to the Green Technology portion of the property. While that road is intended to serve as the eventual access road to the Green Technology Facility, it will also be used to access existing facilities on the landfill portion. The Board imposes this condition to ensure Riverbend's planned use of that road and any portion of the Green Technology portion of the property do not prevent the eventual development of the Green Technology facility.

> Condition #18: The applicant shall apply for site design review for construction of the Green Technology Facility no later than 150 days before the construction is required to begin under Condition of Approval 7 of Ordinance 887.

238. Condition of approval 7 of Ordinance 887 requires Riverbend to commence construction of a Green Technology Facility by a certain time period. The County's approval of Riverbend's application does not alter that condition of approval. In order to commence construction of the Green Technology Facility, Riverbend will have to seek Site Design Review approval, which the County has 150 days to process. This condition is not necessary to satisfy any approval standards, but is imposed to further promote the establishment of the Green Technology Facility by the applicant in a timely manner.

> Condition #19: As part of its Title V air quality permit, the applicant is required to implement a Dust Control Plan and Final Odor Control Compendium. The applicant shall continue to implement those operating and control practices to reduce fugitive dust and odor from its operations as required by DEQ.

239. As discussed in the Findings in section IV, the record contains testimony asserting that odors from the existing landfill has impacted, or will impact, Farm Practices and other uses in the area. As further discussed in those Findings, the Board finds that the existing landfill has not forced significant changes in farm practices or significantly increased the costs of those practices as a result of odor impacts. The Board further finds that odor from the landfill is controlled in part by DEQ regulations. The Board therefore imposes this condition of approval to further ensure that odors from the site remain controlled and, therefore, reduce the likelihood of any impacts to Farm Practices or other uses in the area.

> Condition #20: Upon the disposal of solid waste into Cell 11, the applicant shall take a downwind reading of odor using an olfactometer each weekday, excluding holidays. The readings shall include the location, weather conditions, precipitation, wind direction and wind speed. The readings shall be provided to the Planning Director on a monthly basis.

240. As discussed in the Findings in section IV, the record contains testimony asserting that odors from the existing landfill have impacted, or will impact, uses in the area and/or Farm Practices. As further discussed in those Findings, the Board finds that the existing landfill has not forced significant changes in farm practices or significantly increased the costs of those practices as a

result of odor impacts. The Board finds that the record indicates that odors detected in the McMinnville area may be caused by multiple sources. This condition is not necessary to satisfy any particular approval standard, but will provide a mechanism for the County and the public to evaluate sources of odors over time.

> Condition #21: Modification of any of the above conditions requires approval under Section 1101.02 of the Yamhill County Zoning Ordinance. Violation of any of the above conditions may result in revocation of the site design review permit with the process detailed in Sections 1101.06 and 1101.07 of the Yamhill County Zoning Ordinance.

241. This condition is imposed to provide notice to the Applicant and to the public that the County must review and approve modifications not only to a Final Site Development Plan, but to all conditions of approval. Such modifications are processed through the normal Site Design Review procedures.

VII. Procedural issues.

242. Ex parte Contacts. Questions were raised during the proceedings regarding ex parte contacts, and potential bias arising from ex parte contacts. In response to those questions, at the public hearing on March 12, 2015, Board members placed in the record the substance of communications they had received or had engaged in with the applicant and/or opponents. At, and following the hearing, comments were received regarding the statements placed in the record, and the announcement of those statements made at the hearing. To address those comments, the Board reopened the record to place additional statements regarding the substance of their contacts with the parties or others and to allow an additional period of time for parties or others to rebut the substance of those communications. Opponents, especially Stop the Dump, continued to argue that the county has not followed applicable procedures regarding ex parte contacts.

243. The county has considered the arguments of the opponents regarding ex parte contacts, and rejects claims that the opponents have somehow suffered prejudice due to the process followed by the county. Riverbend Landfill is a high-profile land use topic in Yamhill County. The applicant has consistently promoted itself as a good corporate citizen, and has engaged in a dialogue with the community regarding Riverbend Landfill. Waste Management has most recently promoted a $150,000 grant program, under which $15,000 was offered to each of the ten cities in the county for economic development. While the grant program drew media attention and was characterized by opponents as akin to a bribe, it is not clear who opponents believe was being bribed, since county government received none of the money, and neither did any elected official. All of the money was offered to cities in the county that do not have a decision making role with regard to Riverbend Landfill.

244. The county rejects claims by opponents that the involvement of one of its commissioners with the grant program constituted an ex parte contact that prejudiced the substantial rights of opponents or resulted in bias. The commissioner who was eventually accused of bias, in response to a public records request, released all of his e-mail communications with an employee

of Waste Management, and those e-mails were placed in the record. Those e-mails demonstrate that almost no conversations or other communications of substance occurred between the commissioner and the applicant's employee regarding the application filed by Riverbend in November, 2014. The commissioner denied having had substantive conversations other than those outlined in the e-mails, and denied having substantive conversations with Waste Management executives at a social function attended by numerous public officials from Yamhill County. The opponents provided no substantial evidence that any substantive conversations took place that were capable of being rebutted, regarding the applications for Site Design Review and Floodplain Development.

245. As for claims regarding the other commissioners and their ex parte contacts: The record shows that the county was conscientious in attempting to limit ex parte contacts, and to place in the record the substance of the contacts that took place. In 2014, two of the commissioners who were responsible for reviewing Riverbend's applications ran for election. One received more than 50% of the vote in the primary, and was appointed early. The other commissioner was not elected until November, 2014, and took office in January, 2015. During the election, it would have been impossible for the commissioners to have avoided hearing opinions about Riverbend Landfill, one of the biggest topics of conversation in Yamhill County during 2014. All commissioners were warned to attempt to limit ex parte contacts and to be prepared to place them in the record and allow rebuttal. Some opponents also contacted the board directly, and those comments were placed in the record to allow rebuttal by opponents or the applicant. Newspaper articles were also written regarding the landfill and the applications, the process the Applicant has gone through in its efforts to obtain land use approvals, and the landfill's future. Those articles that may have been viewed by Board members were also placed in the record so that parties could rebut their substance. It should also be noted that no party has provided any evidence that any contact or the substance of any contact reported was not of information that is already in the very extensive record of this proceeding. No effort has been made to hide or exclude any information presented—it has all been placed before the board and the public to allow a full discussion of its substance.

246. Landfill Site Visits. At the March 12, 2015 hearing, Planning Director Mike Brandt described site visits to the landfill that each commissioner had made individually, with the Planning Director. He stated the following:

> "Just for the record a couple more items that are of an ex parte nature. You can hear me, I'm sure, Right? Ok, great. A couple more items. One is, because of the attention that this has received in the newspapers and etcetera, we're entering into the record some newspaper articles and letters to the editor, from the News Register and that is in an abundance of caution in case the commissioners have seen these. Which there is a good chance they have because you walk down the street and you see them.
>
> The second item has to do with site visits on land use applications. The Board of Commissioners always likes to go and view the site of the, of the subject property. In this case that was no distance, or no difference. For the record, on three separate dates, I accompanied an individual Board of Commissioner to Riverbend Landfill for the purpose of doing a site visit in preparation for this application and

this hearing today. On February 20th at 9:00 a.m., I visited the site with Commissioner Primozich. On March 6th at 10:00 a.m., I visited the site with Commissioner Starrett and on March 9th at 9:00 a.m. I visited the site with Commissioner Springer. This, I'm going to give you a brief outline of what took place at all of those visits for the record. What we did was, we met in the parking lot outside of the office at Riverbend Landfill. Jackie Lang was there. She handed out safety gear, a hard hat, a safety vest and then she just made a comment that she was not able or shouldn't talk to the commissioners and she left and went back in the office. In addition, there was a person there on all three occasions who had a falcon. They were standing there and I don't, I never got the person's name. I think, I don't even know if it was the same person each time. And in addition, Mr. Bill Carr from Riverbend was there. Mr. Carr escorted us on the site visit as a matter of safety. Primarily, he walked in front of us and warned us of oncoming trucks and things like that. Because we were walking out where Module 11 is proposed to be expanded into. Along the walk, I would point out the proposed perimeters of Module 11 and I would answer questions from the commissioners that would come up about where the perimeter berm was going to be, what was the height of the landfill going to be, what was the slope of the landfill going to be, etcetera. We ended up walking along the west side of the MSE berm on the gravel road that's already there and we ended up at the leachate pond. When we got to the leachate pond on all three occasions, the commissioners asked questions about the function and capacity and, of the leachate pond. In those instances Mr. Carr briefly explained what the leachate pond was for, its capacity, the number of trucks that were hauling leachate out of there. Nothing that he answered the Board was something that was not already in the record. We then, after those questions were answered, we walked back to the office, handed our safety gear to Bill Car and then we left the site. So...

Allen Springer: Ok. At this point is there any other comment that the commissioners would like to make about the visit? Seeing none, we will move on to the, to the reading of the statement.

Todd Sadlo: Any other ex parte comments from anybody else?

Allen Springer: Ok. Is there any other ex parte contacts? Ok, alright, seeing none we will move on to item 3."

247. Due to ongoing objections from opponents and an additional, new claim of ex parte contact that apparently occurred between a commissioner and an appraiser hired by an opponent, the record was re-opened on March 26, 2015, at which time commissioners entered a second statement of communications and an acknowledgement that Mr. Brandt's description of the substance of contact that occurred with a representative of the applicant at the site visits was accurate. The record remained open to allow written rebuttal of the statements announced and placed in the record on March 26. At no time did any commissioner indicate his or her disagreement with any of the statements regarding the landfill made by the Planning Director.

248. YCZO section 1402.06, entitled "Ex Parte Contact," states:

> "in any land use application subject to a quasi-judicial hearing process, the Board, Commission, or Hearings Officer shall not:
>
> A. Communicate, directly or indirectly, with any party or his representative in connection with any issue involved except upon notice and with opportunity for all parties to participate;
>
> B. Take notice of any communication, reports, staff memoranda, or other materials prepared in connection with the particular case unless all parties are afforded an opportunity to contest the materials so noticed; or
>
> C. Inspect the property with any party or his representative unless all parties are given such notice as the Board determines fair and just."

249. It was noted on the record that an employee of Riverbend was present at the site visit of each of the commissioners. At the time, no notice was given to "all parties" because it was not anticipated that the commissioners would have any contact with Riverbend employees during their individual site visits. The contact that occurred was inadvertent and unplanned. The substance of the comments concerned the leachate pond, which is an existing facility at the landfill that is not being modified or affected by the expansion or any other aspect of the applications before the county. The landfill is currently in operation, and it was necessary to have an employee present for safety reasons. As described by Mr. Brandt on the record, (discussed above) for the most part, the employee walked ahead of the group, and questions were answered only by the Planning Director. At some point, near the leachate pond, each board member asked questions of the employee regarding the pond. As placed in the record, the employee "briefly explained what the leachate pond was for, its capacity, the number of trucks that were hauling leachate out of there. Nothing that he answered the Board was something that was not already in the record."

250. The Board interprets YCZO section 1402.06 as generally reflecting state law regarding ex parte contacts in quasi-judicial land use proceedings. Subsection C prohibits decision makers from inspecting "the property with any party or his representative unless all parties are given such notice as the Board determines fair and just." In this case, no notice was given, because there was no intent to inspect the property "with any party or his representative." The contact was inadvertent and, under the circumstances, no notice was required because no substantive contact with the applicant was anticipated. The Board was, logistically, not in a position to give notice and presumably allow other members of the public to attend the tour of a privately owned and operated facility. The Board believes that the process it has always followed—of making a site visit with the Planning Director or his designee, with limited or no contact with the applicant or the applicant's representative, and then placing the substance of the visit and of any contacts inadvertently made on the record—is fair, just, and incompliance with the intent of section 1402.06 as interpreted by the Board.

251. Bias. The opponents, and especially Stop the Dump, made repeated demands during the proceedings that one of the commissioners (the one that voted against the application) should recuse himself due to bias. The commissioner stated on the record his belief that he could fairly and impartially consider the application, and did not recuse himself. The Board has considered,

and rejects the claims of opponents that any of the commissioners are biased, had prejudged the application, or were incapable of considering the facts in the record and applying the applicable standards in a fair and impartial manner.

VIII. Conclusion

Based on these findings, the Board approves the applications in Planning Dockets SDR-16-14 and FP-03-14.

Exhibit B - Board Order 15-115
Conditions of Approval
Planning Dockets SDR-16-14 and FP-03-14

The County hereby imposes the following conditions of approval:

1. The development shall substantially conform to the revised site maps submitted with this application (see maps dated March 2015 labeled Figure 1 through Figure 4 (Revised) and Drawing No. A-1 through A-7 (Revised)).

2. There shall be no disposal of solid waste into proposed Module 10.

3. The maximum allowed height of the landfill expansion shall not be greater than 286 feet AMSL. This is the permitted height of the existing landfill.

4. No buildings or structures have been approved through this Site Design Review approval. Any future building or structures will be required to receive approval for a Site Design Review.

5. Prior to the development of Module 11, and prior to the enhancement of Modules 1, 2, 3, and 9, the applicant shall obtain approval from the Department of Environmental Quality (DEQ). In the event approval by DEQ or other agencies requires a revision or modification to the Final Site Development Plan approved by Yamhill County, the applicant must obtain approval from the County for the revision or modification as provided by Section 1101 of the Yamhill County Zoning Ordinance.

6. New perimeter berms must be designed and constructed to meet the seismic design criteria for the magnitude 9.0 earthquake outlined in the Oregon Resilience Plan. Except as provided in condition 8.d, new perimeter berms must be developed in phased segments as reflected in a site development plan approved by the Oregon Department of Environmental Quality.

7. Roads, fences, lighting, and signage shall be designed and constructed to minimize their visual impact as set forth in this condition. All construction activities shall be screened to the maximum extent practicable from neighbors and travelers on State Highway 18. Prior to placing waste in Module 11, and prior to the enhancement of Modules 1, 2, 3, and 9, the owner shall establish or maintain, as applicable, vegetation and other screening that limits views of solid waste disposal operations in the following manner:

   a. The existing landscaping along Highway 18 shall be protected from damage and shall be maintained by the applicant.

   b. The existing trees on Tax Lot 5501-101 shall be retained as a visual buffer.

   c. To assure the minimum number of trees are removed, the stand of trees that are shown as subject to removal along Highway 18 (where the applicant plans to

install a bridge over the creek) shall be marked, inspected and approved by the Planning Director, or his designee, prior to their removal.

d. The 30-foot high Module 11 berm along Highway 18 shall be landscaped within a year of its construction and shall be constructed of material that allows the plants to thrive. The landscaping shall be substantially the same as shown on Revised Drawing No. A-6 of the application, in a somewhat random manner to give a natural appearance. Tree species planted for screening shall be sized and selected to achieve an effective visual screen of at least 15 feet in height within 10 years of planting. Trees shall be native, 5 gallon or larger when planted, and spaced appropriately for a natural, filled-in appearance. Trees and landscape plants planted on the berm shall be enhanced with irrigation and regular maintenance during the first four year establishment period, during which period dying trees or landscape plants shall be promptly replaced with material of like size.

e. Any lighting used for either temporary or permanent illumination shall be placed, shielded or deflected so as not to shine onto adjacent dwellings, or create excessive glare along adjacent roads.

f. The colors of fencing, tarps and other manmade screening materials shall be selected so they blend in with the natural environment.

g. A maintenance agreement shall be signed between the applicant and Yamhill County covering all landscaped areas for the first four year establishment period and subsequent years.

8. The roadway that is proposed to be constructed on the perimeter berm parallel to Highway 18 shall include elements to screen the lights of vehicles using this roadway from view by vehicles driving along Highway 18.

9. Prior to use of the expansion area, the owner shall obtain confirmation from the McMinnville Rural Fire Chief that the water supply and site access satisfy minimum safety standards.

10. Five years prior to the landfill reaching capacity, the applicant shall submit a post-closure plan to DEQ consistent with ORS 459.055. The final cover plan shall include contour grading of slopes to give a more natural appearance.

<u>Noise</u>

11. The applicant shall comply with DEQ noise standards required in ORS Chapter 467 and administrative rules in OAR 340 Division 35. The applicant shall submit an annual noise report to the Planning Director showing compliance with these standards.

12. The public hours of operation for the landfill shall continue to be limited to Monday through Friday from 6 am to 5 pm, 7 am to 4 pm on Saturday, and closed Sundays.

13. The operator shall provide "smart" back-up alarms on all loaders and dozers that operate at the site. ("Smart" back-up alarms are those that only emit backing alarm noises when they sense an object in their path, with the alarm increasing in volume as the distance to the object is reduced.)

Floodplain

14. Prior to issuance of the floodplain develop permit, the applicant shall obtain any required permits from the Corps of Engineers and Oregon Department of State Lands. Copies of these permits shall be submitted to the Planning Director.

15. Removal of existing riparian vegetation within the Riparian Corridor shall be the minimum necessary to allow for construction of the berm and the enhancement projects. Any disturbed areas outside the footprint of the berm shall be restored with fill and native plants.

16. All fill used for the construction of the berms proposed in the Floodplain Development Permit Application Narrative shall comply with the requirements of 901.07(F) (1)-(3) of the Yamhill County Zoning Ordinance.

Green Technology

17. To supplement Condition #4 in the Limited Use Overlay applied by Ordinance 887, any activities that would occur on the property identified for future "Green Technology," such as temporary construction support or operational support, shall not prevent the use of that site for future alternative technology.

18. Condition #7 of Ordinance 887, also known as the Green Technology Condition requires:

7. Alternative Disposal Technology. The applicant has stated its intent, to the extent feasible, to "add a Green Technology component to minimize landfill expansion" (an alternative solid waste disposal technology). The County recognizes, as stated in the application, that: "the construction of any particular facility depends on many factors including; proven commercialization of the technology, financial viability for the project, and ability to receive all necessary permits within the current regulatory structure." As such, it will take time to develop a Green Technology facility, as follows, in accordance with this condition:

(a) The applicant shall establish, on-site, a process or procedure to divert municipal solid waste from Riverbend Landfill to a Green Technology Facility.

(b) The process to be employed in meeting this condition shall be at the discretion of the applicant, consistent with applicable law, and may include, but shall not be limited to, the following processes or general classes of processes:

(1) Advanced Thermal Recycling (also referred to as Mass Burn or Waste - to Energy incineration)
(2) Gasification (also referred to as Plasma Arc)

(3) Anaerobic Digestion
(4) Thermal Depolymerization
(5) Pyrolysis
(6) Refuse-Derived Fuel (also referred to as RDF)

(c) Construction of a DEQ-approved facility to satisfy this condition shall commence no later than seven (7) years after the earlier of:

(1) The date a DEQ permit for solid waste disposal outside the former PWS zone becomes final (i.e., no further DEQ action is required and all appeals have been exhausted or the time for filing an appeal has run with no appeal having been filed) and Riverbend has all DEQ authority necessary to commence disposal of waste on the site; or
(2) The date the 3.6 millionth ton of waste is deposited at the expansion site.

(d) The alternative disposal technology facility shall be operational within 18 months after commencement of construction and shall, when fully operational, significantly decrease the current deposit of 510,000 tons per year of municipal solid waste in the landfill. The facility must be designed to function for the duration of the life of the landfill. The 18 month construction window may be extended as a result of unforeseen weather or other natural events, upon written approval by the Planning Director.

(e) Failure to construct and/or operate an on-site alternative disposal technology facility consistent with this condition shall require the landfill to cease operations.

The applicant shall apply for site design review for construction of the Green Technology Facility no later than 150 days before the construction is required to begin under Condition of Approval 7 of Ordinance 887.

<u>Odor conditions</u>

19. As part of its Title V air quality permit, the applicant is required to implement a Dust Control Plan and Final Odor Control Compendium. The applicant shall continue to implement those operating and control practices to reduce fugitive dust and odor from its operations as required by DEQ.

20. Upon the disposal of solid waste into Cell 11, the applicant shall take a downwind reading of odor using an olfactometer each weekday, excluding holidays. The readings shall include the location, weather conditions, precipitation, wind direction and wind speed. The readings shall be provided to the Planning Director on a monthly basis.

21. Modification of any of the above conditions requires approval under Section 1101.02 of the Yamhill County Zoning Ordinance. Violation of any of the above conditions may result in revocation of the site design review permit with the process detailed in Sections 1101.06 and 1101.07 of the Yamhill County Zoning Ordinance.

Recommendation Letter

Yamhill County

DEPARTMENT OF PLANNING AND DEVELOPMENT

525 NE 4th STREET • McMINNVILLE, OREGON 97128

Phone:(503) 434-7516 • Fax:(503)434-7544 • TTY: (800) 735-2900 • Internet Address: http://www.co.yamhill.or.us/plan/

April 24, 2015

Bob Schwartz
Oregon Department of Environmental Quality
400 E Scenic Drive, Suite 307
The Dalles, OR 97058

Re: Riverbend Landfill Permit Modification Application

Riverbend Landfill Company ("Riverbend") is submitting an application to the Oregon Department of Environmental Quality ("DEQ") proposing to modify its existing solid waste disposal permit to allow for an expansion of the Riverbend Landfill. Riverbend has inquired with my office whether the County has any recommendation relating to the application.

Since the County approved the landfill in the 1980's, it has been the County's practice to defer to DEQ with respect to specific approvals for the engineering and design of the landfill. Although it was not always the case, the County now requires that Riverbend seek Site Design Review for an enhancement or expansion of its existing facility. The County recently approved Riverbend's request for Site Design Review and a Floodplain Development Permit for the expansion proposal that will be included in its application to DEQ, but the County is neutral with respect to DEQ's consideration of that proposal. The recommendation, therefore, is that DEQ approve or deny the permit based on DEQ's own approval criteria.

I will point out that the continued operation of local disposal facilities has been at the core of many County decisions over the past two decades. For example, in 2004 the County adopted a new Solid Waste Management Plan recommending that the County continue to work closely with operators of Riverbend Landfill to ensure it provides the highest level of service. Similarly, when the County approved a Zoning Ordinance Amendment, a Zone Change for Riverbend, and Riverbend's Site Design Review application, it addressed the benefits of having a local disposal option like Riverbend remain in the County.

Please do not hesitate to give me a call if you have any questions regarding the contents of this letter.

Sincerely,

Kenneth P. Friday
Planning Division Manager

KF:kf

ATTACHMENT 2

Preliminary Hydraulic Report
(Prepared Waterways Consulting, Inc.)

HYDRAULIC REPORT
RIVERBEND EXPANSION - MODULE 11 EXPANSION, RIVERBEND LANDFILL COMPANY

prepared for

Latimer Environmental LLC

prepared by

Brian Smith, C.E.

WATERWAYS CONSULTING, INC.

REGISTERED PROFESSIONAL ENGINEER
84565PE
OREGON
SEPTEMBER 11, 2010
BRIAN MCKINLEY SMITH

EXPIRES: 6/30/16

April 23, 2015

1 INTRODUCTION 2

2 PEAK FLOW HYDROLOGY 2

3 PEAK FLOW HYDRAULICS 3

METHODS 3
RESULTS 4

4 CONCLUSION 5

5 REFERENCES 6

List of Tables

Table 1: Summary of 100-Year Peak Flow Hydraulics for Existing Conditions and the Proposed Landfill Buildout Conditions and the Channel and Floodplain Enhancement Project

Table 2: Summary of 100-Year Peak Flow Hydraulics for Existing Conditions and the Proposed Landfill Buildout Conditions

List of Figures

Figure 1: Project Vicinity Map

Figure 2: Riverbend Landfill Site Plan and 100-year Flood Boundaries

Figure 3: 100-year Water Surface and Velocity Profiles for the Northern Tributary

Figure 4: 100-year Water Surface and Velocity Profiles for the Southern Tributary

Figure 5: 100-year Water Surface and Velocity Profiles for the South Yamhill River

List of Attachments

Attachment A - Flood Insurance Rate Maps

Attachment B - Hydrologic Calculations

Attachment C - HEC-RAS Model Output

1 INTRODUCTION

Waterways Consulting Inc. (Waterways) has been retained by Latimer Environmental, LLC (LE) to conduct a hydraulic evaluation of the proposed buildout conditions of the Riverbend Landfill – Module 11 Expansion, Riverbend Landfill Company (Project) and a channel and floodplain enhancement plan developed for the southern tributary channel located to the south of the landfill.

The landfill is located in Yamhill County adjacent to the floodplain of the South Yamhill River, approximately three miles southwest of McMinnville (Figure 1). Landfill operation facilities are located north of the South Yamhill River and bounded by two unnamed tributaries to the north and south that originate west of Highway 18 (Figure 2).

The landfill is proposing to expand operations by constructing berms along the southern and southwestern portion of the landfill and building a ramp across the southern tributary to access the existing leachate pond and a future site to be used for an alternative technology for processing solid waste ("Green Technology Facility"). The access ramp will include a stream crossing structure designed to meet fish passage criteria established by the Oregon Department of Fish and Wildlife (ODFW). The Federal Emergency Management Agency (FEMA) has mapped a portion of the proposed landfill expansion areas within the Special Flood Hazard Area (SFHA) (Attachment A).

The following report has been prepared to support a No-Rise certification and presents our hydraulic analysis of existing and proposed conditions and provides recommendations for design of the crossing structure.

2 PEAK FLOW HYDROLOGY

Peak discharges for the South Yamhill River were obtained from the FEMA Flood Insurance Study (FIS) for Yamhill County, Oregon (Unincorporated Areas), dated March 2, 2010. Peak discharges for the tributary channels to the north and the south of the landfill were developed using USGS regional regression equations (Cooper, 2005). Parameters used in the equations include drainage area and the 2-yr 24-hour precipitation amount. These parameters were estimated using StreamStats (USGS, 2012), a web-based geographic information system application that provides an interactive map for calculating basin characteristics and peak flow hydrology.

Our analysis used 100-year peak flow values of 50,000 cfs for the South Yamhill River, 277 cfs for the southern tributary, and 298 cfs in the northern tributary.

3 PEAK FLOW HYDRAULICS

METHODS

Hydraulic modeling was conducted using HEC-RAS version 4.1 river analysis software developed by the United States Army Corps of Engineers (USACE, 2010). An existing conditions (Duplicate Effective) hydraulic model used to prepare a Letter of Map Revision (FEMA Case No. 12-10-1146P) for the South Yamhill River was provided by LE. The LOMR was approved by FEMA with an effective date of May 9, 2013. The duplicate effective model geometry was developed using aerial topographic mapping prepared by Aerometric Geospatial Solutions and dated April 22, 2011. The hydraulic models, topographic mapping, and resulting water surface elevations are referenced to the NAVD88 vertical datum.

Waterways prepared an existing conditions (Corrected Effective) model by revising the duplicate effective model to include the northern and southern tributaries as separate reaches. Fifteen (15) cross sections were used to delineate these tributary channels between the confluence with the South Yamhill River and the Highway 18 crossings (Figure 2). The three culverted crossings along the southern tributary were assumed to be blocked for this hydraulic analysis and were not included in the model as crossing structures because they would not have a significant effect on conveyance of the 100-year flood. Two additional cross sections on the South Yamhill River were added to the corrected effective model that was not present in the duplicate effective model. These sections were added to correctly model the tributaries and their junctions in the HEC-RAS analysis.

The proposed conditions model was created by updating cross section geometry to depict the Project conditions and a channel and floodplain enhancement plan located on the southern tributary channel. Proposed conditions geometry for the Project was based on a Final Grading Plan prepared by Geosyntec Consultants, Inc. and submitted to Yamhill County with the Site Design Review Application for the Riverbend Expansion – Module 11 prepared by Waste Management and dated November 5, 2014. Proposed conditions geometry for the channel and floodplain enhancement on the southern tributary was based on the Riverbend Landfill South Tributary Channel and Floodplain Enhancement 30% Design prepared by Waterways Consulting Inc. and dated November 4, 2014. A bottomless arch or box culvert was selected as the preferred crossing structure at the access ramp and was used in the proposed conditions modeling.

The models cover approximately 2.9 miles of the South Yamhill River and 1.4 miles of tributary channels from their confluence to the Highway 18 crossings. The existing and proposed conditions roughness values within the tributary channel are set to 0.05 for the channel and 0.1 for the overbank areas. The roughness values for the South Yamhill River were not changed from the LOMR analysis and ranged from 0.05 to 0.12 for the channel and from 0.035 to 0.1 for the overbank areas.

The downstream boundary condition for the South Yamhill River was set to a known water surface elevation corresponding to the FEMA Flood Insurance Rate Map Base Flood Elevation listed at Cross Section AE (Attachment A).

RESULTS

The proposed conditions, including both Module 11 and the proposed Channel and Floodplain Enhancement Project) modeling predicts no rise in water surface elevations or increases in average channel velocities relative to existing conditions (Figures 3, 4, and 5). Water surface elevations on each of the tributaries during the 100-yr flood are largely controlled by backwatering from the South Yamhill River. A proposed 16 foot span by 8 foot rise box culvert below the ramp on the southern tributary would result in no rise to the 100-yr water surface elevation relative to existing conditions. Smaller structures resulted in minor increases to the 100-yr flood profile upstream of the crossing. Fish passage design criteria for road crossings presented by ODFW typically require a structure that has a minimum span of at least the active stream channel width or the width that occurs annually at ordinary high water. Channel measurements upstream of the Highway 18 crossing indicate that a 12-foot span culvert would satisfy the ODFW design criteria.

Table 1 presents the 100-year water surface elevations for selected cross sections including the proposed Channel and Floodplain Enhancement project. Complete hydraulic results are presented in Attachment C.

Table 1. Summary of 100-Year Peak Flow Hydraulics for Existing Conditions and the Proposed Landfill Buildout Conditions and the Channel and Floodplain Enhancement Project

100-Year Water Surface Elevation (ft)				
Section ID (River Station)	Location	Existing Conditions	**Proposed Conditions**	**Difference**
22.15	S. Yamhill	140.23	**140.23**	**0.00**
20.28	S. Yamhill	138.80	**138.80**	**0.00**
4449.22	N. Tributary	138.32	**138.32**	**0.00**
3365	S. Tributary	139.54	**139.54**	**0.00**
2865	S. Tributary	139.50	**139.48**	**-0.02**

Figure 2 depicts the 100-year flood boundary for existing and proposed conditions. Flood elevations and inundation areas on the tributaries are caused from backwatering from the South Yamhill River. The flood flows being conveyed down the tributaries have a negligible effect on flood elevations below the Highway 18 crossings.

The Landfill buildout conditions without the addition of the Channel and Floodplain Enhancement Project would result in a slight increase to the BFE relative to existing conditions along a portion of the southern tributary (Table 2). The increase in BFE would begin at River Station 24+62 and continue upstream of the proposed access road across the southern tributary. The maximum increase in BFE of 0.09' (about 1.1 inch) would occur immediately upstream of the proposed access road.

Table 2. Summary of 100-Year Peak Flow Hydraulics for Existing Conditions and the Proposed Landfill Buildout Conditions

100-Year Water Surface Elevation (ft)				
Section ID (River Station)	Location	Existing Conditions	**Proposed Conditions**	**Difference**
22.15	S. Yamhill	140.23	**140.23**	**0.00**
20.28	S. Yamhill	138.80	**138.80**	**0.00**
4449.22	N. Tributary	138.32	**138.32**	**0.00**
3365	S. Tributary	139.54	**139.63**	**0.09**
2865	S. Tributary	139.50	**139.51**	**0.01**

4 CONCLUSION

The proposed Module 11 Expansion, including the Channel and Floodplain Enhancement Project will not cause a rise in the base flood elevation of the southern tributary or the South Yamhill River relative to existing conditions.

5 REFERENCES

Cooper, R.M., 2005. Estimation of Peak Discharges for Rural, Unregulated Streams in Western Oregon: U.S. Geological Survey Scientific Investigation Report 2005-5116.

Federal Emergency Management Agency. 2010. Flood Insurance Study (FIS) for Yamhill County, Oregon and Unincorporated Areas. March 2, 2010.

U.S. Army Corps of Engineers. 2010, Hydrologic Engineering Center. Computer Program HEC-RAS Version 4.1. Davis, California.

U.S. Army Corps of Engineers. 2010, Hydrologic Engineering Center. Hydraulic Reference Manual. Version 4.1. Davis, California.

U.S. Geologic Survey , 2012, The StreamStats program, online at http://streamstats.usgs.gov

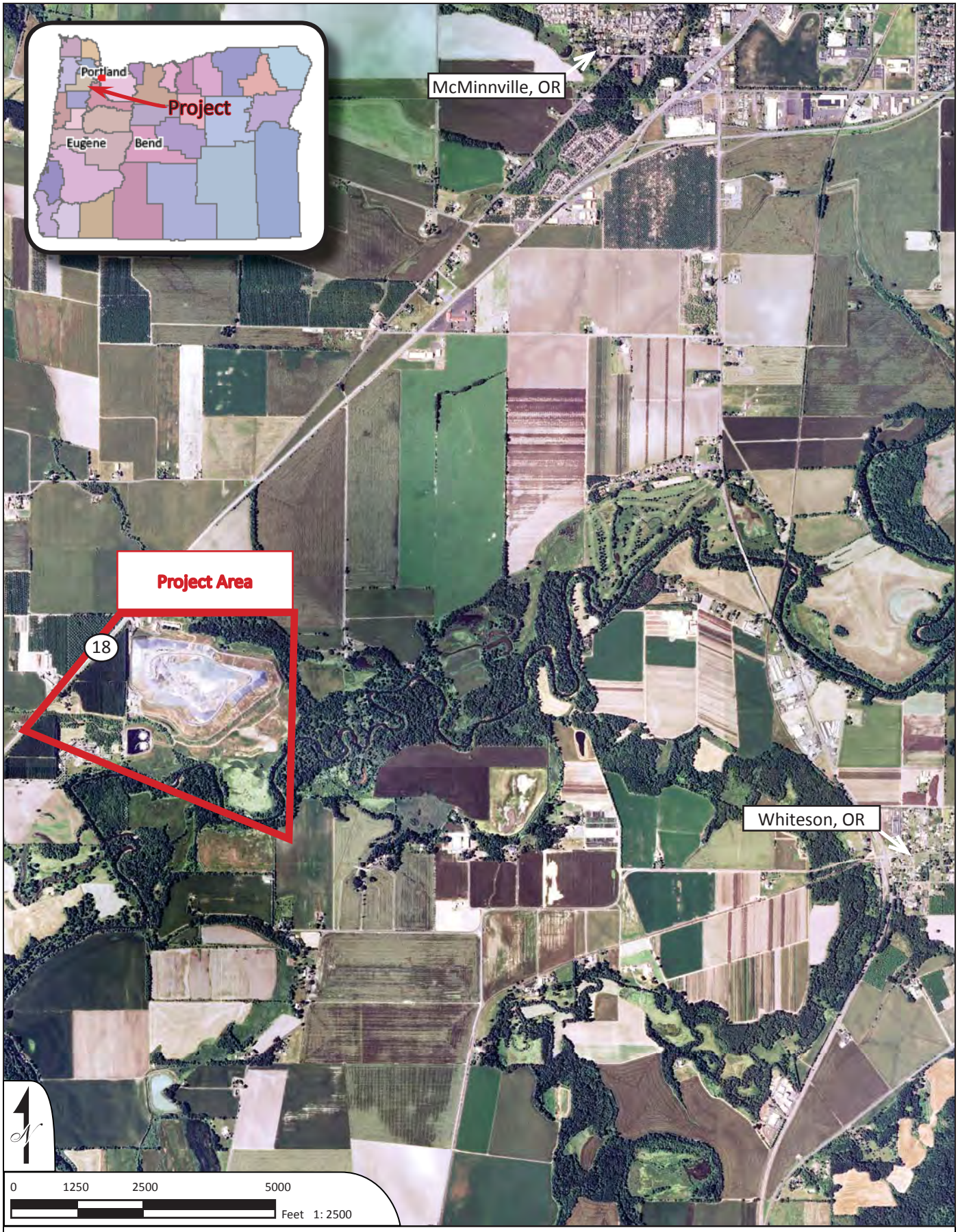
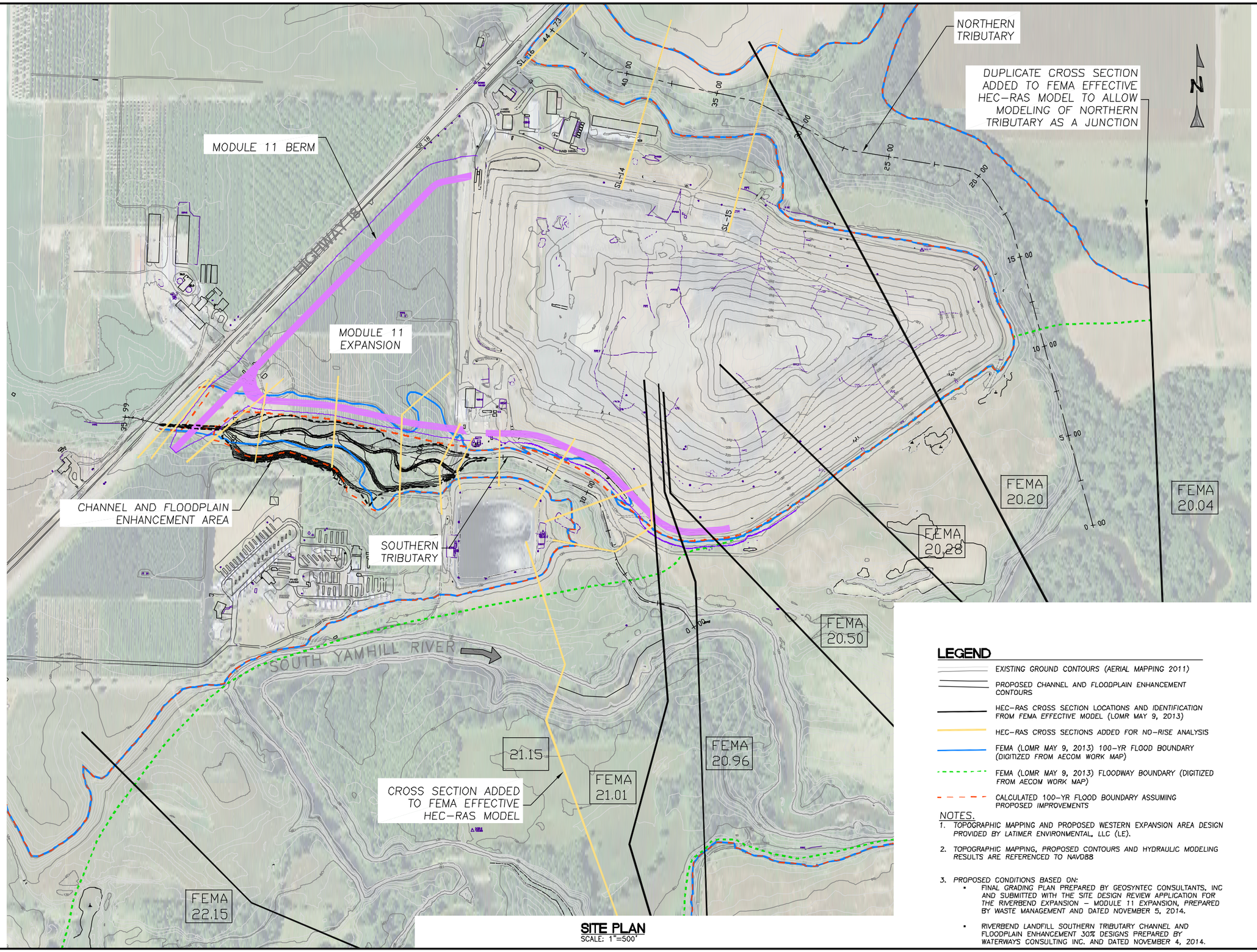


FIGURE 1

Project location for the Riverbend Landfill, located on the South Yamhill River, west of Whiteson, Oregon.

WATERWAYS CONSULTING, INC.

Santa Cruz, CA | watways.com | Portland, OR



SITE PLAN

SCALE: 1"=500'

LEGEND

- EXISTING GROUND CONTOURS (AERIAL MAPPING 2011)
- PROPOSED CHANNEL AND FLOODPLAIN ENHANCEMENT CONTOURS
- HEC-RAS CROSS SECTION LOCATIONS AND IDENTIFICATION FROM FEMA EFFECTIVE MODEL (LOMR MAY 9, 2013)
- HEC-RAS CROSS SECTIONS ADDED FOR NO-RISE ANALYSIS
- FEMA (LOMR MAY 9, 2013) 100-YR FLOOD BOUNDARY (DIGITIZED FROM AECOM WORK MAP)
- FEMA (LOMR MAY 9, 2013) FLOODWAY BOUNDARY (DIGITIZED FROM AECOM WORK MAP)
- CALCULATED 100-YR FLOOD BOUNDARY ASSUMING PROPOSED IMPROVEMENTS

NOTES.

1. TOPOGRAPHIC MAPPING AND PROPOSED WESTERN EXPANSION AREA DESIGN PROVIDED BY LATIMER ENVIRONMENTAL, LLC (LE).
2. TOPOGRAPHIC MAPPING, PROPOSED CONTOURS AND HYDRAULIC MODELING RESULTS ARE REFERENCED TO NAVD88
3. PROPOSED CONDITIONS BASED ON:
   - FINAL GRADING PLAN PREPARED BY GEOSYNTEC CONSULTANTS, INC AND SUBMITTED WITH THE SITE DESIGN REVIEW APPLICATION FOR THE RIVERBEND EXPANSION – MODULE 11 EXPANSION, PREPARED BY WASTE MANAGEMENT AND DATED NOVEMBER 5, 2014.
   - RIVERBEND LANDFILL SOUTHERN TRIBUTARY CHANNEL AND FLOODPLAIN ENHANCEMENT 30% DESIGNS PREPARED BY WATERWAYS CONSULTING INC. AND DATED NOVEMBER 4, 2014.

WATERWAYS CONSULTING INC.
Santa Cruz, CA waterways.com Portland, OR

RIVERBEND LANDFILL
McMINNVILLE, OREGON

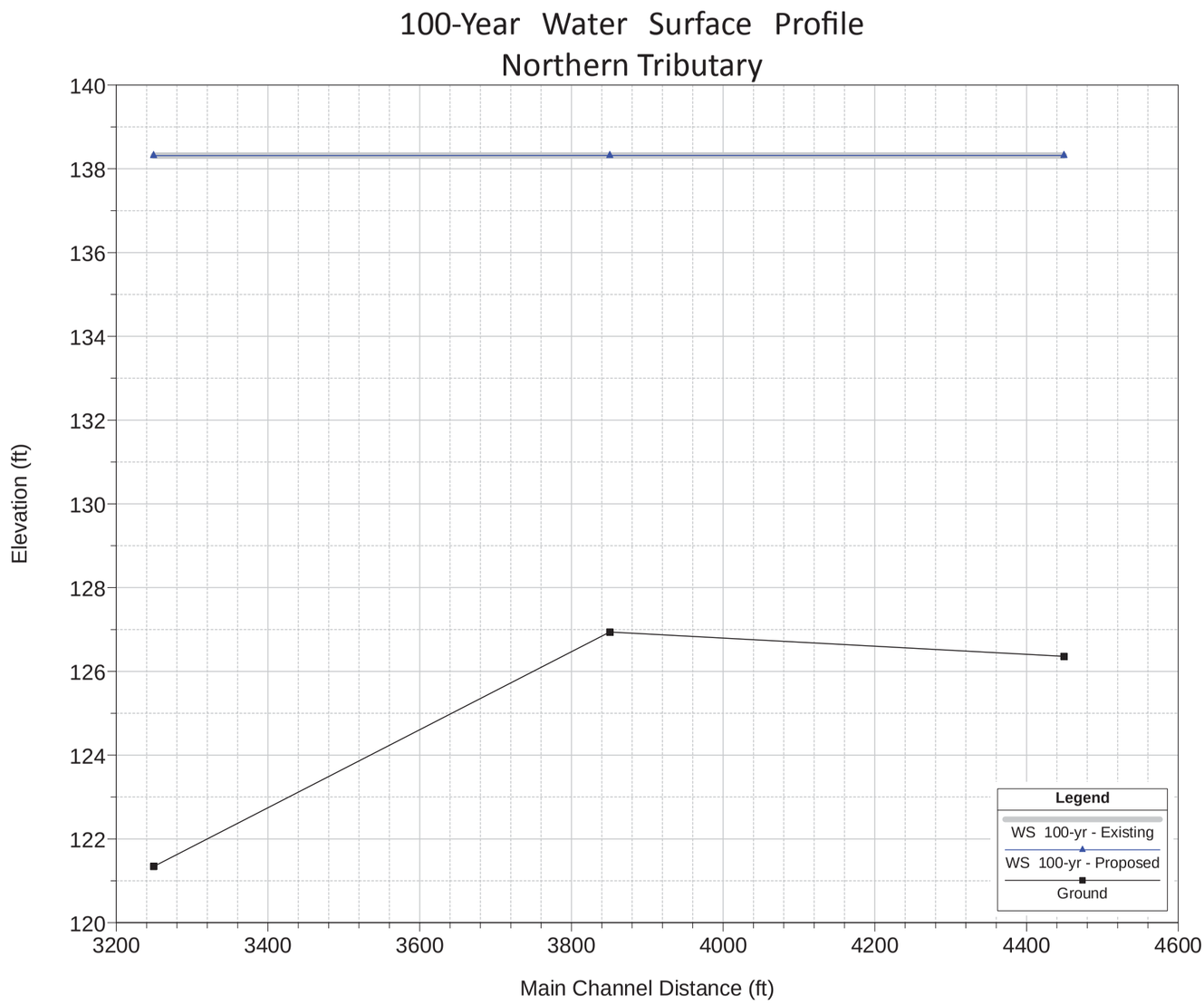
RIVERBEND LANDFILL SITE PLAN AND 100-YR FLOOD BOUNDARIES

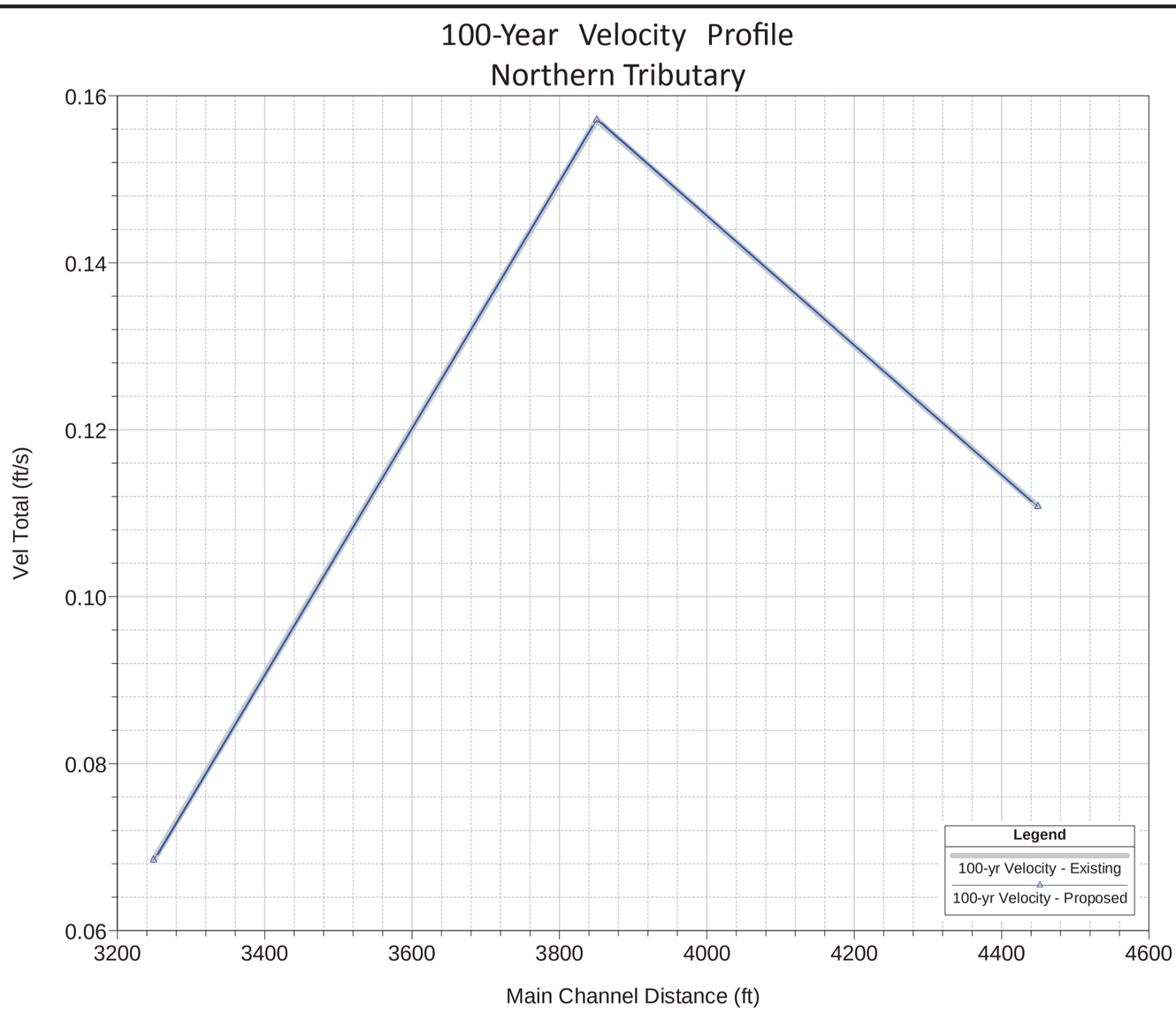
DATE: 4/23/15

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

0 1"

FIGURE
2





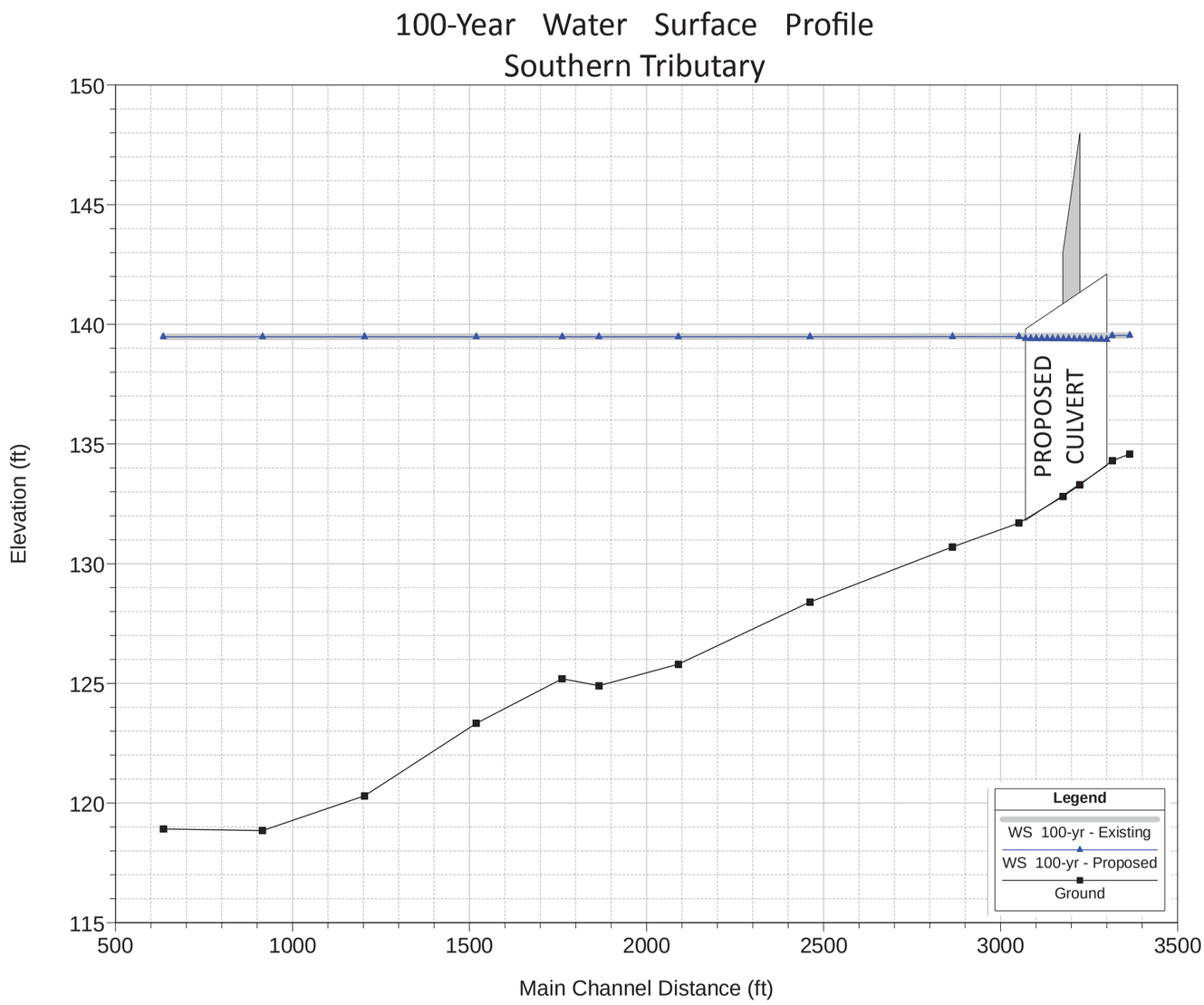
100-year water surface and velocity profiles for existing and proposed conditions on the Northern Tributary. Water surface elevations are controlled by backwatering of the South Yamhill River and are not effected by proposed Landfill Buildout conditions.

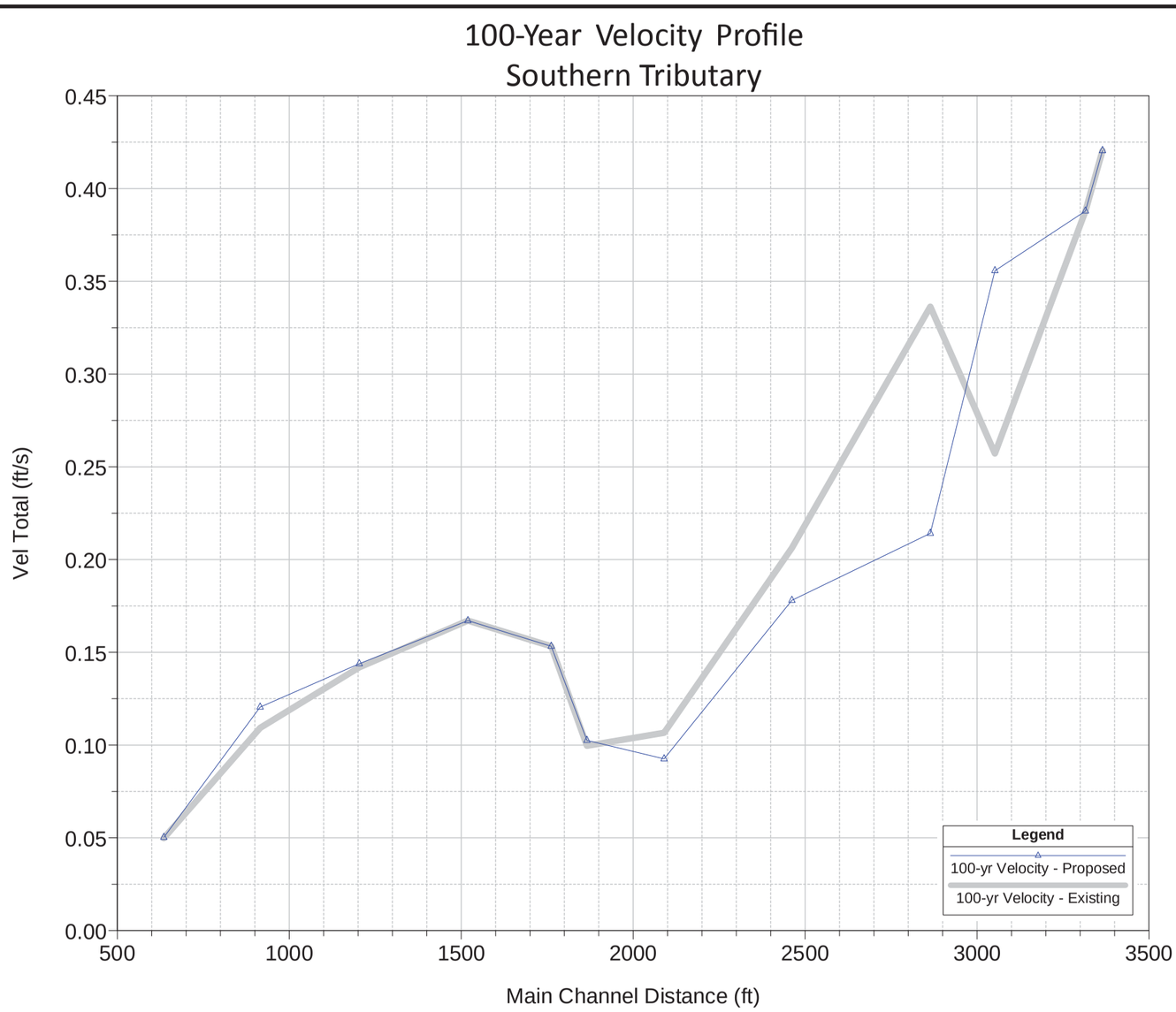
RIVERBEND LANDFILL

HYDRAULIC REPORT

WATERWAYS CONSULTING, INC.
Santa Cruz, CA watways.com Portland, OR

FIGURE
3





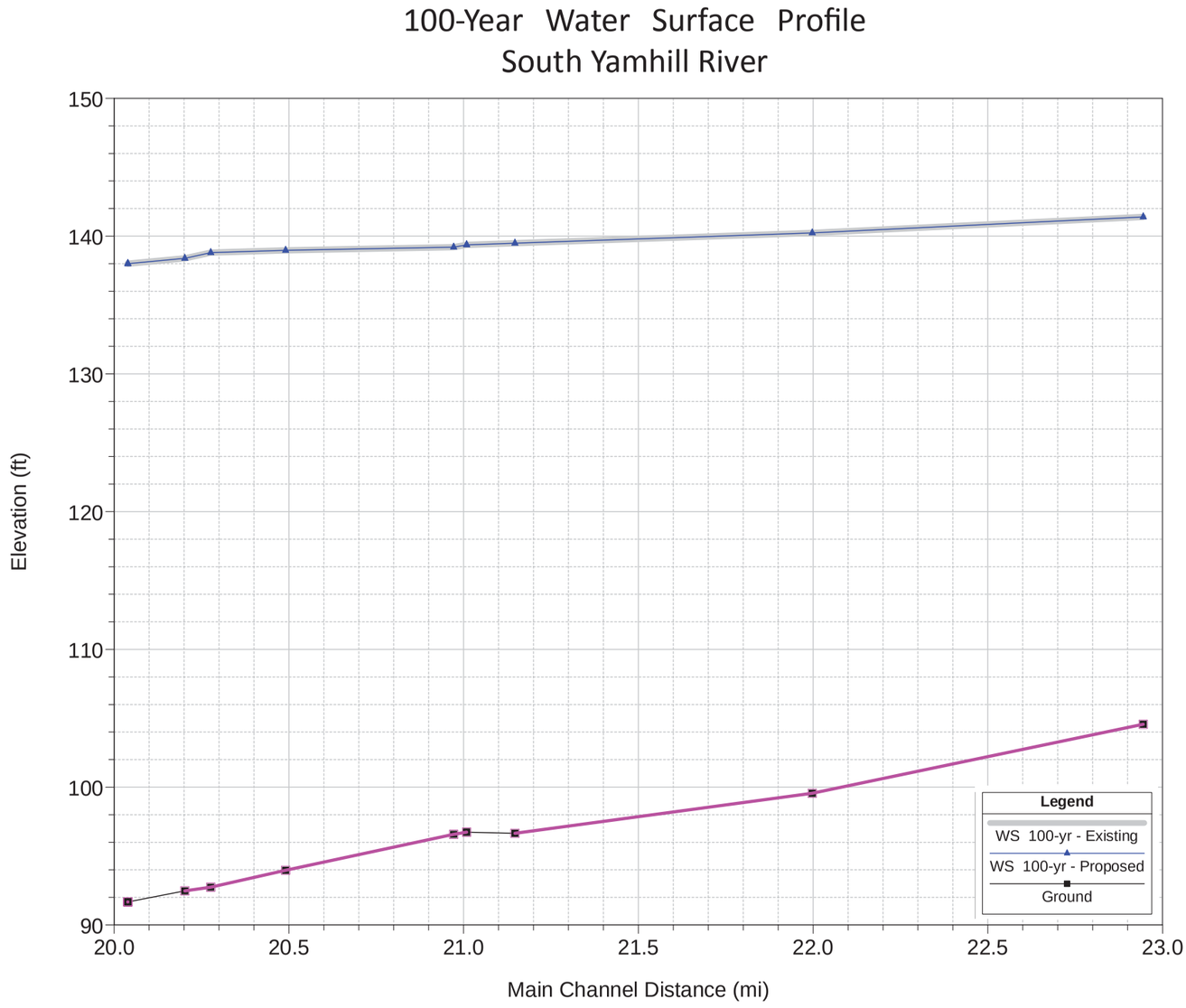
100-year water surface and velocity profiles for existing and proposed conditions on the Southern tributary. Proposed conditions results in a slight (0.02') decrease in the water surface elevation downstream of the proposed culvert. There is virtually no change to the velocity profile except for a slight increase (0.1 ft/sec) due to the proposed culvert crossing.

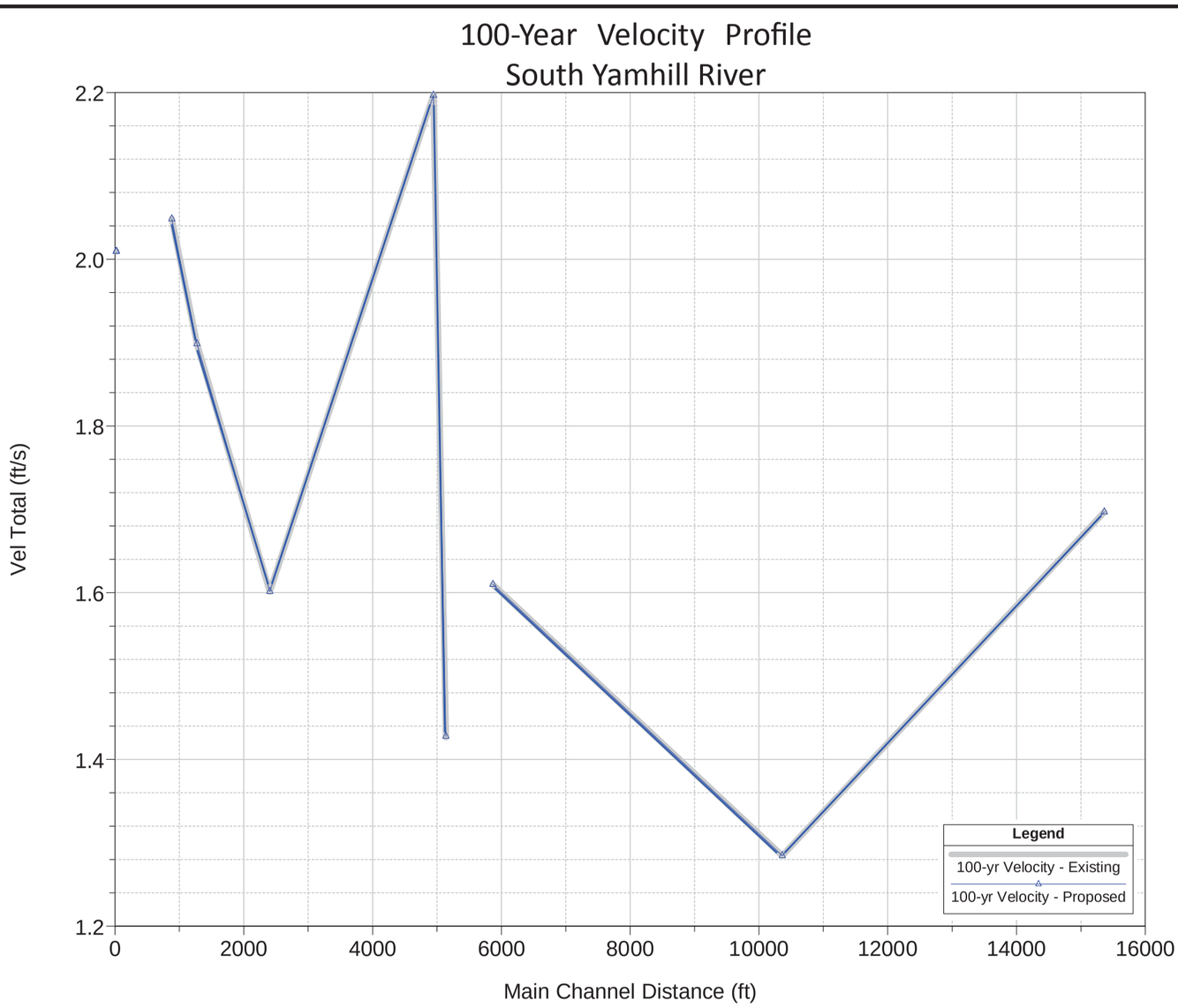
RIVERBEND LANDFILL

HYDRAULIC REPORT

WATERWAYS CONSULTING, INC.
Santa Cruz, CA watways.com Portland, OR

FIGURE 4





100-year water surface and velocity profiles for existing and proposed conditions on the South Yamhill River. There are no changes to the water surface elevations or channel velocities relative to existing conditions.

RIVERBEND LANDFILL

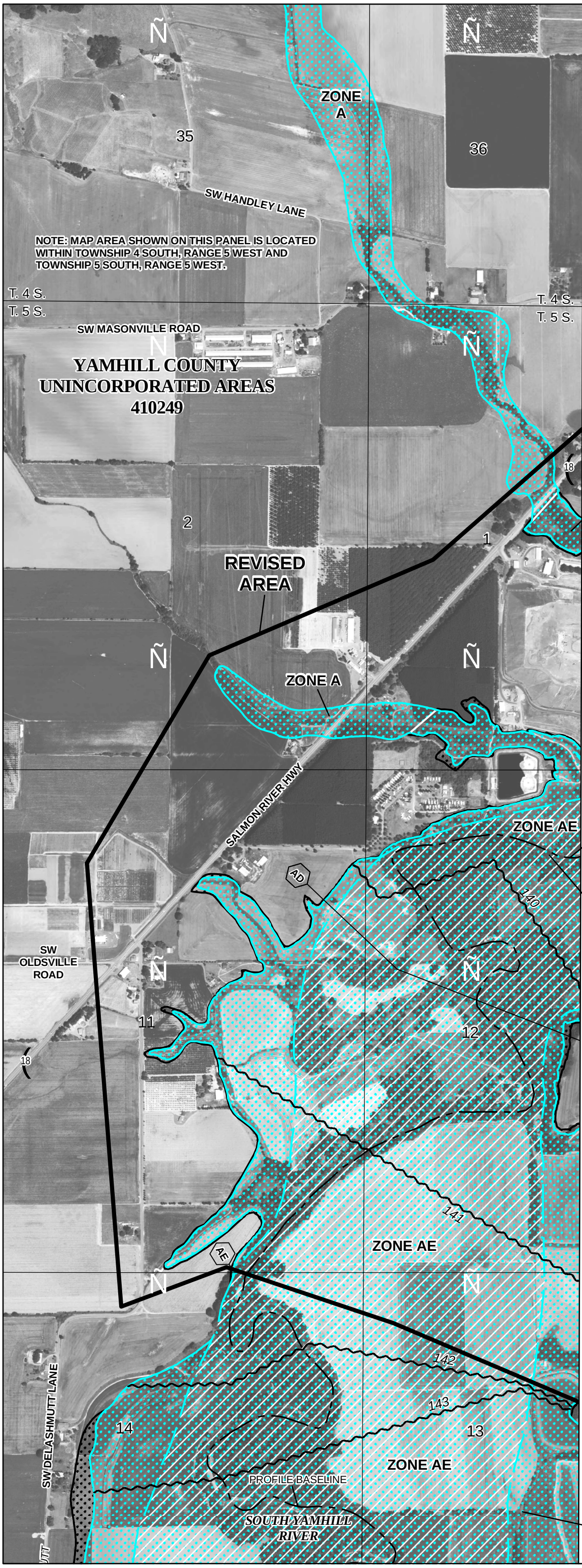
HYDRAULIC REPORT

WATERWAYS CONSULTING, INC.
Santa Cruz, CA watways.com Portland, OR

FIGURE
5

Attachment A

Flood Insurance Rate Maps



Legend

- 1% annual chance (100-Year) Floodplain
- 1% annual chance (100-Year) Floodway
- 0.2% annual chance (500-Year) Floodplain

MAP SCALE 1" = 1000'

500 0 1000 FEET

300 0 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0395D

FIRM

FLOOD INSURANCE RATE MAP

YAMHILL COUNTY, OREGON
AND INCORPORATED AREAS

PANEL 395 OF 675

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
YAMHILL COUNTY	410249	0395	D

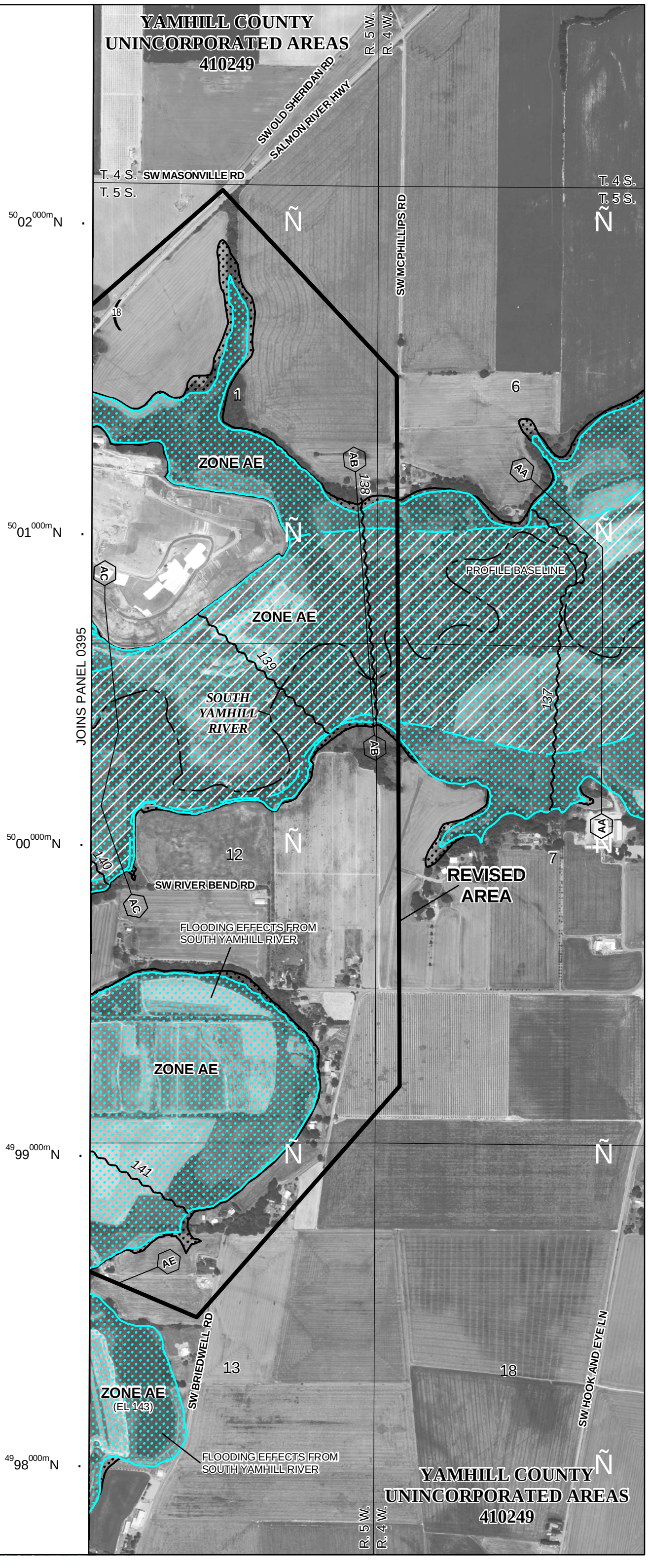
REVISION TO REFLECT LOMR EFFECTIVE: May 9, 2013

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
41071C0395D

EFFECTIVE DATE
MARCH 2, 2010

Federal Emergency Management Agency



Legend

- 1% annual chance (100-Year) Floodplain
- 1% annual chance (100-Year) Floodway
- 0.2% annual chance (500-Year) Floodplain

MAP SCALE 1" = 1000'

500 0 1000 FEET

300 0 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0415D

FIRM

FLOOD INSURANCE RATE MAP

YAMHILL COUNTY, OREGON
AND INCORPORATED AREAS

PANEL 415 OF 675

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MCMINNVILLE, CITY OF	410255	0415	D
YAMHILL COUNTY	410249	0415	D

REVISION TO REFLECT LOMR EFFECTIVE: May 9, 2013

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
41071C0415D

EFFECTIVE DATE
MARCH 2, 2010

Federal Emergency Management Agency

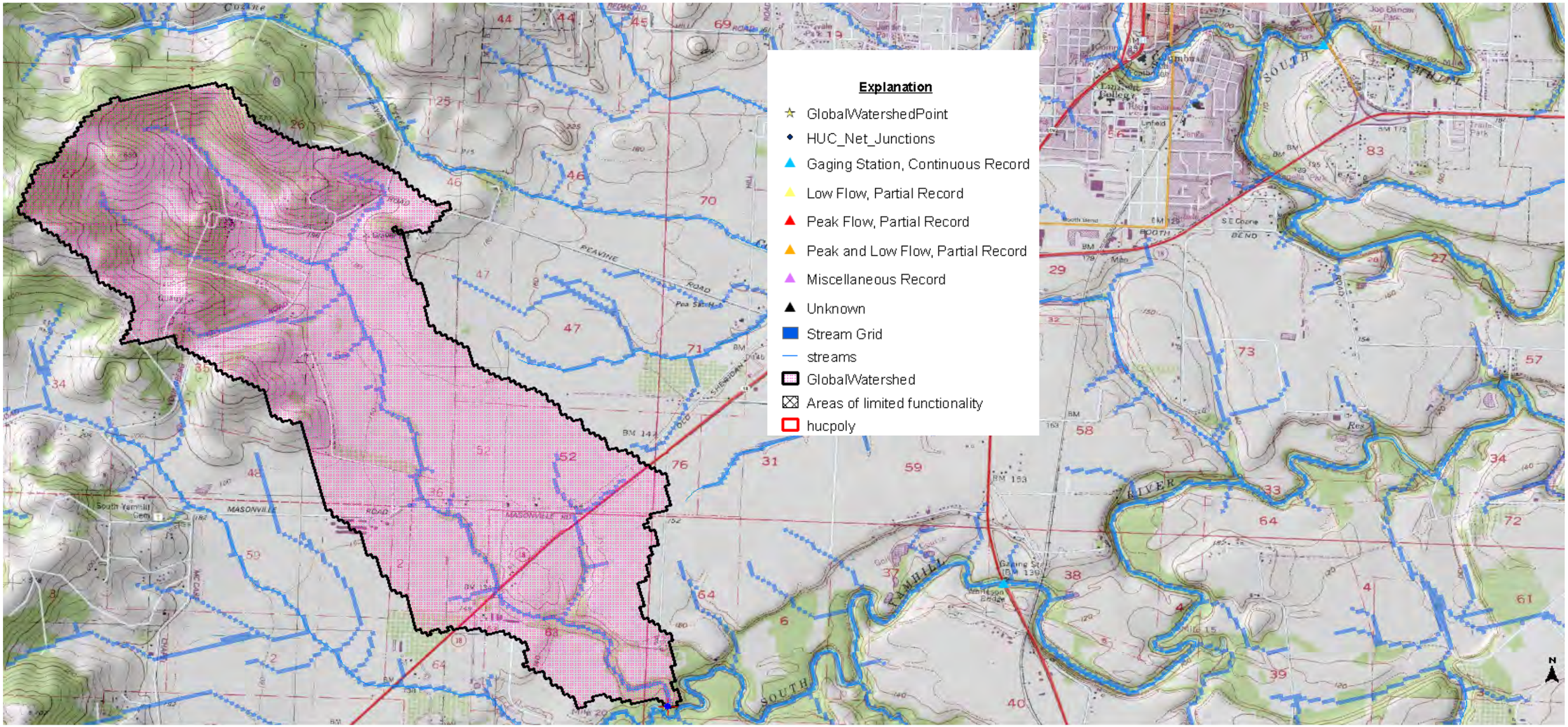
Attachment B

Hydrologic Calculations

Northern Tributary Calculations

USGS
Oregon StreamStats

StreamStats Print Page



10/27/2014 1:55:47 PM

USGS Oregon StreamStats

Streamstats Ungaged Site Report

Date: Tue Oct 14 2014 14:59:54 Mountain Daylight Time
Site Location: Oregon
NAD27 Latitude: 45.1597 (45 09 35)
NAD27 Longitude: -123.2354 (-123 14 07)
NAD83 Latitude: 45.1595 (45 09 34)
NAD83 Longitude: -123.2366 (-123 14 12)
Drainage Area: 3.29 mi2
Percent Urban: 6.19 %
Percent Impervious: 1.85 %

Peak Flows Region Grid Basin Characteristics			
Mean Basin Elevation in feet=252			
100% Reg 2B Western Interior LT 3000 ft Cooper (3.29 mi2)			
Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	3.29	0.37	7270
Mean Basin Slope from 30m DEM (degrees)	4.8 (below min value 5.62)	5.62	28.3
24 Hour 2 Year Precipitation (inches)	2.04	1.53	4.48

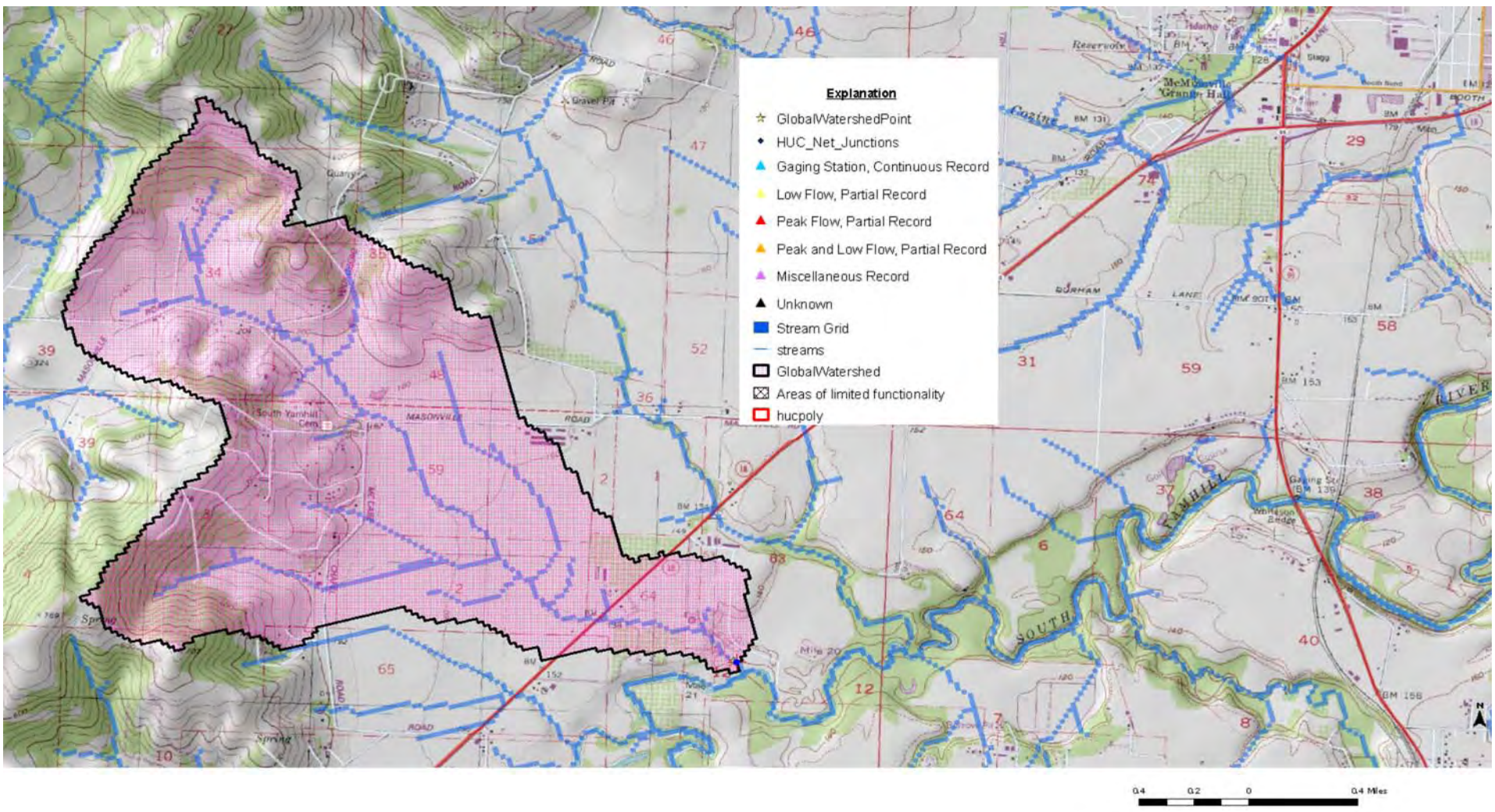
Warning: Some parameters are outside the suggested range. Estimates will be extrapolations with unknown errors.

Peak Flows Region Grid Streamflow Statistics					
Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
PK2	102		2		
PK5	152		2.8		
PK10	186		3.6		
PK25	231		4.8		
PK50	264		5.5		
PK100	298		6.2		

Southern Tributary Calculations

USGS Oregon StreamStats

StreamStats Print Page



6/25/2014 12:42:45 PM

USGS Oregon StreamStats

Streamstats Ungaged Site Report

Date: Wed Jun 25 2014 12:49:28 Mountain Daylight Time
Site Location: Oregon
NAD27 Latitude: 45.1584 (45 09 30)
NAD27 Longitude: -123.2484 (-123 14 54)
NAD83 Latitude: 45.1582 (45 09 30)
NAD83 Longitude: -123.2496 (-123 14 59)
Drainage Area: 2.83 mi2
Percent Urban: 6.22 %
Percent Impervious: 1.29 %

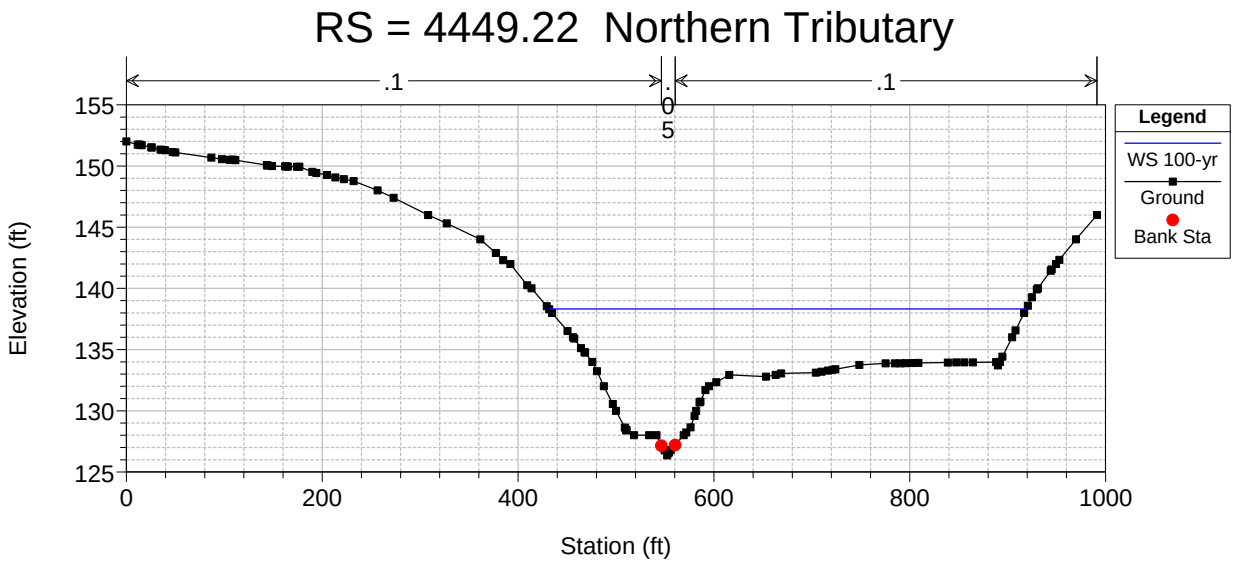
Peak Flows Region Grid Basin Characteristics			
Mean Basin Elevation in feet=266			
100% Reg 2B Western Interior LT 3000 ft Cooper (2.83 mi2)			
Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	2.83	0.37	7270
Mean Basin Slope from 30m DEM (degrees)	5.38 (below min value 5.62)	5.62	28.3
24 Hour 2 Year Precipitation (inches)	2.08	1.53	4.48

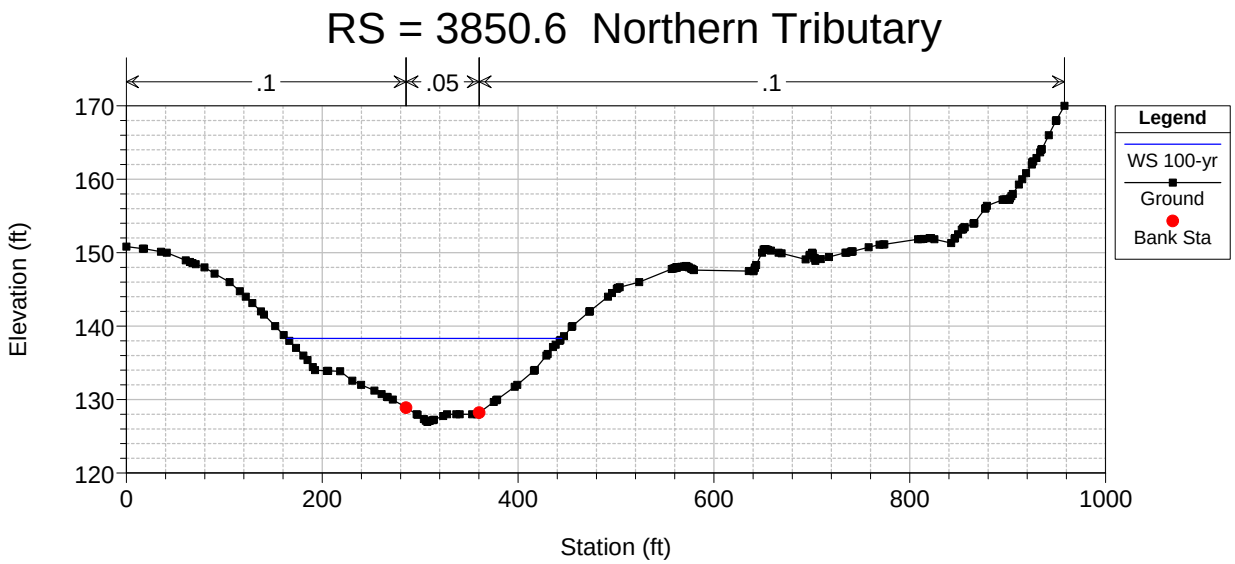
Warning: Some parameters are outside the suggested range. Estimates will be extrapolations with unknown errors.

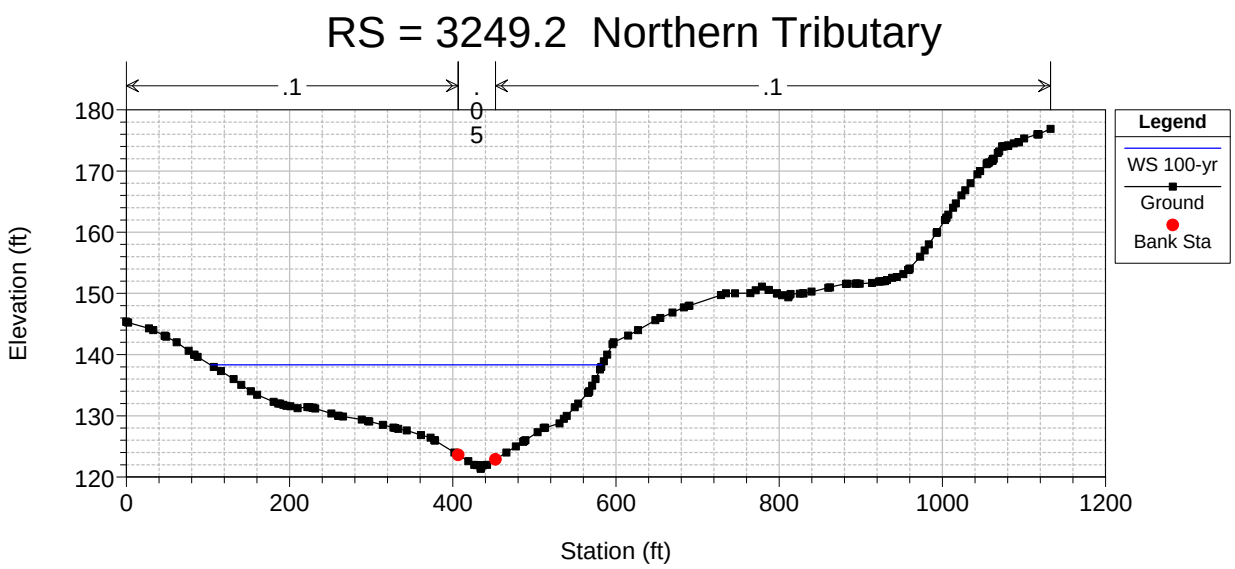
Peak Flows Region Grid Streamflow Statistics					
Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
PK2	95.6		2		
PK5	142		2.8		
PK10	174		3.6		
PK25	215		4.8		
PK50	246		5.5		
PK100	277		6.2		
PK500	351		7.5		

Attachment C

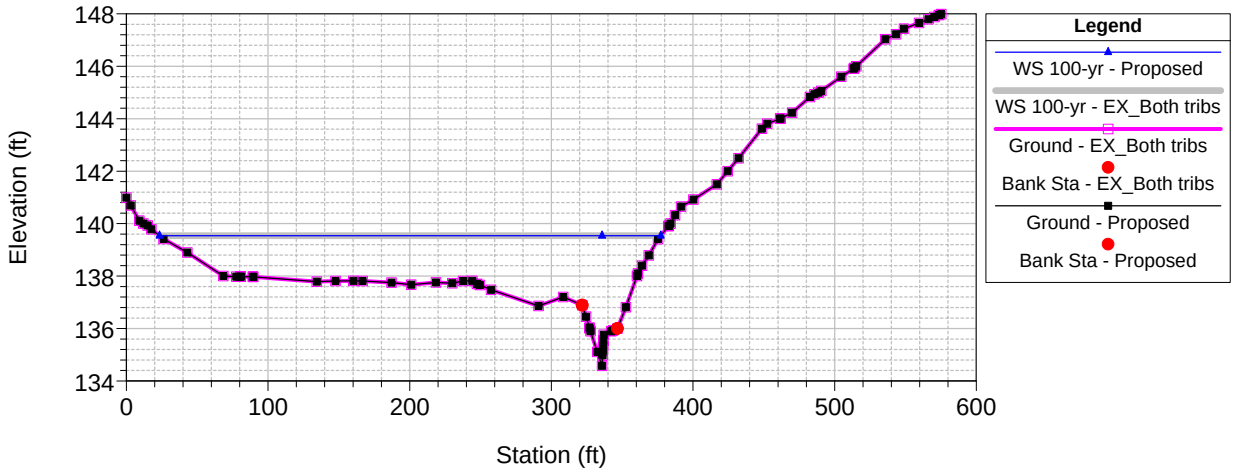
HEC-RAS Model Output


RS = 4449.22 Northern Tributary
.1
.05
.1
Legend
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

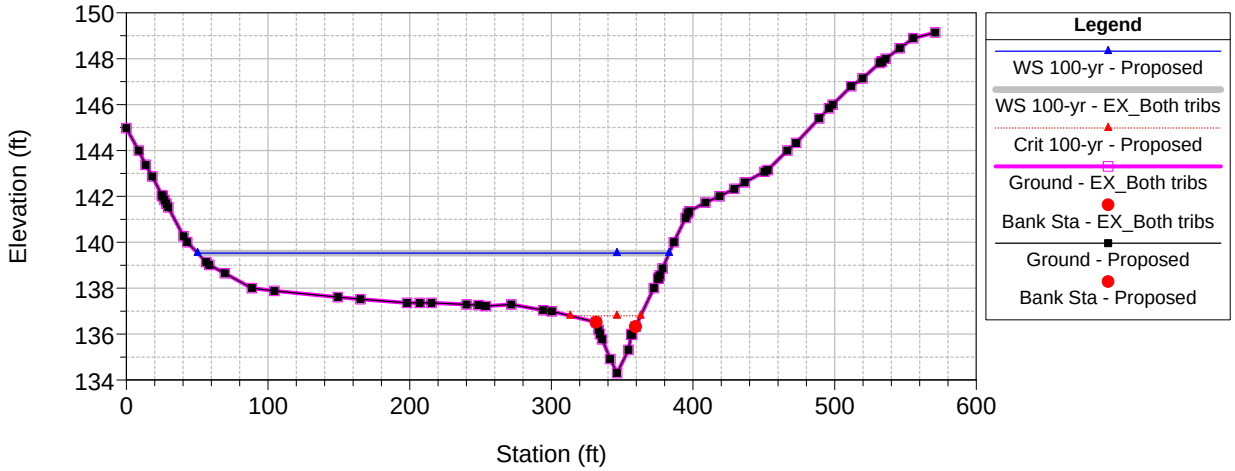

RS = 3850.6 Northern Tributary
.1
.05
.1
Legend
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


RS = 3249.2 Northern Tributary
.1
.05
.1
Legend
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

RS = 3365 Southern Tributary

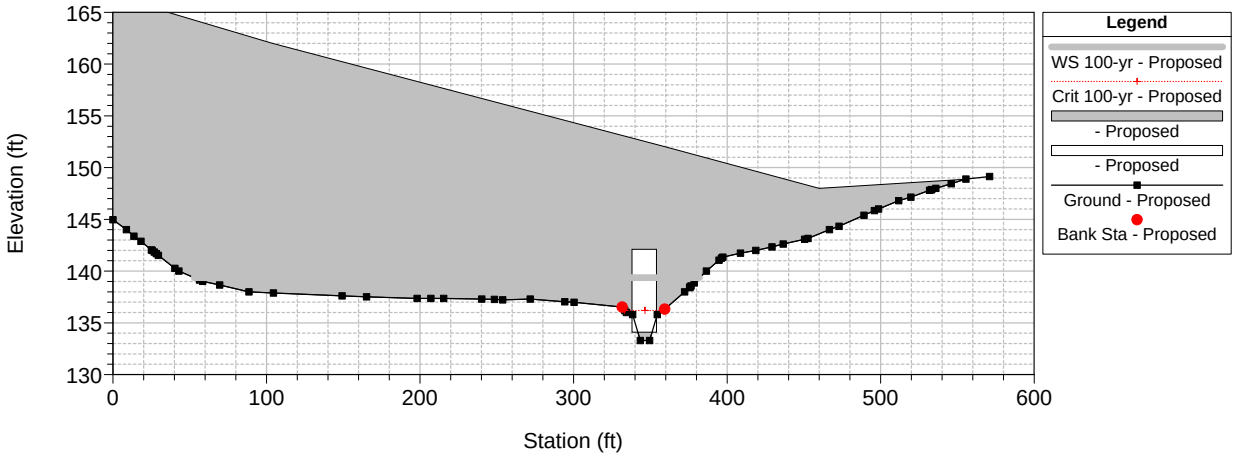


RS = 3316 Southern Tributary



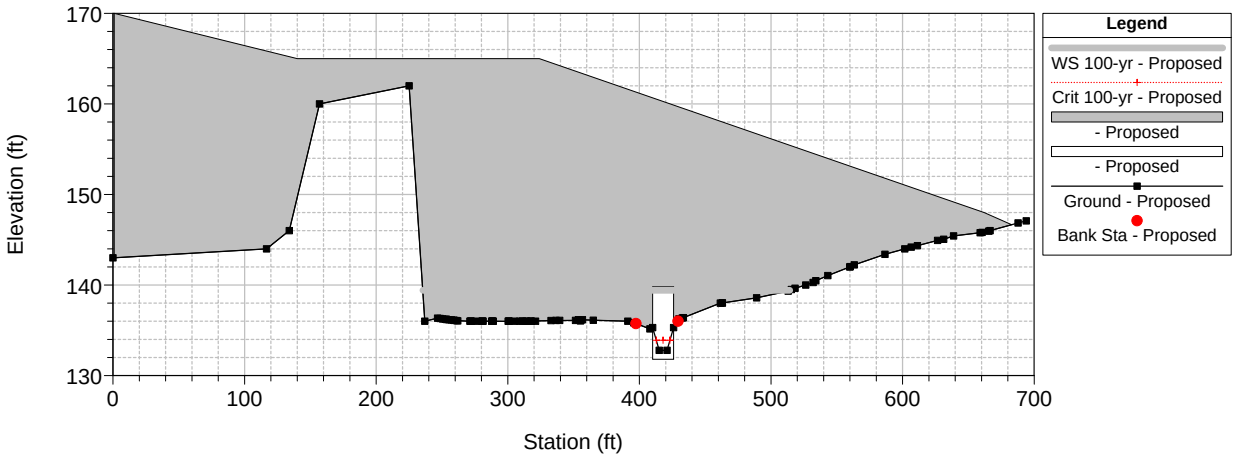
RS = 3200 Culv

Southern Tributary

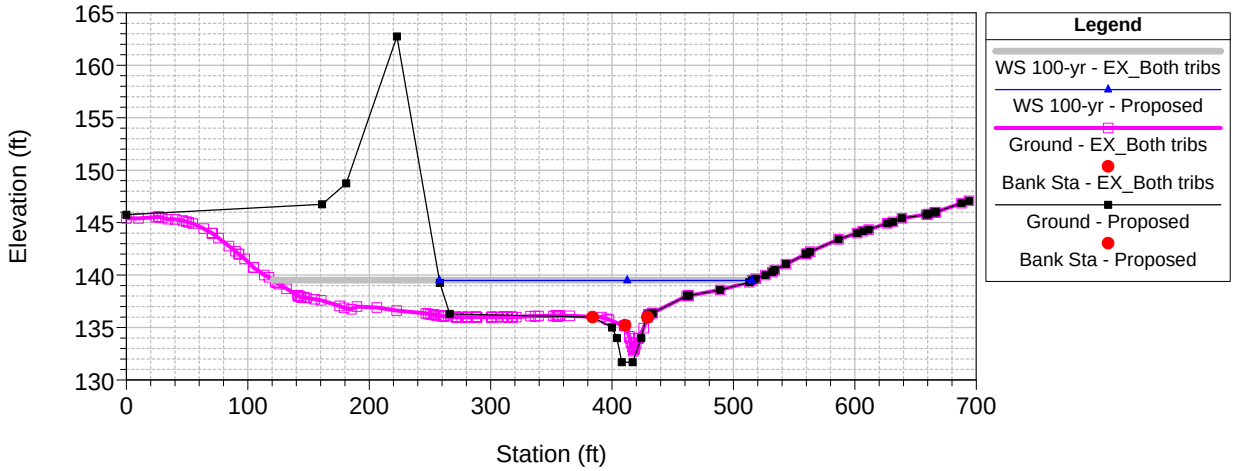


RS = 3200 Culv

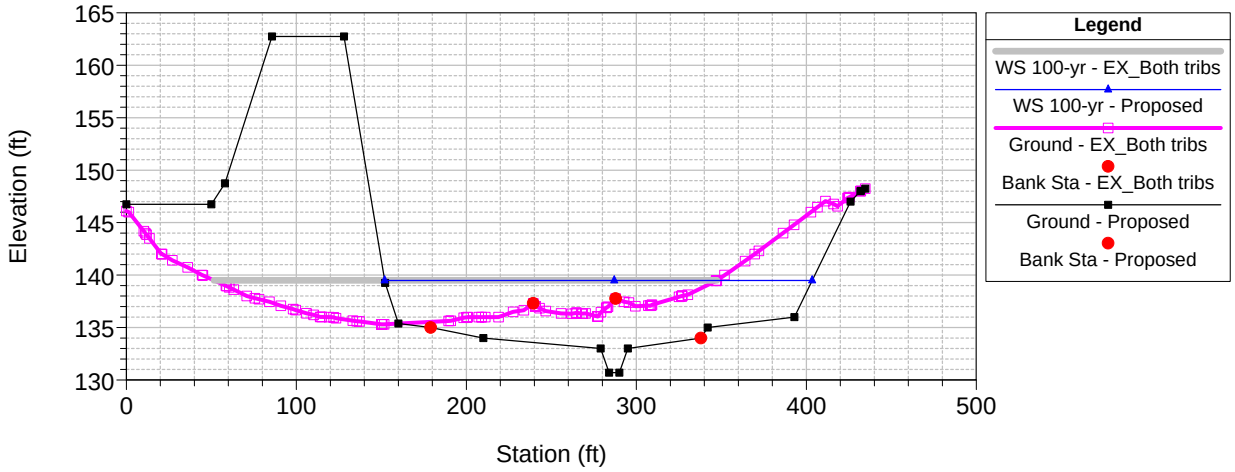
Southern Tributary



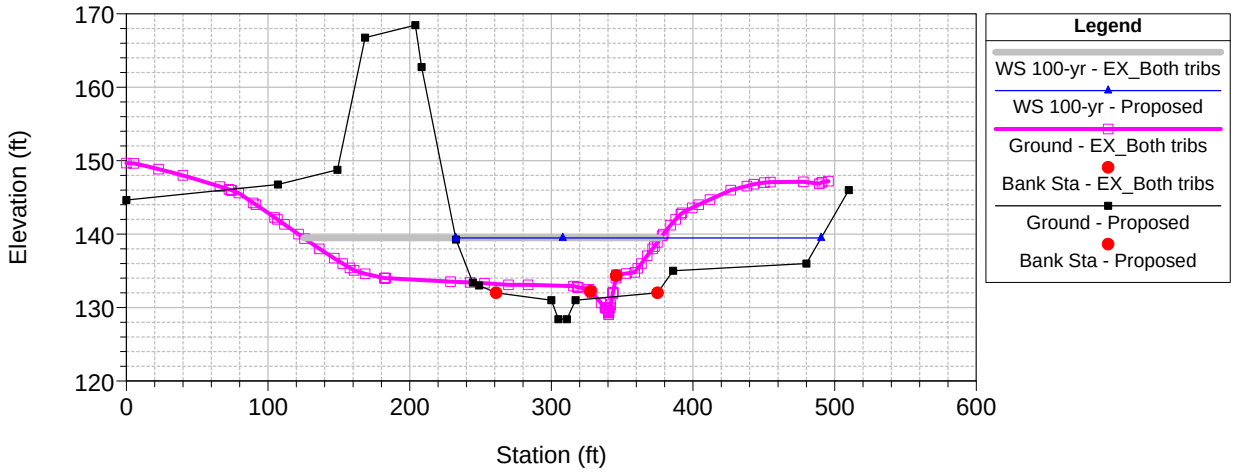
RS = 3052 Southern Tributary



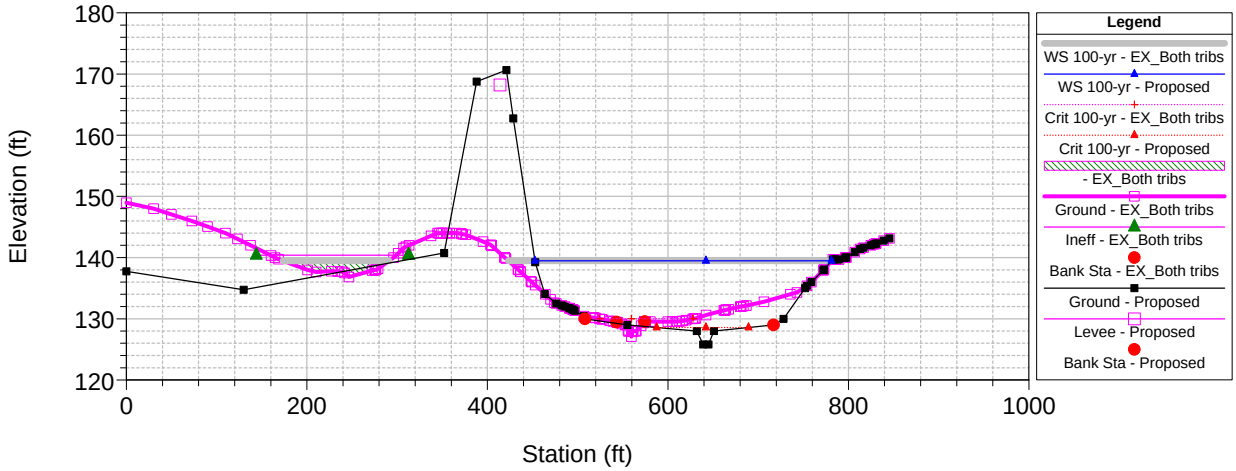
RS = 2865 Southern Tributary



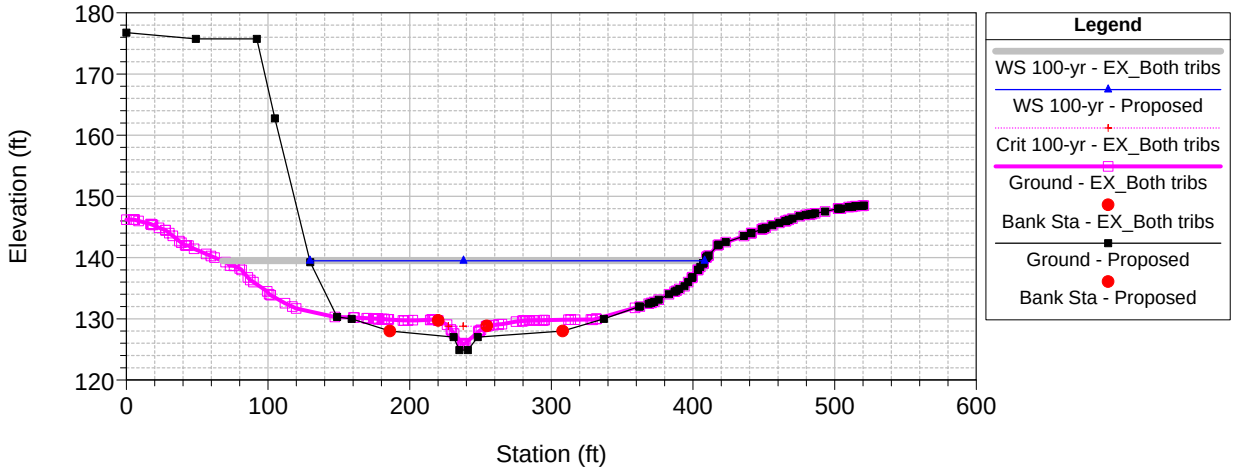
RS = 2462 Southern Tributary



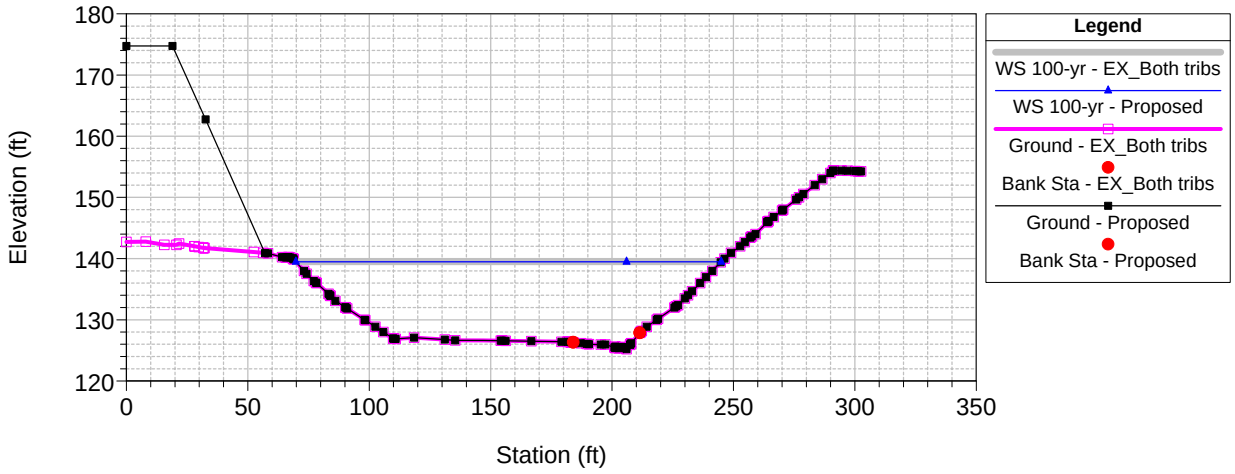
RS = 2090 Southern Tributary



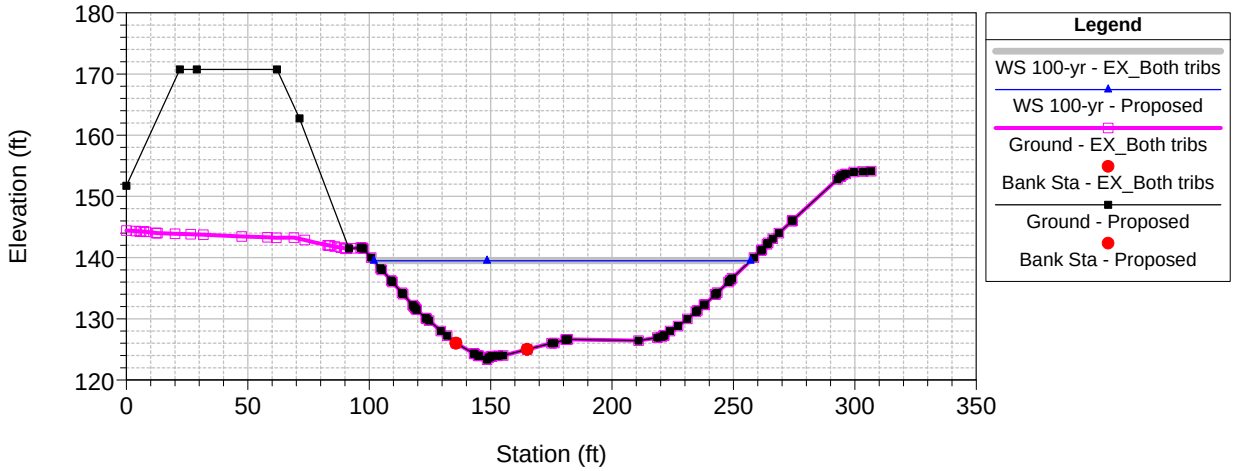
RS = 1866 Southern Tributary



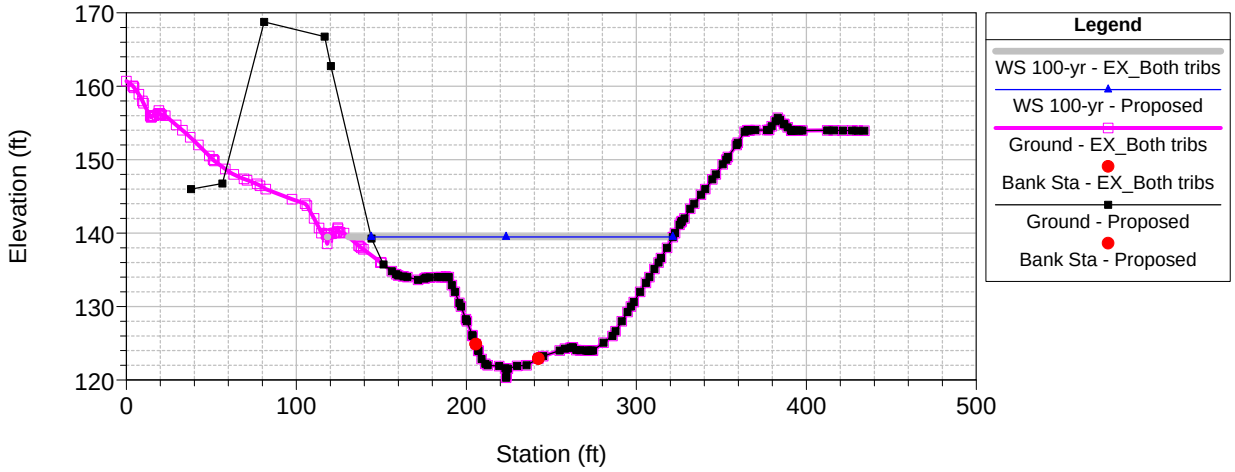
RS = 1763 Southern Tributary



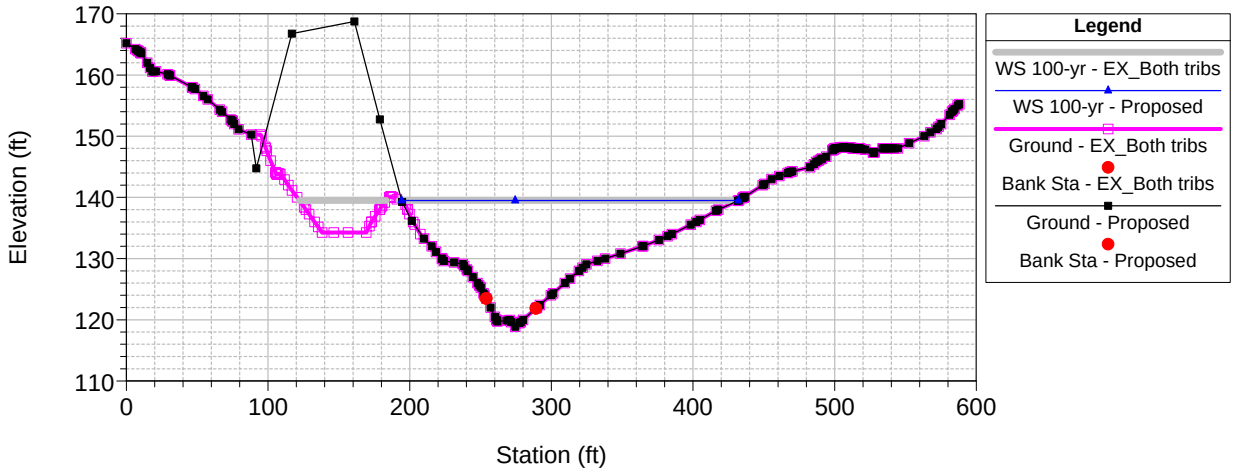
RS = 1520 Southern Tributary



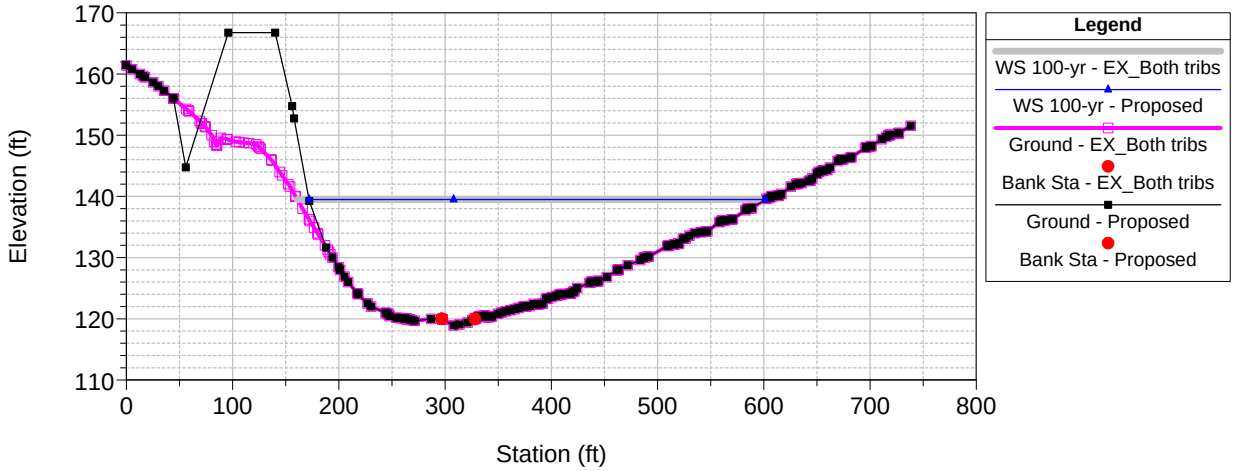
RS = 1204 Southern Tributary



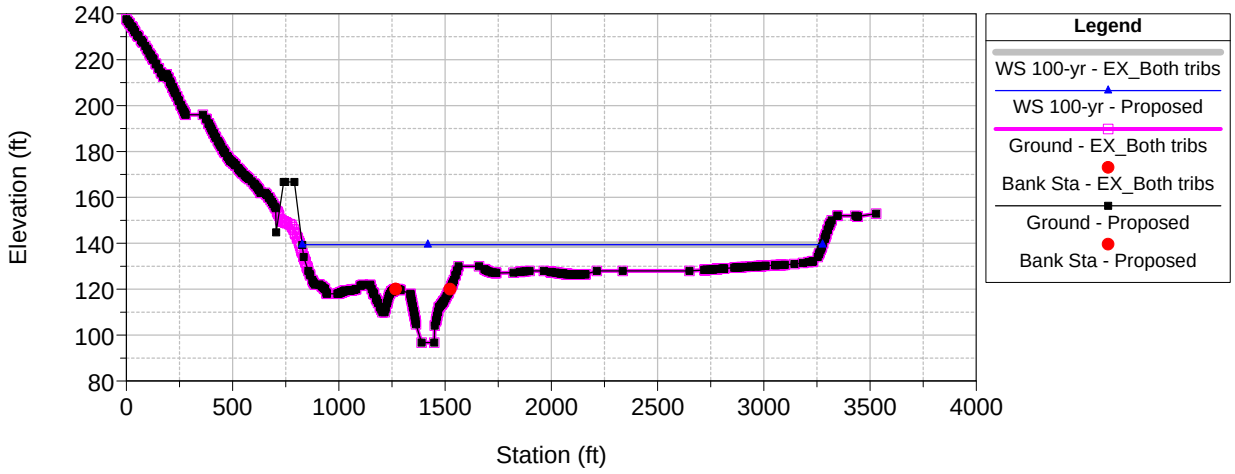
RS = 916 Southern Tributary



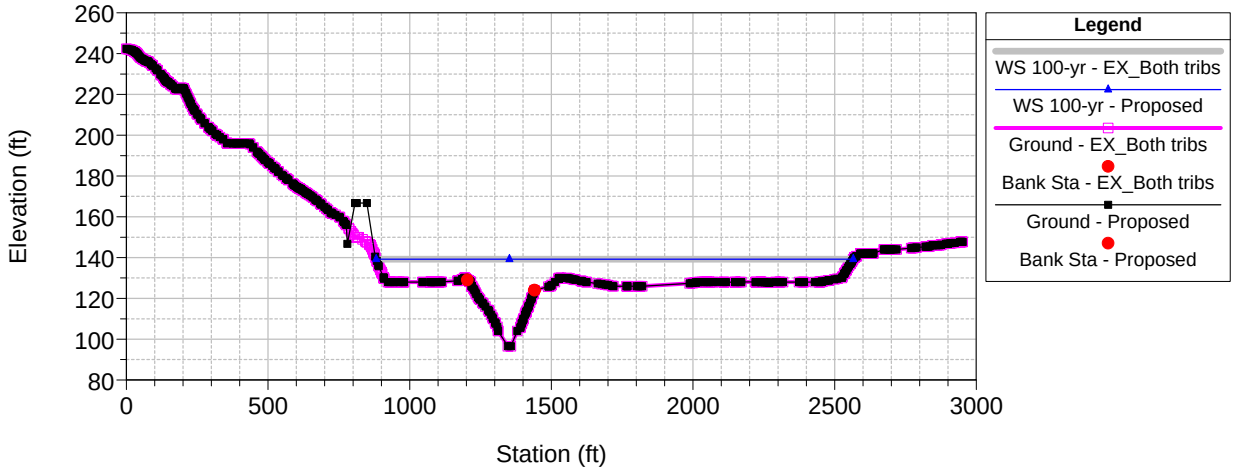
RS = 635 Southern Tributary



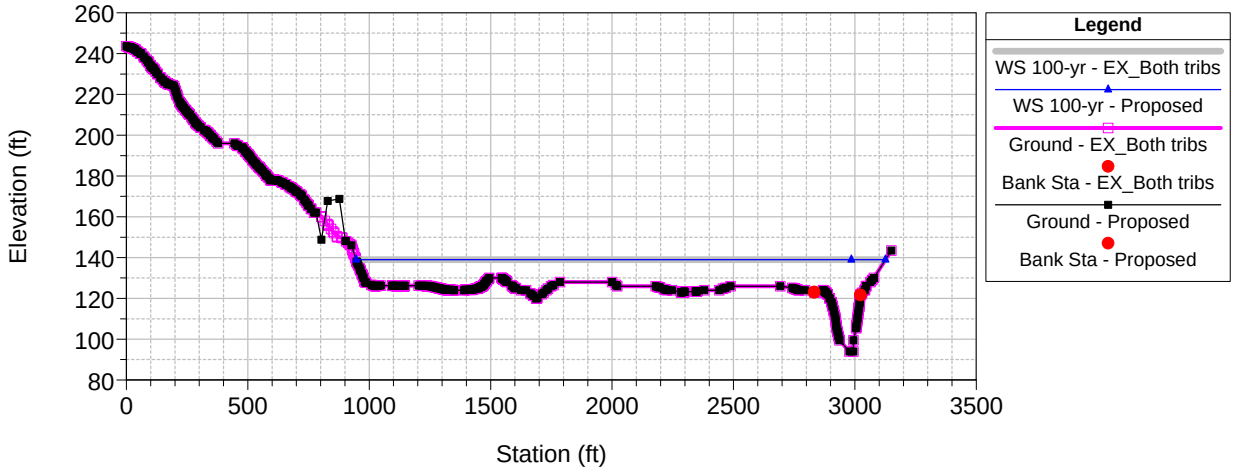
RS = 21.01 South Yamhill River



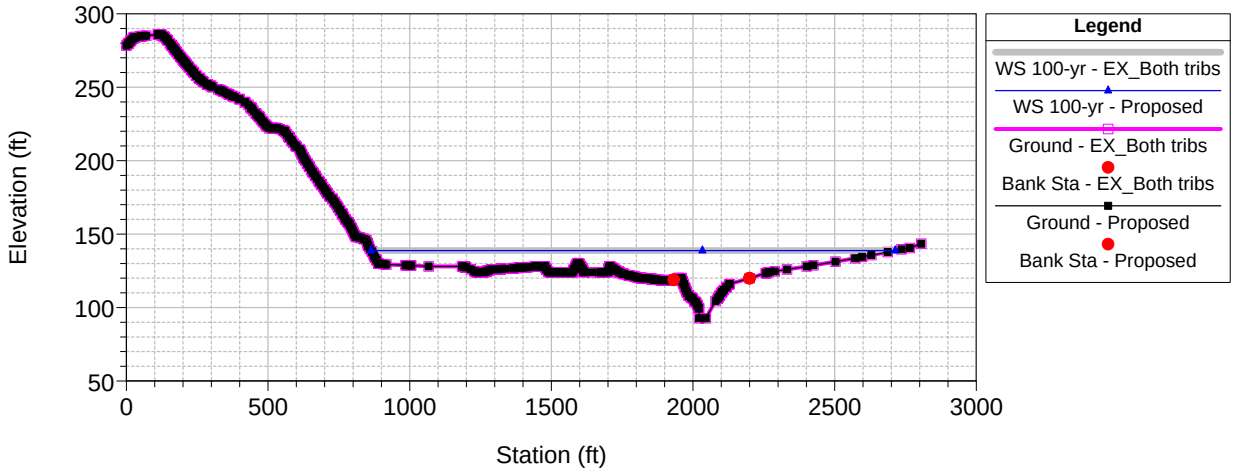
RS = 20.96 South Yamhill River



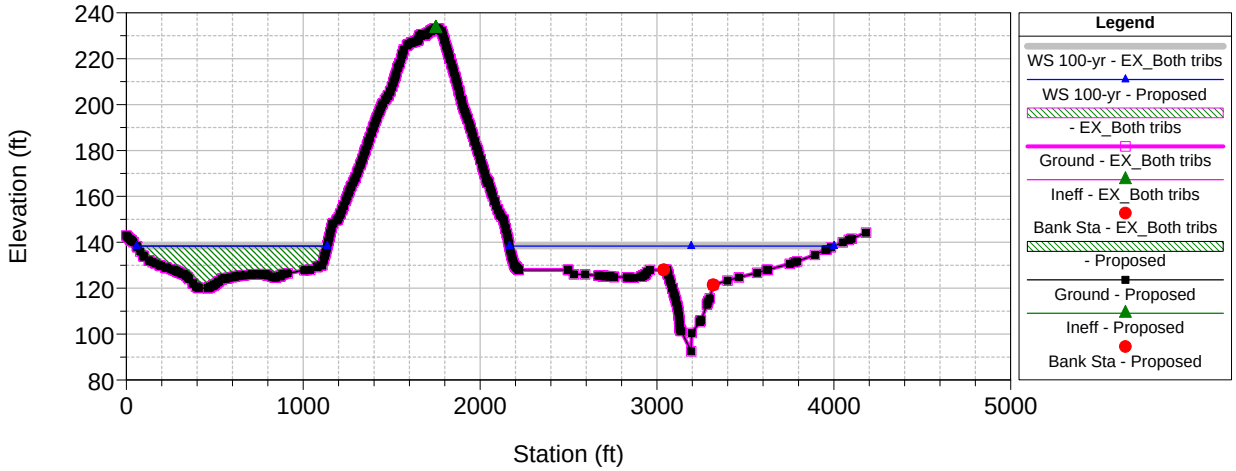
RS = 20.5 South Yamhill River



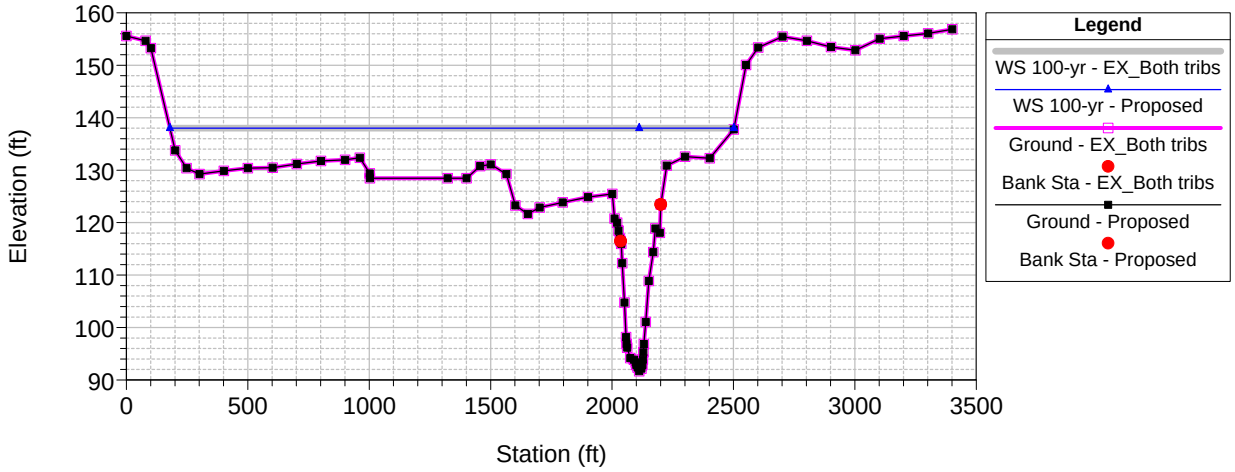
RS = 20.28 South Yamhill River



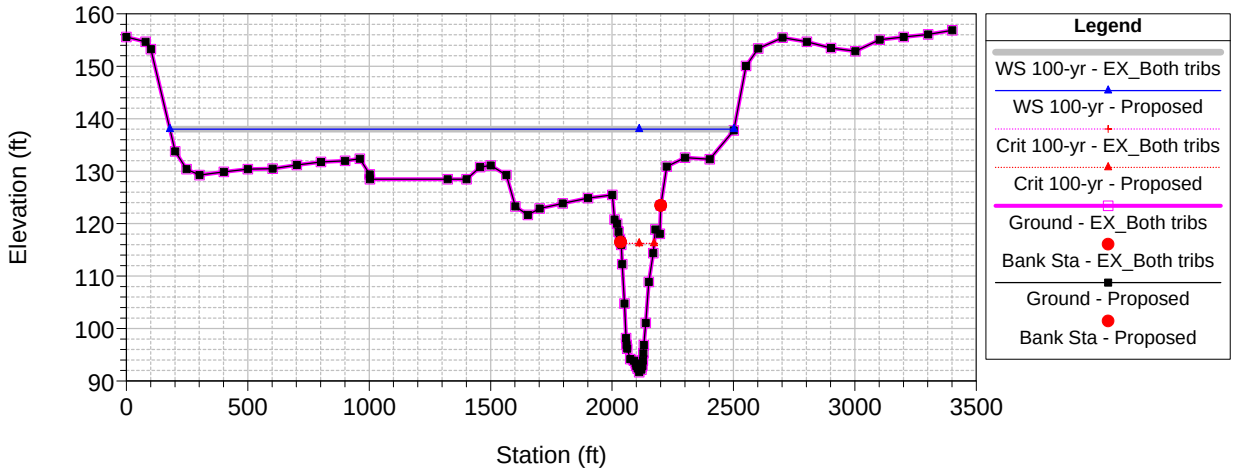
RS = 20.20 South Yamhill River



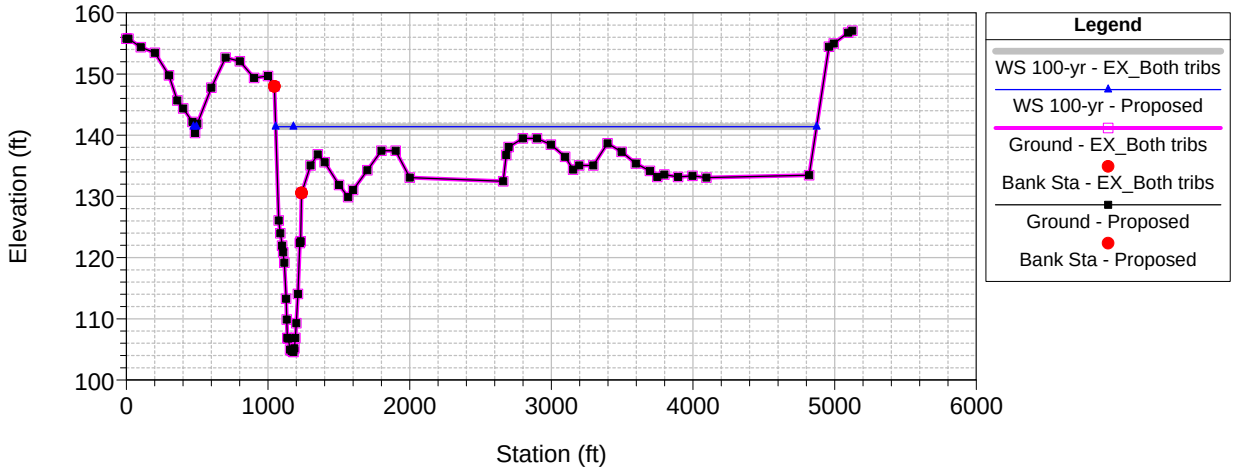
RS = 20.04 South Yamhill River



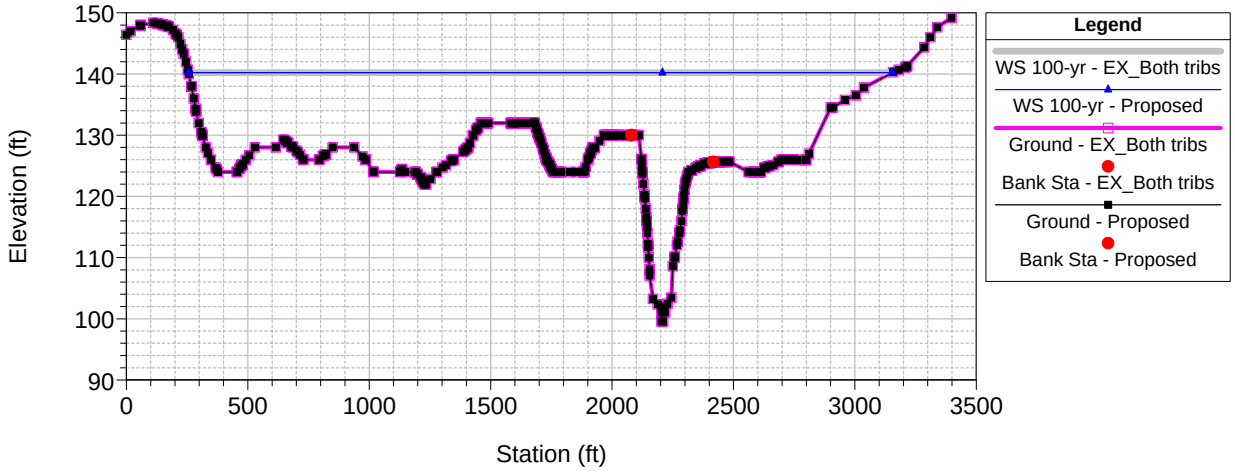
RS = 20.039 South Yamhill River



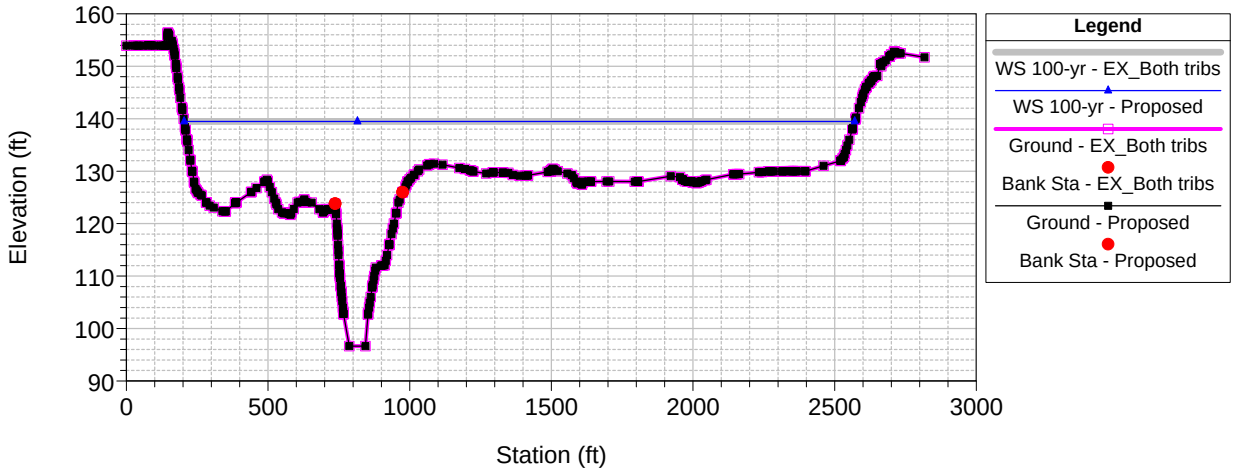
RS = 23.10 South Yamhill River



RS = 22.15 South Yamhill River



RS = 21.15 South Yamhill River



HEC-RAS Profile: 100-yr

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev	Vel Chnl	Flow Area	Top Width
					(cfs)	(ft)	(ft/s)	(sq ft)	(ft)
Yamhill River	Upper	23.10	100-yr	EX_Both tribs	50000	141.39	3.18	29468	3840
Yamhill River	Upper	23.10	100-yr	Proposed	50000	141.39	3.18	29466	3840
Yamhill River	Upper	22.15	100-yr	EX_Both tribs	50000	140.23	1.49	38925	2898
Yamhill River	Upper	22.15	100-yr	Proposed	50000	140.23	1.49	38923	2898
Yamhill River	Upper	21.15	100-yr	EX_Both tribs	50000	139.48	2.33	31060	2367
Yamhill River	Upper	21.15	100-yr	Proposed	50000	139.48	2.33	31058	2367
Yamhill Ri	Lower	21.01	100-yr	EX_Both tribs	50000	139.37	1.97	35050	2460
Yamhill Ri	Lower	21.01	100-yr	Proposed	50000	139.37	1.96	35017	2449
Yamhill Ri	Lower	20.96	100-yr	EX_Both tribs	50000	139.20	3.48	22760	1684
Yamhill Ri	Lower	20.96	100-yr	Proposed	50000	139.20	3.48	22761	1684
Yamhill Ri	Lower	20.5	100-yr	EX_Both tribs	50000	138.97	2.00	31223	2180
Yamhill Ri	Lower	20.5	100-yr	Proposed	50000	138.97	1.99	31223	2180
Yamhill Ri	Lower	20.28	100-yr	EX_Both tribs	50000	138.80	2.47	26334	1850
Yamhill Ri	Lower	20.28	100-yr	Proposed	50000	138.80	2.47	26334	1850
Yamhill Ri	Lower	20.20	100-yr	EX_Both tribs	50000	138.38	3.01	24409	2914
Yamhill Ri	Lower	20.20	100-yr	Proposed	50000	138.38	3.01	24409	2914
Yamhill Ri	Lower Lower	20.04	100-yr	EX_Both tribs	50000	138.00	3.69	24882	2323
Yamhill Ri	Lower Lower	20.04	100-yr	Proposed	50000	138.00	3.69	24882	2323
Yamhill Ri	Lower Lower	20.039	100-yr	EX_Both tribs	50000	138.00	3.69	24881	2323
Yamhill Ri	Lower Lower	20.039	100-yr	Proposed	50000	138.00	3.69	24881	2323
Tributary	Tributary	3365	100-yr	EX_Both tribs	277	139.54	1.05	659	354
Tributary	Tributary	3365	100-yr	Proposed	277	139.54	1.05	659	354
Tributary	Tributary	3316	100-yr	EX_Both tribs	277	139.53	0.93	714	333
Tributary	Tributary	3316	100-yr	Proposed	277	139.53	0.93	714	333
Tributary	Tributary	3052	100-yr	EX_Both tribs	277	139.51	0.65	1077	395
Tributary	Tributary	3052	100-yr	Proposed	277	139.48	0.66	779	257
Tributary	Tributary	2865	100-yr	EX_Both tribs	277	139.50	0.58	824	296
Tributary	Tributary	2865	100-yr	Proposed	277	139.48	0.26	1294	251
Tributary	Tributary	2462	100-yr	EX_Both tribs	277	139.48	0.44	1343	252
Tributary	Tributary	2462	100-yr	Proposed	277	139.48	0.24	1556	258
Tributary	Tributary	2090	100-yr	EX_Both tribs	277	139.48	0.23	2599	476
Tributary	Tributary	2090	100-yr	Proposed	277	139.48	0.11	2991	329
Tributary	Tributary	1866	100-yr	EX_Both tribs	277	139.48	0.21	2780	340
Tributary	Tributary	1866	100-yr	Proposed	277	139.48	0.14	2702	279
Tributary	Tributary	1800			Culvert				
Tributary	Tributary	1763	100-yr	EX_Both tribs	277	139.48	0.29	1808	175
Tributary	Tributary	1763	100-yr	Proposed	277	139.48	0.29	1808	175
Tributary	Tributary	1520	100-yr	EX_Both tribs	277	139.48	0.31	1658	155
Tributary	Tributary	1520	100-yr	Proposed	277	139.48	0.31	1658	155
Tributary	Tributary	1204	100-yr	EX_Both tribs	277	139.48	0.26	1952	191
Tributary	Tributary	1204	100-yr	Proposed	277	139.48	0.26	1926	177

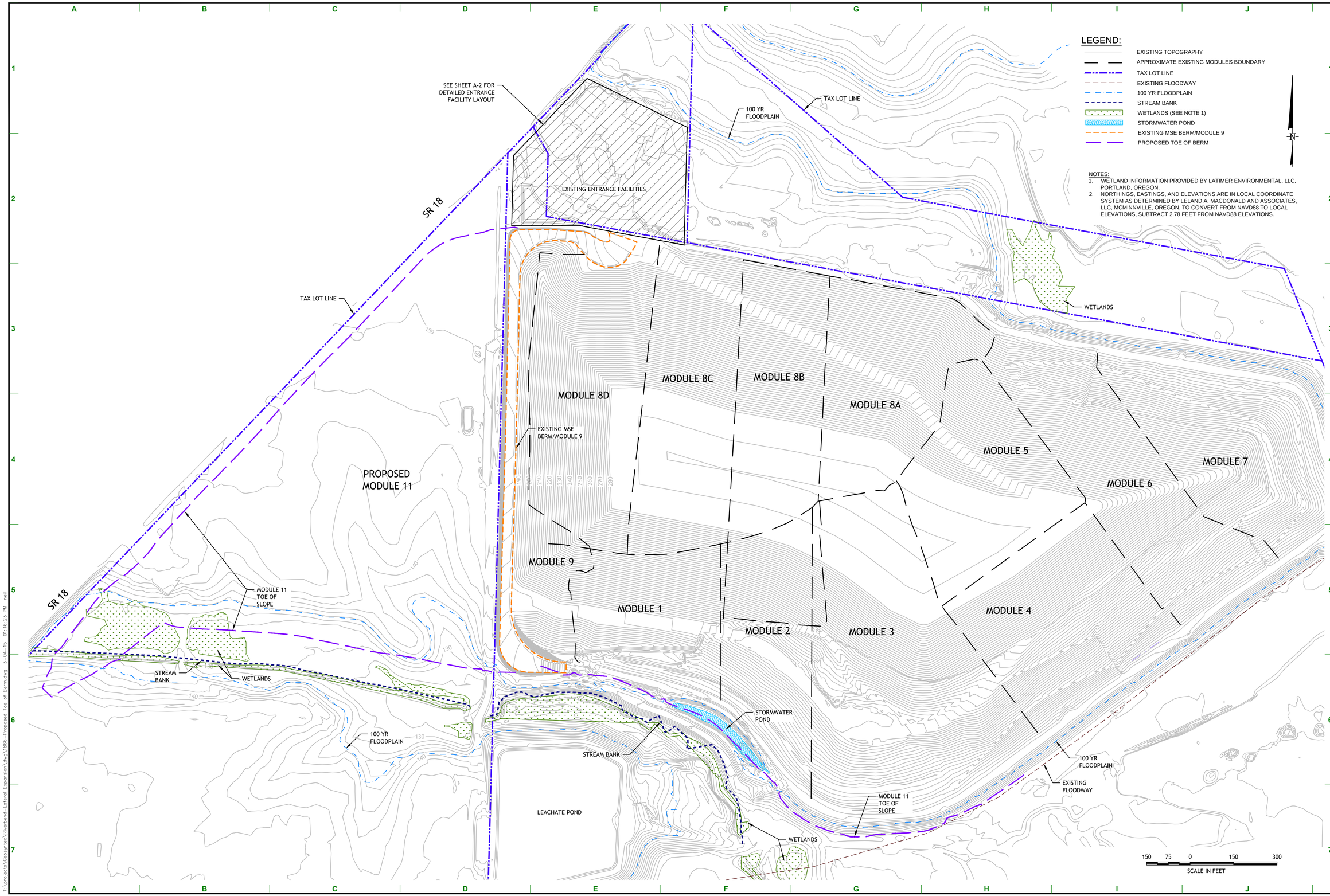
HEC-RAS Profile: 100-yr (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev	Vel Chnl	Flow Area	Top Width
					(cfs)	(ft)	(ft/s)	(sq ft)	(ft)
Tributary	Tributary	916	100-yr	EX_Both tribs	277	139.48	0.24	2535	301
Tributary	Tributary	916	100-yr	Proposed	277	139.48	0.24	2300	238
Tributary	Tributary	635	100-yr	EX_Both tribs	277	139.48	0.12	5561	440
Tributary	Tributary	635	100-yr	Proposed	277	139.48	0.12	5517	429
North Tributary	north tributary	4449.22	100-yr	EX_Both tribs	298	138.32	0.32	2689	487
North Tributary	north tributary	4449.22	100-yr	Proposed	298	138.32	0.32	2689	487
North Tributary	north tributary	3850.6	100-yr	EX_Both tribs	298	138.32	0.26	1897	281
North Tributary	north tributary	3850.6	100-yr	Proposed	298	138.32	0.26	1897	281
North Tributary	north tributary	3249.2	100-yr	EX_Both tribs	298	138.32	0.16	4353	480
North Tributary	north tributary	3249.2	100-yr	Proposed	298	138.32	0.16	4353	480

ATTACHMENT 3

Final Site Development Plan Drawings and Photographic Simulations

Final Site Development Plan Drawings



NO.	DESCRIPTION	DATE

REVISIONS

SHEET TITLE
EXISTING SITE CONDITIONS

PROJECT TITLE
SITE DESIGN REVIEW APPLICATION
RIVERBEND EXPANSION - MODULE 11
RIVERBEND LANDFILL - COWLITZ
YAMHILL COUNTY, OREGON

WASTE MANAGEMENT

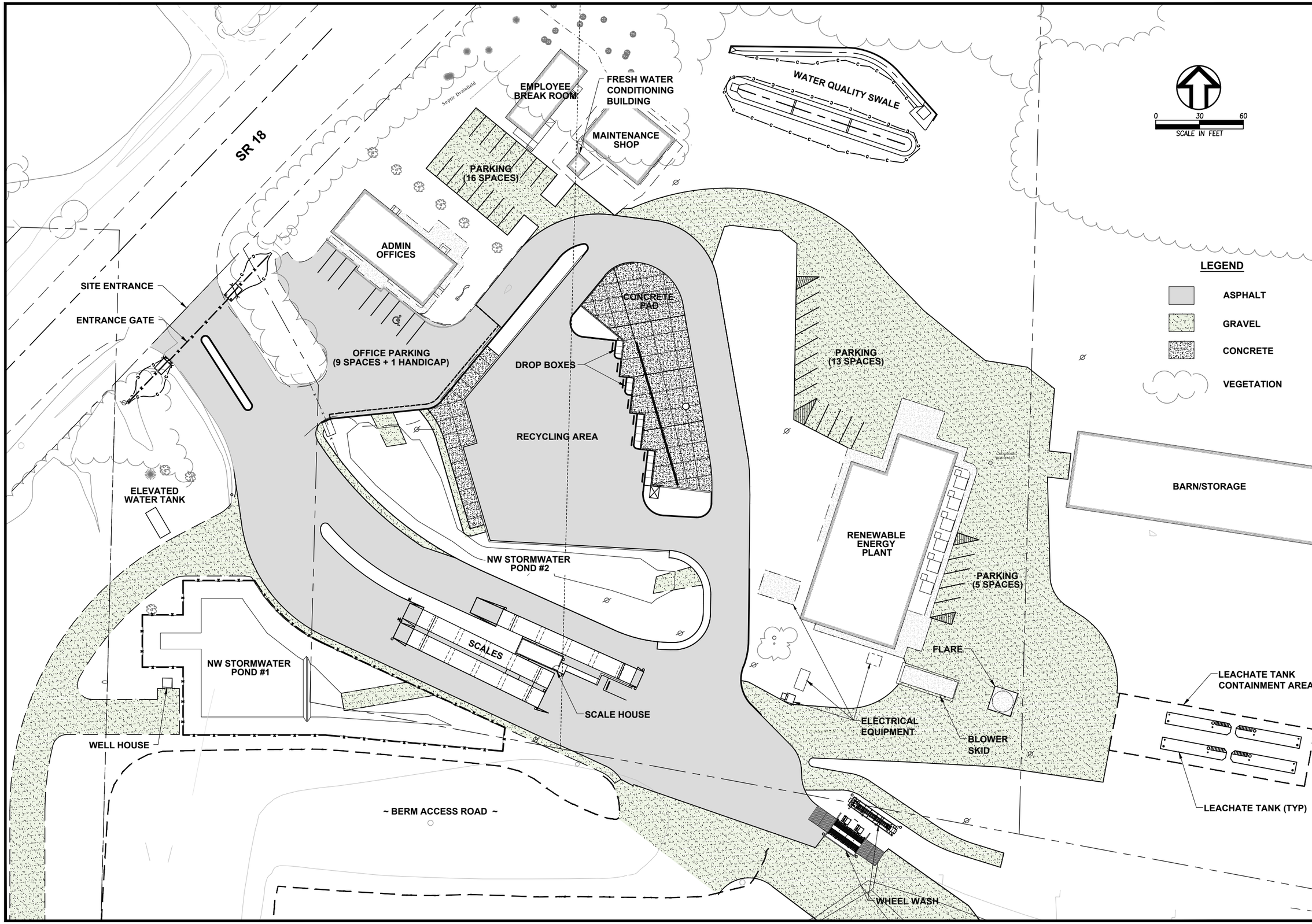
PRELIMINARY DRAWINGS

DES BY:	FWS	DATE:	MARCH 2015
DRN BY:	NTB	SCALE:	AS NOTED
CHK BY:	FWS	PROJECT:	WG1866
REV BY:	FWS	DOCUMENT:	
APP BY:	HDS		
FILE:			

Geosyntec consultants
1111 Broadway
Sixth Floor
Oakland, CA 94607

DRAWING NO.
A-1
(REVISED)

T:\projects\Geosyntec\Riverbend-Lateral Expansion\dwg\1866-Proposed Toe of Berm.dwg 3-04-15 01:16:23 PM neil



NO.	REVISION	DATE
1	REVISED TITLE	2/19/15

SHEET TITLE: EXISTING SITE CONDITIONS: ENTRANCE FACILITY

PROJECT TITLE: SITE DESIGN REVIEW APPLICATION FOR MODULE 11 EXPANSION, RIVERBEND LANDFILL

ONE INCH 0 1"
ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

WASTE MANAGEMENT
RIVERBEND LANDFILL COMPANY

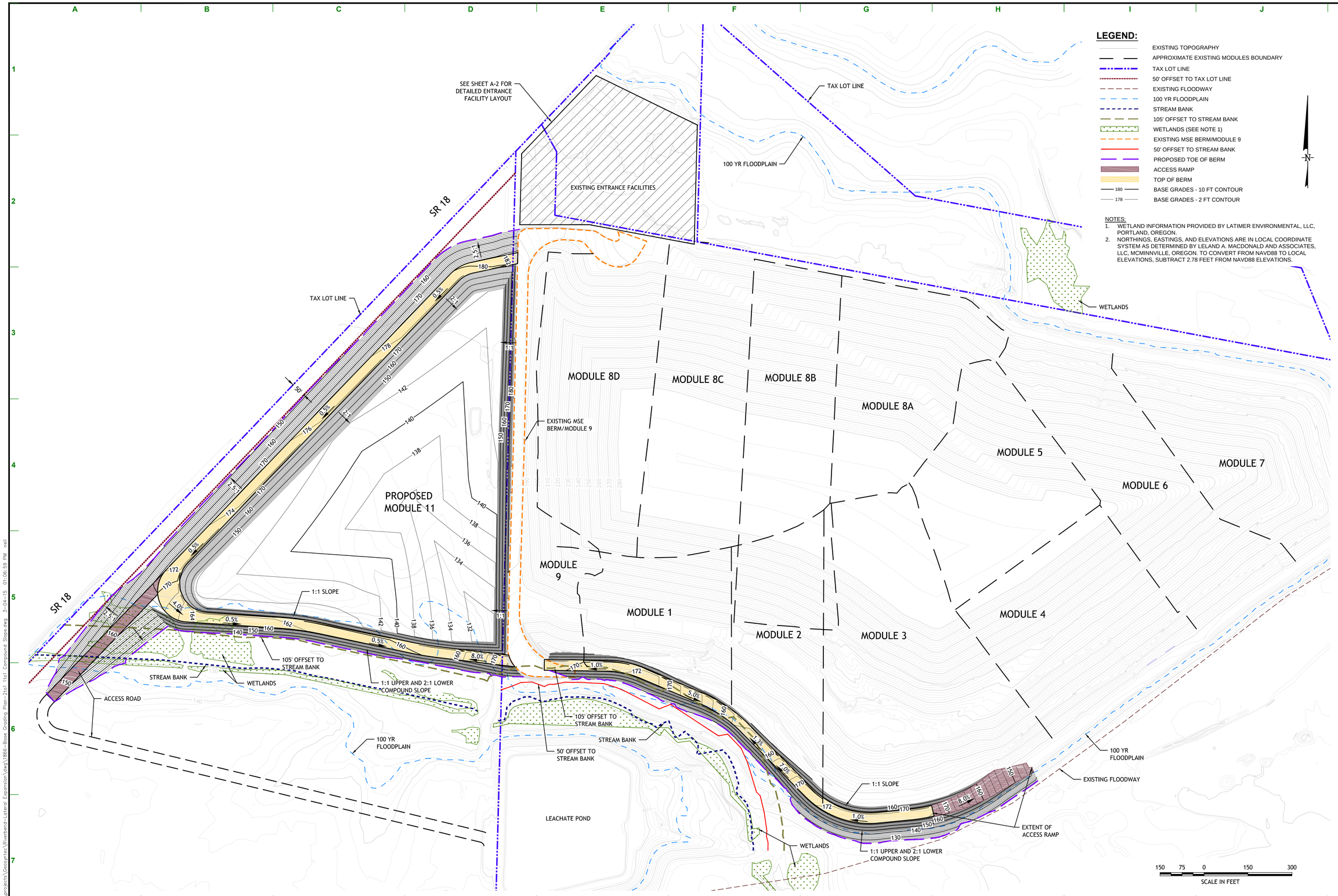
wallis engineering
PLLC
2101 W. Cliff, Suite 200
Vancouver, WA 98660
360.695.7041

PROJ. NO.
DWN BY:
CHK BY:
DSN/APP. BY:

DATE: 11/2014

SCALE: AS SHOWN

DRAWING NO. A-2
REVISED



NO.	DESCRIPTION	DATE

REVISIONS

SHEET TITLE: BASE GRADING PLAN

PROJECT TITLE: SITE DESIGN REVIEW APPLICATION RIVERBEND EXPANSION - MODULE 11 RIVERBEND LANDFILL - COVE WAY YAMHILL COUNTY, OREGON

WASTE MANAGEMENT

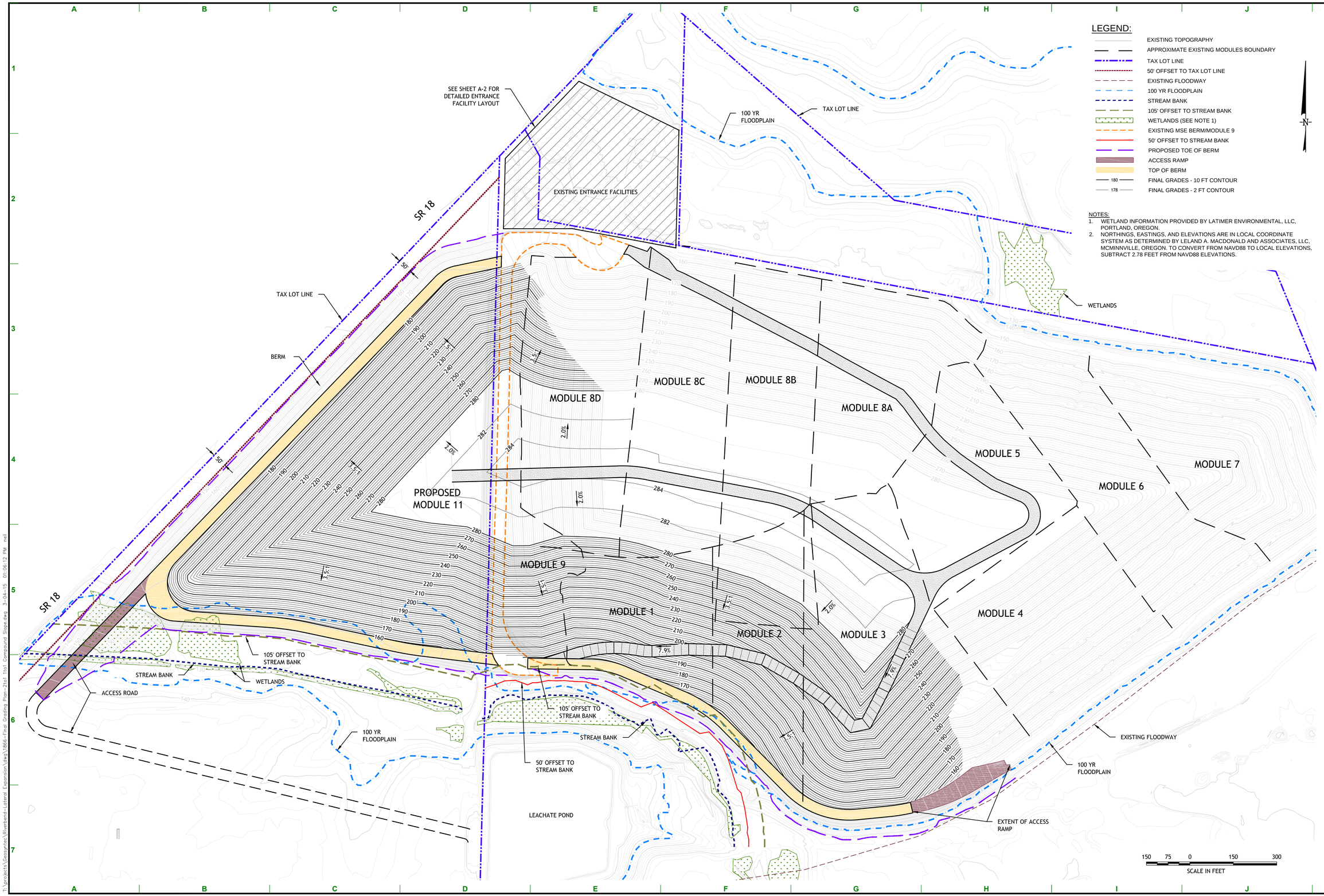
PRELIMINARY DRAWINGS

DES BY:	FWS	DATE:	MARCH 2015
DRN BY:	NTB	SCALE:	AS NOTED
CHK BY:	FWS	PROJECT:	WG1866
REV BY:	FWS	DOCUMENT:	
APP BY:	HDS		
FILE:			

Geosyntec consultants
1111 Broadway
Sixth Floor
Oakland, CA 94607

DRAWING NO.
A-3
(REVISED)

T:\projects\Geosyntec\Riverbend-Lateral Expansion\dwg\1866-Base Grading Plan-2to1 1to1 Compound Slope.dwg 3-04-15 01:06:59 PM neil



NO.	DESCRIPTION	DATE

REVISIONS

SHEET TITLE
FINAL GRADING PLAN

PROJECT TITLE
SITE DESIGN REVIEW APPLICATION
RIVERBEND EXPANSION - MODULE 11
RIVERBEND LANDFILL - COMPANY
YAMHILL COUNTY, OREGON

WASTE MANAGEMENT

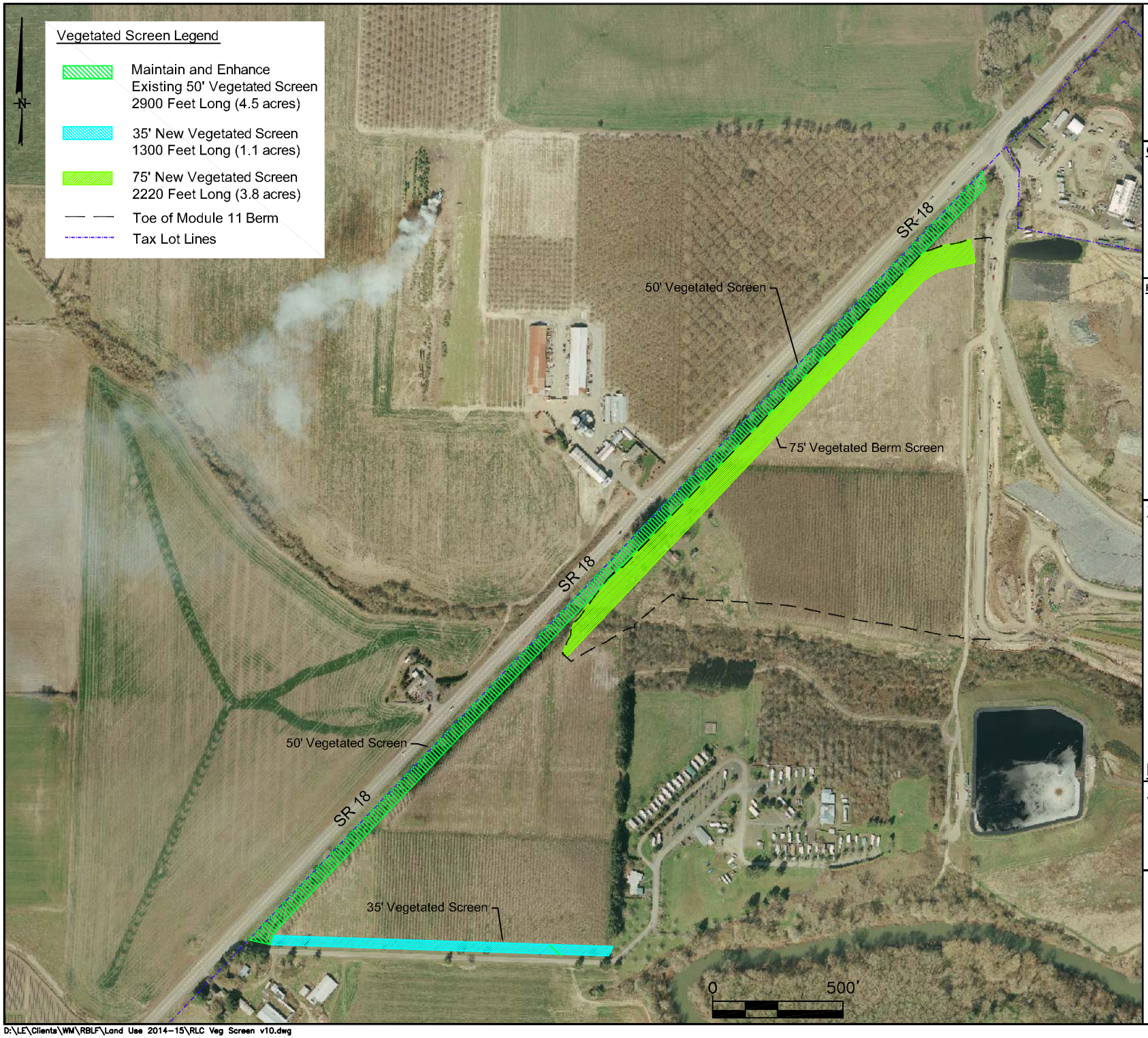
PRELIMINARY DRAWINGS

DES BY:	FWS	DATE:	MARCH 2015
DRN BY:	NTB	SCALE:	AS NOTED
CHK BY:	FWS	PROJECT:	WG1866
REV BY:	FWS	DOCUMENT:	
APP BY:	HDS	FILE:	

Geosyntec consultants
1111 Broadway
Sixth Floor
Oakland, CA 94607

DRAWING NO.
A-4
(REVISED)

T:\projects\Geosyntec\Riverbend-Lateral Expansion\dwg\1866-Final Grading Plan-2to1 1to1 Compound Slope.dwg 3-04-15 01:06:12 PM neil



latimer environmental LLC
35 SE 76th Ave
Portland OR 97215
503-208-3706

CLIENT:

WASTE MANAGEMENT

PROJECT:

Site Design Review Application

Riverbend Expansion
Module 11

Riverbend Landfill Company
Yamhill County, Oregon

TITLE:

Vegetated Screening
Buffers

FOR PLANNING PURPOSES ONLY

DRAWING DATA:

Plotted: 3/3/2015

FIGURE NO.

A-5
(Revised)

D:\LE\Clients\WM\RBLF\Land Use 2014-15\RLC Veg Screen v10.dwg

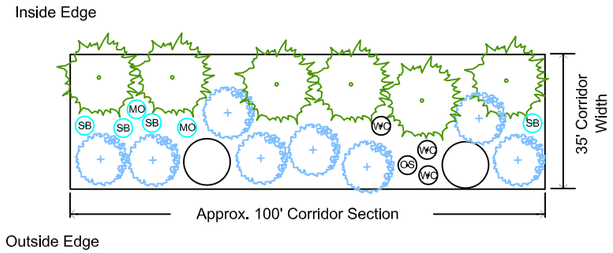
PLANT LAYOUT MODULE NOTES

1. Plant layout modules will be repeated throughout the site; plants will be randomized within each module and will have a random appearance from Highway 18. See Drawing 6a for planting locations for each module type.

2. Plant layout modules are diagrammatic; adjustments will be made in the field to accommodate actual planting area dimensions.

3. Plant quantities shown are estimates. Exact quantities will be based on actual field layout of plants.

PLANT LAYOUT MODULE A: 35' WIDE BUFFER



PLANT LAYOUT MODULE A PLANT KEY

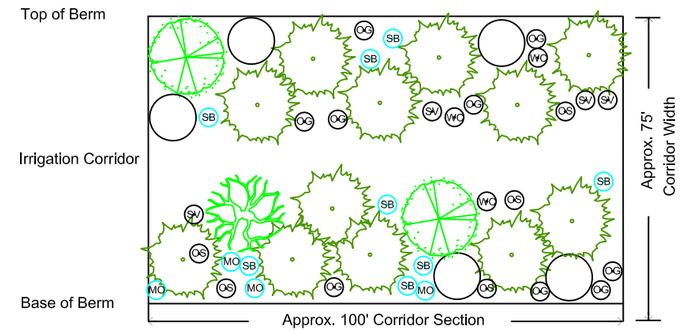
TREES

Symbol	Module Quantity	Total Quantity	Name (Common/Botanical)	Size
	8	104	Blue Spruce Picea pungens 'Glauca'	5-Gal
	6	78	Douglas Fir Psedotsuga menziesii	5-Gal
	2	26	Vine Maple Acer circinatum	5-Gal

SHRUBS--Bare Root

Symbol	Module Quantity	Total Quantity	Name (Common/Botanical)	Size
MO	2	26	Mock Orange Philadelphus lewisii	Bare Root
OS	1	13	Ocean Spray Holodiscus discolor	Bare Root
SB	4	52	Snowberry Symphoricarpos albus	Bare Root
WC	3	39	Red Flowering Currant Ribes sanguineum	Bare Root

PLANT LAYOUT MODULE B: 75' WIDE BUFFER



PLANT LAYOUT MODULE B PLANT KEY

TREES

Symbol	Module Quantity	Total Quantity	Name (Common/Botanical)	Size
	11	451	Douglas Fir Psedotsuga menziesii	5-Gal
	1	41	Giant Sequoia Sequoiadendron giagantium	5-Gal
	2	82	Big Leaf Maple Acer macrophyllum	5-Gal
	5	205	Vine Maple Acer circinatum	5-Gal

SHRUBS--Bare Root

Symbol	Module Quantity	Total Quantity	Name (Common/Botanical)	Size
MO	4	92	Mock Orange Philadelphus lewisii	Bare Root
OS	5	115	Ocean Spray Holodiscus discolor	Bare Root
OG	9	207	Oregon Grape Mahonia aquifolium	Bare Root
SA	4	92	Serviceberry Amelanchier alnifolia	Bare Root
SB	8	184	Snowberry Symphoricarpos albus	Bare Root
WC	3	69	Red Flowering Currant Ribes sanguineum	Bare Root

latimer environmental, LLC
35 SE 76th Ave.
Portland, OR 97215
503.867.1780

CLIENT:

WASTE MANAGEMENT

PROJECT:

Riverbend Landfill Company
Yamhill County, Oregon

Riverbend Landfill Expansion

TITLE:

Riverbend Landfill Expansion

Berm Buffer
Planting Layout

DWG DATA:

March 3, 2015

DRAWING NO.

A-6

(Revised)

NOT FOR CONSTRUCTION

Photographic Simulations

How will Riverbend blend with the natural landscape over time?

Our long-term goal is for Riverbend to blend with the natural landscape.

We took an important step in this direction recently by removing tarps and replacing them with soil and grasses. Additional aesthetic improvements are underway as we continue to cover the existing landfill and plant more grasses. By 2016, much of the existing landfill will be covered with grasses.

The purpose of the photo simulations is to show how the landfill—including the existing landfill area and the expansion—will look to passersby and neighbors over time.

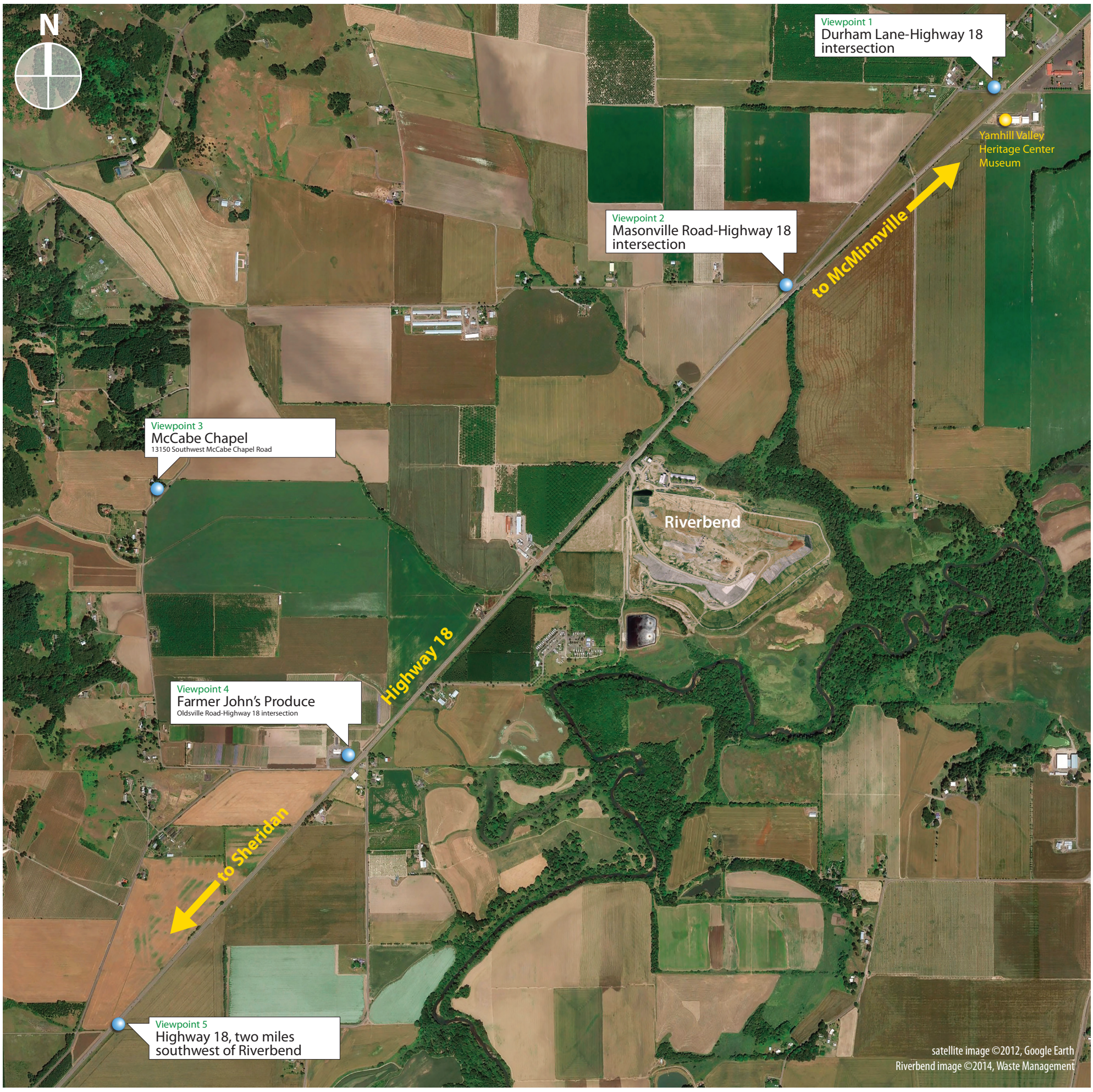
Orientation Map for Photo Simulations

This aerial photograph shows five viewpoints:

1. The intersection of Highway 18 and Durham Lane—the view as seen when traveling from McMinnville
2. Masonville Road-Highway 18 intersection
3. The view from an elevated area in front of McCabe Chapel
4. Oldsville Road-Highway 18 intersection—the view from Farmer John's Produce
5. Two miles southwest of Riverbend on Highway 18—the view when traveling from Sheridan

The simulations will show views at three stages:

1. Today
2. Five years after construction begins for the expansion
3. When expansion area is closed and planted with grasses and shrubs



How will Riverbend blend with the natural landscape over time?

Viewpoint 1

View of Riverbend as seen from the intersection of Highway 18 and Durham Lane, when traveling from McMinnville

Riverbend today

Riverbend 5 years after construction begins for the expansion (2021)

Riverbend when the expansion area is closed and planted with grasses and shrubs—15 years after construction begins (2031)

Simulations are based on actual engineering calculations and drawings from the Riverbend expansion application, to provide the most accurate and realistic representations possible.

Landscaping and plantings shown are based on plans submitted in the application, to show realistic simulations of visual buffers.

How will Riverbend blend with the natural landscape over time?

Viewpoint 2

View of Riverbend as seen from the intersection of Highway 18 and Masonville Road, when traveling from McMinnville

Riverbend today

Riverbend 5 years after construction begins for the expansion (2021)

Riverbend when the expansion area is closed and planted with grasses and shrubs—15 years after construction begins (2031)

Simulations are based on actual engineering calculations and drawings from the Riverbend expansion application, to provide the most accurate and realistic representations possible.

Landscaping and plantings shown are based on plans submitted in the application, to show realistic simulations of visual buffers.

How will Riverbend blend with the natural landscape over time?

Viewpoint 3

View of Riverbend as seen from McCabe Chapel, approximately one mile east of Riverbend

Riverbend today

Riverbend 5 years after construction begins for the expansion (2021)

Riverbend when the expansion area is closed and planted with grasses and shrubs—15 years after construction begins (2031)

Simulations are based on actual engineering calculations and drawings from the Riverbend expansion application, to provide the most accurate and realistic representations possible.

Landscaping and plantings shown are based on plans submitted in the application, to show realistic simulations of visual buffers.

How will Riverbend blend with the natural landscape over time?

Viewpoint 4

View of Riverbend as seen from Farmer John's Produce at the intersection of Highway 18 and Oldsville Road

Riverbend today

Riverbend 5 years after construction begins for the expansion (2021)

Riverbend when the expansion area is closed and planted with grasses and shrubs—15 years after construction begins (2031)

Simulations are based on actual engineering calculations and drawings from the Riverbend expansion application, to provide the most accurate and realistic representations possible.

Landscaping and plantings shown are based on plans submitted in the application, to show realistic simulations of visual buffers.

How will Riverbend blend with the natural landscape over time?

Viewpoint 5

View of Riverbend as seen from Highway 18 two miles southwest of Riverbend, when traveling from Sheridan

Riverbend today

Riverbend 5 years after construction begins for the expansion (2021)

Riverbend when the expansion area is closed and planted with grasses and shrubs—15 years after construction begins (2031)

Simulations are based on actual engineering calculations and drawings from the Riverbend expansion application, to provide the most accurate and realistic representations possible.

Landscaping and plantings shown are based on plans submitted in the application, to show realistic simulations of visual buffers.

ATTACHMENT 4

Revised Hydrogeologic Site Characterization Work Plan (Prepared by SCS Engineers)

SCS ENGINEERS

Work Plan for Hydrogeologic Site Characterization In Support of Module 11 Expansion Permit (Revised)

Riverbend Landfill
McMinnville, Oregon

Prepared for:

RIVERBEND LANDFILL COMPANY
13469 SW Highway 18
McMinnville, Oregon 97128
(503) 472-8788

WASTE MANAGEMENT

Prepared by:

SCS ENGINEERS
14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224
(503) 639-9201

April 23, 2015
File No. 04215015.00

SCS ENGINEERS

Work Plan for Hydrogeologic Site Characterization In Support of Module 11 Expansion Permit (Revised)

Riverbend Landfill
McMinnville, Oregon

Prepared for:

RIVERBEND LANDFILL COMPANY
13469 SW Highway 18
McMinnville, Oregon 97128
(503) 472-8788

WASTE MANAGEMENT

Prepared by:

SCS ENGINEERS
14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224
(503) 639-9201

REGISTERED
OREGON
DAVID LAMADRID
G1905
GEOLOGIST
Expires 1/31/16

April 23, 2015
File No. 04215015.00

David Lamadrid, R.G.
Senior Project Geologist
SCS ENGINEERS

Louis Caruso
Project Director
SCS ENGINEERS

Table of Contents

Section **Page**

List of Tables iii
List of Figures iii
List of Appendices iii
Acronyms and Abbreviations iv
1.0 Introduction 1
1.1 Site Description 2
1.2 Purpose and Objectives 2
1.3 Work Plan Organization 3
2.0 Regional Setting 4
2.1 Physiography 4
2.2 Climate 4
2.3 Regional Geology and Hydrogeology 4
3.0 Existing Geologic and Hydrogeologic Information and DAta 6
3.1 Investigation History in proposed Module 11 6
3.2 Site Geology and Hydrogeology 8
3.2.1 Geology 9
3.2.2 Hydrogeology 10
3.3 Groundwater Chemistry 12
3.3.1 Upper Silt-Clay Water-Bearing Zone 12
3.3.2 Lower Sand-Gravel Water-Bearing Zone 13
3.4 Water-Use Survey 13
4.0 Approach and Proposed Work Plan Scope of Work 15
4.1 Approach 15
4.2 Proposed Work Plan Scope of Work 15
4.2.1 Surficial Geology and Soils Evaluation 15
4.2.2 Hydraulic Conductivity Testing 16
4.2.3 Aquifer Pumping Test 16
4.2.4 Update Water-Use Survey 18
4.2.5 Reporting 18
5.0 Schedule 20
6.0 References 21

List of Tables

Table 3-1 Construction Information for Groundwater Monitoring Wells and Piezometers

Table 3-2 Summary of Subsurface Explorations within or in Close Proximity to Proposed Module 11

Table 3-3 Summary of Historical Slug Testing Results

List of Figures

Figure 1-1 Site Location Map

Figure 1-2 Site Plan and Existing Monitoring Locations

Figure 3-1 Site Plan and Historical Monitoring/Exploratory Locations

Figure 3-2 Shallow Water-Bearing Zone Potentiometric Surface Contours (November 18, 2013)

Figure 3-3 Deep Water-Bearing Zone Potentiometric Surface Contours (November 18, 2013)

Appendices

Appendix A Borehole Logs and Well Construction Diagrams for Existing and Former Wells and Borings Within or in Close Proximity to Proposed Module 11

Appendix B Production Well PW-1 Documentation

ACRONYMS AND ABBREVIATIONS

AEMR	annual environmental monitoring report
AHI	additional hydrogeological investigation
As	arsenic
Ba	barium
Ca	calcium
Co	cobalt
Cr	chromium
Cu	copper
Cl	chloride
cm/sec	centimeters per second
DEQ	Oregon Department of Environmental Quality
EMCON	EMCON Northwest, Inc.
EMP	environmental monitoring plan
^{o}F	degrees Farenheight
Fe	iron
ft/ft	feet per foot
gpm	gallons per minute
HSC	hydrogeologic site characterization
HCO_3	bicarbonate alkalinity
Mg	magnesium
mg/L	milligrams per liter
Mn	manganese
Na	sodium
Ni	Nickel
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RL	Riverbend Landfill
RLC	Riverbend Landfill Company
SCS	SCS Engineers
SSL	site-specific limit
TDS	total dissolved solids
TSS	total suspended solids
V	vanadium
WBZ	water-bearing zone
WRD	Oregon Water Resources Department
Zn	zinc

1.0 INTRODUCTION

This work plan, prepared by SCS Engineers (SCS) on behalf of Riverbend Landfill Company (RLC), describes a scope of work to perform a hydrogeologic site characterization (HSC) in support of a solid waste permit application to expand the Riverbend Landfill (RL) in Yamhill County, Oregon. The expansion consists of proposed Module 11 expansion area (proposed Module 11), an approximately 29-acre area directly west of the existing landfill. The scope of work is intended to meet the requirements specified in the following:

- Resource Conservation and Recovery Act (RCRA) Subtitle D (40 CFR Part 258) regulations, and Oregon Solid Waste Regulations (Oregon Administrative Rule [OAR] Chapter 340, Division 40 and 93 through 97).

- Section 12, Site Characterization, of RL's solid waste disposal site permit No. 345 (SWDP) issued by the Oregon Department of Environmental Quality (DEQ) in December 1999.

- Section 3, Phase II Landfill Site Characterization, of the DEQ's Solid Waste Landfill Guidance document dated September 1, 1996.

This work plan includes a summary of previous site characterizations and investigations relevant to characterizing the geology and hydrogeology of proposed Module 11 area, along with key results and findings from these studies. This extensive historical information formed the basis for (1) interpreting the hydrogeologic conditions of proposed Module 11 area, (2) identifying data gaps that need to be filled to complete the HSC, and (3) defining the scope of the additional data collection efforts proposed in this work plan.

SCS submitted a previous version of this work plan dated February 13, 2015 (SCS, 2015) to the DEQ. The following was stated in the DEQ's review letter (DEQ, 2015) of the previous work plan:

> "*DEQ agrees there is an abundance of existing data, and in general, the proposed work plan adequately captures the needs of characterizing the geology and hydrogeology of the expansion area. However, DEQ recommends the site characterization work include conducting an aquifer test using one of the site's production wells (PW-1, MB-1, or MB-2). The goal of this test is to determine the extent of communication between the shallow and deep water-bearing zones of this area.*"

In accordance with the DEQ's recommendation, this work plan includes an additional task to perform an aquifer pumping test of production well PW-1.

Other requirements of the Solid Waste Landfill Guidance document that are relevant to the solid waste permit application, specifically geotechnical investigation and landfill engineering design, are being addressed concurrently but separate from the HSC.

1.1 SITE DESCRIPTION

RL is located approximately 3 miles southwest of McMinnville, Oregon, in Yamhill County (see Figure 1-1). RL is owned and operated by RLC, and is permitted by the DEQ to receive municipal solid waste and approved special waste.

The RL property boundary, various site features, and proposed Module 11 expansion area are shown in Figure 1-2. The RL property encompasses over 500 acres of which the permitted landfill occupies approximately 85 acres. The north and south poplar tree farms are located to the west and southwest, respectively, of the landfill and occupy approximately 43 acres. An RV park is located between the landfill and south poplar tree farm. The South Yamhill River borders the site to the south, and agricultural land surrounds the site to the north, west, and east.

1.2 PURPOSE AND OBJECTIVES

The primary objective of the HSC is to demonstrate that the characterized subsurface conditions within the proposed Module 11 area are consistent with the conceptual hydrogeologic model developed as part of previous investigations. The conceptual hydrogeologic model is based on several phases of site investigations performed at RL to assess site conditions, including stratigraphy, nature and extent of water bearing zones (WBZs), and groundwater quality. Discussion of the historical findings and results of previous investigations is provided in Section 3.0. This background information provides the rationale for developing the scope of work presented in this work plan.

The findings and results of previous investigations were evaluated in terms of meeting the objectives for characterizing the hydrogeologic conditions of proposed Module 11 in accordance Section 3 of the Solid Waste Landfill Guidance document (DEQ, 1996). Specifically, the following components were considered as part of the evaluation:

- Hydrogeologic characteristics of proposed Module 11, including: hydrostratigraphy; nature, extent and hydraulic characteristics of the target WBZs; seasonal groundwater levels and fluctuations; groundwater flow direction and velocity; and potential contaminant transport pathways.

- The chemistry and quality of groundwater within the target WBZs beneath the proposed Module 11 area, including assessment of background (i.e., naturally occurring) groundwater conditions.

- The existing groundwater monitoring network at RL and its effectiveness at monitoring groundwater quality in target WBZs hydraulically downgradient of proposed Module 11.

1.3 WORK PLAN ORGANIZATION

The remainder of this work plan is organized as follows:

- Section 2.0 describes the regional setting of RL.
- Section 3.0 summarizes background information on the geology, hydrogeology and groundwater chemistry relevant to proposed Module 11.
- Section 4.0 presents the proposed approach and scope of work for the HSC.
- Section 5.0 provides an implementation schedule for the HSC.
- Section 6.0 lists the references cited in this work plan.
- Appendix A includes borehole logs and well construction diagrams for existing and former wells and borings within or in close proximity to proposed Module 11.

2.0 REGIONAL SETTING

The following information related to the regional setting of RL was obtained from the *Additional Hydrogeological Investigation* (AHI) report for RL (EMCON Northwest, Inc. [EMCON], 1994).

2.1 PHYSIOGRAPHY

RL is situated within the northern Willamette Basin physiographic province north of the South Yamhill River. The basin is characterized by a series of uplands bounded by low-lying plains and valleys. The subbasin between the Eola Amity Hills to the east and the foothills of the Coast Range to the west is known as the West Valley Plain (Price, 1967). The West Valley Plain consists of an undulating surface of bedrock hills that outcrop locally from beneath overlying terrace sediments. The sediments were deposited within the Yamhill Valley downwarp, a structural trough trending eastward and generally coinciding with the South Yamhill River for most of its length. Foothills of the Coast Range outcrop approximately 1.5 miles to the northwest, along the northwest flank of the Willamette Basin. In the local area near RL, there are no bedrock outcrops, and the topography is divided into upper and lower river terraces, which differ in elevation by about 20 feet.

The area drains primarily to the South Yamhill River, which flows east and north from the Coast Range and joins the North Yamhill River about 2 miles northeast of McMinnville, Oregon. From that confluence, the Yamhill River flows east and drains into the Willamette River. Near RL there are various unnamed drainages that originate in uplands to the northeast of RL, dissect the terraces, and drain into the South Yamhill River.

2.2 CLIMATE

The McMinnville area has a temperate climate, with mild, wet winters and warm, dry summers. Most precipitation falls between October and May, with over 50 percent of the average annual precipitation occurring from November through January. Average rainfall for McMinnville, Oregon, is about 44 inches. The average annual temperature in McMinnville is about 52 degrees Farenheight (^{o}F). The hottest month is July, with an average temperature of about 65 ^{o}F, and the coldest month is January, with an average temperature of about 38 ^{o}F.

2.3 REGIONAL GEOLOGY AND HYDROGEOLOGY

The regional geologic units in the vicinity of RL include, from oldest to youngest, the upper Eocene Nestucca Formation (which comprises the bedrock beneath RL), Pliocene sands and gravels, Quaternary Willamette Silt, and younger (Recent) alluvium associated with the Willamette River and its tributaries (Price, 1967). Detailed descriptions of these geologic units are provided in Section 3.0.

Groundwater occurs under various hydrogeologic conditions in both bedrock and surficial geological materials in the vicinity of RL. In the Nestucca Formation, groundwater moves through a network of interconnected fractures, which, because of the low permeability associated with fractured rocks,

generally provides low yields to wells. Locally, however, well yields may be sufficient for domestic water supply use. Groundwater in the bedrock occurs under confined to semi confined conditions.

Of the overlying surficial units, the Pliocene sand and gravel deposits and the Recent alluvium represent the region's primary WBZs. These units are relatively permeable, although their distribution is limited to ancient and recent stream valleys. The Willamette Silt is not considered a regional aquifer because of its low permeability. Nevertheless, it locally contains groundwater under unconfined conditions.

Near RL, groundwater flows from higher elevations, in the foothills to the west and northwest, to lower elevations near the South Yamhill River valley. The configuration of the regional water table is similar to that of the land surface.

3.0 EXISTING GEOLOGIC AND HYDROGEOLOGIC INFORMATION AND DATA

Several phases of site characterizations and investigations have been performed at RL, beginning in 1981 and including explorations within proposed Module 11. This section summarizes relevant background information on the geology, hydrogeology, and groundwater chemistry at RL based on interpretive information collected as part of previous hydrogeologic investigations (EMCON, 1993b, 1994, 1995, 1996; and CH2M Hill, 2000), and groundwater data (elevations and chemistry) collected since 1993. These studies provide the foundation for hydrogeologic interpretations and the technical basis for developing (1) the site hydrogeologic model, and (2) RL's current monitoring program established in the site's approved Environmental Monitoring Plan (EMP) (SCS. 2014).[1]

In general, the investigations included drilling exploratory borings, installing monitoring wells and piezometers, conducting geophysical investigations, collecting and analyzing soil and groundwater samples, and analyzing aquifer hydraulic parameters. Figure 1-2 shows existing monitoring locations (i.e., monitoring wells and piezometers) at RL, and Figure 3-1 shows historical monitoring and exploratory locations.

3.1 INVESTIGATION HISTORY IN PROPOSED MODULE 11

As shown in Figure 3-1, many exploratory boreholes, monitoring wells, and piezometers have been advanced throughout the RL site, including many within or in close proximity to proposed Module 11. These included existing monitoring wells MW-1A, MW-1B, MW-10A, MW-10B, MW-18A, MW-18B, MW-20A, MW-20B, and existing piezometers P-05A, P-06A, and GT10-1 (see Figure 1-2).[2] Table 3-1 presents a summary of construction information for these and other existing wells and piezometers at RL. Borehole logs and well construction diagrams for existing and former monitoring wells, piezometers, and borings within or in close proximity to proposed Module 11 are provided in Appendix A.

Key reports summarizing hydrogeologic investigations and/or providing groundwater elevation and quality information that included the proposed Module 11 area are summarized in Table 3-2 and discussed below.

[1] An updated EMP dated July 2013 (SCS, 2013) was submitted to and conditionally approved by the DEQ (2014a) pending submittal of additional information. The requested information was submitted to the DEQ in June 2014 (SCS, 2014b) and subsequently approved (DEQ, 2014b). Another updated EMP was submitted to the DEQ in December 2014 (SCS, 2014c) that incorporated the requested information and supersedes the July 2013 EMP.

[2] The "A" designation denotes wells screened in the upper (shallow) silt-clay WBZ, and the "B" designation denotes wells screened in the lower (deep) sand-gravel WBZ. One exception is the monitoring well pair MW-1A and MW-1B whose designations are reversed from this nomenclature.

- AHI (EMCON, 1994). This report presented a comprehensive hydrogeologic characterization of the current permitted footprint of the landfill in support of a lateral expansion. The AHI involved extensive subsurface drilling, monitoring well installations, geophysical methods (borehole geophysics, cone penetrometer soundings, and seismic refraction studies), and groundwater monitoring, including the following performed in the proposed Module 11 area:

  - Well pair MW-10A and MW-10B was installed on the upgradient (west) edge of proposed Module 11. Wells MW-10A and MW-10B have been sampled for background water quality data from 1993 through 1997, from 2000 to 2003, and most recently in 2008 and 2013 as part of RL's approved five-year comprehensive monitoring events.

  - Former piezometer pair P-04A/P-04B (decommissioned in 2013) was installed to monitor groundwater levels and was located near the southeast corner of proposed Module 11. Piezometer P-04B was drilled and sampled to the depth of bedrock.

  - Exploratory boring EW-1 was drilled along the eastern edge of proposed Module 11. This boring was drilled and sampled to the depth of bedrock.

- Technical Memorandum (re: Installation of Eight Monitoring Wells at Riverbend Landfill) (CH2M Hill, 2000). This memorandum described the installation of eight monitoring wells, including monitoring well pairs MW-18A/MW-18B and MW-20A/MW-20B in the proposed Module 11 area. These wells were installed to expand the RL's monitoring network in response to development of the poplar tree farm irrigation areas. Wells MW-20A and MW-20B were incorporated into RL's detection monitoring program after they were installed and have since been sampled on a routine (semiannual basis). Well pair MW-18A/MW-18B was sampled for background groundwater quality data from 2001 to 2003 and most recently in 2008 and 2013 as part of RL's approved five-year comprehensive monitoring events.

- Water Quality Assessment of the North Poplar Tree Farm (Shaw Environmental, Inc. [Shaw], 2006). A water-quality assessment was conducted in 2005 to further investigate changes in groundwater conditions observed in the vicinity of the north poplar tree farm area. As part of this assessment, two shallow piezometers (P-05A and P-06A) were installed and four direct-push borings were drilled and sampled in the north poplar tree farm area (i.e., proposed Module 11 expansion area) to provide additional groundwater quality information and refine the interpretation of groundwater flow in this area. These piezometers were incorporated in RL's detection monitoring program after they were installed and have since been sampled on a routine (semiannual or annual) basis.

- Report of Drilling and Piezometer/Monitoring Well Installations for Hydrogeologic Site Characterization in Support of Landfill Expansion Permitting (SCS, 2011). A hydrogeologic site characterization and geotechnical investigation were performed in 2010 associated with expansion permitting in 2010 for a former proposed expansion

design. The work included drilling and sampling three geotechnical boreholes (GT-10-01, GT10-02, and GT10-03) within proposed Module 11. Borehole GT-10-01 was converted to a piezometer for groundwater elevation monitoring. Boreholes GT10-02 and GT10-03 were drilled into bedrock.

- Phase 1 MSE Berm – Updated Permit Design Report (Geosyntec Consultants, 2012). Two phases of geotechnical investigations were performed in 2011 and 2012 to characterize geotechnical subsurface conditions and to address geotechnical landfill design considerations for Phase 1 of the mechanically stabilized earthen (MSE) berm adjacent to the existing western landfill boundary. Several boreholes were drilled in or surrounding proposed Module 11: GT11-01, GT11-02, GT12-01A through GT12-06A, GT12-01B through GT12-06B, and GT12-07 through GT12-13. Boreholes GT12-05A and GT12-06A were drilled into bedrock.

- Geosyntec Consultants conducted geotechnical investigations in 2014 for proposed Module 11 permitting. This work included drilling 17 boreholes (GT14-01 through GT14-17) in or surrounding proposed Module 11. Soil samples were collected from all the borings for geotechnical laboratory testing. The results of these additional geotechnical investigations have not yet been reported to the DEQ, and the borehole logs for these borings are not included in this work plan. It is anticipated that the borehole logs for these borings will be included in the HSC and used for geologic and hydrogeologic interpretation as part of the HSC.

- Annual Environmental Monitoring Reports. Existing piezometers and monitoring wells installed in or near proposed Module 11 have provided extensive information on background groundwater quality and/or groundwater flow conditions based on routine monitoring since 1993, in some cases. Currently, routine semiannual groundwater monitoring is performed as part of RL's environmental monitoring program consistent with the site's EMP (SCS, 2014).[1] The results of routine groundwater monitoring, including wells/piezometers located in and surrounding the proposed Module 11 area, are presented and interpreted in the site's annual environmental monitoring reports (AEMRs), including most recently the 2013 AEMR (SCS, 2014a).

3.2 SITE GEOLOGY AND HYDROGEOLOGY

This section describes the geology and hydrogeology at RL and within proposed Module 11 based on information and data from previous investigations (described in the previous section). In general, the geologic and hydrogeologic units are flat-lying and relatively uniform across the entire site, and monitoring well and exploratory boring information indicate that the units extend across proposed Module 11.

3.2.1 Geology

Four geologic units in the vicinity of RL are important from a hydrogeologic perspective. From youngest to oldest, these geologic units are:

- Eocene-age Nestucca Formation bedrock.
- Pliocene-age sands and gravels, which overlie the Nestucca Formation and underlie more recent alluvial sediments.
- Early to middle Quaternary-age alluvial Willamette Silt associated with the Willamette River and its tributaries. The Willamette Silt comprises the upper and lower river terraces near RL.
- Late Quaternary (Recent)-age alluvium associated with the recent floodplain of the South Yamhill River.

3.2.1.1 Nestucca Formation

The Nestucca Formation bedrock underlying RL is composed mostly of basaltic lava flows, with localized occurrences of marine sediments. Nestucca Formation bedrock units were encountered in several boreholes (EW-1, GT10-02, GT10-03, GT12-05A, GT12-06A, P-04B) in the vicinity of proposed Module 11. The elevation of the top of bedrock ranges from approximately 65 to 90 feet mean sea level (msl) in the proposed Module 11 area.

3.2.1.2 Sand and Gravel Unit

Overlying the Nestucca Formation is a mostly laterally continuous unit consisting of sandy gravels and gravelly sands, with localized interbeds of clayey and silty gravels and clay and silt lenses. The sand-and-gravel material is generally well-graded, angular to subrounded, and in places, cemented. The gravel consists primarily of fine-grained volcanic and marine sedimentary rocks. Silty and clayey sands and gravels of variable thickness occur near or at the top of the unit.

The elevation of the top of the sand-gravel unit is relatively uniform across RL, ranging from approximately 87 to 112 feet msl. The overall thickness of the unit, however, varies widely due to variations in the elevation of the underlying bedrock surface. The thickest deposits occur in the northwest part of RL in the proposed Module 11 area at well MW-10B where the unit is approximately 43.5 feet thick (EMCON, 1994) and at GT14-02 where the unit is greater than 44 feet thick. The unit thins towards the east-southeast (7 to 15.5 feet in the vicinity of MW-5B, MW-6B, and former MW-8B) and southwest where it eventually disappears at GT10-10 and MW-19A.

3.2.1.3 Quaternary Alluvial Deposits

Two Quaternary alluvial units are present at RL: early to middle Quaternary Willamette Silt and Late Quaternary silt-clay unit. The materials in both units are similar and consist of bedded silts, clays, clayey silts, silty clays, and minor amounts of silty fine sand. The deposits range in thickness

from 17 feet near MW-21A, in the southern portion of the site, to 63 feet near SB-17B, in the extreme southwest part of the site (CH2M Hill, 2000). The unit ranges in thickness from approximately 30 to 46 feet in proposed Module 11.

3.2.2 Hydrogeology

The upper (shallow) silt-clay alluvial deposits (both the Willamette Silt and the late-Quaternary alluvium) and lower (deep) sand-gravel deposits are significant at RL because they contain either localized or regionally extensive WBZs. As a result, groundwater monitoring at RL is performed in the shallow silt-clay WBZ and deep sand-gravel WBZ. The nature and hydraulic characteristics of these WBZs are described in this section.

3.2.2.1 Upper (Shallow) Silt-Clay Water-Bearing Zone

The groundwater flow and gradient conditions in the silt-clay WBZ across proposed Module 11 have been previously determined based on historical water level-data from the existing network of monitoring wells and piezometer. Across most of RL, the groundwater flow direction and gradient in the upper silt-clay WBZ show minor seasonal and spatial variability, typically in response to variations in seasonal precipitation patterns. The direction of groundwater flow in the upper silt-clay WBZ is predominantly south-southeast, towards the South Yamhill River. In the extreme southwestern portion of the site, groundwater flow is predominantly toward the east. A groundwater potentiometric surface contour map showing the typical groundwater flow directions in the upper silt-clay WBZ across the site, including in the proposed Module 11 area, is provided in Figure 3-2.

The historical seasonal range of groundwater gradients is generally from 0.005 to 0.01 foot per foot (ft/ft). Average groundwater flow velocities in the upper silt-clay WBZ range from 0.1 to 16.2 feet per year (ft/yr) using (1) an average seasonal gradient of 0.005 to 0.007 ft/ft, (2) hydraulic conductivity values ranging from 4.68×10^{-4} to 2.08×10^{-6} centimeters per second (cm/sec), as determined from slug tests performed as part of the AHI (EMCON, 1994), and (3) an effective porosity of 15 percent.

Historical groundwater-level data for monitoring wells screened in the upper silt-clay WBZ near the South Yamhill River indicate that temporal fluctuations of approximately 10 to 15 feet occur. Generally, groundwater elevations in those wells are higher than the river elevation, indicating that groundwater in the upper silt-clay WBZ discharges to the river. This relationship between the South Yamhill River and groundwater indicates that the South Yamhill River acts as a hydraulic boundary to groundwater flow in the upper silt-clay WBZ (SCS, 2014).

3.2.2.2 Lower (Deep) Sand-Gravel Water-Bearing Zone

The groundwater flow direction and gradient in the lower sand-gravel WBZ do not vary significantly as a result of seasonal changes in precipitation. In most areas of RL, groundwater flows toward the southeast, in the direction of the South Yamhill River, and shifts southward as it approaches the river. A groundwater potentiometric surface contour map showing the typical groundwater flow directions in the lower sand-gravel WBZ across the site, including in the proposed Module 11 area, is provided in Figure 3-3.

The historical seasonal range of groundwater gradients is generally from 0.0088 to 0.012 ft/ft. The average groundwater flow velocity in the lower sand-gravel WBZ is 124 ft/yr, using an average seasonal gradient of 0.01 ft/ft, a hydraulic conductivity value of 3.6 x 10^{-3} cm/sec, as determined from a variable discharge test performed as part of the AHI (EMCON, 1994), and an effective porosity of 30 percent (SCS, 2013).

RL has a production well designated as PW-1, located near the facility entrance. The well is completed in and pumps water from the lower sand-gravel WBZ. There are also two production wells (MB-1 and MB-2) on the former Bernard property on the east side of the RL entrance. MB-1 is active and MB-2 has been disconnected. During the dry season, when PW-1 and MB-1 are used most frequently, groundwater elevations in the sand-gravel WBZ are affected in the northwest corner of RL by production well pumping.

3.2.2.3 Hydraulic Conductivities

Slug testing has previously been performed to evaluate hydraulic conductivities in the shallow and deep WBZs across the site, including wells and piezometers located within or in close proximity to proposed Module 11. These included slug tests performed in wells MW-10A, MW-10B, and P-04A as part of the AHI (EMCON, 1994), and wells MW-18B, MW-20A, and MW-20B (and MW-17A and MW-19A to the south) as part of the expansion of RL's groundwater monitoring network in the north and south poplar tree farm areas (CH2M Hill, 2000). Table 3-3 presents a summary of slug testing results for these and other former or existing wells and piezometers at RL.

The slug testing results showed somewhat higher than expected hydraulic conductivities in the shallow WBZ in the area of proposed Module 11 (mean value of 6.8 x 10^{-3} cm/sec) (CH2M Hill, 2000). Seams of coarser-grained sediments (i.e., silty sand and very fine sand) were encountered at various depth intervals in the upper silt-clay WBZ, which probably accounts for the higher hydraulic conductivity values in this area (SCS, 2014). Slug testing of deep WBZ wells MW-18B and MW-20B, located generally upgradient and downgradient, respectively, of proposed Module 11, showed hydraulic conductivity values of 1.68 x 10^{-2} and 4.66 x 10^{-2} cm/sec, respectively (CH2M Hill, 2000).

3.2.2.4 Vertical Hydraulic Gradients and Hydraulic Connection Between WBZs

Trends in groundwater elevations between the upper and lower WBZs (exhibited by adjacent shallow and deep monitoring well pairs) are generally similar, with periods of high and low elevations occurring at the same time of the year. The highest water levels in the upper silt-clay and lower sand-gravel WBZs generally occur in the spring, while the lowest elevations occur in the fall. The fluctuations are directly influenced by precipitation. Although seasonal trends are similar in the two WBZs, the magnitude of the water-level fluctuation varies significantly (SCS, 2014).

The relative degree of hydraulic connection between the upper and lower WBZs was evaluated through a pumping test of well MW-3B (EMCON, 1994). The results of the evaluation indicated that the WBZs have a low degree of hydraulic connection. More indirectly, impacts to groundwater from volatile organic compounds (VOCs) in well MW-5A, located adjacent to the south side of the

landfill, have historically not been detected in well MW-5B. This also suggests a low degree of hydraulic connection between the two WBZs.[3]

3.3 GROUNDWATER CHEMISTRY

The following information related to the general groundwater chemistry in the target WBZs was obtained from the 2014 EMP (SCS, 2014) and recent AEMRs, and is based in part on groundwater chemistry data collected from wells installed near or within the proposed Module 11 area.

3.3.1 Upper Silt-Clay Water-Bearing Zone

Groundwater chemistry in the upper silt-clay WBZ is characterized by the predominance of calcium (Ca), magnesium (Mg), and bicarbonate ions (HCO_3), and a pH generally less than 8.0. Sulfate shows little variability. Groundwater in the upper silt-clay WBZ is generally classified as moderately hard to hard.

Manganese (Mn) is routinely detected above the secondary regulatory standard (0.05 milligrams per liter [mg/L]) in groundwater collected from most upgradient and downgradient monitoring wells screened in the silt-clay WBZ. Iron (Fe) is commonly detected in groundwater samples collected from the upper WBZ; however it is found at concentrations above the secondary standard detected (0.3 mg/L) only in samples collected from a few upgradient and downgradient wells.

While the relative concentrations of inorganic parameters in groundwater samples collected from the silt-clay WBZ are generally consistent among wells, some parameter concentrations vary spatially, with higher concentrations detected in both upgradient and downgradient wells (e.g., Fe). The variability can be attributed to the lithologic heterogeneity of the upper silt-clay WBZ. The spatial variability also reflects potential variations in hydraulic conductivity, which may serve to increase groundwater residence time in localized zones across RL.

The most common metals detected in groundwater samples from the silt-clay WBZ are arsenic (As), barium (Ba), chromium (Cr), copper (Cu), and zinc (Zn), each of which occurs naturally in soil (EMCON, 1994). The metals are widely distributed and have been detected in samples collected from both upgradient and downgradient wells. The correlation between total metals and high levels of total suspended solids (TSS) indicates that the detected metals represent naturally occurring elements in the fine-grained soils. Higher concentrations that have historically been detected are most likely related to high concentrations of particulates in unfiltered samples.

Analytical results of groundwater samples collected in 2013 from detection monitoring well MW-20A located downgradient of the poplar tree farm area (i.e., the proposed Module 11 expansion area) continued to show concentrations of some inorganic parameters (including sodium [Na], chloride [Cl], Mg, and total dissolved solids [TDS]) above their statistical prediction limits (i.e., site specific limits or SSLs), although the concentrations are below the secondary regulatory standards, except for Cl and TDS (SCS, 2014a). Leachate irrigation of the poplar tree farms was suspended in 2013 in

[3] Results of the remedial investigation performed in 1993 demonstrated that landfill gas is the source of VOCs impacting shallow groundwater in the MW-5A area (EMCON, 1993).

response to these water-quality changes (CH2M Hill, 2013); the poplar trees have been irrigated exclusively by precipitation since 2013.

3.3.2 Lower Sand-Gravel Water-Bearing Zone

Groundwater chemistry in the sand-gravel WBZ is characterized by the predominance of Ca, Mg, and HCO_3 ions. Groundwater in the lower sand-gravel WBZ is generally harder than in the upper silt-clay WBZ, and is classified as hard to very hard (EMCON, 1994).

Groundwater samples collected from upgradient and downgradient monitoring wells screened in the lower sand-gravel WBZ typically contain Mn at concentration above the secondary standard. Fe is commonly detected in groundwater samples collected from the lower WBZ; however, it is detected at concentrations above the secondary standard only in a few upgradient and downgradient wells. In addition, Cl and TDS were detected above their secondary drinking water standards (250 and 500 mg/L, respectively) in groundwater collected from former upgradient well MW-8B and compliance well MW-12B. Additional investigations showed the higher concentrations of inorganic constituents in groundwater samples collected from compliance well MW-12B were representative of natural groundwater conditions influenced by the vertical flow from the underlying bedrock (marine sedimentary rocks). Previous site investigations have also shown that the degree of spatial and temporal variation in groundwater chemistry in the sand-gravel WBZ beneath the site is pronounced.

Eleven metals have previously been detected at low-to-trace concentrations in groundwater samples collected at RL from the sand-gravel WBZ. The most commonly detected metals are Ba, cobalt (Co), Cu, nickel (Ni), vanadium (V), and Zn. The presence of these metals in unfiltered samples from upgradient wells demonstrates that they occur naturally in this WBZ.

3.4 WATER-USE SURVEY

Water uses in the vicinity of RL were assessed as part of a beneficial water-use survey performed in 1993 (EMCON, 1993a). The survey included:

- Reviewing agency files to compile information on water wells on site and within a 1-mile radius of RL, extending south to the South Yamhill River (i.e., southern extent of survey area).
- Performing a door-to-door survey to identify undocumented groundwater use.
- Identifying groundwater wells and surface water rights on a location map.
- Compiling well construction data from driller's logs and from oral reports provided by well owners.

Additional beneficial water-use information was collected in 1993 and 1994 and summarized in the AHI report (EMCON, 1994). Results of the water-use surveys as presented in the AHI report (EMCON, 1994) are provided below.

Twenty-five active wells were identified within a 1-mile radius of RL, with pumping principally from the Pliocene sand and gravel deposits and lesser quantities derived from underlying marine sediments and basalts. Drillers' logs indicated that eight wells were screened in the sand-gravel WBZ, and six wells were inferred to be pumping groundwater from this WBZ based on their completion depths. Four wells pumped groundwater from bedrock zones as indicated by drillers' logs, and one well was inferred to be screened in bedrock from its completion depth. Insufficient information was available for six wells to assess what groundwater zone they were screened in.

Regional groundwater studies documented that wells completed in the sand-gravel WBZ can yield up to 75 gallons per minute (gpm). The bedrock aquifer generally yields less than 10 gpm (Price, 1967). Average pumping rates for wells within a 1-mile radius of RL, estimated from short term pumping tests reported on drillers' logs, were generally within these ranges. Review of four wells screened in the sand-and-gravel WBZ indicated pumping rates ranging from 20 to 40 gpm and averaging 28 gpm. Drawdowns recorded during the tests ranged from 22 to 57 feet. Similar data collected from four wells screened in bedrock showed well yields ranging from 6 to 13 gpm and averaging 9.4 gpm.

Groundwater was reportedly used primarily for domestic purposes; a secondary use of groundwater is for agricultural purposes, including irrigation and livestock watering. A few wells were shared by several residences, and one supplied domestic and irrigation water to trailer park residents. An older water-supply well on the landfill was decommissioned in 1989.

Water quality information was not recorded on drillers' logs. In response to the door-to-door survey, two residences described the water quality from their wells as hard, saline, or having a sulfur smell. The well described as producing hard and saline water appears to penetrate bedrock WBZs based on its depth and location. Such water quality is consistent with regional water quality data from wells that produce groundwater from bedrock WBZs.

4.0 APPROACH AND PROPOSED WORK PLAN SCOPE OF WORK

4.1 APPROACH

As discussed in previous sections, the extensive hydrogeologic information collected as part of previous and ongoing studies and monitoring activities provides a solid foundation for meeting the objectives for performing a Phase 2 site characterization of proposed Module 11 in accordance Section 3 of the Solid Waste Landfill Guidance document (DEQ, 1996). A few exceptions are discussed in Section 4.2. Specifically, the existing data are sufficient to complete the following in the proposed Module 11 expansion area:

- Characterize the geology and hydrogeology, including the soil stratigraphy, thickness and extent of the target WBZs (i.e., shallow silty-clay and deep sand-gravel WBZs), and groundwater flow directions and gradients of the target WBZs.
- Characterize potential contaminant transport pathways.
- Establish background groundwater quality.

To address data gaps or outdated information, the following data collection tasks are proposed for the HSC as further discussed in Section 4.2:

- Evaluating surficial geology and soils per Section 3 of the Solid Waste Landfill Guidance document.
- Conducting a single-well aquifer slug test in shallow (silt-clay) WBZ piezometer GT-10-1 in proposed Module 11 and analyzing the test data to obtain additional hydraulic conductivity data for the shallow WBZ.
- Conducting an aquifer pumping test, per the DEQ's recommendation (DEQ, 2015), at production well PW-1 (screened in the deep sand-gravel WBZ) to determine the extent of hydraulic communication, if any, between the shallow and deep WBZs in this area.
- Updating the water-use survey.

4.2 PROPOSED WORK PLAN SCOPE OF WORK

4.2.1 Surficial Geology and Soils Evaluation

Review of existing information and data will be performed to evaluate surficial geology and soil types within proposed Module 11. This task does not include drilling, trenching, or other intrusive data collection methods.

4.2.2 Hydraulic Conductivity Testing

As previously mentioned, slug tests to evaluate hydraulic conductivity values were previously performed in shallow WBZ wells MW-10A, MW-20A, and former P-04A located generally at the upgradient and downgradient margins of proposed Module 11. Slug tests were also previously performed in deep WBZ wells MW-18B and MW-20B located generally at the upgradient and downgradient margins of proposed Module 11 (see Table 3-3). Consequently, one additional slug test is proposed to be performed in piezometer GT-10-1 (see Figure 1-2) to provide hydraulic data in the central portion of proposed Module 11.

The objective of the slug testing is to estimate the "in-situ" hydraulic conductivity in the shallow WBZ at piezometer GT-10-1. The following describes the procedure for conducting a slug test:

- Measure the static water level using an electronic water-level probe before performing the slug test.
- Install an electronic pressure transducer in the well being tested and verify that the water level has stabilized before beginning the test. A data logger will be used to record transducer data.
- Artificially raise the water level in the well by rapidly lowering a 10-foot long by 1-1/4-inch diameter PVC slug into the saturated portion of the well. Water-level data will be collected using the pressure transducer until the water level recovers to within 10 percent or less of its original level. Water levels will also be measured with an electronic water-level probe to verify the transducer results and as a backup in case of transducer failure.
- After the water level has sufficiently recovered, the PVC slug will be rapidly removed and the water level will continue to be recorded with the pressure transducer until the water level recovers to within 10 percent or less of its original level.

Hydraulic conductivity values will be calculated using data from the slug tests. Slug test data will be analyzed using industry-standard data analysis software such as AQTESOLVE™ by Geraghty & Miller, Inc., or AquiferTest™ by Waterloo Hydrogeologic, Inc. Data analyses methods may include the Hvsorslev, Bouwer-Rice, or Cooper-Bredehoft-Papadopulos methods.

4.2.3 Aquifer Pumping Test

An aquifer pumping test of production well PW-1 (screened in the sand-gravel WBZ) will be conducted to determine the extent of hydraulic communication, if any, between the shallow and deep WBZs in this area. Well PW-1 is located at the northern tip of proposed Module 11 close to monitoring well pair MW-1A/MW-1B (see Figure 1-2). The test will also be used to provide additional hydraulic conductivity data for the sand-gravel WBZ.

A Water Well Report for well PW-1 (obtained through the Oregon Water Resources Department [WRD] website and provided in Appendix B) confirms that this well is screened in the deep sand-gravel WBZ. Although the Water Well Report does not identify the well as PW-1, information

presented in the Remedial Investigation (RI) report (EMCON, 1993b) reveals that the Water Well Report is associated with Well PW-1. Table H-2-1a and Figure H-2-1 from the RI report[4] (provided in Appendix B) show that that the location of EMCON Well No. 6 corresponds with the location of well PW-1, and the well construction details described for EMCON Well No. 6 correspond exactly to the well construction details in the attached Water Well Report. The Water Well Report indicates well PW-1 was drilled to a total depth of 97 feet bgs and constructed with 6-inch-diameter steel casing perforated from 57 to 97 feet bgs in the sand-gravel WBZ (perforated in alternating clay and gravel).

Electronic water-level pressure transducers will be installed in the pumping well (PW-1) and nearby monitoring wells pairs MW-1A/MW-1B and MW-10A/MW-10B that will be used as observation wells to measure groundwater level response to pumping. The pressure transducers in the pumping well and nearby well pair MW-1A/MW-1B will be connected to a datalogger to electronically record synchronized groundwater level measurements (i.e., head pressure measurements). The pressure transducers in well pair MW-10A/MW-10B will be stand-alone transducers (i.e., not connected to the datalogger) to record groundwater levels at preprogrammed intervals. Pre-pumping groundwater levels in the pumping well and observation wells will be monitored for 48 hours before starting the aquifer pump test.

Groundwater levels will also be measured manually (using an electronic water-level probe) in additional monitoring wells and piezometers located in the central and southern portions of proposed Module 11. These will include monitoring well pair MW-18A/MW-18B and shallow WBZ piezometers P-05A and GT-10A (see Figure 1-2). Water levels will be recorded in these wells approximately every 1 to 3 hours during pumping, depending if water-level response is observed at any time during the pumping test.

An initial step-drawdown pumping test will be performed at production well PW-1 to estimate a sustainable pumping rate for the follow-up 24-hour constant rate pumping test. The PW-1 Water Well Report (in Appendix B) indicates a bailer well test was performed at the time of drilling. Groundwater was removed by bailing at a rate of 30 gpm for 2 hours with a water level drawdown of 50 feet. Based on this information, it is likely that the sustainable pumping rate may be about 10 to 20 gallons per minute.

After a suitable pumping rate is determined, a 24-hour constant rate pumping test will be performed in well PW-1. Groundwater levels in the pumping well and observation wells noted above will be recorded during the pumping phase of the test. Groundwater levels will also continue to be recorded after the pump is shut off in the wells with pressure transducers to obtain water-level recovery data.

Deep WBZ hydraulic properties (i.e., transmissivity, hydraulic conductivity) will be calculated using data from the aquifer pumping test. The pump test data will be analyzed using industry-standard data analysis software such as AQTESOLVE™ by Geraghty & Miller, Inc., or AquiferTest™ by Waterloo Hydrogeologic, Inc. Data analyses methods may include Theis, Cooper-Jacob, distance-drawdown,

[4] Table H-2-1a and Figure H-2-1 were included in an Endangerment Assessment report presented in Appendix H of the RI report.

and Hantush methods; the method(s) used will depend on whether drawdown is observed in observation wells.

4.2.4 Update Water-Use Survey

An updated water-use survey will be performed that will include the following activities:

- Conducting an internet search of water well records and surface water rights from the Oregon Water Resources Department website to confirm the location and use of water (groundwater and surface water) within a 1-mile radius of RL (excluding areas south of the Yamhill River) and to potentially identify new users since 1993/1994.
- Compiling and documenting newly-identified well-construction data from drillers' logs
- Documenting the location of any newly identified water wells within the survey area and surface water rights (if present) on a location map.

4.2.5 Reporting

The HSC report will be prepared as a stand-alone document that will be incorporated into the DEQ expansion permit application. Hydrogeologic data obtained from the previous investigations and studies that are used to support the HSC (e.g., boring logs and well construction details) will be incorporated into the HSC final report.

The HSC report will contain the following information:

- Background information including discussion of previous studies and investigations performed at RL.
- A summary of local and regional climate, geology, and hydrology based on previous information and data.
- A discussion of site geology and hydrogeology, including soil stratigraphy and groundwater occurrence and conditions.
- Results of the updated water-use survey.
- Hydrogeologic interpretation of proposed Module 11, including but not be limited to:
  - Vertical and lateral extent of the shallow (silt-clay) and deep (sand-gravel) WBZs.
  - Hydraulic characteristics of the shallow and deep WBZs, including hydraulic conductivities.
  - Groundwater flow, hydraulic gradients, and flow velocities in the monitored WBZs.
  - Characterization of groundwater quality.

- Updated conceptual site hydrogeologic model and recommendations for long-term monitoring to ensure environmental protection.

The report will include tables, graphs, figures, and supplemental information in support of the HSC findings and results, including but not limited to:

- A topographic map of the site showing drainage patterns, an outline of the waste management area and municipal solid waste landfill units, property boundary, and the location of monitoring wells.
- Boring logs with information on soil and rock descriptions and classifications, sampling methods, depth sampled, water-level measurements, and as-built well construction diagrams.
- Hydrogeologic cross-sections showing lithology, soil and bedrock types, groundwater levels, and other pertinent geologic features. Figure 3-1 shows the proposed alignments of planned hydrogeologic cross section lines.
- Topographic map showing interpretative elevation contours of the top of the bedrock surface.
- Groundwater potentiometric elevation contour maps of the shallow and deep WBZs.
- Slug test data and analytical results.
- Water use inventory map showing the locations of vicinity water wells and surface water rights, and a table summarizing water well construction information.
- Time-concentration plots and/or geochemical diagrams (Piper diagrams and Stiff plots).

5.0 SCHEDULE

The proposed HSC field data collection activities, and preparation and submittal of the HSC report to the DEQ, is anticipated to be completed within approximately 2 months after submittal of this revised work plan to the DEQ.

6.0 REFERENCES

CH2M Hill, 2000, Technical memorandum (Re: installation of eight new monitoring wells at Riverbend Landfill) to G. Duvendack, Riverbend Landfill, from B. Long, CH_2M Hill, Portland, Oregon, November 21.

CH2M Hill, 2013, 2013 Technical memorandum (2013 Poplar Tree Farm Monitoring, Riverbend Landfill), prepared for Waste Management, by CH2M Hill, Portland, Oregon, December 20.

EMCON Northwest, Inc. (EMCON), 1993a, *Beneficial Use Survey for the Riverbend Landfill, McMinnville, Oregon*, prepared for Riverbend Landfill, McMinnville, Oregon, by EMCON, Portland, Oregon, May 19.

EMCON, 1993b, *Remedial Investigation, Riverbend Landfill Co., Inc., Yamhill County, Oregon*, prepared for Riverbend Landfill Co., Inc., McMinnville, Oregon, by EMCON, Portland, Oregon, October 1.

EMCON, 1994, *Additional Hydrogeological Investigation, Riverbend Landfill, Yamhill County*, Oregon, prepared for Riverbend Landfill Co., Inc., McMinnville, Oregon, by EMCON Northwest, Inc., Portland, Oregon, July 29.

EMCON, 1995, Letter (re: Riverbend Landfill, installation of monitoring wells MW-12A and MW-12B) to D. Wilson, Riverbend Landfill Company, Inc., McMinnville, Oregon, from L. Caruso and C. Fanshier, EMCON, Portland, Oregon, August 22.

EMCON, 1996, Installation of new compliance boundary monitoring wells and decommissioning of monitoring wells MW-8A and MW-8B, EMCON, Portland, Oregon.

Geosyntec Consultants, 2012, *Phase 1 MSE Berm – Updated Permit Design Report*, prepared for Riverbend Landfill Company, Inc., McMinnville, Oregon, by Geosyntec Consultants, Oakland, California, March 22.

HWA GeoSciences, Inc., 2001, Letter (Re: informal preliminary assessment to address water-quality issues in MW-12B, Riverbend Landfill), to R. North, Waste Management, Inc., Portland, Oregon, from L. Caruso and K. Mathiot, HWA, Lake Oswego, Oregon, April 13.

Oregon Department of Environmental Quality (DEQ), 1998, Letter (Re: Response to preliminary assessment at Riverbend Landfill) to R. North, Riverbend Landfill Co., Inc., USA Waste, from C. Donaldson, DEQ, Salem, Oregon. February 27.

Oregon Department of Environmental Quality, 2014a, Letter (Re: 2013 Riverbend Environmental Monitoring Plan, Yamhill County SWDP #345), to F. Willman, Waste Management, Portland, Oregon, from A. Eldridge, DEQ Eastern Region, The Dalles, Oregon, March 18

Oregon Department of Environmental Quality, 2014b, Letter (Re: Update to 2013 Riverbend Environmental Monitoring Plan, Yamhill County SWDP #345), to F. Willman, Waste Management, Portland, Oregon, from A. Eldridge, DEQ Eastern Region, The Dalles, Oregon, October 6.

Oregon Department of Environmental Quality, 2015, Letter (Re: Work Plan for Hydrogeologic Site Characterization – Module 11 Expansion, Yamhill County SWDP #345), to F. Willman, Waste Management, Portland, Oregon, from A. Eldridge, DEQ Eastern Region, The Dalles, Oregon, April 14.

Price, D., 1967, *Geology and Water Resources in the French Prarie Area, Northern Willamette Valley, Oregon*, Washington: U.S. Government Printing Office, Geological Survey Water-Supply Paper 1833, 1967.

SCS Engineers, 2011, *Report of Drilling and Piezometer/Monitoring Well Installations for Hydrogeologic Site Characterization in Support of Landfill Expansion Permitting, Riverbend Landfill, McMinnville, Oregon*, prepared for Riverbend Landfill Company, Inc., McMinnville, Oregon, by SCS Engineers, Portland, Oregon, March 8.

SCS Engineers, 2013, *Environmental Monitoring Plan, Riverbend Landfill, McMinnville, Oregon*, prepared for Riverbend Landfill Company, Inc., McMinnville, Oregon, by SCS Engineers, Portland, Oregon, July 30.

SCS Engineers, 2014a, *2013 Annual Environmental Monitoring Report*, prepared for Riverbend Landfill Company, McMinnville, Oregon, by SCS Engineers, Portland, Oregon, April 29.

SCS Engineers, 2014b, Letter (Re: Responses to DEQ's review comments of the July 30, 2013, environmental monitoring plan for Riverbend Landfill, McMinville, Oregon, solid waste disposal permit No. 345), to F. Willman, Riverbend Landfill Company, McMinnville, Oregon, from D. Lamadrid and L. Caruso, SCS Engineers, Portland, Oregon, June 10.

SCS Engineers, 2014c, *Environmental Monitoring Plan, Riverbend Landfill, McMinnville, Oregon*, prepared for Riverbend Landfill Company, McMinnville, Oregon, by SCS Engineers, Portland, Oregon, December 2.

SCS Engineers, 2015, *Work Plan for Hydrogeologic Site Characterization in Support of Module 11 Expansion Permit, Riverbend Landfill, McMinnville, Oregon*, prepared for Riverbend Landfill Company, McMinnville, Oregon, by SCS Engineers, Portland, Oregon, December 2.

Shaw, 2006, *Water-Quality Assessment of the North Poplar Tree Farm, Riverbend Landfill, McMinnville, Oregon*, prepared for Waste Management, Inc., Portland, Oregon by Shaw Environmental, Inc., Portland, Oregon, December 27.

Sweet, Edwards, and Associates, Inc., 1981, *Geotechnical Feasibility Report, River Bend Sanitary Landfill*, July 27.

USA Waste, Inc. (USAW), 1997, *Preliminary Assessment Report*, Riverbend Landfill, Yamhill County, Oregon. Prepared for Riverbend Landfill Co., Inc., by USAW, San Rafael, California. December 30.

TABLES

Table 3-1
Construction Information for Groundwater Monitoring Wells and Piezometers
Riverbend Landfill

Well Designation	Lithologic Unit Screened	Date Installation Completed	Eastings[a]	Northings[a]	Ground Elevation[a] (ft-msl)	TOC Elevation[a] (ft-msl)	Boring Depth (ft-bgs)	Boring Diameter (inches)	Well Diameter (inches)	Well Screen Interval (ft-bgs)	Sand Pack Interval (ft-bgs)	Well Seal Interval (ft-bgs)
Monitoring Wells												
MW-1A	Sand-Gravel	6-Sep-89	3999.9	4210.2	153.40	155.30	61.5	10	2	50.0 to 60.0	48.0 to 61.5	3.0 to 48.0
MW-1B	Silt-Clay	8-Sep-89	4001.1	4214.5	153.40	155.00	26.5	10	2	15.0 to 25.0	13.0 to 26.5	3.0 to 13.0
MW-2	Silt-Clay	26-Jan-81	5123.7	4126.2	146.30	148.30	40.0	NA	2	NA	NA	NA
MW-5A	Silt-Clay	8-Sep-92	5490.7	2069.0	132.00	138.73	28.0	10	2	18.0 to 28.0	16.0 to 28.0	3.0 to 16.0
MW-5B	Sand-Gravel	9-Mar-92	5481.2	2073.1	132.80	138.88	44.7	10	2	42.0 to 45.0	40.0 to 45.0	3.0 to 40.0
MW-9A	Silt-Clay	21-Oct-93	6486.5	3663.2	128.10	128.42	24.5	8	2	14.3 to 23.8	27.0 to 40.0	2.0 to 11.0
MW-9BR	Sand-Gravel	24-Aug-94	5903.2	3760.8	124.76	127.40	36.5	10	2	28.2 to 33.7	27.0 to 37.5	2.0 to 26.0
MW-10A	Silt-Clay	28-Oct-93	3501.0	3805.0	150.75	153.21	28.3	8	2	17.3 to 26.8	14.0 to 28.3	2.2 to 14.0
MW-10B	Sand-Gravel	27-Oct-93	3492.5	3795.5	150.76	152.87	69.0	10	2	44.3 to 53.8	40.9 to 55.3	2.0 to 40.9
MW-12A	Silt-Clay	19-Jul-95	5650.8	1676.5	123.80	126.00	25.5	10	2	15.3 to 24.8	12.0 to 25.5	0.5 to 15.3
MW-12B	Sand-Gravel	19-Jul-95	5643.6	1676.5	124.00	126.54	49.9	10	2	34.3 to 43.8	31.0 to 45.0	0.5 to 31.0
MW-14A	Silt-Clay	16-Oct-96	4863.8	1652.6	118.80	121.87	21.0	10	2	10.7 to 20.2	7.8 to 21.0	2.2 to 7.8
MW-14B	Sand-Gravel	15-Oct-96	4854.1	1653.7	119.10	123.32	42.0	10	2	31.7 to 41.2	2.85 to 42.0	2.2 to 28.5
MW-15A	Silt-Clay	21-Oct-96	6385.5	2209.1	126.00	130.07	22.8	10	2	12.5 to 22.0	10.0 to 22.8	2.0 to 10.0
MW-15B	Sand-Gravel	21-Oct-96	6393.5	2214.7	126.00	129.73	44.0	10	2	33.2 to 42.7	30.2 to 44.0	2.0 to 30.2
MW-16A	Silt-Clay	23-Oct-96	7010.7	2675.6	126.30	128.89	23.5	10	2	13.5 to 23.0	11.0 to 23.5	1.5 to 11.0
MW-16B	Sand-Gravel	23-Oct-96	7004.3	2670.7	126.30	128.95	45.0	10	2	34.8 to 44.3	31.6 to 45.0	2.0 to 31.6
MW-17A	Silt-Clay	26-Sep-00	1221.4	1431.4	151.12	153.83	24.5	10	2	14.0 to 24.0	11.5 to 24.5	0.5 to 11.5
MW-18A	Silt-Clay	26-Sep-00	2612.9	2938.0	146.77	148.77	26.0	10	2	13.5 to 23.5	11.0 to 24.0	0.5 to 11.0
MW-18B	Sand-Gravel	26-Sep-00	2621.6	2931.1	146.58	148.57	62.0	10	2	47.0 to 53.0	45.0 to 53.0	0.5 to 45.0
MW-19A	Silt-Clay	27-Sep-00	2537.0	1437.0	149.05	151.27	30.0	10	2	18.0 to 28.0	18 .5 to 28.5	0.5 to 16.5
MW-20A	Silt-Clay	26-Sep-00	3776.2	2490.1	127.20	129.92	21.0	10	2	10.0 to 20.0	8.5 to 21.0	0.5 to 8.5
MW-20B	Sand-Gravel	26-Sep-00	3759.5	2491.2	127.10	129.72	40.0	10	2	29.0 to 34.0	26.5 to 95.3	0.5 to 26.5
MW-21A	Silt-Clay	26-Sep-00	4645.5	1945.3	116.18	120.02	13.0	10	2	8.0 to 13.0	7.0 to 23.0	0.5 to 7.0
MW-21B	Sand-Gravel	26-Sep-00	4631.3	1941.6	116.56	119.53	34.0	10	2	21.0 to 26.0	18.5 to 27.0	0.5 to 18.5
MW-22A	Silt-Clay	23-Sep-10	4105.3	1578.5	123.50	125.38	22.5	10	2	10.0 to 20.0	8.0 to 21.0	2.0 to 8.0
MW-22B	Sand-Gravel	23-Sep-10	4110.8	1584.6	123.50	125.43	38.0	10	2	27.0 to 37.0	25.0 to 38.0	2.0 to 25.0
MW-23A	Silt-Clay	18-Aug-10	3281.9	1515.9	129.00	131.79	28.0	10	2	16.0 to 26.0	14.0 to 28.0	2.0 to 14.0
MW-23B	Sand-Gravel	17-Aug-10	3290.0	1516.5	129.00	131.60	42.0	10	2	36.5 to 41.5	34.5 to 42.0	2.0 to 34.5
MW-24A	Silt-Clay	20-Aug-10	2140.0	984.2	147.50	149.93	26.0	10	2	15.0 to 25.0	13.0 to 26.0	2.0 to 13.0
Piezometers												
MW-3A	Silt-Clay	23-Jun-93	4430.9	2493.9	138.20	140.81	35.0	8	2	24.0 to 34.0	21.0 to 35.0	2.2 to 21.0
MW-3B	Sand-Gravel	28-Jun-93	4415.6	2496.3	137.80	140.57	63.5	10	2	45.0 to 55.0	42.0 to 56.0	36.8 to 42.0
MW-4A	Silt-Clay	25-May-93	4798.0	2238.7	139.46	142.31	36.0	8	2	26.0 to 36.0	22.5 to 36.0	2.0 to 22.5
MW-4B	Sand-Gravel	10-Jun-93	4805.5	2239.4	139.24	141.81	72.0	10	2	52.0 to 62.0	49.0 to 63.0	47.0 to 49.0
MW-6A	Silt-Clay	24-May-93	6043.5	2437.7	127.00	128.95	22.5	8	2	11.5 to 21.5	8.5 to 22.5	2.0 to 8.5
MW-6B	Sand-Gravel	9-Jun-93	6054.4	2443.0	127.00	128.59	56.0	8	2	36.0 to 46.0	34.2 to 47.0	2.5 to 34.2
P-01	Silt-Clay	21-Dec-92	5482.1	2038.3	123.20	125.93	19.0	8	2	8.0 to 18.0	5.9 to 19.0	2.0 to 5.9
P-02	Silt-Clay	22-Dec-92	5498.5	1994.0	121.10	123.88	18.0	8	2	6.8 to 16.8	5.0 to 18.0	1.0 to 5.0

Table 3-1
Construction Information for Groundwater Monitoring Wells and Piezometers
Riverbend Landfill

Well Designation	Lithologic Unit Screened	Date Installation Completed	Eastings[a]	Northings[a]	Ground Elevation[a] (ft-msl)	TOC Elevation[a] (ft-msl)	Boring Depth (ft-bgs)	Boring Diameter (inches)	Well Diameter (inches)	Well Screen Interval (ft-bgs)	Sand Pack Interval (ft-bgs)	Well Seal Interval (ft-bgs)
Piezometers (continued)												
P-03	Silt-Clay	23-Jun-93	5601.9	1754.2	120.90	123.63	19.5	8	2	9.0 to 19.0	7.3 to 19.5	2.0 to 9.3
P-05A	Silt-Clay	13-Oct-05	3612.4	2875.1	138.60	140.74	20.0	3.5	1	9.7 to 19.5	7.5 to 20.0	0.5 to 7.5
P-06A	Silt-Clay	13-Oct-05	3363.7	2566.2	129.30	131.58	20.0	3.5	1	9.7 to 19.5	7.5 to 20.0	0.5 to 7.5
P-07A	Silt-Clay	3-Feb-12	3804.2	2168.8	145.70	147.90	31.0	10	2	16.0 to 26.0	14.0 to 26.5	2.0 to 14.0
GT10-1	Silt-Clay	10-Sep-10	3444.2	3211.7	143.80	145.56	66.5	5.9	2	15.0 to 25.0	13.0 to 30.0	2.0 to 13.0/ 30.0 to 65.0
GT10-11	Silt-Clay	9-Sep-10	2518.1	1781.3	149.30	150.08	61.0	5.9	2	15.0 to 25.0	13.0 to 30.0	2.0 to 13.0 / 30.0 to 60.0
GT10-12	Silt-Clay	14-Sep-10	1736.5	1971.4	150.60	152.41	55.0	5.9	2	15.0 to 25.0	13.0 to 30.0	2.0 to 13.0/ 30.0 to 65.0
SA-BH-1	Silt-Clay	24-Aug-10	716.6	3175.5	152.80	155.21	23.0	10	2	12.0 to 22.0	10.0 to 23.0	2.0 to 10.0
SA-BH-3	Silt-Clay	24-Aug-10	813.1	1679.7	152.80	155.07	26.5	10	2	12.0 to 22.0	10.0 to 23.5	2.0 to 10/ 23.5 to 25.0
SA-BH-5	Silt-Clay	23-Aug-10	1773.0	586.9	148.60	151.01	28.5	10	2	18.0 to 28.0	15.5 to 28.5	2.0 to 15.5
SA-BH-6	Silt-Clay	29-Sep-10	2895.0	597.7	123.80	125.93	25.0	10	2	14.0 to 24.0	12.0 to 25.0	2.0 to 12.0
Decommissioned Monitoring Wells and Piezometers												
MW-7A[c]	Silt-Clay	26-May-93	4359.8	3103.9	146.70	149.56	32.5	8	2	16.0 to 26.0	13.0 to 27.0	2.5 to 13.0
MW-7B[c]	Sand-Gravel	17-Jun-93	4369.0	3105.4	146.50	149.34	82.6	8	2	49.0 to 59.0	47.2 to 60.0	2.0 to 47.2
MW-11A[d]	Silt-Clay	21-Oct-93	5340.9	3362.8	143.10	146.33	29.0	8	2	16.3 to 25.8	13.0 to 27.0	2.0 to 13.0
MW-11B[d]	Sand-Gravel	2-Nov-93	5330.6	3357.7	143.10	146.25	73.8	10	2	41.3 to 50.8	38.1 to 51.7	2.0 to 38.1
MW-13A[e]	Silt-Clay	17-Oct-96	4341.2	2093.9	146.60	149.66	44.0	10	2	33.7 to 43.2	31.5 to 44.0	2.0 to 31.5
MW-13B[e]	Sand-Gravel	17-Oct-96	4348.6	2089.7	146.50	149.45	65.5	10	2	55.2 to 64.7	52.1 to 65.5	2.0 to 52.1
P-04A[f]	Silt-Clay	28-Oct-93	4067.0	2530.1	139.00	141.15	32.5	8	2	19.3 to 28.8	15.9 to 29.8	2.0 to 15.9
P-04B[f]	Sand-Gravel	10-Nov-93	4078.5	2531.9	139.00	141.65	75.8	10	2	42.3 to 51.8	39.0 to 52.4	2.0 to 39.0

NOTES:

NA = not available; TOC = top of casing; ft-msl = feet mean sea level; ft-bgs = feet below ground surface.

[a] All monitoring wells and piezometers were re-surveyed in July 2013.

[b] Monitoring wells MW-1A and MW-1B were installed in 1989. Logs for these wells are available but the document source for the logs could not be identified..

[c] MW-7A and MW-7B were decommissioned in June 2009 to accommodate construction of landfill Module 8D.

[d] MW-11A and MW-11B were decommissioned in May 2012 to accommodate construction of landfill Module 8A.

[e] MW-13A and MW-13B were decommissioned in May 2001 to accommodate construction of the leachate pond.

[f] P-04A and P-04B were decommissioned in June 2013 to accommodate construction of the mechanically stabilized earthen (MSE) berm.

Indicates well or piezometer located within or in close proxmity to the proposed Module 11 expansion area.

Table 3-2
Summary of Subsurface Explorations Within Or In Close Proximity To Proposed Moduile 11 Expansion Area Riverbend Landfill

Investigation Source	Type of Exploratory Feature [a]
MW-1A and MW-1B Installation (source unknown)	Monitoring Wells MW-1A and MW-1B
Additional Hydrogeological Investigation (EMCON, 1994)	Monitoring Wells MW-10A and MW-10, Former Piezometers P-04A and P-04B; Borehole EW-1
Technical Memorandum (re monitoring well installations (CH2M Hill, 2000)	Monitoring Wells MW-18A, MW-18B, MW-20A, and MW-20B
North Poplar Tree Farm Water Quality Assessment (Shaw, 2006)	Piezometers P-05A and P-06A
2010 Hydrogeologic Site Characterization Report (SCS, 2011)	Piezometer GT-10-1; Boreholes GT10-02 and GT10-03
Phase I MSE Berm Report (Geosyntec Consultants, 2012)	Boreholes GT11-01 and GT11-02, GT12-01A through GT12-06A GT12-01B through BT12-06B, and GT12-07 through GT12-13
2014 Western Expansion Area Geotechncial Investigation (Geosyntec Consultants, unreported)	Boreholes GT14-01 through GT14-07

Notes

[a] Borehole logs and construction details for above-listed borings, wells, and piezometers are provided in Appendix A, excluding 2014 geotechnical boreholes which have not yet been reported to the Oregon Department of Environmental Quality (DEQ).

Table 3-3
Summary of Historical Slug Testing Results
Riverbend Landfill

Piezometer or Monitoring Well Designation [a]	Boring Depth (ft-bgs)	Static Water Level (ft-bgs)	Sand Pack Interval (ft-bgs)	Saturated Thickness (ft) [e]	Test Method	Hydraulic Conductivity (cm/sec)	Hydraulic Conductivity (ft/min)
Silt-Clay Water Bearing Zone							
MW-3A [b]	35.0	19.1	24.3 - 33.8	9.5	Falling Head [f]	1.18E-04	2.32E-04
MW4A [b]	36.2	31.3	26.3 - 35.8	4.5	Rising Head [f]	3.86E-05	7.60E-05
MW-7A [b]	32.5	15.9	16.3 - 25.8	9.5	Rising Head [f]	1.72E-05	3.39E-05
MW-7A [b]	32.5	14.8	16.3 - 25.8	9.5	Falling Head [f]	1.51E-05	2.97E-05
MW-8A [c]	24.5	11.0	12.1 - 25.4	13.3	Falling Head [g]	4.14E-06	8.15E-06
MW-9A [c]	24.5	10.7	13.5 - 27.0	13.5	Rising Head [g]	1.39E-05	2.74E-05
MW-9A [c]	24.5	10.7	13.5 - 27.0	13.5	Falling Head [g]	1.91E-05	3.76E-05
MW-10A [c]	28.3	4.9	16.4 - 30.7	14.3	Rising Head [g]	2.17E-03	4.27E-03
MW-10A [c]	28.3	4.9	16.4 - 30.7	14.3	Falling Head [g]	2.55E-03	5.02E-03
MW-11A [c]	29.0	19.5	16.2 - 30.2	10.7	Rising Head [g]	2.29E-05	4.51E-05
MW-11A [c]	29.0	19.5	16.2 - 30.2	10.7	Falling Head [g]	3.28E-05	6.46E-05
MW-17A [d]	25.7	13.5	12.7 - 25.7	13.8	Rising Head [f]	1.06E-02	2.09E-02
MW-17A [d]	25.7	13.5	12.7 - 25.7	13.8	Falling Head [f]	7.61E-03	1.50E-02
MW-19A [d]	30.2	10.0	17.2 - 30.2	14.2	Rising Head [f]	9.81E-03	1.93E-02
MW-19A [d]	30.2	10.0	17.2 - 30.2	14.2	Falling Head [f]	4.54E-03	8.94E-03
MW-20A [d]	21.2	4.0	9.2 - 21.2	12.6	Rising Head [f]	1.52E-03	2.99E-03
P-01 [b]	19.0	14.0	8.0 - 18.0	4.0	Falling Head [f]	4.68E-04	9.21E-04
P-02 [b]	18.0	13.8	6.8 - 16.8	3.0	Rising Head [f]	1.88E-04	3.70E-04
P-02 [b]	18.0	12.1	6.8 - 16.8	4.7	Falling Head [f]	2.23E-04	4.39E-04
P-03 [b]	19.5	14.3	9.3 - 18.8	4.5	Rising Head [f]	4.68E-04	9.21E-04
P-04A [c]	32.5	15.3	18.1 - 31.9	13.8	Rising Head [g]	1.88E-04	3.70E-04
P-04A [c]	32.5	15.3	18.1 - 31.9	13.8	Falling Head [g]	2.23E-04	4.39E-04

Table 3-3
Summary of Historical Slug Testing Results
Riverbend Landfill

Piezometer or Monitoring Well Designation [a]	Boring Depth (ft-bgs)	Static Water Level (ft-bgs)	Sand Pack Interval (ft-bgs)	Saturated Thickness (ft) [e]	Test Method	Hydraulic Conductivity (cm/sec)	Hydraulic Conductivity (ft/min)
Sand-Gravel Water Bearing Zone							
MW-3B [b]	63.5	21.8	45.3 - 54.8	9.5	Rising Head [f]	8.46E-04	1.67E-03
MW-4B [b]	71.8	31.1	52.3 - 61.8	9.5	Rising Head f	1.47E-03	2.89E-03
MW-6B [b]	56.0	19.3	36.3 - 45.8	9.5	Rising Head [f]	1.22E-03	2.40E-03
MW-7B [b]	82.6	25.0	49.3 - 58.8	9.5	Rising Head [f]	8.04E-04	1.58E-03
MW-7B [b]	82.6	24.7	49.3 - 58.8	9.5	Falling Head [f]	5.30E-05	1.04E-04
MW-8B [c]	49.5	14.0	29.7 - 42.7	13.0	Falling Head [g]	1.02E-02	2.01E-02
MW-9B [c]	44.5	7.7	28.9 - 39.4	10.5	Falling Head [g]	2.34E-02	4.61E-02
MW-10B [c]	69.0	18.2	43.0 - 57.4	14.4	Rising Head [g]	4.73E-03	9.31E-03
MW-10B [c]	69.0	18.2	43.0 - 57.4	14.4	Falling Head [g]	4.38E-03	8.62E-03
MW-11B [c]	73.8	21.0	41.3 - 54.8	13.6	Rising Head [g]	4.46E-03	8.78E-03
MW-11B [c]	73.8	21.0	41.3 - 54.8	13.6	Falling Head [g]	3.99E-03	7.85E-03
MW-18B [d]	62.0	18.2	46.7 - 54.2	8.5	Rising Head [f]	1.68E-02	3.31E-02
MW-20B [d]	38.5	20.2	27.8 - 35.3	9.2	Rising Head [f]	4.66E-02	9.17E-02
P-04B [c]	75.8	16.1	41.7 - 55.1	13.4	Rising Head [g]	5.50E-03	1.08E-02
P-04B [c]	75.8	16.1	41.7 - 55.1	13.4	Falling Head [g]	7.94E-03	1.56E-02

NOTES:

ft = feet; ft-bgs = feet below ground surface; cm/sec = centimeters per second; ft/min = feet per minute

[a] All wells and piezometers are or were (if decommissioned) constructed of 2-inch diameter casing. Existing monitoring wells include MW-6B, MW-10A, MW-10B, MW-17A, MW-19A, MW-20A, and MW-20B.

[b] EMCON Northwest, Inc., 1993, Remedial Investigation, Riverbend Landfill Co., Inc., Yamhill County, Oregon, October 1.

[c] EMCON Northwest, Inc., 1994, Additional Hydrogeologic Investigation, Riverbend Landfill., Inc., Yamhill County, Oregon, July 29.

[d] CH2M Hill, 2000, Technical Memorandum (re: Drilling Log Report to Department of Environmental Quality), November 21. Static water level was estimated by SCS Engineers based on water column height reported on slug test data analysis sheet. Saturated thickness was based on value reported on slug test data analysis sheet.

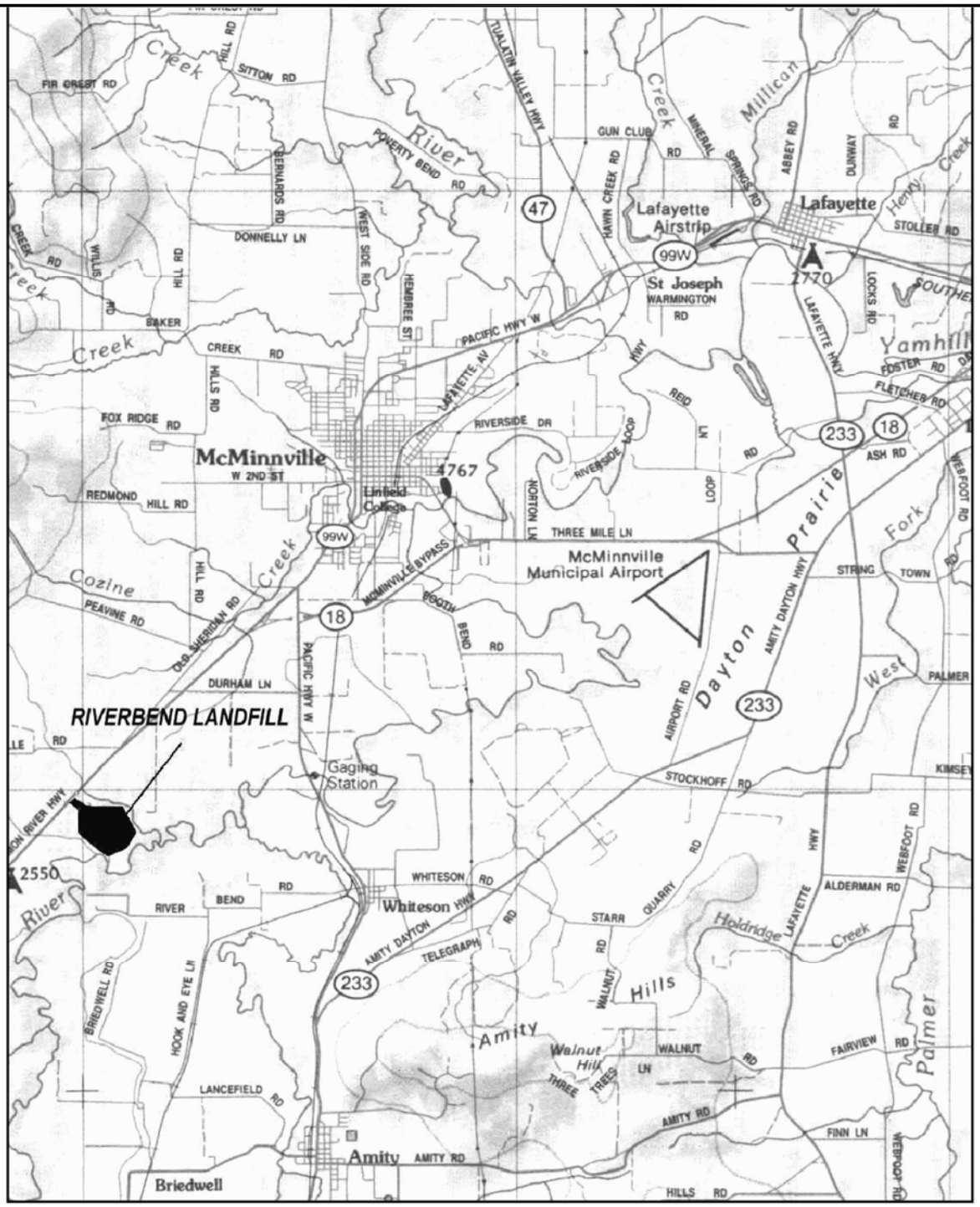
[e] The effective thickness of the water bearing zone is equal to the sand pack interval or the saturated portion of the sand pack interval.

[f] Analyzed using the Bouwer-Rice method (1976) and Bouwer (1989).

[g] Analyzed using the Cooper et. al. method (1967).

Indicates well or piezometer located within or in close proximity to the proposed Module 11 expansion area.

FIGURES



Basemap from Oregon Atlas and Gazetteer (DeLorme)

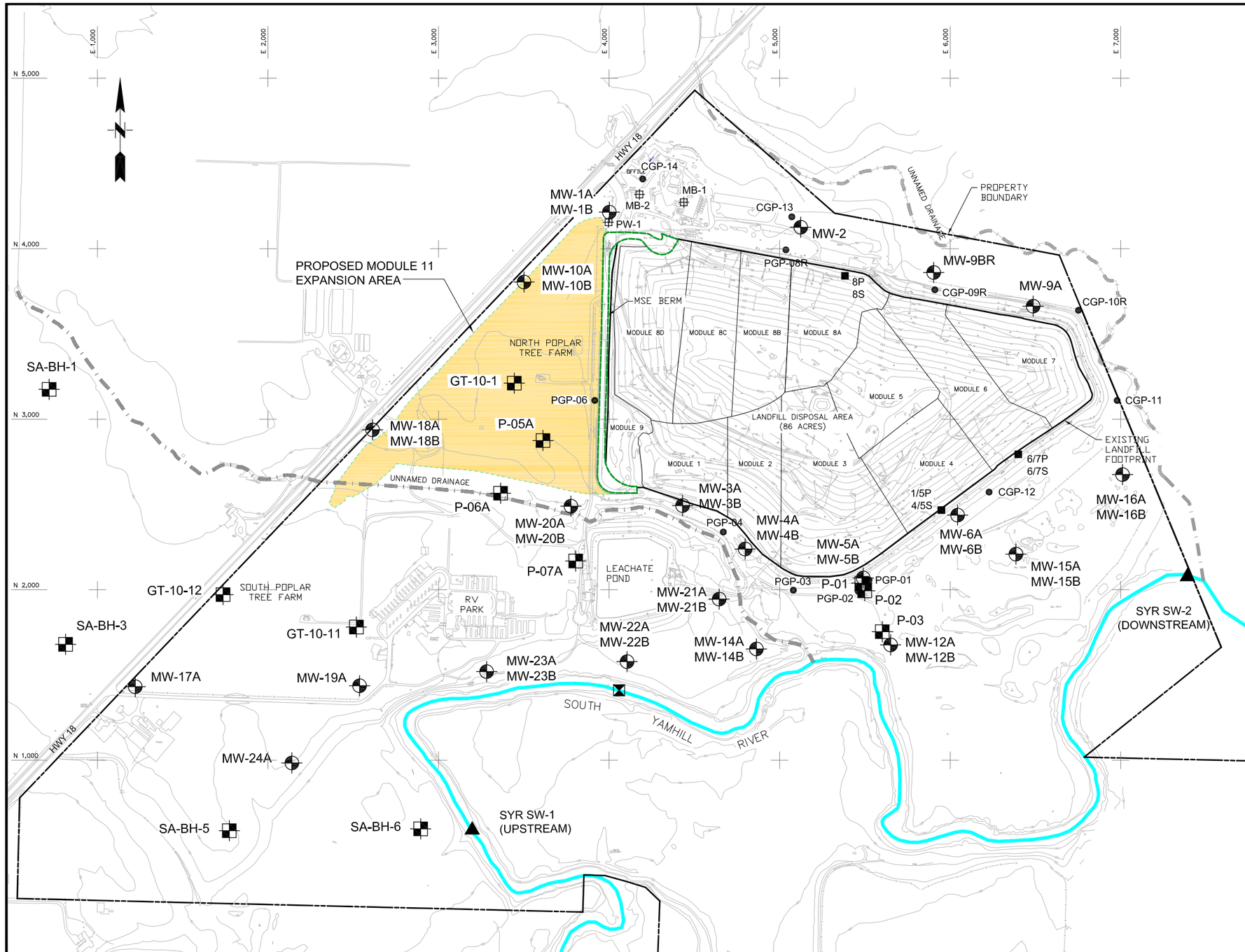
0 1 2
MILES

OREGON

WASTE MANAGEMENT

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

PROJECT NO.	DES BY	SITE LOCATION MAP	DATE
04214039.00	D.L.		FEBRUARY 2015
SCALE	CHK BY	RIVERBEND LANDFILL	FIGURE
AS SHOWN	D.L.	McMINNVILLE, OREGON	1-1
CAD FILE	APP BY		
FIGURE 1-1	L.C.		



LEGEND:

- Topographic Contours (Surveyed)
- Topographic Contours (USGS)
- Property Boundary
- Flow Line - Yamhill River
- Flow Line - Tributary Stream
- Proposed Expansion Area
- Mechanically Stabilized Earthen (MSE) Berm
- MW-19A — Groundwater Monitoring Well
- P-05A — Piezometer
- MB-2 — On-Site Water Well
- South Yamhill River Gauging Station
- CGP-11 — Landfill Gas Monitoring Probe
- 6/7P 6/7S — LCRS and LSCS Monitoring Location
- SYR SW-1 — South Yamhill River Sampling Location (Approximate)

SOURCE:

1) Topographic base map prepared by Miller Creek Aerial Mapping, using photogrammetric survey methods, date of photograph March 22, 2014. Contours are based on NAVD 88.

NOTES:

1) Monitoring wells and piezometers with "A" designation are screened in the shallow (Silt-Clay) water-bearing zone, and monitoring wells and piezometers with "B" designation are screened in the deeper (Sand-Gravel) water-bearing zone.

2) Piezometers with "GT" and "SA-BH" designations are screened in the shallow (Silt-Clay) water-bearing zone.

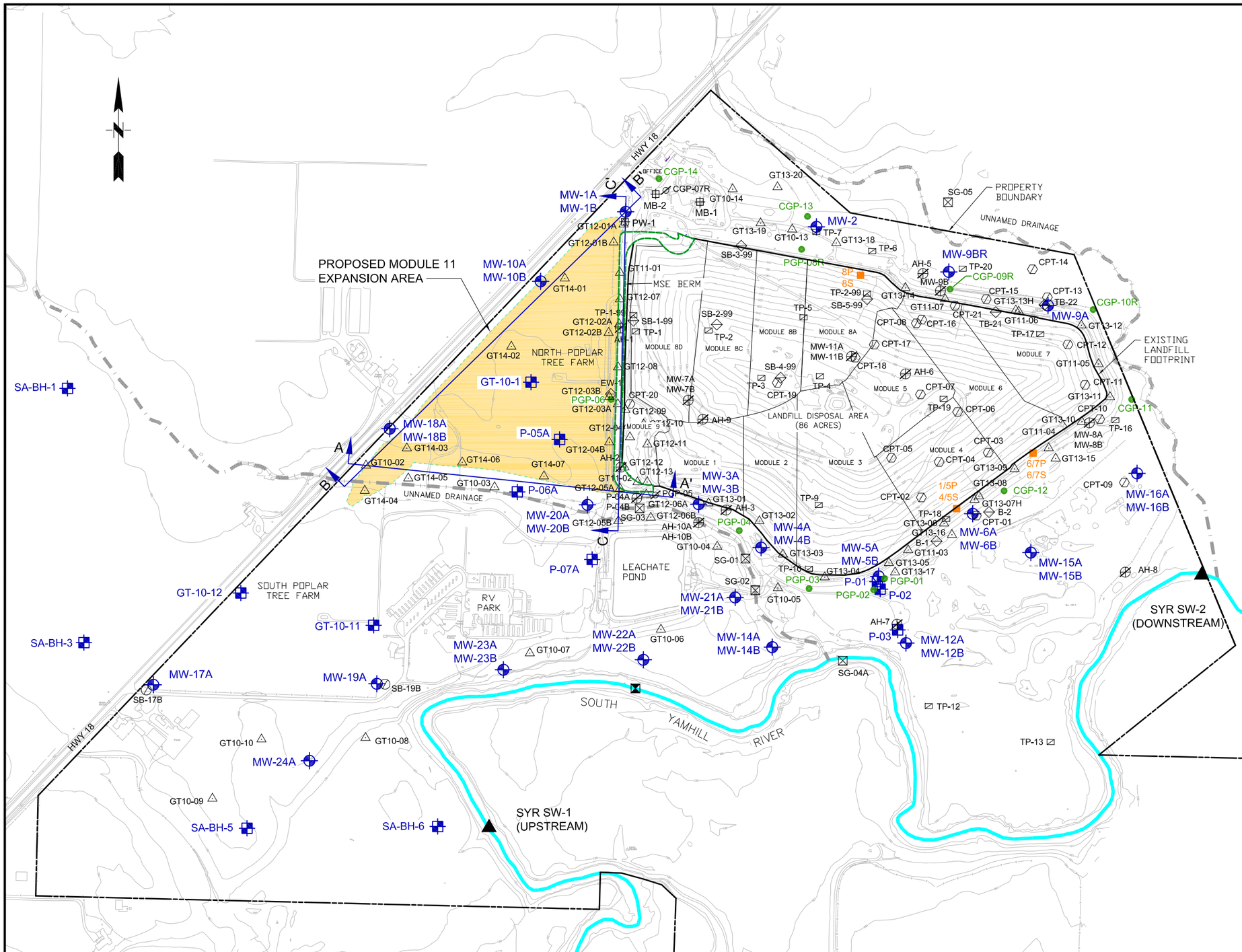
3) Leachate Collection and Removal System (LCRS) monitoring locations are identified by a "P" designation and Leachate Secondary Containment System (LSCS) monitoring locations are identified with a "S" designation.

4) Landfill gas monitoring probes with a "CGP" designation are compliance probes. Landfill gas monitoring probes with a "PGP" designation are performance evaluation probes.

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

0 600 1200
SCALE IN FEET

PROJECT NO. 04214039.00	DES BY D.L.	SITE PLAN AND EXISTING MONITORING LOCATIONS	DATE FEBRUARY 2015
SCALE AS SHOWN	CHK BY D.L.	RIVERBEND LANDFILL McMINNVILLE, OREGON	FIGURE 1-2
CAD FILE FIGURE 1-2	APP BY L.C.		



LEGEND:

- Topographic Contours (Surveyed)
- Topographic Contours (USGS)
- Property Boundary
- Flow Line - Yamhill River
- Flow Line - Unnamed Drainage
- Proposed Expansion Area
- Mechanically Stabilized Earthen (MSE) Berm
- A — A' Planned Hydrogeologic Cross Section Line

EXISTING MONITORING LOCATIONS

MW-19A	Groundwater Monitoring Well
P-05A	Piezometer
MB-2	On-Site Water Well
	South Yamhill River Gauging Station
CGP-14	Landfill Gas Monitoring Probe
6/7P 6/7S	LCRS and LSCS Monitoring Location
SYR SW-1	South Yamhill River Sampling Location (Approximate)

FORMER MONITORING OR EXPLORATORY LOCATIONS

AH-5	Decommissioned Monitoring Well or Piezometer
CGP-07A	Decommissioned Landfill Gas Monitoring Probe
B-1, EW-1, TB-21, SB-5-99	1993 or 1999 Test Boring
SB-19B	2000 Test Boring
CPT-10	1993 Cone Penetrometer Test Boring
GT13-06	2010 - 2014 Geotechnical Borehole
TP-10, TP-2-99	1981 or 1999 Test Pit
SG-05	Former Stream Level Monitoring Location

SOURCE:

1) Topographic base map prepared by Miller Creek Aerial Mapping, using photogrammetric survey methods, date of photograph March 22, 2014. Contours are based on NAVD 88.

NOTES:

1) Monitoring wells and piezometers with "A" designation are screened in the shallow (Silt-Clay) water-bearing zone, and monitoring wells and piezometers with "B" designation are screened in the deeper (Sand-Gravel) water-bearing zone.

2) Piezometers with "GT" and "SA-BH" designations are screened in the shallow (Silt-Clay) water-bearing zone.

3) Leachate Collection and Removal System (LCRS) monitoring locations are identified by a "P" designation and Leachate Secondary Containment System (LSCS) monitoring locations are identified with a "P" designation.

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

WASTE MANAGEMENT

0 600 1200
SCALE IN FEET

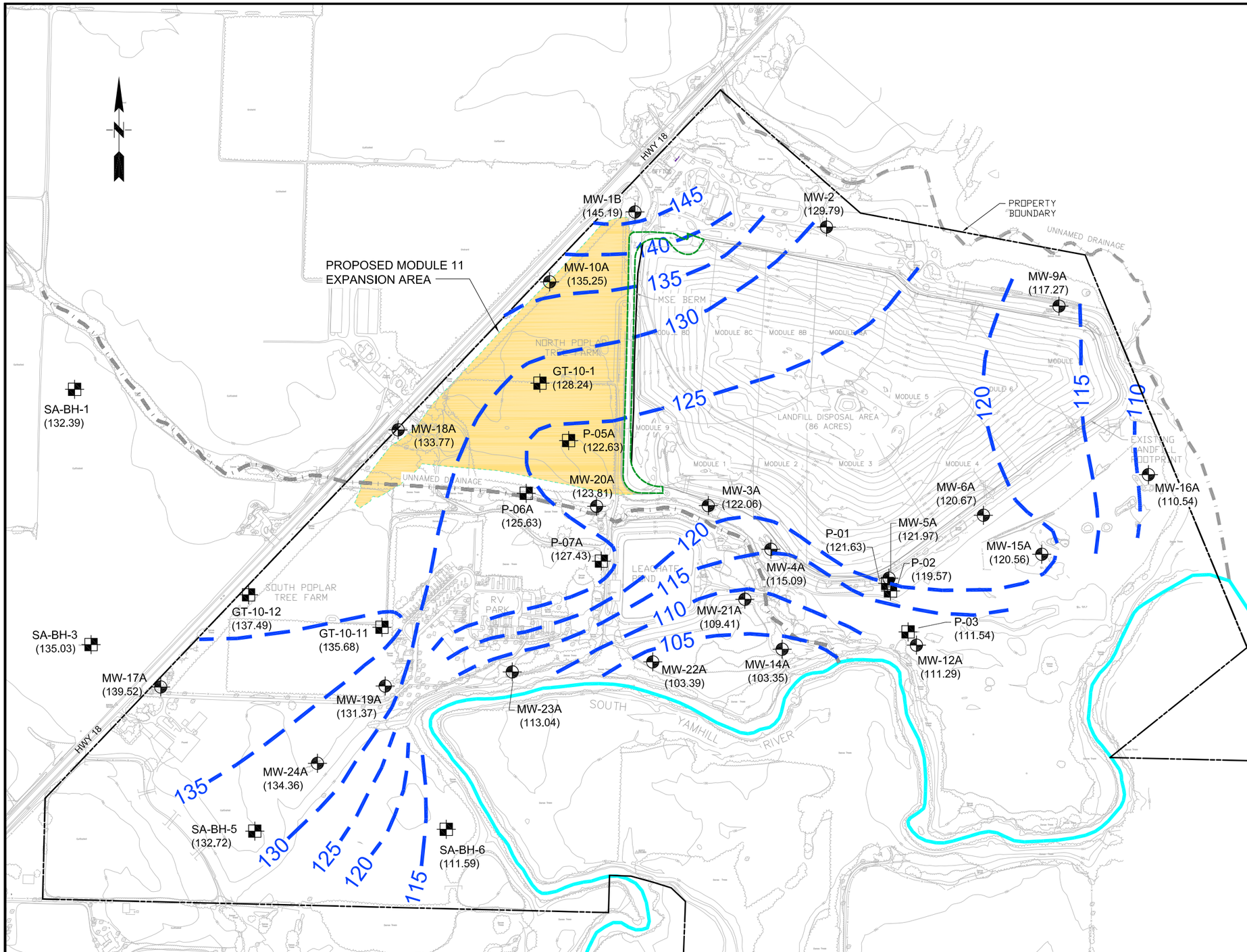
PROJECT NO. 04214039.00	DES BY D.L.
SCALE AS SHOWN	CHK BY D.L
CAD FILE FIGURE 3-1	APP BY L.C.

SITE PLAN AND HISTORICAL MONITORING/EXPLORATORY LOCATIONS

RIVERBEND LANDFILL
McMINNVILLE, OREGON

DATE FEBRUARY 2015

FIGURE 3-1



LEGEND:

- Topographic Contours (Surveyed)
- Topographic Contours (USGS)
- Property Boundary
- Flow Line - Yamhill River
- Flow Line - Tributary Stream
- 100 — Potentiometric Surface Contours for shallow water - bearing zone (Feet MSL) Contour Interval = 5 Feet
- MW-19A — Groundwater Monitoring Well
- P-05A — Piezometer
- (117.27) — Groundwater Elevation in Feet Above Mean Sea Level on November 18, 2013
- Proposed Expansion Area
- Mechanically Stabilized Earthen (MSE) Berm

SOURCE:

1) Topographic base map prepared by Miller Creek Aerial Mapping, using photogrammetric survey methods, date of photograph March 22, 2014. Contours are based on NAVD 88.

NOTES:

1) Monitoring wells and piezometers with "A" designation are screened in the shallow (Silt-Clay) water-bearing zone, and monitoring wells and piezometers with "B" designation are screened in the deeper (Sand-Gravel) water-bearing zone.

2) Piezometers with "GT" and "SA-BH" designations are screened in the shallow (Silt-Clay) water-bearing zone.

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

WASTE MANAGEMENT

0 600 1200
SCALE IN FEET

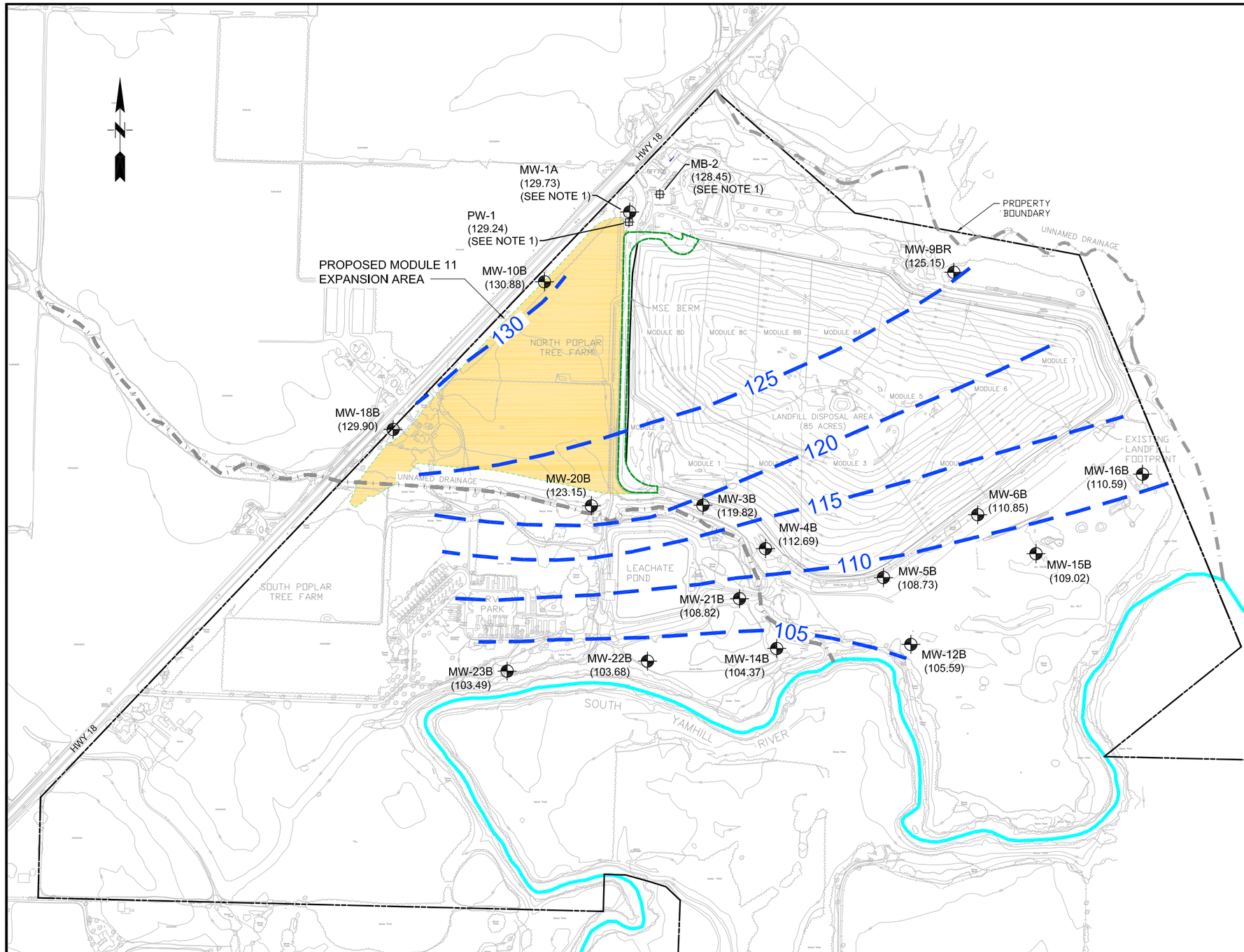
PROJECT NO. 04214039.00	DES BY D.L.
SCALE AS SHOWN	CHK BY D.L.
CAD FILE FIGURE 3-2	APP BY L.C.

SHALLOW WATER - BEARING ZONE
POTENTIOMETRIC SURFACE CONTOURS
(NOVEMBER 18, 2013)

RIVERBEND LANDFILL
McMINNVILLE, OREGON

DATE FEBRUARY 2015

FIGURE 3-2



LEGEND:

- Topographic Contours (Surveyed)
- Topographic Contours (USGS)
- Property Boundary
- Flow Line - Yamhill River
- Flow Line - Tributary Stream
- 120 — Potentiometric Surface Contours for deep water - bearing zone (Feet MSL) Contour Interval = 5 Feet
- MW-18B — Groundwater Monitoring Well
- P-04B — Piezometer
- MB-2 — On-Site Water Well
- (129.90) — Groundwater Elevation in Feet Above Mean Sea Level on November 18, 2013
- Proposed Expansion Area
- Mechanically Stabilized Earthen (MSE) Berm

SOURCE:

1) Topographic base map prepared by Miller Creek Aerial Mapping, using photogrammetric survey methods, date of photograph March 22, 2014. Contours are based on NAVD 88.

NOTES:

1) Water level in well is depressed due to periodic pumping of the site production well (PW-1). These wells were not used in the interpretation of potentiometric contours.

2) Monitoring wells and piezometers with "A" designation are screened in the shallow (Silt-Clay) water-bearing zone, and monitoring wells and piezometers with "B" designation are screened in the deeper (Sand-Gravel) water-bearing zone.

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

WASTE MANAGEMENT

0 600 1200
SCALE IN FEET

PROJECT NO. 04214039.00	DES BY D.L.
SCALE AS SHOWN	CHK BY D.L.
CAD FILE FIGURE 3-3	APP BY L.C.

DEEP WATER - BEARING ZONE
POTENTIOMETRIC SURFACE CONTOURS
(NOVEMBER 18, 2013)

RIVERBEND LANDFILL
McMINNVILLE, OREGON

DATE FEBRUARY 2015

FIGURE 3-3

APPENDIX A

Borehole Logs and Well Construction Diagrams for Existing and Former Wells and Borings Within or in Close Proximity to Proposed Module 11

LOG OF EXPLORATORY BORING

PROJECT NAME	Riverbend Landfill	BORING NO.	MW- 1A
LOCATION	McMinnville, Oregon	PAGE	1 OF 4
DRILLED BY	Geo-Tech	GROUND ELEV.	
DRILL METHOD	H/S AUGER	TOTAL DEPTH	61.50'
LOGGED BY	G. Kelty	DATE COMPLETED	09/06/89

SAMPLE NUMBER	RECOVERY (ft./ft.)	BLOW COUNTS (N COMP)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHOLOGIC COLUMN	LITHOLOGIC DESCRIPTION
								0-5' SILTY CLAY (CL), black (5Y, 2.5/1); 90% fines, low to medium plasticity; 10% fine sand; common wood chips; damp.
#1	1.5/1.5	3-4-6 (10)		5				5-10.1' SILTY CLAY (CL), grayish brown (2.5Y, 5/2); 100% fines, low to medium plasticity, slightly silty; trace fine sand; stiff; damp.
#2	1.5/1.5	2-2-4 (6)		10				10.1-15' CLAYEY SILT (ML), dark grayish brown (10YR, 4/2); 100% fines, low to medium plasticity; trace fine sand, common quartz or mica (identification difficult due to size); minor rootlets; rapid dilatency; firm; damp.
#3	1.5/1.5	2-2-4 (6)		15				15-26' SILTY CLAY (CL) AND CLAYEY SILT (ML) INTERBEDDED, dark grayish brown (10YR, 4/2); 10% fine sand; firm. Silty Clay: 90% fines, low to medium plasticity; slow dilatency. Clayey Silt: 90% fines, slight to low plasticity; rapid dilatency; damp to wet.
			▽	20				

REMARKS

Drilled by 10-inch O.D. continuous flight, hollow stem auger. Samples collected with 1 1/2-inch O.D. split spoon sampler. Borehole converted to a 2-inch monitoring well.

LOG OF EXPLORATORY BORING

PROJECT NAME Riverbend Landfill
LOCATION McMinnville, Oregon
DRILLED BY Geo-Tech
DRILL METHOD H/S AUGER
LOGGED BY G. Kelty

BORING NO. MW- 1A
PAGE 2 OF 4
GROUND ELEV.
TOTAL DEPTH 61.50'
DATE COMPLETED 09/06/89

SAMPLE NUMBER	RECOVERY (ft./ft.)	BLOW COUNTS (N COMP)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHOLOGIC COLUMN	LITHOLOGIC DESCRIPTION
#4	1.5/1.5	1-2-4 (6)	20'					@20 ft: increasing silty content.
#5	1.5/1.5	2-3-3 (6)		25				26-35' SILTY CLAY (CL), dark gray (5Y, 4/1); 100% fines, low to medium plasticity; trace fine sand; slow dilatency; firm; damp to wet.
#6	1.5/1.5	1-2-3 (5)		30				26-35' SILTY CLAY (CL), continued from previous page.
#7	1.5/1.5	5-9-10 (19)		35				35-40' SILTY CLAY (CL), dark gray (5Y, 3/2); 100% fines; low to medium plasticity; trace fine sand; common quartz or mica; common hard clay nodules; very stiff; damp.
				40				

REMARKS

Drilled by 10-inch O.D. continuous flight, hollow stem auger. Samples collected with 1 1/2-inch O.D. split spoon sampler. Borehole converted to a 2-inch monitoring well.

LOG OF EXPLORATORY BORING

PROJECT NAME Riverbend Landfill
LOCATION McMinnville, Oregon
DRILLED BY Geo-Tech
DRILL METHOD H/S AUGER
LOGGED BY G. Kelty-

BORING NO. MW- 1A
PAGE 3 OF 4
GROUND ELEV.
TOTAL DEPTH 61.50'
DATE COMPLETED 09/06/89

SAMPLE NUMBER	RECOVERY (ft./ft.)	BLOW COUNTS (N COMP)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHOLOGIC COLUMN	LITHOLOGIC DESCRIPTION
#8	1.5/1.5	4-4-6 (10)						40-45' CLAY (CL), dark gray (5Y, 4/1); 100% fines, low to medium plasticity; trace fine sand; common iron oxide staining; common white altered feldspar; stiff; damp.
#9	1.5/1.5	6-8-11 (19)		45				45-50' SILTY CLAY (CL), olive gray (5Y, 5/2); 100% fines, low to medium plasticity; trace fine sand; common iron staining; common organic material; very stiff; damp.
#10	0.8/1.5	45-50-0 (50)		50				50-55' CLAYEY SANDY GRAVEL (GC), dark grayish brown (10YR, 4/2); 15% fines, low to medium plasticity; 35% fine sand; 50% fine to coarse gravel; common iron oxide staining; very dense; damp.
#11	1.5/1.5	5-35-50 (85)		55				55-55.5' CLAYEY SAND (SC), olive (5Y, 4/4); 40% fines low to medium plasticity, slightly silty; 60% fine sand; occasional fine gravel; dense; wet.
								55.5-56' SANDY CLAY (CL), pale olive (5Y, 6/3); 60% fines, low to medium plasticity, slightly silty; 40% fine sand; common altered feldspar; dense; damp.
								56-60' CLAYEY SANDY GRAVEL (GC), dark grayish brown (10YR, 4/2); 15% fines, low to medium
				60				

REMARKS

Drilled by 10-inch O.D. continuous flight, hollow stem auger. Samples collected with 1 1/2-inch O.D. split spoon sampler. Borehole converted to a 2-inch monitoring well.

LOG OF EXPLORATORY BORING

PROJECT NAME Riverbend Landfill
LOCATION McMinnville, Oregon
DRILLED BY Geo-Tech
DRILL METHOD H/S AUGER
LOGGED BY G. Kelty

BORING NO. MW- 1A
PAGE 4 OF 4
GROUND ELEV.
TOTAL DEPTH 61.50'
DATE COMPLETED 09/06/89

SAMPLE NUMBER	RECOVERY (ft./ft.)	BLOW COUNTS (N COMP)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHOLOGIC COLUMN	LITHOLOGIC DESCRIPTION
#12	1.5/1.5	12-14-16 (30)						plasticity; 35% fine sand; 50% fine to coarse gravel; common iron oxide staining; very dense; damp to wet.
								60-61.5' CLAY (CL), dark gray (2.5Y, N/4); 100% fines, low to medium plasticity; trace fine sand; common hard gray blue clay nodules; very stiff; damp.
								BOTTOM OF BORING AT 61.5 FEET.
				65				
				70				
				75				
				80				

REMARKS

Drilled by 10-inch O.D. continuous flight, hollow stem auger. Samples collected with 1 1/2-inch O.D. split spoon sampler. Borehole converted to a 2-inch monitoring well.

LOG OF EXPLORATORY BORING

PROJECT NAME Riverbend Landfill
LOCATION McMinnville, Oregon
DRILLED BY Geo-Tech
DRILL METHOD H/S AUGER
LOGGED BY G. Kelty

BORING NO. MW- 1B
PAGE 1 OF 2
GROUND ELEV.
TOTAL DEPTH 26.50'
DATE COMPLETED 09/08/89

SAMPLE NUMBER	RECOVERY (ft./ft.)	BLOW COUNTS (N COMP)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHOLOGIC COLUMN	LITHOLOGIC DESCRIPTION
								0-5' SILTY CLAY (CL), black (5Y, 2.5/1); 90% fines, low to medium plasticity; 10% fine sand; common wood chips; damp.
#1	0.8/1.5	3-5-9 (14)		5				5-10.1' SILTY CLAY (CL), grayish brown (2.5Y, 5/2); 100% fines, low to medium plasticity, slightly silty; trace fine sand; stiff; damp.
#2	1.5/1.5	2-3-4 (7)		10				10.1-15' CLAYEY SILT (ML), dark grayish brown (10YR, 4/2); 100% fines, low to medium plasticity; trace fine sand, common quartz or mica (identification difficult due to size); minor rootlets; rapid dilatency; firm; damp.
#3	1.5/1.5	1-2-2 (4)		15				15-26' SILTY CLAY (CL) AND CLAYEY SILT (ML) INTERBEDDED, dark grayish brown (10YR, 4/2); 10% fine sand; firm. Silty Clay: 90% fines, low to medium plasticity; slow dilatency. Clayey Silt: 90% fines, slight to low plasticity; rapid dilatency; damp to wet.
			▽	20				

REMARKS

Drilled by 10-inch O.D. continuous flight, hollow stem auger. Samples colected with 1 1/2-inch O.D. split spoon sampler. Borehole converted to a 2-inch monitoring well.

LOG OF EXPLORATORY BORING

PROJECT NAME Riverbend Landfill
LOCATION McMinnville, Oregon
DRILLED BY Geo-Tech
DRILL METHOD H/S AUGER
LOGGED BY G. Kelty

BORING NO. MW- 1B
PAGE 2 OF 2
GROUND ELEV.
TOTAL DEPTH 26.50'
DATE COMPLETED 09/08/89

SAMPLE NUMBER	RECOVERY (ft./ft.)	BLOW COUNTS (N COMP)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHOLOGIC COLUMN	LITHOLOGIC DESCRIPTION
#4	1.5/1.5	2-3-5 (8)	20'					@20 ft: increasing silty content.
				25				
#5	1.5/1.5	2-5-10 (15)						26-26.5' SILTY CLAY (CL), dark gray (5Y, 4/1); 100% fines, low to medium plasticity; trace fine sand; slow dilatency; firm; damp to wet.
								BOTTOM OF BORING AT 26.5 FEET.
				30				
				35				
				40				

REMARKS

Drilled by 10-inch O.D. continuous flight, hollow stem auger. Samples colected with 1 1/2-inch O.D. split spoon sampler. Borehole converted to a 2-inch monitoring well.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	MW-10A
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	1 OF 2
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	150.80'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	28.30'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	10/27/93

RECOVERY PERCENT	POCKET PENETROMETER (Tons/SF)	PENETRATION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
100								0 to 25.5 feet: CLAYEY SILT (ML), dark grayish (10YR 4/2); 95 percent low plasticity fines; 5 percent sand, micaceous; abundant small macro pores, 1/32 to 1/15 inch in diameter, minor amount of slightly larger ones approximately 3/32 inch in diameter; minor amounts of 1/4 to 3/8 inch horizontal soil partings; stiff to very stiff; damp.
	>1.5		1/5/94					
	3.5							
	2.5							
94	2.0							
	2.5			5				
	2.5							
	2.5							@ 7.5 feet: 3-inch-thick SILTY SAND (SM) lense, 10 percent low plasticity fines (silt); 90 percent fine sand, rounded to subrounded, well sorted; appears loose; moist.
	1.75							
100	1.0							@ 8.0 feet: brown (10YR-4/3); moist.
	1.25			10				@ 10.5 feet: 3-inch-thick SILTY SAND (SM) lense, similar to the one at 7.5 feet.
	1.25							
	1.5							
	1.5							
100		11	5/27/93					@ 14.5 feet: wet.
				15				
97								
	2.0							@ 16.0 feet: 0.4-foot-thick SILTY CLAY (CL) lense. Paleo-soil horizon with black (carbon) root traces.
	1.0							
	0.5							@ 16.4 to 19.0 feet: minor amounts of almost indistinct SILTY SAND lenses, approximately 1- to 3-inch-thick, abundant platy varves, gradational between silt and sand. Note: core is very wet.
	0.5							
80	0.75							
				20				

REMARKS

Drilled with 8-inch O.D. (4.25-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	MW-10A
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	2 OF 2
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	150.80'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	28.30'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	10/27/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
	0.5							0 to 25.5 feet: CLAYEY SILT (ML), continued.
	0.5							@ 21.0 feet: color changes to dark grayish gray (5G 4/1); 2-inch sand lense above color change.
	0.5							@ 22.0 to 23.5 feet: platy varves, sandy surface to each varve (fine sand).
	0.75							
100	0.5							
	1.0			25				
	1.5							25.5 to 27.0 feet: SILTY SAND (SM), dark greenish gray (5G 4/1); 10 percent low platicity fines; 90 percent fine sand; appears loose, wet.
	3.0							27.0 to 28.3 feet: SILTY CLAY (CL), dark greenish gray (5G 4/1); medium plasticity fines; very stiff; wet.
	3.5							BORING TERMINATED AT 28.3 FEET.
				30				
				35				
				40				

REMARKS

Drilled with 8-inch O.D. (4.25-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

EMCON NORTHWEST

WELL DETAILS

CLIENT Riverbend Landfill Company, Inc.

PROJECT NUMBER 0258-001.28

PROJECT NAME Additional Hydrogeologic Inv.

LOCATION McMinnville, Oregon

WELL PERMIT NO. 59129

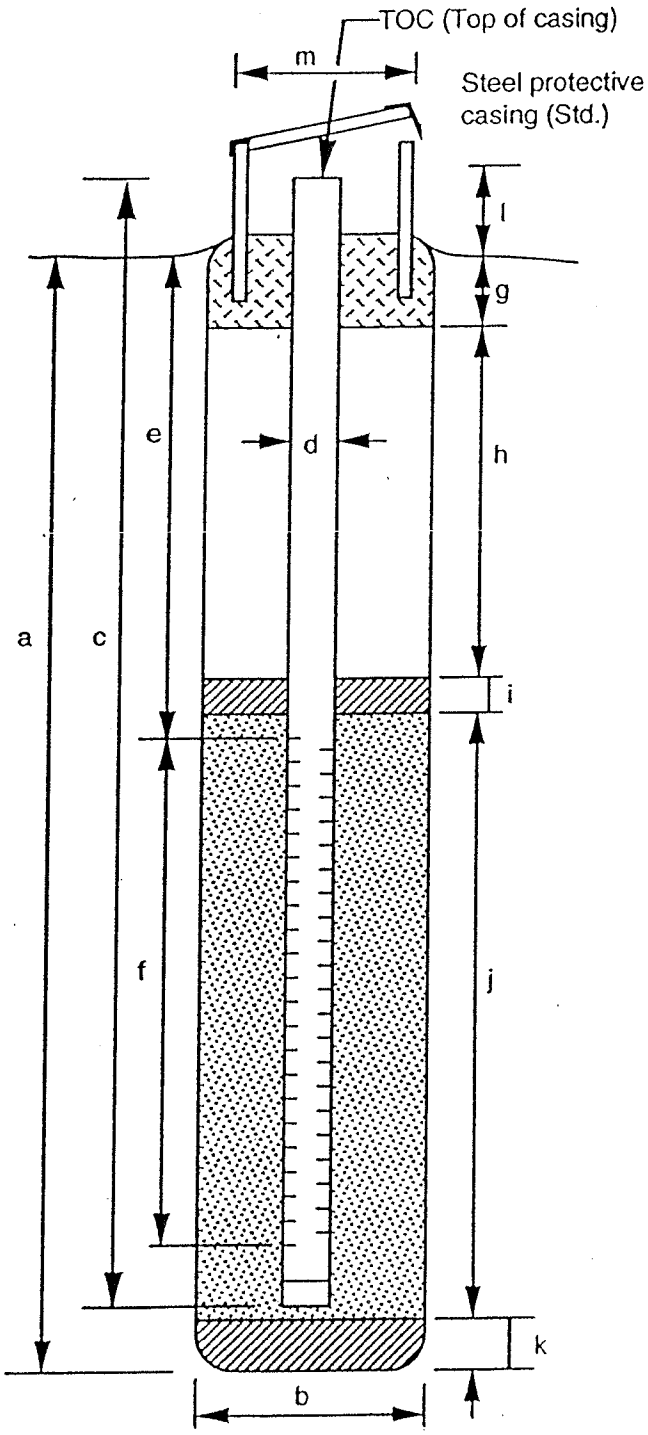
BORING / WELL NO. MW-10A

TOP OF CASING ELEV. 153.21

GROUND SURFACE ELEV. 150.8

DATUM Feet-Mean Sea Level

INSTALLATION DATE 10/28/93



EXPLORATORY BORING

a. Total depth 28.3 ft.

b. Diameter 8 in.

Drilling method Hollow Stem Auger

WELL CONSTRUCTION

c. Total casing length (+2.4 to 27.6) 30.0 ft.

Material Schedule 40 PVC

d. Diameter 2 in.

e. Depth to top perforations 17.3 ft.

f. Perforated length 9.5 ft.

Perforated interval from 17.3 to 26.8 ft.

Perforation type Machine Slotted

Perforation size 0.010 Inches

g. Surface seal (0 to 2.5) 2.5 ft.

Material Concrete

h. Backfill N.A. ft.

Material N.A.

i. Seal (2.2 to 14.0) 11.8 ft.

Material Bentonite

j. Gravel pack 14.3 ft.

Gravel pack interval from 14.0 to 28.3 ft.

Material 10-20 Gradation Sand

k. Bottom seal/fill N.A. ft.

Material N.A.

l. Casing stickup 2.4 ft.

m. Protective casing diameter 6.5 in.

Prepared by: Craig Fanshier

Ventura Form 4 Rev. 7/23/91

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	MW-10B
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	1 OF 4
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	150.80'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	69.00'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	10/25/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
90	1.0							0 to 4.0 feet: CLAYEY SILT (ML), brown (10YR 5/3), mostly evenly colored, trace lightly reddish brown mottling; low plasticity fines; trace fine sand, micaceous; some small macro pores (approximately 1/16-inch-diameter); very stiff; damp. Approximately 3/8-inch-thick poorly developed horizontal partings.
	4.0							
	4.0							
	3.5							
	2.5							
100	2.0							4.0 to 28.0 feet: SANDY SILT (SM), brown (10YR 4/3), approximately 5 percent small, light reddish brown mottling; 50 to 80 percent low plasticity fines; 20 to 50 percent fine sand, moderately sorted, subangular to subrounded, micaceous; abundant small (at 4.0 to 24.0 feet) macro pores (approximately 1/32- to 1/16-inch-diameter), approximately (5 to 10 per square inch) some larger vertically oriented macro pores (1/4-inch-diameter) approximately 1 to 2 per foot of core, open with no moisture, horizontal partings, are absent or very poorly developed; very stiff; damp to moist, moist at 8.0 feet, minor 2- to 3-inch-thick SILTY SAND lenses from 4.0 to 19.0 feet interbedded with gradational contact.
	2.5			5				
	2.0							
	2.5							
100	1.75		10/25/93 ▽					
	1.5			10				
	1.0							
	1.5							@ 9.0 feet: changes to medium stiff to stiff.
	1.0							@ 11.0 feet: wet.
100	0.75							@ 14.0 to 14.5 feet: SILTY SAND (SM) lense.
	0.5			15				
	0.75		▼ 1/5/94					
	0.5							
	3.0							@ 17.5 to 17.9 feet: CLAYEY SILT (ML), very stiff.
	1.5							@ 18.4 to 18.9 feet: SILTY SAND (SM) lense.
100	3.5							@ 19.5 feet: very sharp change in color to dark greenish gray (5G 4/1); strongly developed 1/4 to 3/8 inch varves (soil partings).
				20				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	MW-10B
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	2 OF 4
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	150.80'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	69.00'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	10/25/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
	2.0							**4.0 to 28.0 feet: SANDY SILT (SM)**, continued.
	1.5							@ 20.0 feet: interbedded small (0.2- to 0.6-foot-thick) CLAYEY SILT (ML) and SILTY SAND (SM) lenses.
	1.5							@ 20.0 to 23.0 feet: slight purplish tint.
	0.5							
	0.5							
	1.0							
100	1.0	25						
				25				
100	2.5							
	4.0							@ 26.0 feet: SANDY SILT (ML) lenses.
	2.5							
	1.0							@ 28.0 feet: soil is crumbly; wet.
	3.5							**28.0 to 38.0 feet: SILTY CLAY (CL)**, dark greenish gray (5G 4/1), evenly colored; 95 percent low to medium plasticity fines; 0 to 5 percent fine sand; abundant very small 1/32 inch macro pores; some minor lenses of varves (1/4-inch-thick partings); soft to medium stiff; wet.
100	0.75							
	1.5			30				
	>0.5							
	>0.5							
	1.0							
	1.5							
	>0.5							
80		25						
				35				@ 35.0 to 39.0 feet: drilling gets harder (hard layers with several small gravels); very stiff.
100	3.0							
	2.5							@ 37.0 to 38.0 feet: 20 percent fine gravels; grayish green (5G 4/2).
								@ 38.0 feet: rocky drilling noise.
								38.0 to 39.0 feet: SANDY GRAVEL (GP), grayish green (5G 4/2); 10 to 15 percent low to medium plasticity fines; continues.
40								
				40				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	MW-10B
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	3 OF 4
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	150.80'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	69.00'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	10/25/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
								38.0 to 39.0 feet: SANDY GRAVEL (GP), continued: 30 to 40 percent fine to coarse sands; 50 to 60 percent fine to coarse gravel; appears medium dense; wet.
100		50/6"		45				**39.0 to 44.5 feet:** CLAYEY GRAVEL (GC), dark yellowish brown (10YR 3/4), shade varies, some moderate iron oxide staining; 10 to 30 percent medium plasticity fines; 10 to 20 percent fine to coarse sand; 50 to 60 percent fine gravels, matrix supported, mostly rounded; appears medium dense; wet. Note: the clayey matrix is sticky. Minor 2 to 6 inch lense with approximately 5 percent fines; loose.
57								@ 41.0 feet: core barrel recovery blocked by 3 inch rock wedged into the core barrel.
								@ 44.0 feet: split spoon in CLAYEY GRAVEL (GC), penetration blocked by gravel; dense.
96				50				**44.5 to 60.0 feet:** SANDY GRAVEL (GP), dark yellowish brown (10YR 3/6); 10 to 15 percent low plasticity fines; 30 percent fine to coarse sand (F:C = 1:1); 55 to 60 percent fine to coarse gravel (F:C = 2:1), gravels subangular, matrix supported; dense to very dense; wet.
								@ 49.0 to 54.0 feet: mostly fine gravel in a dense silty sand with trace clay matrix; very hard drilling, engine is lugging.
96				55				@ 53.5 to 53.8 feet: 2-inch-thick SILTY CLAY (CL) lense in the core barrel shoe.
								@ 54.0 feet: color changes to dark greenish gray (5GY 4/1).
								@ 54.0 to 54.3 feet: CLAYEY GRAVEL (GC).
								@ 57.5 to 58.2 feet: lenses of SILTY CLAY (CL) with 5 percent medium sand (possibly altered volcanic ash).
100								@ 59.0 feet: thin clay lense.
				60				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	MW-10B
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	4 OF 4
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	150.80'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	69.00'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	10/25/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
	4.0							60.0 to 61.0 feet: CLAYEY SAND (SC), dark greenish gray; 40 percent medium plasticity fines; 60 percent fine to medium sand; hard; wet.
								61.0 to 61.5 feet: SILTY SAND (SM)
								61.5 to 62.5 feet: SAND (SP)
100				65				62.5 to 69.0 feet: SANDY GRAVEL (GP), dark greenish gray; 40 percent medium to coarse sand (M:C = 1:1), angular to subrounded; 60 percent gravels (F:C = 2:1), larger gravels are smooth (water worked); minor amounts of brown wood fragments at 62.0 to 64.0 feet; appears dense; wet.
								@ 67.0 feet: several 1-inch by 1/16-inch gravels (flat), many gravels rounded.
								@ 68.0 to 69.0 feet: appears looser.
								@ 69.0 feet: 1-foot of sand heave in auger.
								BORING TERMINATED AT 69.0 FEET.
				70				
				75				
				80				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

EMCON NORTHWEST

WELL DETAILS

CLIENT Riverbend Landfill Company, Inc.

PROJECT NUMBER 0258-001.28

PROJECT NAME Additional Hydrogeologic Inv.

LOCATION McMinnville, Oregon

WELL PERMIT NO. 59133

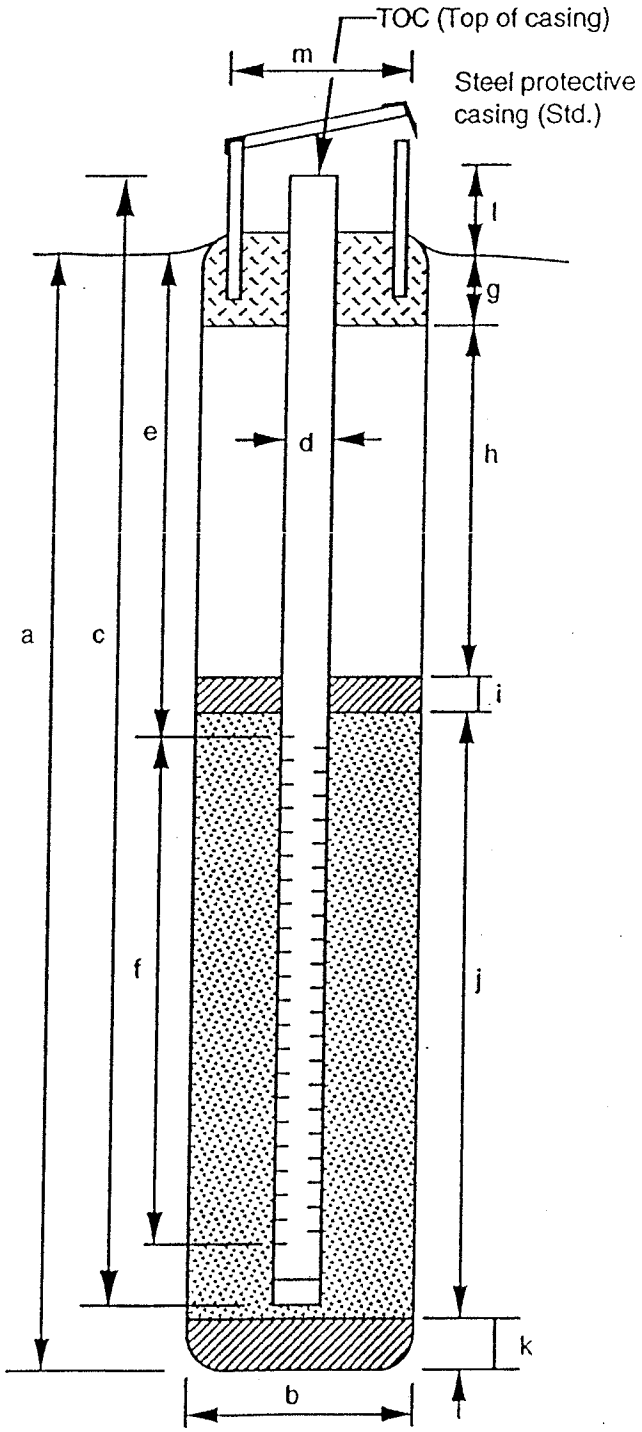
BORING / WELL NO. MW-10B

TOP OF CASING ELEV. 152.87

GROUND SURFACE ELEV. 150.8

DATUM Feet-Mean Sea Level

INSTALLATION DATE 10/27/93



EXPLORATORY BORING

a. Total depth 69.0 ft.

b. Diameter 10 in.

Drilling method Hollow Stem Auger

WELL CONSTRUCTION

c. Total casing length (+2.1 to 54.6) 56.7 ft.

Material Schedule 40 PVC

d. Diameter 2 in.

e. Depth to top perforations 44.3 ft.

f. Perforated length 9.5 ft.

Perforated interval from 44.3 to 53.8 ft.

Perforation type Machine Slotted

Perforation size 0.010 Inches

g. Surface seal (0 to 2.0) 2.0 ft.

Material Concrete

h. Backfill N.A. ft.

Material N.A.

i. Seal (2.0 to 40.9) 38.9 ft.

Material Bentonite

j. Gravel pack 14.4 ft.

Gravel pack interval from 40.9 to 55.3 ft.

Material 10-20 Gradation Sand

k. Bottom seal/fill (55.3 to 69.0) 13.7 ft.

Material Bentonite

l. Casing stickup 2.1 ft.

m. Protective casing diameter 6.5 in.

Centralizers at 20.0 and 43.0 feet bgs.

Prepared by: Craig Fanshier

Rev. 7/23/91

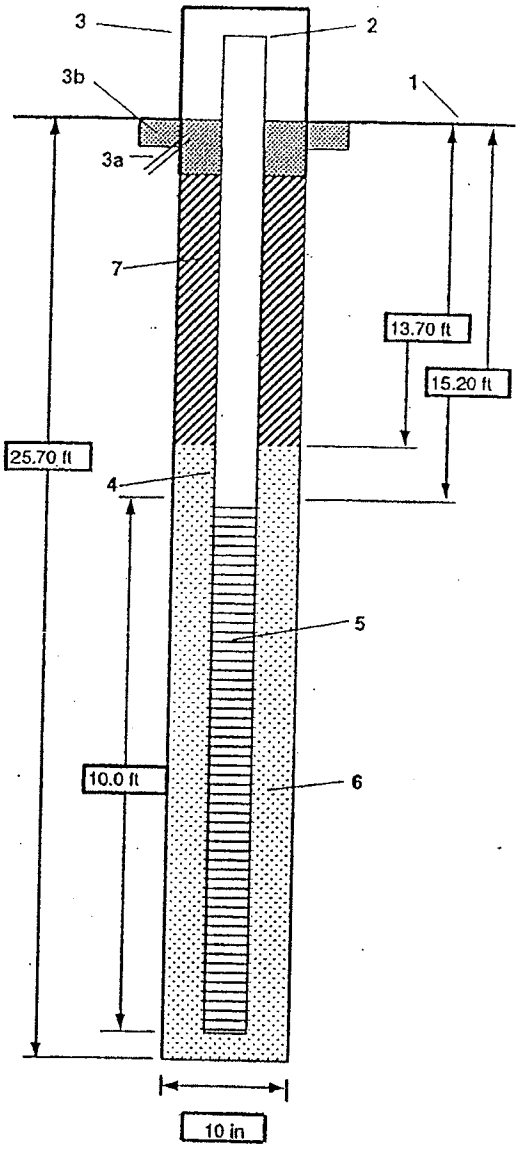
Ventura Page 4

CH2MHILL

PROJECT NUMBER	BORING NUMBER
159636.A0.03	MW-18A (L40375) SHEET 1 OF 1

WELL COMPLETION DIAGRAM

PROJECT : Riverbend Landfill LOCATION : McMinnville, Oregon Installation date(s): 09/26/2000
ELEVATION : 146.77 ft msl DRILLING CONTRACTOR : Geo-Tech Explorations, Inc.
DRILLING METHOD AND EQUIPMENT USED : B-59 Mobile Hollow-Stem Auger (6.25" ID)
WATER LEVELS : START : END : LOGGER : B. Long



1- Ground elevation at well: 146.77 ft msl

2- Top of casing elevation: 148.77 ft msl

3- Wellhead protection cover type: Above-ground monument
a) drain tube? No
b) concrete pad dimensions: Approx. 2' x 2'

4- Diameter/type of well casing: 2" Sch. 40 PVC

5- Type/slot size of screen: 2" Sch.40 PVC / 0.010 slot

6- Type screen filter: Silica sand (20-40)
a) Quantity used: 8-50 lb bags

7- Type of seal: Med. bentonite chips (45-43 ft), bent. grout to conc pad
a) Quantity used: 8-50 lb bags
b) Top of seal: Concrete

Development method: Pump & surge

Development time: Approx. 3 hours

Estimated purge volume: 33 gallons

Comments: Well screen length is nominal; actual screened portion is approx. 1 foot shorter than labeled length

CH2MHILL

BORING NUMBER
MW-18A

SOIL BORING LOG

PROJECT : Riverbend Landfill
LOCATION : McMinnville, Oregon
DATE: 09/26/2000
ELEVATION : 146.77 ft msl
DRILLING CONTRACTOR: Geo-Tech Explorations, Inc.
DRILLING METHOD : Hollow-Stem Auger
WATER LEVELS :
START :
END:
LOGGER : B. Long

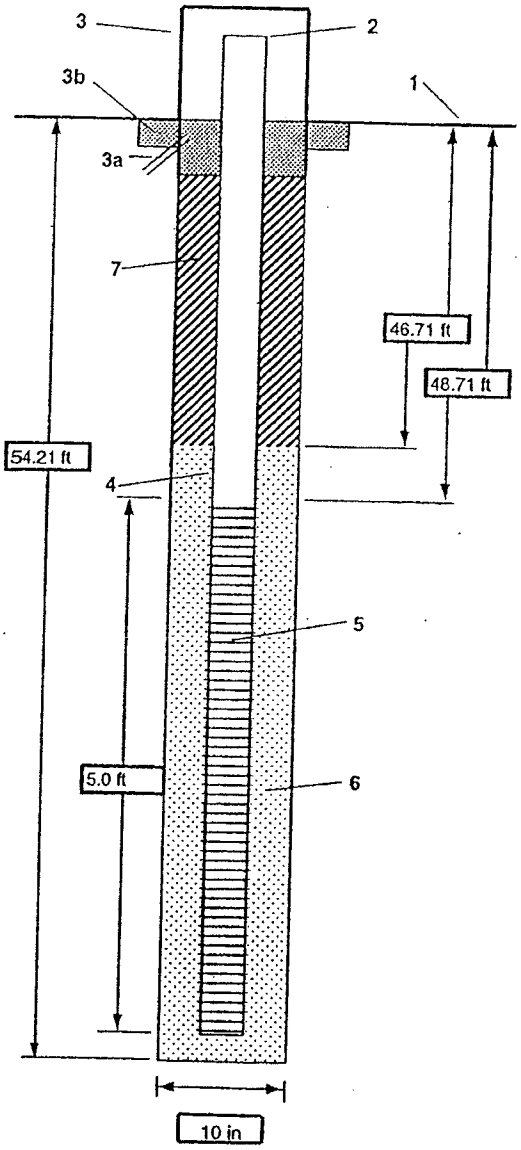
DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL, #	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS
			Grass field, pea gravel (old road bed) Samples not obtained 0'-4'	
5		ML	SILT (ML), Lt. Brown, moist, medium stiff, platey, massive, mica fragments, fine roots, macropores, trace clay.	
10			CLAY (CL), Lt brown (10-30% clay), medium stiff, platey, mica fragments, rootlets, macropores, increasing moisture @ 10' From 13-25 feet - 1"-2" seams of sandy silt @ 6"-10" intervals;	
15			As above, but mottled lt brown, fewer rootlets & macropores, saturated	
20		CL	As above w/some organic fragments, no rootlets or macropores	
25			Clay (CL), bluish-gray, wet, stiff, homogeneous, trace mica.	

CH2MHILL

PROJECT NUMBER	BORING NUMBER
159636.A0.03	MW-18B (L40374) SHEET 1 OF 1

WELL COMPLETION DIAGRAM

PROJECT: Riverbend Landfill LOCATION: McMinnville, Oregon Installation date(s): 09/25/2000
ELEVATION: 146.58 ft msl DRILLING CONTRACTOR: Geo-Tech Explorations, Inc.
DRILLING METHOD AND EQUIPMENT USED: B-59 Mobile Hollow-Stem Auger (6.25" ID)
WATER LEVELS: START: END: LOGGER: B. Long



1- Ground elevation at well: 146.58 ft msl

2- Top of casing elevation: 148.57 ft msl

3- Wellhead protection cover type: Above-ground monument
a) drain tube? No
b) concrete pad dimensions: Approx. 2' x 2'

4- Diameter/type of well casing: 2" Sch. 40 PVC

5- Type/slot size of screen: 2" Sch.40 PVC / 0.010 slot

6- Type screen filter: Silica sand (10-20)
a) Quantity used: 7-50 lb bags

7- Type of seal: Bentonite grout
a) Quantity used: 2-50 lb bags
b) Top of seal: Concrete

Development method: Pump & surge

Development time: Approx. 2.5 hrs

Estimated purge volume: 80 gallons

Comments: Well screen length is nominal; actual screened portion is approx. 6 inches shorter than labeled length

CH2MHILL

BORING NUMBER MW-18B

SOIL BORING LOG

PROJECT : Riverbend Landfill
LOCATION : McMinnville, Oregon
DATE: 09/25-26/2000
ELEVATION :
DRILLING CONTRACTOR: Geo-Tech Explorations, Inc.
DRILLING METHOD : Hollow-Stem Auger
WATER LEVELS :
START : 12:00
END:
LOGGER : B. Long

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL, #	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS
			Grass field, pea gravel (old road bed), over light brown SILT Samples not obtained 0'-4'	
5		ML	SILT (ML), Lt. Brown, moist, medium stiff, platey, massive, mica fragments, fine roots, macropores, trace clay.	
10			CLAY with silt (CL), Lt brown, medium stiff, platey, mica fragments, rootlets, macropores, increasing moisture @ 10' From 13-25 feet - 1"-2" seams of sandy silt @ 6"-10" intervals	
15			As above, but mottled lt brown, fewer rootlets & macropores, saturated	
20		CL	As above w/some organic fragments, no rootlets or macropores	
25	S-11		Clay (CL), bluish-gray, wet, stiff, homogeneous, trace mica.	
	S-12			
	S-13			
30	S-14			
	S-15			
35	S-16			

CH2MHILL

BORING NUMBER
MW-18B

SOIL BORING LOG

PROJECT : Riverbend Landfill
LOCATION : McMinnville, Oregon
DATE: 09/25-26/2000
ELEVATION :
DRILLING CONTRACTOR: Geo-Tech Explorations, Inc.
DRILLING METHOD : Hollow-Stem Auger
WATER LEVELS :
START :
END:
LOGGER : B. Long

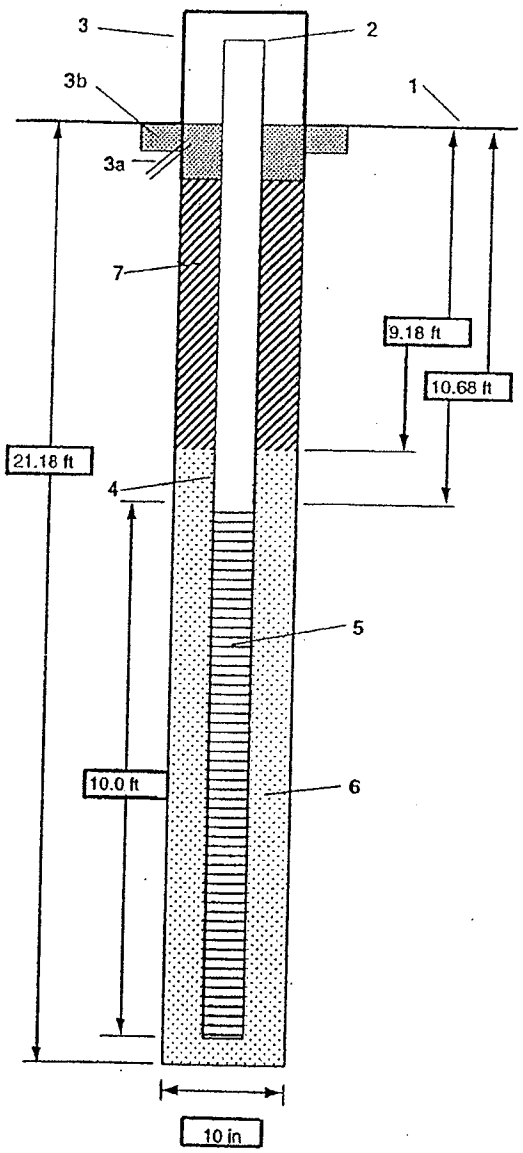
DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL, #	GRAPHIC LOG	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.)	COMMENTS
		CL	CLAY (CL), dark gray, moist, med stiff to stiff, homogeneous, trace of mica fragments	
		GP	Poorly graded fine GRAVEL with clay (GP), dark gray, moist, very dense, iron oxide on gravel clasts; basalt clasts to 1/2"	
40		CL	CLAY (CL), Yellowish-brown to lt gray (mottled), moist, stiff, trace coarse sand, highly weathered	
45				
		GP	Poorly graded fine GRAVEL (GP) with sand and silt, reddish brown, wet, dense, clast supported, basalt.	
50				
55				
60		GP-GC	As above with greater silt content	End of boring @ 62 ft

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
159636.A0.03	MW-20A (L40378)	SHEET 1 OF 1

WELL COMPLETION DIAGRAM

PROJECT: Riverbend Landfill LOCATION: McMinnville, Oregon Installation date(s): 10/02/2000
ELEVATION: 127.20 ft msl DRILLING CONTRACTOR: Geo-Tech Explorations, Inc.
DRILLING METHOD AND EQUIPMENT USED: B-59 Mobile Hollow-Stem Auger (6.25" ID)
WATER LEVELS: START: END: LOGGER: B. Long



1- Ground elevation at well: 127.20 ft msl

2- Top of casing elevation: 129.92 ft msl

3- Wellhead protection cover type: Above-ground monument
a) drain tube? No
b) concrete pad dimensions: Approx. 2' x 2'

4- Diameter/type of well casing: 2" Sch. 40 PVC

5- Type/slot size of screen: 2" Sch.40 PVC / 0.010 slot

6- Type screen filter: Silica sand (20-40)
a) Quantity used: 9 - 50 lb bags

7- Type of seal: Medium bentonite chips
a) Quantity used: 6 - 50 lb bags
b) Top of seal: Concrete

Development method: Pump & surge

Development time: Approx 3.5 hrs

Estimated purge volume: 68 gallons

Comments: Well screen length is nominal; actual screened portion is approx. 1 foot shorter than labeled length

CH2MHILL

BORING NUMBER
MW-20A

SOIL BORING LOG

PROJECT : Riverbend Landfill
LOCATION : McMinnville, Oregon
DATE: 10/02/2000
ELEVATION : 127.20 ft msl
DRILLING CONTRACTOR: Geo-Tech Explorations, Inc.
DRILLING METHOD : Hollow-Stem Auger
WATER LEVELS :
START :
LOGGER : B. Long

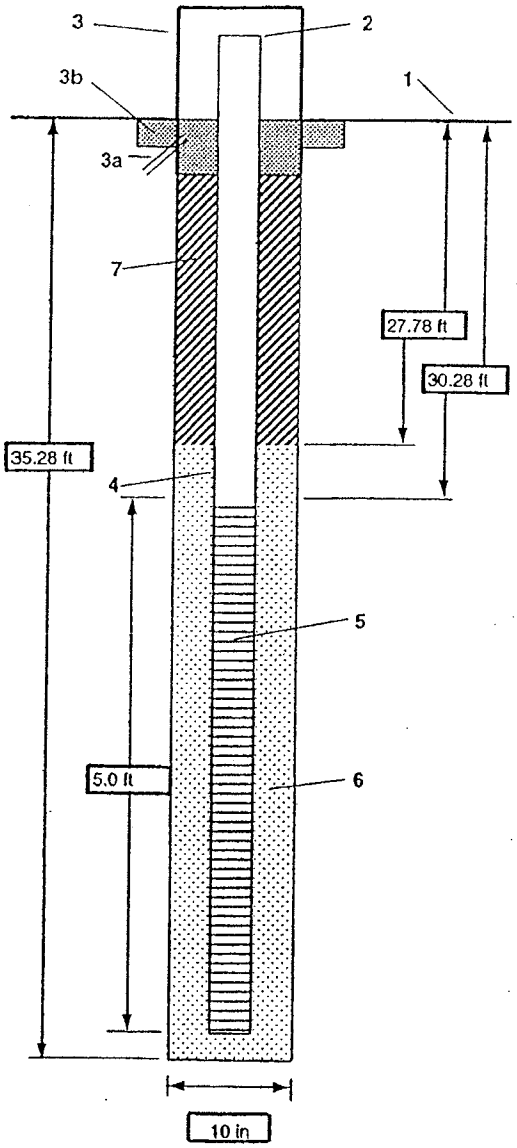
DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL, #	GRAPHIC LOG	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.)	COMMENTS
			Grassy field	
			Cuttings: CLAY (CL), gray, moist, medium stiff	
5		CL	CLAY w/silt (CL), mottled reddish-brown, medium stiff, moist, trace organics, sand-sized iron nodules, small root channels	
10			As above, but stiffer, moist to wet; darker gray beginning @ 12'	
15		CL	CLAY with silt and very fine sand (CL), gray , moist, stiff, few root channels, moist	
20				

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
159636.A0.03	MW-20B (L40377)	SHEET 1 OF 1

WELL COMPLETION DIAGRAM

PROJECT : Riverbend Landfill LOCATION : McMinnville, Oregon Installation date(s): 10/02/2000
ELEVATION : 127.10 ft msl DRILLING CONTRACTOR : Geo-Tech Explorations, Inc.
DRILLING METHOD AND EQUIPMENT USED : B-59 Mobile Hollow-Stem Auger (6.25" ID)
WATER LEVELS : START : END : LOGGER : B. Long



1- Ground elevation at well	127.10 ft msl
2- Top of casing elevation	129.72 ft msl
3- Wellhead protection cover type	Above-ground monument
a) drain tube?	No
b) concrete pad dimensions	Approx. 2' x 2'
4- Diameter/type of well casing	2" Sch. 40 PVC
5- Type/slot size of screen	2" Sch.40 PVC / 0.010 slot
6- Type screen filter	Silica sand (10-20)
a) Quantity used	7 -50 lb bags
7- Type of seal	Bentonite chips
a) Quantity used	26 - 50 lb bags
b) Top of seal	Concrete

Development method	Pump & surge
Development time	Approx. 4 hours
Estimated purge volume	248 gallons

Comments Well screen length is nominal; actual screened portion is approx. 6 inches shorter than labeled length

CH2MHILL

MW-20B

SOIL BORING LOG

PROJECT : Riverbend Landfill
LOCATION : McMinnville, Oregon
DATE: 09/30/2000
ELEVATION : 127.10 ft msl
DRILLING CONTRACTOR: Geo-Tech Explorations, Inc.
DRILLING METHOD : Hollow-Stem Auger
WATER LEVELS :
START :
LOGGER : B. Long

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL, #	GRAPHIC LOG	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.)	COMMENTS
			Grassy field	
			Cuttings: CLAY (CL), gray, moist, medium stiff.	
5			CLAY w/silt (CL), mottled reddish-brown, medium stiff, moist, trace organics, sand-sized iron nodules, small root channels,	
		CL		
10			As above, but stiffer, moist to wet; darker gray beginning @ 12'	
15			CLAY with silt and very fine sand (CL), gray , moist, stiff, few root channels, moist	
		CL		
20				
			fine root channels to 24 feet.	
25			Poorly graded fine GRAVEL with sand and silt, yellow-brown to red-brown, wet, very dense, oxidized weathered gravel, occasional interbeds of gray plastic clay (GP)	
30		GP		
	S-14			
35	S-15			

CH2MHILL

BORING NUMBER
MW-20B

SOIL BORING LOG

PROJECT : Riverbend Landfill
LOCATION : McMinnville, Oregon
DATE: 09/30/2000
ELEVATION : 127.10 ft msl
DRILLING CONTRACTOR: Geo-Tech Explorations, Inc.
DRILLING METHOD : Hollow-Stem Auger
WATER LEVELS :
START :
LOGGER : B. Long

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL, #	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS
		GC	GRAVEL with clay, reddish-brown, moist to wet, dense, matrix supported, basalt gravel clasts	
40				End of boring @ 40 ft

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	P-04A
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	1 OF 2
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	139.00'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	32.50'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	10/28/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
95	3.5							**0 to 12.75 feet:** SILTY CLAY (CL), dark brown (7.5YR 3/2), patchy lenses of shades of brown and gray; medium plasticity fines; no macro pores; hard; damp. (FILL MATERIAL)
	4.5							
	4.5							
	3.0							
100	2.0			5				
	1.5							
	2.5							@ 6.5 feet: wood chips, 2-inch black organic layer.
	3.0							@ 6.7 feet: color changes to dark greenish gray (5GY 4/1) mixed with light olive brown mottling; changes to a medium to high plasticity clay; no pores, no bedding structure.
	3.0							
100	2.5			10				
	2.75							
	2.5							
	4.5		▼ 1/5/94					**12.75 to 29.0 feet:** CLAYEY SILT (ML), brown (10YR 4/3), slight olive tint; low to medium plasticity fines; abundant macro pores (open), small 1/16- to 1/32-inch-diameter, some larger 1/8-inch vertical, trace of roots; very stiff; moist. (NATIVE SOIL)
	2.5							
100	2.0			15				@ 12.75 to 14.75 feet: dark grayish brown.
	2.5							@ 14.5 feet: moist.
	1.5							
	2.0		▽ 10/26/93					@ 17.5 feet: wet (large macro pore approximately half full with free water) and along poorly developed granular soil peds.
	1.5							@ 19.0 feet: minor interbedded CLAYEY SANDS (SC) and SILTY SANDS (SM) lenses.
100				20				

REMARKS

Drilled with 8-inch O.D. (4.25-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	P-04A
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	2 OF 2
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	139.00'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	32.50'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	10/28/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
	1.75							**12.75 to 29.0 feet: CLAYEY SILT (ML)**, continued.
	2.0							@ 20.0 feet: slight mix of light, indistinct reddish brown and tan brown mottling, minor horizontal parting (weakly developed), trace fine sands, well rounded, spherical, minor amounts of mica, abundant (approximately 5 to 10 per square inch) macro pores; stiff; moist.
	1.0							
	1.5							
	1.5							
100	1.5			25				@ 24.5 to 26.5 feet: well developed 3/8- to 1/2-inch-thick platy horizontal soil partings.
	1.5							
	1.5							
	0.5							@ 27.5 feet: color changes to dark greenish gray (5G 4/1) with 50 percent indistinctly mottled light olive brown mottling (2.5Y 5/3), occurring at separate 0.3- to 0.5-foot-thick layers.
	1.0							
100	1.5			30				**29.0 to 32.5 feet: SILTY CLAY (CL)**, dark greenish gray (5GRY 4/1); medium to high plasticity fines; glazed (glistening) soil ped partings, irregular soil partings, stiff; wet.
	1.0							
	1.0							
								BORING TERMINATED AT 32.5 FEET.
				35				
				40				

REMARKS

Drilled with 8-inch O.D. (4.25-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

EMCON NORTHWEST

WELL DETAILS

CLIENT Riverbend Landfill Company, Inc.

PROJECT NUMBER 0258-001.28

PROJECT NAME Additional Hydrogeologic Inv.

LOCATION McMinnville, Oregon

WELL PERMIT NO. 59130

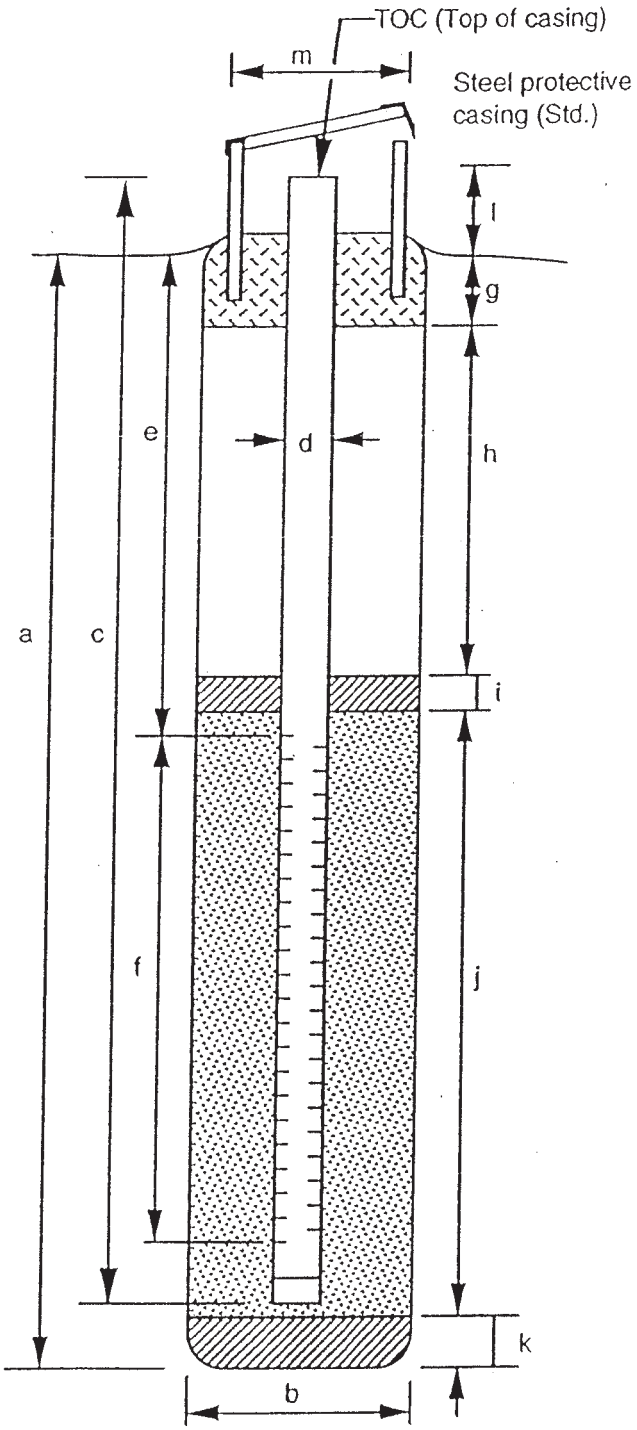
BORING / WELL NO. P-04A

TOP OF CASING ELEV. 141.15

GROUND SURFACE ELEV. 139.0

DATUM Feet-Mean Sea Level

INSTALLATION DATE 10/28/93



EXPLORATORY BORING

a. Total depth 32.5 ft.

b. Diameter 8 in.

Drilling method Hollow Stem Auger

WELL CONSTRUCTION

c. Total casing length (+2.2 to 29.6) 31.8 ft.

Material Schedule 40 PVC

d. Diameter 2 in.

e. Depth to top perforations 19.3 ft.

f. Perforated length 9.5 ft.

Perforated interval from 19.3 to 28.8 ft.

Perforation type Machine Slotted

Perforation size 0.010 Inches

g. Surface seal (0 to 2.0) 2.0 ft.

Material Concrete

h. Backfill N.A. ft.

Material N.A.

i. Seal (2.0 to 15.9) 13.9 ft.

Material Bentonite

j. Gravel pack 13.9 ft.

Gravel pack interval from 15.9 to 29.8 ft.

Material 10-20 Gradation Sand

k. Bottom seal/fill (29.8 to 32.5) 2.7 ft.

Material Bentonite

l. Casing stickup 2.2 ft.

m. Protective casing diameter 6.5 in.

Prepared by: Craig Fanshier

Rev. 7/23/91

Ventura Mac 4

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	P-04B
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	1 OF 4
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	139.00'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	75.80'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	11/09/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
9.2	>4.5							0 to 12.5 feet: SILTY CLAY (CL), dark reddish brown (5YR 3/3); medium plasticity fines; hard; damp. (FILL)
	>4.5							
	4.0							
	>4.5							
100	3.5							
	3.5			5				
	2.5							
	3.0							@ 7.5 feet: color changes to dark olive gray (5Y 3/2); slight odor.
	2.5							
80		32						@ 9.0 feet: very stiff.
				10				
100	1.5							
	3.5							12.5 to 21.0 feet: CLAYEY SILT (ML), very dark grayish brown (10YR 3/2); very abundant small macro pores and some large vertical macro pores, some very fine roots; very stiff; damp.
	2.5							
94			1/5/94					
	2.0			15				@ 14.0 feet: moist.
	3.0							@ 15.5 feet: color changes to dark brown (7.5YR 3/2).
	2.0		11/9/93					@ 16.7 feet: wet.
	1.5							@ 17.0 feet: approximately 10 percent gray mottling, as rinds around vertical macro pores.
	2.0							@ 17.0 to 21.0 feet: approximately 10 percent light reddish brown mottling, approximately 10 percent black mottling.
100	2.0			20				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. Bedrock was cored with NX (3.5-inch O.D.) diamond core. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	P-04B
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	2 OF 4
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	139.00'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	75.80'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	11/09/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
	2.5							12.5 to 21.0 feet: CLAYEY SILT (ML), continued.
	2.5							21.0 to 30.0 feet: SILT (ML), light yellowish brown (2.5Y 6/3); low plasticity fines; less macro pores than above (approximately 3 to 5 per square inch), no large ones; some 1/4-inch platy varves; stiff; wet.
	2.5							
	2.0							
67		17						
				25				
100	1.0							@ 25.5 to 29.0 feet: approximately 1- to 3-inch-thick bands of grayish coloration.
	2.5							@ 27.0 to 29.0 feet: abundant small bedding structures approximately 1/16- to 1/8-inch-thick, appears to have more clay than 13.0 to 25.0 feet zone above.
	2.5							
	2.5							
100								@ 29.0 feet: approximately 50 percent gray and 50 percent brown.
	1.0			30				30.0 to 37.0 feet: SILTY CLAY (CL), dark bluish gray (5B 4/1); medium to high plasticity fines; approximately 1 to 2 macro pores per square inch (small), some vertical root traces; stiff; wet.
	1.5							@ 32.0 feet: slightly harder/sticky drilling, smooth, glassy, glazed soil, ped surface.
100		21						
				35				
100	1.25							
	1.25							
	1.0							37.0 to 38.0 feet: CLAYEY SAND (SC), dark bluish gray (5B 4/1), with 50 percent large oval shaped olive brown mottling; 20 to 25 percent low to medium plasticity fines; 75 to 80 percent fine sand, angular moderately well sorted; minor brown root hairs; appears medium, continues.
100								
				40				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. Bedrock was cored with NX (3.5-inch O.D.) diamond core. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	P-04B
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	3 OF 4
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	139.00'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	75.80'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	11/09/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
								37.0 to 38.0 feet: CLAYEY SAND (SC), continued: dense; moist. Unit grades into the sand below.
								38.0 to 39.0 feet: SAND (SP), dusky red (G5YR 3/3); 5 percent low plasticity fines; 95 percent fine to medium sand, angular; appears medium dense; moist.
60								39.0 to 41.0 feet: CLAYEY SAND (SC), light tannish brown; 30 percent low to medium plasticity fines; 70 percent fine sand; appears medium dense; moist.
				45				41.0 to 45.0 feet: SAND (SP), and GRAVELLY SAND (SP), dusky red (10R 3/3); little to no fines; 70 to 90 percent fine to coarse sand (F:M:C=1:3:2); 10 to 30 percent gravels (F:C=3:1); appears medium dense; wet. @ 41.0 to 42.5 and 42.5 to 44.0 feet: two distinct fining upwards sequences, each grades from a fine sand at the top to a gravelly sand at the bottom. @ 42.5 feet: 1 inch sand lense, color changes to brown (7.5YR 4/3). @ 44.0 feet: large 2 to 3 inch gravels.
80								
				50				
								45.0 to 55.0 feet: CLAYEY GRAVEL (GC), dark yellowish brown (10YR 4/3); 20 percent low to medium plasticity fines (as matrix), sticky; 20 to 30 percent SAND (F:M:C=1:1:1); 40 to 50 percent gravels (F:C=1:2), rounded, matrix supported; appears dense; wet.
20								
				55				@ 55.0 feet: drillers note less gravels, hard dense drilling.
								55.0 to 59.5 feet: SILTY SAND (SM), inferred from drilling action.
100		71						
				60				59.5 to 65.0 feet: SANDY SILT (SM), continues.

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. Bedrock was cored with NX (3.5-inch O.D.) diamond core. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	P-04B
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	4 OF 4
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	139.00'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	75.80'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	11/09/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
86								**59.5 to 65.0 feet: SANDY SILT (SM)**, continued: dark greenish gray (5G 4/1); 70 to 75 percent low plastic fines; 25 to 30 percent fine sand; moderately well sorted; 3 percent wood fragments, several 1/4 by 3/8-inch; brown leaf fossils, dense; wet.
100								Note: very similar to the lower section of MW-7B. @ 64.0 to 66.0 feet: very hard drilling.
				65				**65.0 to 75.8 feet: BASALT**, olive gray (5Y 3/2) (GSA rock color chart); medium grain; weathered zone approximately 1-inch-thick, drilled with hollow stem auger to 65.8 feet. @ 65.8 to 68.5 feet: abundant fracture filling, quartz veining, zeolites.
				70				
				75				**BORING TERMINATED AT 75.8 FEET.**
				80				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) Hollow Stem Auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. Bedrock was cored with NX (3.5-inch O.D.) diamond core. A 2-inch PVC monitoring well was constructed in the borehole. Well construction information presented in Well Details. See explanation for definition of symbols.

EMCON NORTHWEST

WELL DETAILS

CLIENT Riverbend Landfill Company, Inc.

PROJECT NUMBER 0258-001.28

PROJECT NAME Additional Hydrogeologic Inv.

LOCATION McMinnville, Oregon

WELL PERMIT NO. 59135

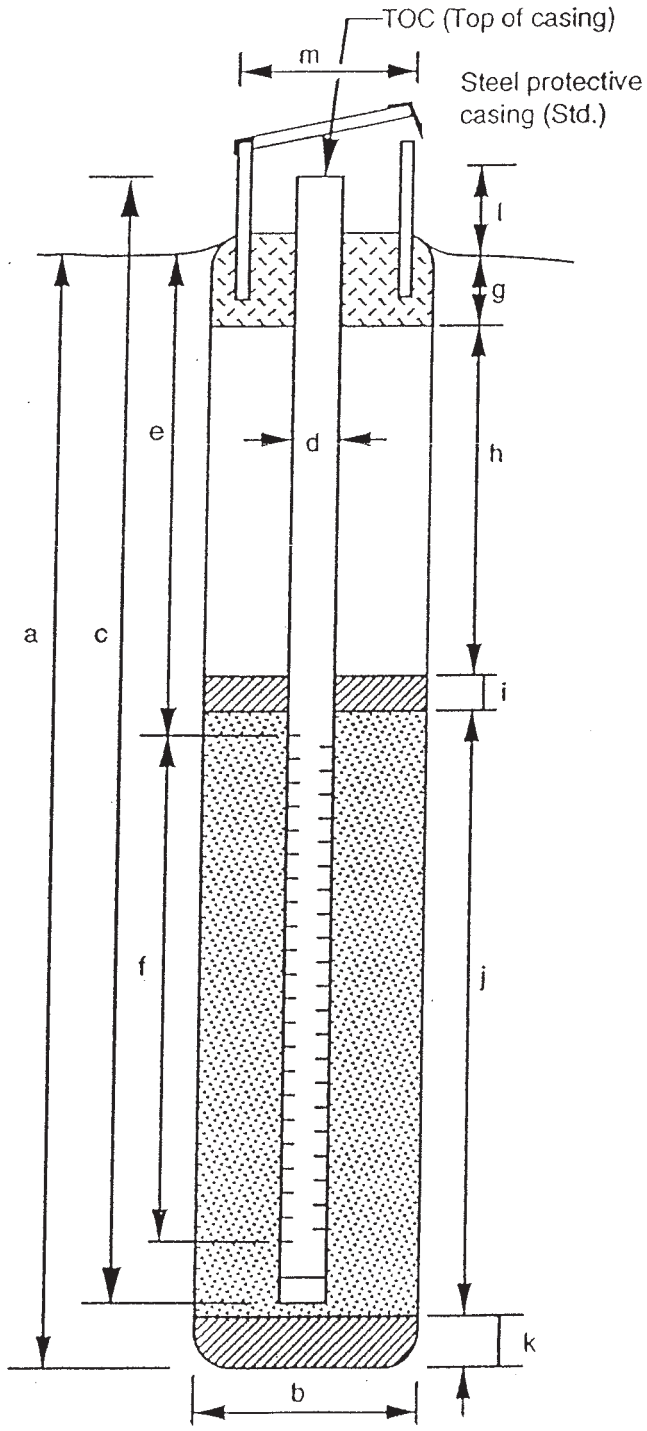
BORING / WELL NO. P-04B

TOP OF CASING ELEV. 141.65

GROUND SURFACE ELEV. 139.0

DATUM Feet-Mean Sea Level

INSTALLATION DATE 11/10/93



EXPLORATORY BORING

a. Total depth 75.8 ft.

b. Diameter 10 in.

Drilling method Hollow Stem Auger

WELL CONSTRUCTION

c. Total casing length (+2.7 to 52.6) 55.3 ft.

Material Schedule 40 PVC

d. Diameter 2 in.

e. Depth to top perforations 42.3 ft.

f. Perforated length 9.5 ft.

Perforated interval from 42.3 to 51.8 ft.

Perforation type Machine Slotted

Perforation size 0.010 Inches

g. Surface seal (0 to 2.0) 2.0 ft.

Material Concrete

h. Backfill N.A. ft.

Material N.A.

i. Seal (2.0 to 39.0) 37.0 ft.

Material Bentonite

j. Gravel pack 13.4 ft.

Gravel pack interval from 39.0 to 52.4 ft.

Material 10-20 Gradation Sand

k. Bottom seal/fill (52.4 to 75.8) 23.4 ft.

Material Bentonite

l. Casing stickup 2.7 ft.

m. Protective casing diameter 6.5 in.

Centralizers at 15.0 and 41.0 feet bgs.

Prepared by: Craig Fanshier

Ventura .mac 4 Rev. 7/23/91

LOG OF EXPLORATORY BORING

PROJECT NAME	**North Poplar Tree Farm**	BORING NO.	**P-05A**
LOCATION	**Riverbend Landfill, McMinnville, Oregon**	PAGE	**1 of 2**
DRILLED BY	**GeoTech Explorations, Inc.**	APPROX. GROUND ELEV.	**138.60**
DRILL METHOD	**Geoprobe**	TOTAL DEPTH	**20.0'**
LOGGED BY	**Craig D. Fanshier, R.G.**	DATE COMPLETED	**10/13/05**

SAMPLE NUMBER (SAMPLE METHOD)	RECOVERY (feet)	PID (in ppm)	GROUND WATER LEVEL	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION
	4.2							**0 to 6.8 feet: CLAYEY SILT (ML)**; brown (10YR 4/3); 100 percent non to low plasticity fines; platy soil peds; trace macro pores; damp.
	4.0			5				
								6.8 to 17.3 feet: SILTY CLAY (CL); brown (10YR 4/3) with dark brown mottling (6.8 to 7.9 feet); 100 percent low plasticity fines; damp to moist.
								@ 8.0 feet: mostly clay.
	4.8			10				@ 10.0 feet: dark brown, soft, moist.
								@ 11.0 feet: root traces.
								@ 12.0 feet: evenly colored brown.
	4.2			15				@ 15.0 feet: wet.
								@ 15.8 to 16.2 feet: SILTY SAND (wet).
								@ 16.8 to 17.2 feet: SILTY SAND to CLAYEY SILT (ML); (wet).
								17.3 to 20.0 feet: SILTY CLAY (CL) to CLAYEY SILT (ML); dark greenish gray (5G 4/1); damp to moist.
				20				Bottom of boring = 20.0 feet.
				25				See Page 2 for Well Completion Details.

REMARKS

Geoprobe boring was advanced and soil samples were collected with a 5-foot-long, 2 1/6-inch outside-diameter soil macro-sampler. The borehole was widened to 3.5 inches by advancing a separate geoprobe casing. A 1-inch i.d. schedule 40 PVC piezometer was constructed in the boring using a prepacked 0.010-inch slot well screen and 20-40 sand. A 10-20 sand pack was added to the borehole annulus and topped with bentonite casing seal.

Shaw™ Environmental, Inc.

LOG OF EXPLORATORY BORING

PROJECT NAME	**North Poplar Tree Farm**	BORING NO.	**P-05A**
LOCATION	**Riverbend Landfill, McMinnville, Oregon**	PAGE	**2 of 2**
DRILLED BY	**GeoTech Explorations, Inc.**	APPROX. GROUND ELEV.	**138.60**
DRILL METHOD	**Geoprobe**	TOTAL DEPTH	**20.0'**
LOGGED BY	**Craig D. Fanshier, R.G.**	DATE COMPLETED	**10/13/05**

SAMPLE NUMBER (SAMPLE METHOD)	RECOVERY (feet)	PID (in ppm)	GROUND WATER LEVEL	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION
				30				**WELL COMPLETION DETAILS** 0 to 9.7 feet: 1-inch-diameter, Schedule 40 PVC piezometer. 9.7 to 19.5 feet: 1-inch-diameter, prepacked Schedule 40 PVC well screen with 0.010-inch machined slots and 1-inch-diameter threaded end cap. 0 to 0.5 foot: Concrete. 0.5 to 7.5 feet: Bentonite chips hydrated with potable water. 7.5 to 20.0 feet: 10-20 Colorado Silica Sand. PVC Elevation: 140.74 Northing: 2875.1 Easting: 3612.4
				35				
				40				
				45				
				50				

REMARKS

Geoprobe boring was advanced and soil samples were collected with a 5-foot-long, 2 1/6-inch outside-diameter soil macro-sampler. The borehole was widened to 3.5 inches by advancing a separate geoprobe casing. A 1-inch i.d. schedule 40 PVC piezometer was constructed in the boring using a prepacked 0.010-inch slot well screen and 20-40 sand. A 10-20 sand pack was added to the borehole annulus and topped with bentonite casing seal.

Shaw™ Environmental, Inc.

LOG OF EXPLORATORY BORING

PROJECT NAME	**North Poplar Tree Farm**	BORING NO.	**P-06A**
LOCATION	**Riverbend Landfill, McMinnville, Oregon**	PAGE	**1 of 2**
DRILLED BY	**GeoTech Explorations, Inc.**	APPROX. GROUND ELEV.	**129.30**
DRILL METHOD	**Geoprobe**	TOTAL DEPTH	**20.0'**
LOGGED BY	**Craig D. Fanshier, R.G.**	DATE COMPLETED	**10/13/05**

SAMPLE NUMBER (SAMPLE METHOD)	RECOVERY (feet)	PID (in ppm)	GROUND WATER LEVEL	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION
	2.7							**0 to 20 feet: CLAY (CL)**; very dark gray brown (10YR 3/2), 30 to 50 percent mottling; 100 percent medium plastic fines (70 percent clay, 30 percent silt); damp; with root traces, root remains.
	5.0			5				@ 5.0 feet: CLAY (CL); very dark gray (10YR 3/1), 20 percent reddish mottles (2 to 5 mm); medium to high plasticity fines; damp to moist.
								@ 8.0 feet: trace (but not very many) small (<1/32") macro pores.
	5.0			10				@ 10.0 to 15.0 feet: high plasticity, very stiff.
								@ 13.0 feet: some gray to greenish gray mottling.
								@ 14.3 feet: color changes to dark greenish gray (5G 4/1).
	1.5			15				@ 15.0 feet: medium plasticity, ~20 to 30 percent silt; soft; damp to moist; probably wet (slow recharge).
				20				Bottom of boring = 20.0 feet.
				25				See Page 2 for Well Completion Details.

REMARKS

Geoprobe boring was advanced and soil samples were collected with a 5-foot-long, 2 1/6-inch outside-diameter soil macro-sampler. The borehole was widened to 3.5 inches by advancing a separate geoprobe casing. A 1-inch i.d. schedule 40 PVC piezometer was constructed in the boring using a prepacked 0.010-inch slot well screen and 20-40 sand. A 10-20 sand pack was added to the borehole annulus and topped with bentonite casing seal.

Shaw™ Environmental, Inc.

LOG OF EXPLORATORY BORING

PROJECT NAME	**North Poplar Tree Farm**	BORING NO.	**P-06A**
LOCATION	**Riverbend Landfill, McMinnville, Oregon**	PAGE	**2 of 2**
DRILLED BY	**GeoTech Explorations, Inc.**	APPROX. GROUND ELEV.	**129.30**
DRILL METHOD	**Geoprobe**	TOTAL DEPTH	**20.0'**
LOGGED BY	**Craig D. Fanshier, R.G.**	DATE COMPLETED	**10/13/05**

SAMPLE NUMBER (SAMPLE METHOD)	RECOVERY (feet)	PID (in ppm)	GROUND WATER LEVEL	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION
				30				**WELL COMPLETION DETAILS** 0 to 9.7 feet: 1-inch-diameter, Schedule 40 PVC piezometer. 9.7 to 19.5 feet: 1-inch-diameter, prepacked Schedule 40 PVC well screen with 0.010-inch machined slots and 1-inch-diameter threaded end cap. 0 to 0.5 foot: Concrete. 0.5 to 7.5 feet: Bentonite chips hydrated with potable water. 7.5 to 20.0 feet: 10-20 Colorado Silica Sand. PVC Elevation: 131.58 Northing: 2566.2 Easting: 3363.7
				35				
				40				
				45				
				50				

REMARKS

Geoprobe boring was advanced and soil samples were collected with a 5-foot-long, 2 1/6-inch outside-diameter soil macro-sampler. The borehole was widened to 3.5 inches by advancing a separate geoprobe casing. A 1-inch i.d. schedule 40 PVC piezometer was constructed in the boring using a prepacked 0.010-inch slot well screen and 20-40 sand. A 10-20 sand pack was added to the borehole annulus and topped with bentonite casing seal.

Shaw™ Environmental, Inc.

RIVER.gds:4.11/08/05.RIVER...842541.06002005

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	EW- 1
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	1 OF 5
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	148.40'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	89.20'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	11/11/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
100	>4.5							**0 to 22.0 feet: CLAYEY SILT (ML)** brown to dark yellowish brown (10YR 4/3 to 4/1); low plasticity fines; trace fine sand; abundant small macro pores (5 to 10 per inch); very stiff to hard; damp.
	>4.5							@ 0 to 13.0 feet: very abundant macro pores (1/16 to 1/18 inch); mostly horizontal, 20 percent vertical, open.
	3.0							@ 0 to 21.0 feet: minor (5 to 15 percent) fine sand lenses mixed in with the clayey silt as 2- to 4-inch-thick zones, some contain less fines, contacts are gradational.
100	2.5							
				5				
	2.5							
	2.5							
	2.0							@ 8.0 to 11.0 feet: 5 to 10 percent fine sand.
100	2.0							
	2.0			10				
	1.5							
	1.5							
	1.5							@ 13.0 feet: moist; decrease in abundance of macro pores (2 to 3 per inch).
100			▽ 11/11/93					@ 14.0 feet: wet.
	1.5			15				
	1.5							@ 16.0 to 16.5 feet: 1/4- to 3/8-inch-thick varves.
	1.5							@ 17.0 feet: 10 to 20 percent black organic material in a 3-inch-thick zone.
	1.0							@ 19.0 to 21.0 feet: varves (1/4 to 3/8 inch); several sand lenses, alternating soft and firm zones; wet.
100	0.25							
				20				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) hollow stem auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. Bedrock was cored with the 5-foot-long split barrel core. The boring was backfilled with bentonite. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	EW- 1
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	2 OF 5
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	148.40'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	89.20'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	11/11/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
	1.0							**0 to 22.0 feet: CLAYEY SILT (ML)**, continued.
	2.5							
	2.0							**22.0 to 24.5 feet: SILTY CLAY (CL)**, dark greenish gray (5GY 4/1); medium plasticity fines; varves (1/8- to 3/8-inch-thick); minor amounts of very small to small macro pores, some macro pores are oriented vertically, open with an olive brown lining; very stiff to hard.
	4.0							
100	1.0							
	2.5			25				**24.5 to 36.0 feet: CLAYEY SILT (ML)**, brown to dark yellowish brown (10YR 4/3 to 4/4); low plasticity fines; trace fine sand; abundant small macro pores (5 to 10 per inch); medium stiff to very stiff.
	1.0							
	4.5							@ 27.0 feet: driller notes harder drilling, alternating lenses of SILTY SAND (SM) and minor SILTY CLAY (CL) lenses up to 0.4 foot thick.
	1.0							
	0.5							
100								
	1.5			30				
								@ 31.0 to 36.0 feet: variable clay content.
	4.0							
	4.0							
100								
	3.5			35				
	2.0							**36.0 to 40.5 feet: SILTY CLAY (CL)**, dark greenish gray (5G 4/1); medium to high plasticity fines; some black organics, weak clay deposition features (smooth blocky soil peds); very stiff; wet.
	2.5							
	2.0							
	2.5							
100								
	2.5			40				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) hollow stem auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. Bedrock was cored with the 5-foot-long split barrel core. The boring was backfilled with bentonite. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	EW- 1
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	3 OF 5
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	148.40'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	89.20'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	11/11/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
	2.0							**36.0 to 40.5 feet: SILTY CLAY (CL)**, continued.
								40.5 to 42.0 feet: GRAVELLY CLAY (GC), dark greenish gray (5G 4/1); 50 percent medium plasticity fines; 20 percent fine to medium angular sand; 30 percent gravels (F:C = 1:1), mostly 1/2 to 3/4 inch, rounded, mostly basalt, possible tuffaceous reworked sediments; appears medium dense; wet.
60								**42.0 to 49.5 feet: SILTY GRAVEL (GM)**, dark greenish gray (5G 4/1); 10 to 20 percent low to medium plasticity fines; 10 to 20 percent fine to coarse sand, angular, poorly sorted; 60 to 70 percent fine to coarse gravels (F:C = 1:1), mostly matrix supported; some clayey gravel lense 0.1- to 0.4-foot-thick (very sticky clayey matrix); appears medium dense; wet.
				45				@ 44.0 to 47.0 feet: 30 to 40 percent fines, 20 percent sand, 50 percent gravels, very sticky clayey matrix.
40								@ 45.0 feet: color changes to brown (5G 4/1).
				50				**49.5 to 71.0 feet: SANDY GRAVEL (GP)**, dark greenish gray (5G 4/1); 5 percent low plasticity fines; 35 percent; fine to coarse sand (F:C = 1:2) poorly sorted; 60 percent gravels (F:C = 1:1), up to 3 inches, mostly 3/8 to 1/2 inch, rounded, basalt; appears medium dense; wet.
80								
				55				
								@ 57.5 feet: 1-inch-thick lense of tuffaceous sands.
88								
				60				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) hollow stem auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. Bedrock was cored with the 5-foot-long split barrel core. The boring was backfilled with bentonite. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	EW- 1
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	4 OF 5
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	148.40'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	89.20'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	11/11/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
								49.5 to 71.0 feet: SANDY GRAVEL (GP), continued.
								@ 61.0 feet: 5-inch-thick clayey silt lense.
								@ 61.0 to 63.5 feet: 20 percent fines; dense.
80								
				65				@ 65.0 to 69.0 feet: 10 to 20 percent low plasticity fines, appears dense; very hard drilling.
80								
				70				
	2.5							**71.0 to 72.0 feet: GRAVELLY SAND (SP),** 60 to 70 percent medium to coarse sand; 30 to 40 percent fine gravel; medium dense; wet; gradational contact.
								@ 71.5 feet: 5 to 10 percent brown wood fragments.
100								**72.0 to 75.0 feet: SILTY CLAY (CL),** dark greenish gray (5BG 4/1); medium plasticity fines; stiff; wet. Grades to a clayey silt with sand.
				75				@ 74.5 feet: horizontal bedding with tan layers.
								75.0 to 76.0 feet: SILTY SAND (SM), dark greenish gray (5BG 4/1); 20 to 30 percent low plasticity fines; 70 to 80 percent fine to medium sand.
								76.0 to 80.0 feet: SANDY GRAVEL (GP), dark greenish gray (5G 4/1); 20 to 40 percent poorly sorted, 5 percent low plasticity fines. Continued on next page.
100								
				80				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) hollow stem auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. Bedrock was cored with the 5-foot-long split barrel core. The boring was backfilled with bentonite. See explanation for definition of symbols.

LOG OF EXPLORATORY BORING

PROJECT NAME	Additional Hydrogeologic Investigation	BORING NO.	EW- 1
LOCATION	Riverbend Landfill; McMinnville, Oregon	PAGE	5 OF 5
DRILLED BY	Geo-Tech Explorations, Inc.	GROUND ELEV.	148.40'
DRILL METHOD	Hollow Stem Auger	TOTAL DEPTH	89.20'
LOGGED BY	Craig D. Fanshier	DATE COMPLETED	11/11/93

RECOVERY PERCENT	POCKET PENETRO-METER (Tons/SF)	PENETRA-TION (Blows/Ft)	GROUND WATER LEVELS	DEPTH IN FEET	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
100	3.5							**76.0 to 80.0 feet: SANDY GRAVEL (GP),** continued: fine to coarse sand (F:C = 1:2); 60 percent gravels (F:C = 1:1) up to 3 inches; mostly 3/8 to 1/2 inch, rounded; basalt.
	4.0							@ 77.5 feet: 2 inch silt lense.
	4.5							@ 78.5 feet: several angular rock fragments.
	4.0							**80.0 to 84.0 feet: SILTY CLAY (CL),** dark greenish gray (5BG 4/1); 80 percent low to medium plasticity fines; 20 percent sands; 10 percent fine gravels; very stiff to hard; moist; some high angle fracture planes, relic texture (altered tuffaceous sediments?).
100				85				**84.0 to 89.2 feet: BASALT,** gray; fine to medium grained; localized small sub vertical fractures filled with quartz and zeolites; low hardness; deeply weathered.
								BORING TERMINATED AT 89.2 FEET.
				90				
				95				
				100				

REMARKS

Drilled with 10-inch O.D. (6.5-inch I.D.) hollow stem auger. Samples continuously collected with 5-foot long, 3-inch I.D. split barrel and 1.5-foot long, 3-inch O.D. split spoon fitted with rings. Bedrock was cored with the 5-foot-long split barrel core. The boring was backfilled with bentonite. See explanation for definition of symbols.

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-01

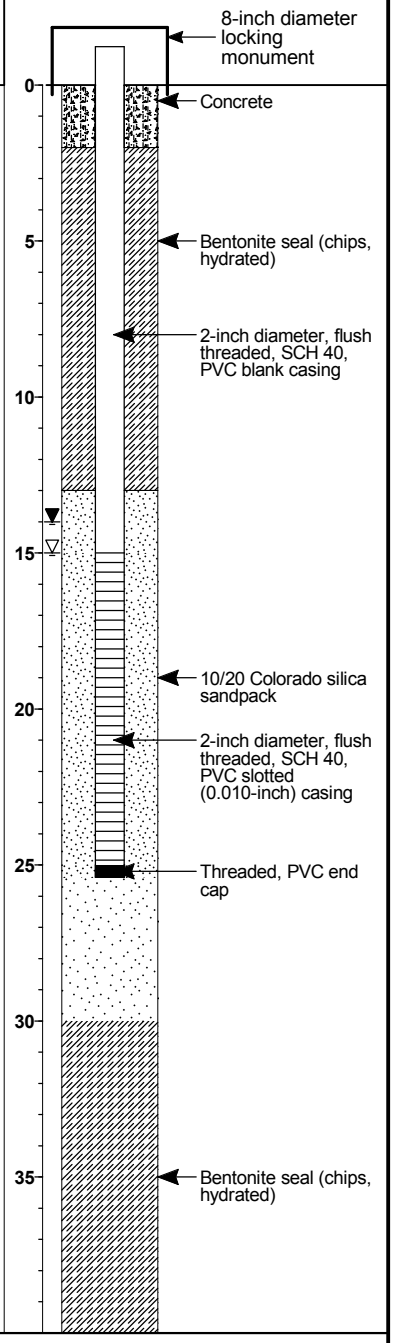
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04210010.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0		1-1	---		ML		Surface: natural ground surface (grass)
1								
2	5		1-2	3 3 5	0.5			SILT (ML), light olive brown (2.5Y 5/3) with some orange brown oxide (iron) mottling, moist to wet, firm, trace clay, low plasticity
			1-3	---				
3	10				0.75			At 10.0 feet (bottom of Shelby tube sample), FINE SANDY SILT (ML), dark yellowish brown (10YR 4/6), moist, sand 10-20 percent, slightly micaceous
4								
5	15		1-4	3 2 4	0.25	CL ML		- At 15 feet, same as above but wet At 15.8 feet, 2-inch thick CLAY (CL) seam, very dark gray (5Y 3/1), wet, apparent soft consistency, high plasticity
			1-5	---				At 16.0 feet, SILT (ML), very dark gray (5Y 3/1), wet, firm, faintly micaceous, low to medium plasticity
6	20				0.75			- At 20.0 feet (bottom of Shelby tube sample), same silt at above
7			1-6	5 5 5	0.25	ML		Thinly bedded SILT (ML) and CLAYEY SILT (ML), very dark gray (5Y 3/1), moist, stiff, 2- to 4-inch thick beds with varying clay content from 0 to 10-20 percent, moist, stiff, with two clay lenses (1.5 inch thick)
8	25		1-7	---		CL		At 27.5 feet (bottom of Shelby tube sample), SILTY CLAY (CL), very dark gray (5Y 3/1), moist, medium to high plasticity
9	30		1-8	0 3 7	1.5			CLAY (CL), dark gray (5Y 4/1), moist, very soft, massive - At 30.7 feet, sharp color change to very dark gray (5Y 3/1) with greenish tint, damp to moist, stiff, faintly micaceous, more apparent firmness than above, medium to high plasticity
10								
11	35		1-9	0 3 4	1.0			- Same as above but greenish gray, firm, faint oxide (iron) mottling
			1-10	---				
12	40							Driller reports harder push last approximately 4 inches of Shelby tube sample No. 1-10

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **9/9/10**
Date Ended: **9/10/10**
Boring Diameter: **5.9" (to 26.0 ft.); 4.9" (from 26.0 - 66.5 ft.)**
Elevation: **143.8 ft.**
Depth to Water: **14.0 ft.**
Total Depth: **66.5 ft.**

STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-01

Riverbend Landfill Company

JOB NUMBER: 04210010.00

Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
40		1-11	12 15 22	1.0	CL	At 40.0 feet, CLAY (CL) with fine sand and gravel, mottled light olive brown (2.5Y 5/3) and orange brown (iron oxide), moist, hard, very weathered appearance, fine subrounded gravel 5-15 percent at top of sample, fine to coarse subrounded gravel 20-30 percent to 1-inch diameter at bottom 3 inches of sample
45		1-12	15 28 32		GC	SANDY, CLAYEY GRAVEL (GC), mottled very pale brown (10YR 7/4), light olive brown (2.5Y 5/3), and orange brown (iron oxide), wet, dense, fine to coarse sand (f:m:c = 20:40:40), fine to coarse subrounded gravel to 2-inch diameter, weathered appearance
50		1-13	15 21 33		SW/GW	GRAVELLY SAND/SANDY GRAVEL (SW/GW), dark yellowish brown (10YR 3/4), wet, dense, trace fines, weathered appearance, fine to coarse sand (f:m:c = 10:40:50), fine to coarse subrounded gravel to 2-inch diameter
55		1-14	13 20 22			- Same as above but black (7.5YR N2/), medium dense, fine to coarse sand (f:m:c = 30:40:30), fine to coarse gravel to 1-inch diameter, predominantly fine gravel
						At 59.0 feet, driller reports softer drilling
60		1-15	3 4 4		SP	SAND (SP), black (7.5YR N2/), wet, loose, very fine to fine sand, few scattered fine gravels to 1/4-inch diameter, trace medium grained sand, wood layer at least 4 inches thick observed at bottom of upper ring and top of lower ring samples - At 63.0 feet, driller reports harder drilling - At 65.0 feet, GRAVELLY SAND / SANDY GRAVEL (SW/GW), black (7.5YR N2/), wet, medium dense, fine to coarse sand (f:m:c = 40:30:30) but coarsening with depth, fine to coarse subrounded gravel to 1-inch diameter, predominantly fine gravel
65		1-16	9 14 17		SW/GW	

Total Depth = 66.5 feet

NOTES:

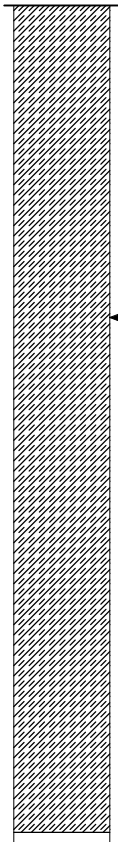
1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample from 0 to 5.0 feet.

2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 1-12 at 45 feet and for remainder of borehole. Hammers not used for Shelby tube samples.

3. Pushed 36-inch Shelby tube sample 30 inches only.

4. Static groundwater level measured on September 13, 2010.

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-02

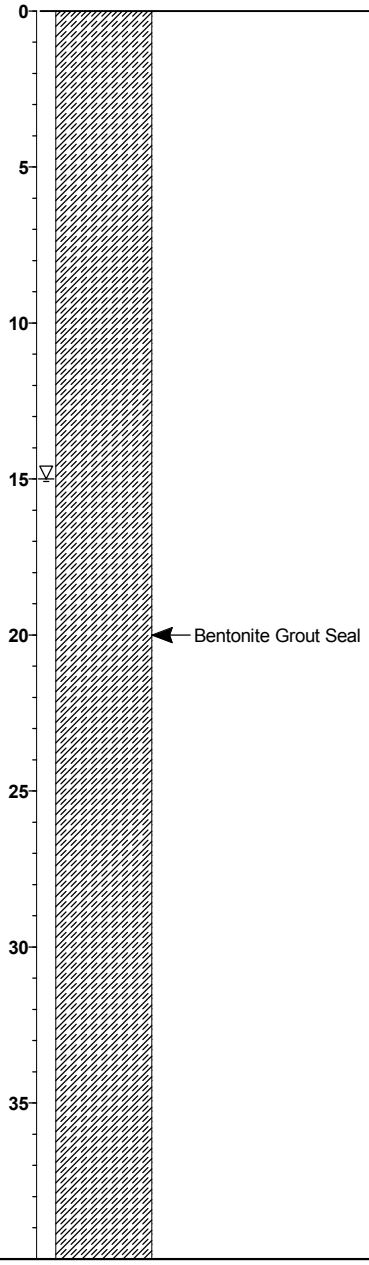
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04210010.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0		2-1	---		CL		Surface: natural ground surface (grass)
1								
2	5		2-2	2 3 5	1.0			CLAY (CL), mottled dark grayish brown (2.5Y 4/2) and orange brown (iron oxide), moist, firm, medium plasticity
3			2-3	---				
4	10				0.25			At 10.0 feet (bottom of Shelby tube sample), same as above
5	15		2-4	1 3 4	1.0			Becomes dark gray (2.5Y N4) with slight greenish tint, moist to wet
6	20		2-5	0	0.0	CH		CLAY (CH), dark gray (2.5Y N4), wet, soft, (sample 2-5 pushed by weight of rods), minor orange brown oxide (iron) mottling, scattered small (less than 1/4 inch) wood fragments; with 4-inch thick slightly silty clay lens, black (2.5YN2), moist, abundant wood fragments, organic odor
7			2-6	---	0.75	CL		
8	25							At 25.0 feet (bottom of Shelby tube sample), CLAY (CL), dark gray (2.5Y N4), medium plasticity
9			2-7	2 3 4	0.75			CLAY (CL), green-gray with slight oxide (iron) mottling, moist, firm, rare scattered fine gravel, minor scattered small wood fragments, medium plasticity
10	30							
11			2-8	---				Shelby tube sample 2-8 slightly damaged at bottom during sampling
12	35		2-9	4 7 13	1.75	SP SW		- At 35 feet, FINE SAND (SP) with clay, mottled yellowish brown (10YR 5/6) and light yellowish brown (2.5Y 6/3), moist to wet, medium dense, rare fine rounded gravels, grades with depth to trace or no fines - At 36.4 feet, sharp contact with FINE TO COARSE SAND (SW), wet, same color as above, medium dense, fine to coarse sand (f:m:c = 20:40:40), single rounded gravel to 3/4-inch diameter
	40							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **9/13/10**
Date Ended: **9/13/10**
Boring Diameter: **4.9 inches**
Elevation: **135.0 ft.**
Total Depth: **55.8 ft.**

STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-02

Riverbend Landfill Company

JOB NUMBER: 04210010.00

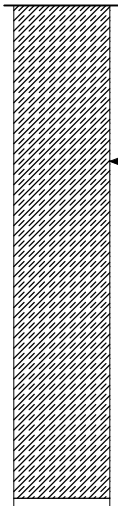
Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
40		2-10	12 22 37	3.25	SW	GRAVELLY SAND (SW), strong brown (7.5 YR 4/6), wet, very dense, very weathered appearance, fine to coarse sand (f:m:c = 40:40:20), fine to coarse subrounded gravel 20-30% to 1-inch diameter (predominantly fine), some thin lenses (less than 3 inches) with trace fines
45		2-11	14 17 14			At 45 feet, same as above
					ML	SILT (ML), dark yellowish brown (10YR 4/6), damp, very stiff to hard
50		2-12	5 6 14		SW	At 50 feet, GRAVELLY SAND (SW) with trace fines, black (2.5Y N2/), wet, loose to medium dense, fine to coarse sand (f:m:c = 50:30:20), fine to coarse subrounded gravel 15-25 percent to 1-inch diameter
					SLTST	- At 51.2, SILTSTONE (SLTST), dark gray (10YR 4/1), dry, indurated
55		2-13	24 50/4"			SILTSTONE (SLTST) as above

Total Depth = 55.8 feet

NOTES:

1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample from 0 to 5.0 feet.
2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 2-11 at 45 feet and for remainder of borehole. Hammers not used for Shelby tube samples.
3. Pushed 36-inch Shelby tube sample 30 inches only.

Completion Detail



STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-03

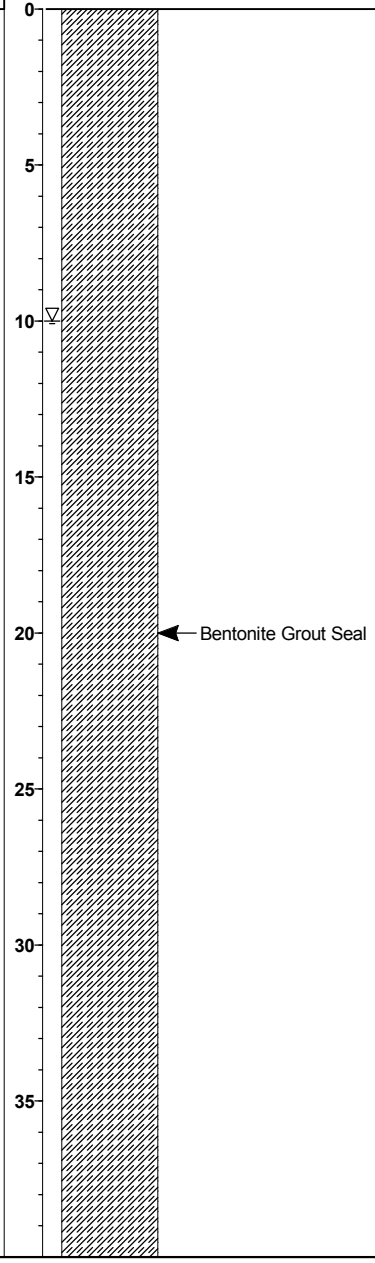
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04210010.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0		3-1	---		CL		Surface: natural ground surface (grass)
5		3-2	3 5 7				CLAY (CL), mottled dark brown (10YR 4/3) and gray (2.5Y N5/), moist, stiff, medium plasticity
		3-3	---				
10		3-4	1 3 6				Same as above, but with black carbonized (possibly remnant wood fragments) scattered nodules and flecks, moist to wet
15		3-5	2 5 6				CLAY (CL), dark gray (2.5Y N4/), damp, stiff, massive, medium to high plasticity
		3-6	---				
20		3-7	0				Same as above, but very soft (sample 3-7 pushed by weight of rods), wet, scattered coarse sand grains; high plasticity; sample is disturbed and does not stay intact in sampler
		3-8	---				
25		3-9	0/12" 3/6"				CLAY (CL) as above, but no sand and more apparent firmness (first 12 inches pushed by weight of rods)
					SM		SILTY FINE SAND (SM), dark gray (5Y 4/1) with greenish tint, moist to wet, very loose, some olive (5Y 4/3) mottling, silt 10-20 percent
		3-10	3 3 5		ML		FINE SANDY SILT (ML), mottled yellowish brown (10YR 5/8) and light olive brown (2.5Y 5/3), moist, firm, sand 20-30 percent, low plasticity; with 1-inch thick gray clayey silt lens
30		3-11	---				
		3-12	9 6 7		CL		SANDY CLAY (CL), olive gray (5Y 4/2) with greenish tint, moist, stiff, fine sand 20-30 percent, abundant wood fragments at top of sample, rare fine gravels, low plasticity - At 34.1 feet, becomes mottled yellowish brown (10YR 5/8) and light olive brown (2.5Y 5/6), moist, stiff, fine to medium sand (f:m = 90:10) 30-40 percent, low plasticity
35		3-13	24 33 35				At 37.5 feet, SANDY, GRAVELLY CLAY (CL), yellowish brown (10YR 5/8), moist, very dense, weathered appearance, fine to coarse sand (f:m:c = 40:40:20), fine to coarse subangular gravel 20-30 percent to 1-inch diameter, matrix supported
40							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary (Hollow Stem Auger 0 - 5.0 ft.)**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **9/3/10**
Date Ended: **9/7/10**
Boring Diameter: **4.9 inches**
Elevation: **130.5 ft.**
Total Depth: **60.3 ft.**

STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-03

Riverbend Landfill Company

JOB NUMBER: 04210010.00

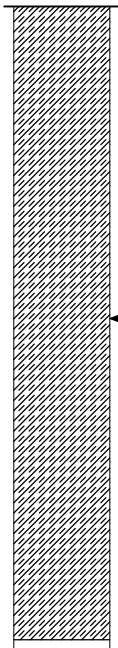
Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
40		3-14	11 14 15		CL	Same as above, but moist to wet, medium dense, predominantly fine subrounded gravel
45		3-15	17 34 50/4"		GW	SANDY GRAVEL (GW) with clay, mottled yellowish brown (10YR 5/8) and dark yellowish brown (10YR 4/4), moist to wet, very dense, weathered appearance, fine to coarse sand (f:m:c = 20:40:40), fine to coarse subgrounded gravel to 1-inch diameter
50		3-16	7 10 19		ML GW	At 50.0 feet, same as above CLAYEY SILT (ML) lens, dark gray (2.5Y N4/), moist At 51.5 feet, SANDY GRAVEL (GW) as above
55		3-17	24 50/5"		CL BASALT	At 55.3 feet, CLAYSTONE (CLST), light olive brown (2.5Y 5/4), dry, hard, cemented, some fine to coarse rounded gravel mixed in matrix At 55.6 feet, BASALT, black, some orange-brown oxide mottling, massive, fine grained, calcite or zeolite filled vein, few open vesicles, crumbly due to weathering
60		3-18	50/4"			BASALT, black, massive, fine grained, unweathered

Total Depth = 60.3 feet

NOTES:

1. Initially drilled borehole with hollow stem augers to collect bulk soil cuttings sample from 0 to 5.0 feet, then switched to mud rotary drilling.
2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 3-14 at 40 feet and for remainder of borehole. Hammers not used for Shelby tube samples.
3. 36-inch Shelby tube used; applied 36-inch push.

Completion Detail



STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT11-01

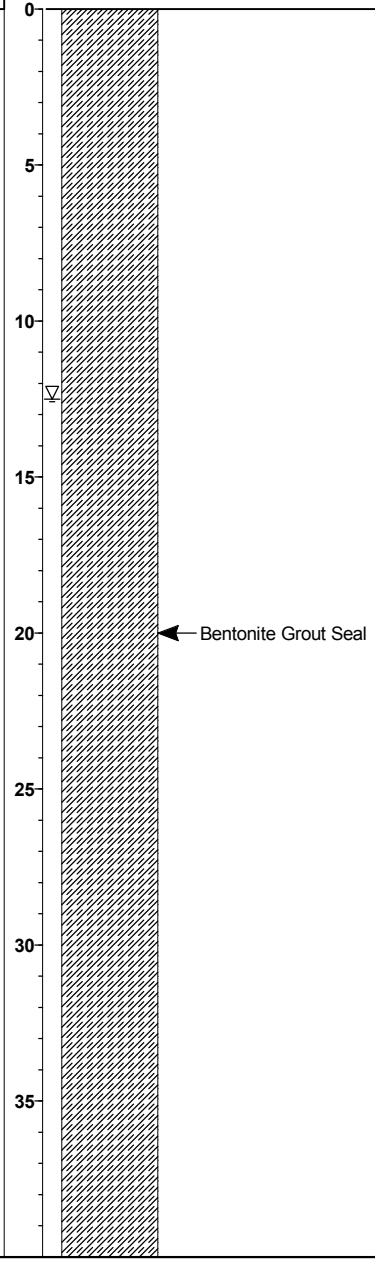
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0	0					FILL	Surface: gravel fill Note: Initially use 140 lb. hammer and switch to 300 lb. hammer as noted below
1							**ALLUVIUM**
2	5		1-1	1 2 3		CL	SILTY CLAY (CL), yellowish brown (10YR 5/4) with some olive gray (5Y 4/2) mottling, moist to wet, firm, medium plasticity
			1-2	---			
3	10					ML	At 10.0 feet (bottom of Shelby tube sample 1-2), CLAYEY SILT (ML), yellowish brown (10YR 5/4), moist, firm, low to medium plasticity
4			1-3	0 1 2			Same as above but wet, soft (first 6 inches pushed by weight of rods)
5	15		1-4	1 2 3		ML	At 15.0 feet, same as above Becomes mottled yellowish brown as above and light yellowish brown (10YR 6/4), wet, firm, low to medium plasticity
6	20		1-5	---			
7						ML	At 22.5 feet (bottom of Shelby tube sample 1-5), SILT (ML) with trace sand, dark gray (5Y 4/1) with greenish tint, wet, low to medium plasticity
8	25		1-6	3 3 4		ML	CLAYEY SILT (ML), same color as above, moist to wet, firm, bedded zones with varying clay content from 10 - 40 percent, beds up to 5 inches thick, zones with less clay are visibly wet, low to medium plasticity
9	30		1-7	1 5 6			Same as above but stiff
10							
11	35		1-8	---		CL	At 37.5 feet, SILTY CLAY (CL) with fine gravel, grayish green, moist to wet, apparent hard, low to medium plasticity
12	40		1-9	12 25 33		CL	- At 38.0 feet, SANDY, GRAVELLY CLAY (CL), mottled grayish green, light green, and very dark gray (5Y 3/1), moist to wet, hard, coarse sand and fine gravel 30 - 40 percent

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/26/11**
Date Ended: **1/26/11**
Elevation: **152.1 ft.**
Total Depth: **66.5 ft.**
Boring Diameter: **4.9" (to 45.0 ft.); 3.9" (from 45.0 - 66.5 ft.)**

STANDARD_LOG RLF_MSE BERM GEOTECHNICAL BOREHOLE LOGS_V2.0.GPJ STD_LOG.GDT 7/7/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT11-01

Riverbend Landfill Company

JOB NUMBER: 04211001.00

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
							Abundant gravels in drill cuttings
							Switch to 300 lb. hammer before collecting sample 1-10 and for remainder of borehole
45		1-10	15 26 50		GW		SANDY GRAVEL (GW) with clay, strong brown (6.5Y 4/6), moist, very dense, fine to coarse sand (f:m:c = 20:40:40) 30 - 40 percent, fine and coarse (50:50) subrounded gravel with oxidized surfaces, slightly weathered appearance
50		1-11	9 8 9		SW SM		At 50.0 feet, GRAVELLY SAND (SW) with trace fines, strong brown as above, wet, fine gravel 20 - 30 percent, medium to coarse sand (m:c = 30:60), weathered appearance - Contact in ring sample with SILTY FINE SAND (SM), dark gray (5Y 4/1) with bluish tint, silt 20 - 30 percent, medium dense, wet - At 53.5 feet, driller reports gravels encountered
55		1-12	7 13 16		SW/GW		At 55.0 feet, GRAVELLY SAND / SANDY GRAVEL (SW/GW), very dark gray (5Y 3/1), wet , medium dense to dense, fine to coarse sand (f:m:c = 20:40:40), fine subrounded gravel - At 57.5 feet, driller reports harder drilling - At 59.0 feet, driller reports softer drilling - At 60.0 feet, GRAVELLY SILTY SAND (SM), dark gray (5Y 4/1) with greenish tint, wet, fine to coarse sand (f:m:c = 60:20:20), silt 30 - 40 percent, fine gravel 10 - 20 percent, rare small wood fragments
60		1-13	7 8 11		SM SM		- Contact in ring sample with SILTY FINE SAND (SM), dark gray as above, silt 30 - 40 percent, wet, medium dense, faintly micaceous, rare small wood fragments - At 63.0 feet, driller reports harder drilling
65		1-14	10 15 22		SC		- At 65.0 feet, GRAVELLY CLAYEY SAND (SC), grayish green, moist to wet, dense, fine to coarse sand (f:m:c = 40:30:30), clay 20 - 30 percent, predominantly fine gravel but 2.5-inch gravel in sample shoe

Total Depth = 66.5 feet

(Northing 3856.08, Easting 3967.99)

NOTES:

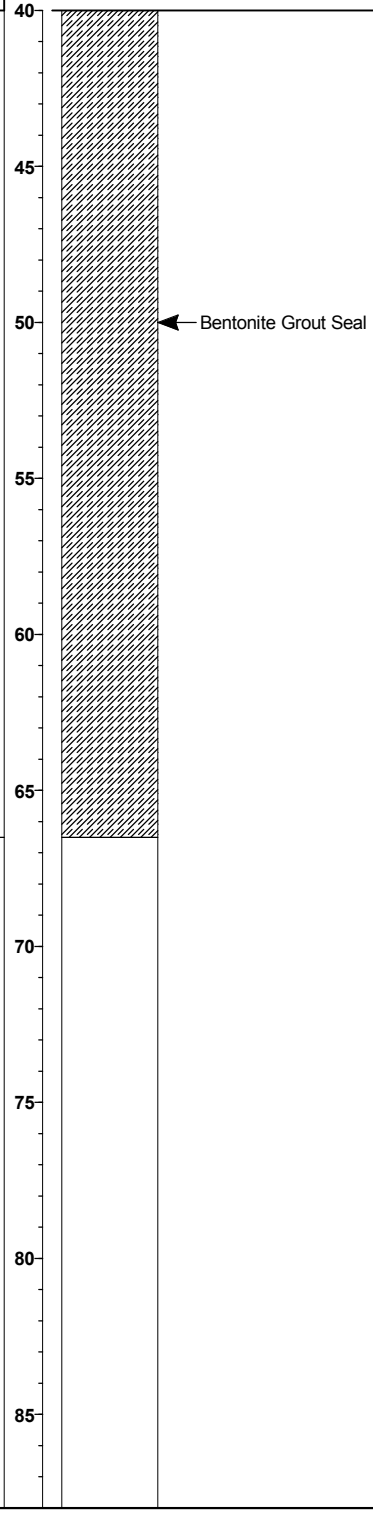
1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample 1-15 from 0 to 10.0 feet.

2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 1-10 at 45 feet and for remainder of borehole. Hammers not used for Shelby tube samples.

3. 36-inch long Shelby tube samples were pushed 30 inches only.

4. Shallow (Silt-Clay unit) groundwater encountered at 12.5 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 50.0 feet during drilling.

Completion Detail



STANDARD_LOG RLF_MSE BERM GEOTECHNICAL BOREHOLE LOGS_V2.0.GPJ STD_LOG.GDT 7/7/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT11-02

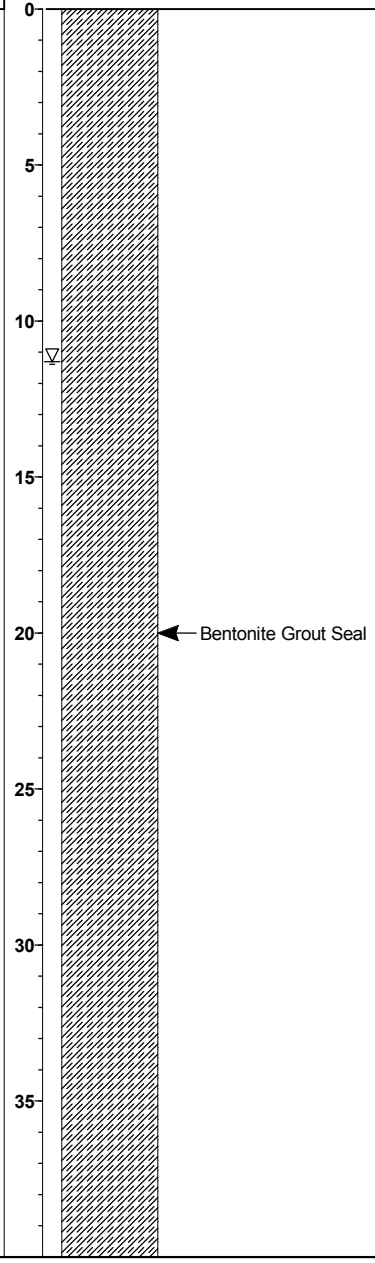
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0					FILL	Surface: gravel fill
						Note: Initially use 140 lb. hammer and switch to 300 lb. hammer as noted below.
						ALLUVIUM
5		2-1	0 3 4		CL	SILTY CLAY (CL), mottled very dark grayish brown (2.5Y 3/3) and dark yellowish brown (10YR 4/4), quickly grades to dark gray (5Y 4/1) with depth, moist to wet, firm, low to medium plasticity
		2-2	---			
10		2-3	2 3 5			At 10.0 feet, SILTY CLAY (CL), very dark gray (5Y 3/1), moist, firm, low to medium plasticity
					ML	At 11.3 feet, contact with CLAYEY SILT (ML), olive (2.5Y 4/3), wet, firm, clay 20 - 30 percent, low plasticity
15		2-4	1 2 3		CL	Very limited sample recovery, SILTY CLAY (CL), same appearance as above, firm
						Switch to 300 lb. hammer before collecting sample 2-5 at 20.0 feet
20		2-5	1 1 2		ML	SILT (ML), yellowish brown (10YR 5/4) with minor black (manganese?) mottling, moist, soft, trace to some clay, low to medium plasticity
		2-6	---			
25						At 24.5 feet (bottom of Shelby tube sample 2-6), CLAYEY SILT (ML), dark gray (5Y 4/1), moist, clay 20-30 percent, low to medium plasticity
						Switch to 140 lb. hammer before collecting sample 2-7 at 30.0 feet
30		2-7	3 4 5		CL	SILTY CLAY (CL), same color as above, moist, stiff, silt 10 - 20 percent, low to medium plasticity
		2-8	---			
35						At 35.0 feet (bottom of Shelby tube sample 2-8), CLAY (CL), dark gray (5Y 4/1) with greenish tint, moist, trace silt, medium to high plasticity
40					CL/ML	

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/24/11**
Date Ended: **1/24/11**
Elevation: **141.4 ft.**
Total Depth: **61.5 ft.**
Boring Diameter: **4.9" (to 45.0 ft.); 3.9" (from 45.0 - 61.5 ft.)**

STANDARD_LOG RLF_MSE BERM GEOTECHNICAL BOREHOLE LOGS_V0.1.GPJ STD_LOG.GDT 2/15/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

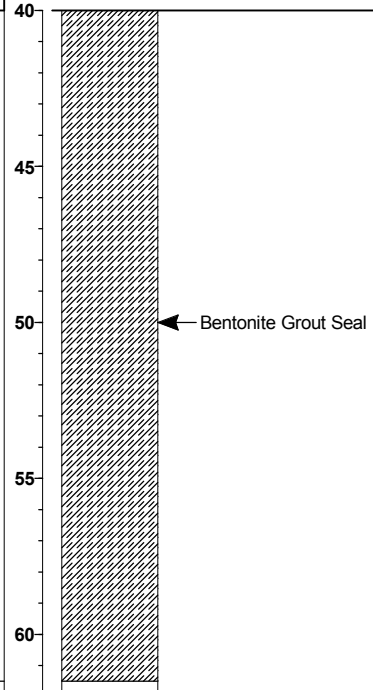
BORING NUMBER: GT11-02

Riverbend Landfill Company

JOB NUMBER: 04211001.00

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
	40		2-9	3 5 19		CL/ML		At 40.0 feet, SILTY CLAY / CLAYEY SILT (CL/ML), greenish gray, moist to wet, firm to stiff, slight orange brown oxide (iron) mottling
						ML		- At 41.3 feet, contact with SILT (ML) with fine sand, same color as above but with abundant oxide mottling
13								- Switch to 300 lb. hammer before collecting sample 2-10 at 45.0 feet and for remainder of borehole
	45		2-10	19 50/6"		GC		- At 45.0 feet, CLAYEY SANDY GRAVEL (GC), dark yellowish brown (10YR 4/4) with slight yellowish and orange brown oxide (iron) mottling, moist, very dense, clay 10 - 20 percent, fine to coarse sand (f:m:c = 20:40:40) 10 - 20 percent, subrounded gravel to 1.5-inch diameter, predominantely fine gravel
14								
15								
	50		2-11	21 50/6"		GC		Same as above but mottled olive brown (2.5Y 4/3) with abundant orange brown oxide (iron) mottling, gravel to 2.5-inch diameter, large gravel stuck in sample shoe
16								
	55		2-12	2 31 50		ML		SILT (ML), greenish gray with minor orange brown oxide (iron) mottling, moist, hard, few scattered gravels to 2-inch diameter
17								
18								GRAVELLY SAND / SANDY GRAVEL (SW/GW), black (5Y 2.5/1), wet, dense, trace to some fines, fine to coarse sand (f:m:c = 10:30:60), predominantely fine gravel
	60		2-13	11 15 22		SW/GW		
19								Total Depth = 61.5 feet
20	65							NOTES: 1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample 2-14 from 0 to 10.0 feet.
21								2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer for samples 2-5 (at 20 feet) and 2-10 (at 45 feet) through 2-13 (at 60 feet). Hammers not used for Shelby tube samples.
	70							
22								3. 36-inch long Shelby tube samples were pushed 30 inches only.
23	75							4. Shallow (Silt-Clay unit) groundwater encountered at 11.3 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 60.0 feet during drilling.
24								
	80							
25								
26	85							

Completion Detail



STANDARD_LOG RLF_MSE BERM GEOTECHNICAL BOREHOLE LOGS_V0.1.GPJ STD_LOG.GDT 2/15/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-01A

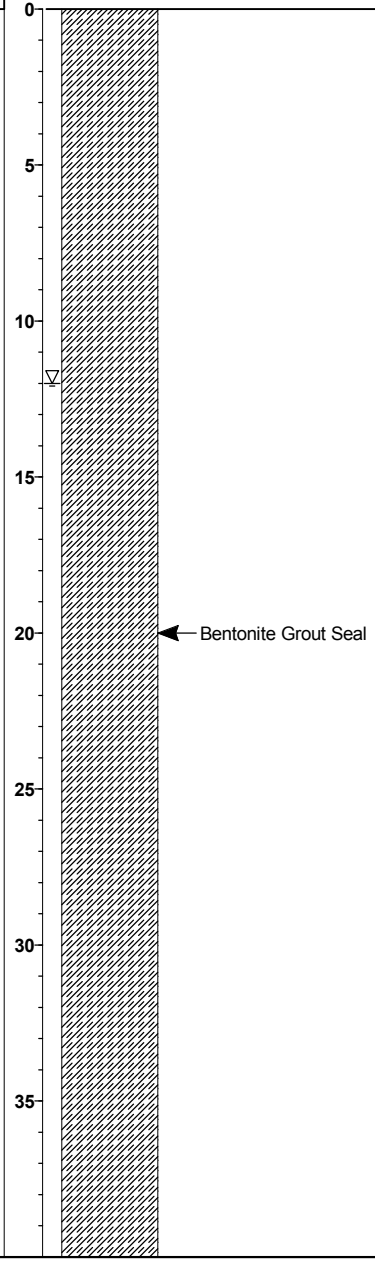
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0	0					FILL	Surface: gravel fill Note: Initially use 140 lb. hammer and switched to 300 lb. hammer as noted below. **ALLUVIUM**
			1A-1	---			
1						CL	At 4.5 feet (bottom of Shelby tube sample 1A-1), CLAYEY SILT (ML), brown (10YR 5/3), very moist, slight orange brown (oxide) mottling, medium plasticity
	5		1A-2	---			
2							Sample 1A-2 disturbed and poor recovery, did not retain sample
			1A-3	---			Sample 1A-3 no recovery
3	10		1A-4	---			
			1A-5	---		ML	At 12.0 feet (bottom of Shelby tube sample 1A-4), CLAYEY SILT (ML), brown (10YR 5/3), wet, low to medium plasticity
4						ML	At 14.5 feet (bottom of Shelby tube sample 1A-5), SILT (ML), yellowish borwn (10YR 5/4), wet, some orange brown (oxide) mottling, slightly micaceous, low to medium plasticity
5	15						
6	20		1A-6	---			
7			1A-7	3 4 5		ML	At 22.5 feet (bottom of Shelby tube sample 1A-6), same SILT (ML) as above in sample 1A-5 Sample 1A-7 disturbed, apparent slough only, did not retain. Firm to stiff based on blow counts.
	25		1A-8	---			
8						CL	At 27.5 feet (bottom of Shelby tube sample 1A-8), SILTY CLAY (CL), dark gray (5Y 4/1), very moist, scattered small (< 1.8-inch) hard nodules, low to medium plasticity
9	30		1A-9	---		CL/ML	At 32.5 feet (bottom of Shelby tube sample 1A-9), SILTY CLAY / CLAYEY SILT (CL/ML), dark gray (5Y 4/1), very moist, scattered small (<1.8-inch) hard nodules, medium plasticity
10	35		1A-10	---		CH	At 37.5 feet (bottom of Shelby tube sample 1A-10), SILTY CLAY (CH), dark gray (5Y 4/1) with greenish tint, moist to very moist, more apparent firmness than all soils above but high plasticity, slight orange-brown mottling
11			1A-11	---			Sample 1A-11 disturbed and poor recovery, did not retain sample. Sample tube was bent/damaged at the bottom.
12	40						

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/26/12**
Date Ended: **1/27/11**
Boring Diameter: **5.0"**

Elevation: **151.7 ft.**
Total Depth: **66.5 ft.**

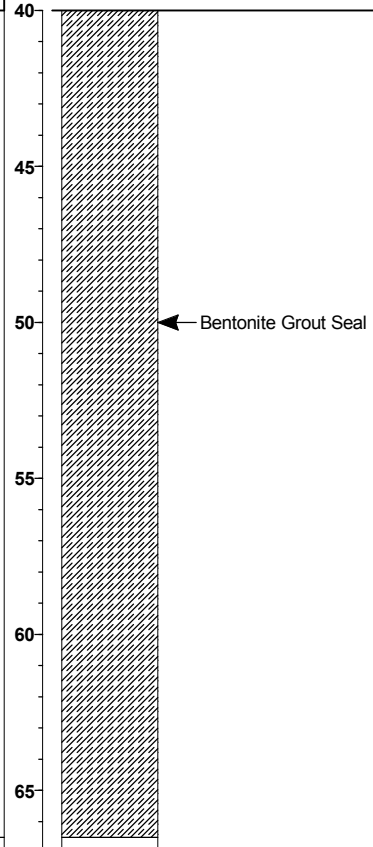
STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
	40		1A-12	5 7 11		ML-SM		**ALLUVIUM (Continued)** At 40.0 feet, crudely layered SILT (ML), SANDY SILT (ML), and SILTY SAND (SM), some clay, mottled dark yellowish brown (10YR 4/4), pale brown (2.5Y 7.4), and pale olive (5Y 6/3), moist, very stiff, 1/2-inch gravel at bottom of sample
13								
	45		1A-13	7 7 11		ML CL		At 45.0 feet, CLAYEY SILT (ML), light brownish gray (2.5Y 6/2) with orange-brown (oxide) mottling (abundant mottling at top of sample), damp to moist Quickly grades to SILTY CLAY (CL), same color as above, damp to moist, very stiff
14								
15								Drilled reported gravel encountered at 49.8 feet
	50		1A-14	17 27 38		GW		SANDY GRAVEL (GW) with clay, dark yellowish brown (10YR 4/4), wet, dense, fine to coarse sand (f,m,c -= 20,20,60), fine to coarse subangular gravel to 1-inch diameter
16								Switch to 300 lb. hammer before collecting sample 1A-15 and for remainder of samples
	55		1A-15	18 28 47		GM/GW		SILTY GRAVEL / SANDY GRAVEL (GM/GW), dark yellowish brown (10YR 4/4), very moist, dense, sand-silt approximately 50 percent, fine to coarse sand (f,m,c = 20,40,20), fine to coarse subangular gravel to 1-inch diameter
17								
18								
	60		1A-16	7 37 50/5"		SM		SILTY SAND (SM) with some fine gravels, very dark gray (5Y 3/1) with greenish tint, damp, silt 10 - 20 percent, fine to medium sand, predominantly fine sand
19								
	65		1A-17	15 40 50/2"		SM		Same SILTY SAND (SM) as above but with 20 - 30 percent fine to coarse gravel to 3/4-inch diameter
20								
21								Total Depth = 66.5 feet (Northing 4140.530, Easting 3989.042)
	70							NOTES: 1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample 1A-18 from 0 to 10.0 feet.
22								
	75							2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 1A-15 at 55 feet and for remainder of borehole. Hammers not used for Shelby tube samples.
23								
								3. 36-inch long Shelby tube samples were pushed 30 inches only.
24								
	80							4. Shallow (Silt-Clay unit) groundwater encountered at 12.0 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 50.0 feet during drilling.
25								
								5. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
26	85							

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-01B

Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. hammer; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0						Surface: Grass **ALLUVIUM**
		1B-1	---			
5		1B-2	1 2 2		MH	CLAYEY SILT (ML), very moist, brown (10YR 4/3), soft, slightly micaceous, high plasticity
		1B-3	---			
10					ML	At 10.0 feet (bottom of Shelby tube sample 1B-3), same as above in sample 01B-2, but trace to some clay, wet, medium to high plasticity
		1B-4	---			
15		1B-5	1 3 2		ML	VERY CLAYEY SILT (ML), mottled brown (10YR 4/3) and yellowish brown (10YR 5/4), wet, firm, medium plasticity
		1B-6	---			
20					ML	At 20.0 feet (bottom of Shelby tube sample 1B-6), CLAYEY SILT (ML), brown (10YR 5/3), wet, less clay than in sample 01B-5
		1B-7	---			
25		1B-8	---		ML	At 25.0 feet (bottom of Shelby tube sample 1B-7), SILT (ML), brown (10YR 5/3), wet, faintly micaceous, trace to some clay, low to medium plasticity
		1B-9	---		ML	At 27.5 feet (bottom of Shelby tube sample 1B-8), same SILT (ML) as above in sample 1B-7, but dark gray (5Y 4/1), very moist
30					CL/ML	At 30.0 feet (bottom of Shelby tube sample 1B-9), SILTY CLAY / CLAYEY SILT (CL/ML), dark gray (5Y 4/1), very moist, medium plasticity

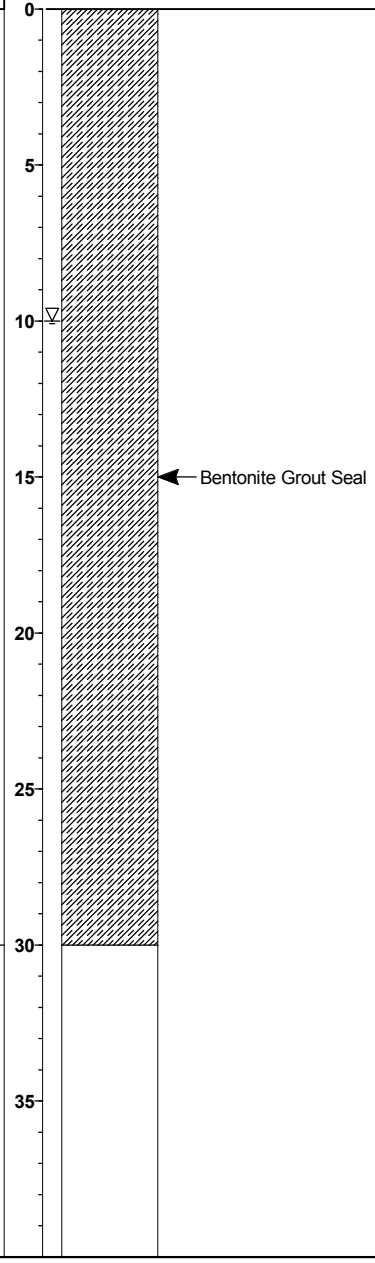
Total Depth = 30.0 feet

(Northing 4034.671, Easting 3930.587)

NOTES:

1. 36-inch long Shelby tube samples were pushed 30 inches only.
2. Used 140 lb. hammer throughout entire borehole for SPT sample collection.
3. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



Drilling Company:	**Major Drilling Environmental, LLC**
Drilling Method:	**Mud Rotary**
Logged By:	**David Lamadrid**
Sampling Method:	**See legend for explanation of sample types**

Date Started:	**1/27/12**	Elevation:	**150.8 ft.**
Date Ended:	**1/27/12**	Total Depth:	**30.0 ft.**
Boring Diameter:	**5.0"**		

STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-02A

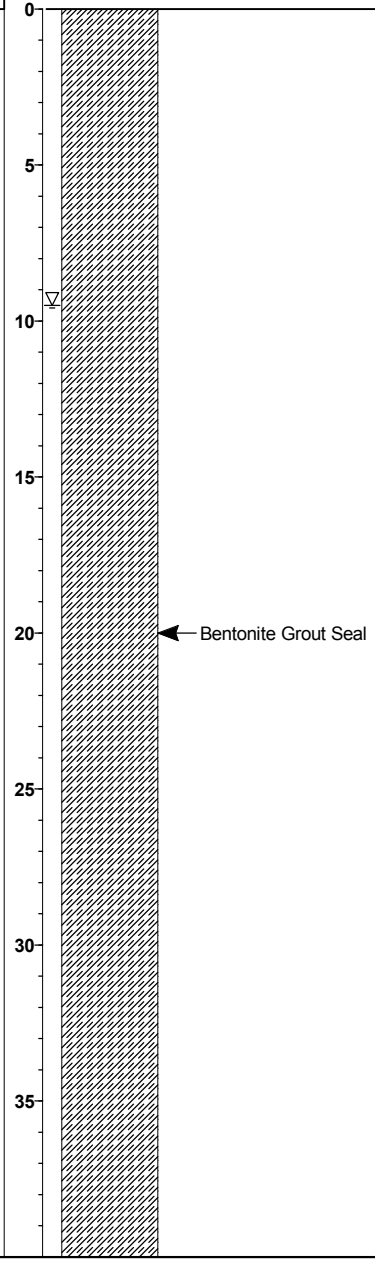
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0	0					FILL	Surface: gravel road base Initially used 140 lb. hammer and switched to 300 lb. hammer as noted below. **ALLUVIUM**
1			2A-1	---			
	5		2A-2	---		CL	At 4.5 feet (bottom of Shelby tube sample 2A-1), SILTY CLAY (CL), brown (10YR 5/3), very moist, low to medium plasticity
2			2A-3	---		CL	At 7.0 feet (bottom of Shelby tube sample 2A-2), SILTY CLAY (CL), brown (10YR 4/3) with slight orange brown (oxide) mottling, very moist, faintly micaceous, low to medium plasticity
3	10		2A-4	---		CL	At 9.5 feet (bottom of Shelby tube sample 2A-3), same SILTY CLAY (CL) as above in sample 2A-3, but wet
4			2A-5	---		CL	
5	15		2A-6	1 1 1		CL-ML	Bedded SILTY CLAY (CL) and CLAYEY SILT (ML), brown (10YR 5/3) with slight orange-brown (oxide) mottling, wet, soft, beds up to 4 inches thick
6	20		2A-7	---			
7						CL/ML	At 22.5 feet (bottom of Shelby tube sample 2A-7), SILTY CLAY / CLAYEY SILT (CL/ML), dark gray (5Y 4/1), wet, scattered, small (<1/16 inch) granules)
8	25		2A-8	---			Driller reported more firm drilling than above
			2A-9	1 3 5		CL	SILTY CLAY (CL), dark gray (5Y 4/1), very moist, firm, low to medium plasticity
9	30		2A-10	---		CL	Grades to SILTY CLAY (CL), same color and characteristics as above but with slight orange-brown (oxide) mottling
10						CL	At 32.5 feet (bottom of Shelby tube sample 2A-10), slightly SILTY CLAY (CL), dark gray (5Y 4/1), very moist, medium plasticity, small (<1/16 inch) granules
11	35		2A-11	---			
12	40		2A-12	---		CH	At 37.5 feet (bottom of Shelbe tube sample 2A-11), same SILTY CLAY (CL) as above in sample 2A-10, with trace fine sand, high plasticity

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/30/12**
Date Ended: **1/31/12**
Boring Diameter: **5.0"**
Elevation: **149.3 ft.**
Total Depth: **68.0 ft.**

STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

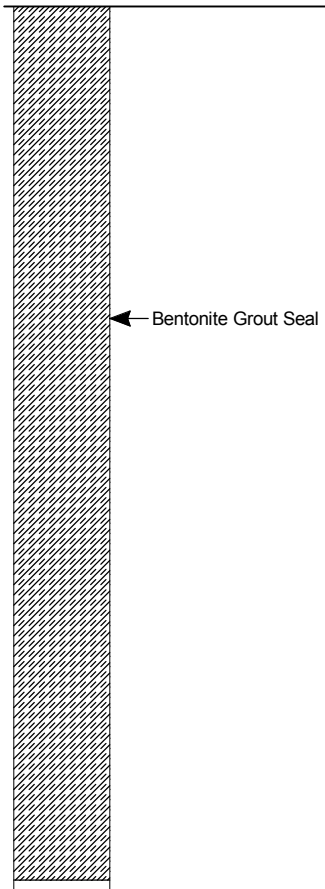
Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
	40					CL/ML	**ALLUVIUM (Continued)** At 40 feet (bottom of Shelby tube sample 2A-12), SILTY CLAY / CLAYEY SILT (CL/ML), dark greenish gray (5GY 4/2) with slight orange brown (oxide) mottling, moist, faintly micaceous, low to medium plasticity
13							At 42 feet, driller reported harder drilling and gravel
	45		2A-13	17 36 32		SC	CLAYEY SAND (SC) with gravel, mottled srong brown (7.5Y 4/6) and brownish yellow (10YR 6/6), very moist, clay 30 - 40 percent, fine to coarse sand (f,m,c = 40,40,20), fine to coarse gravel to 1-inch diameter, weathered appearance
14							
15							Switch to 300 lb. hammer before collecting sample 2A-14 and for remainder of samples
	50		2A-14	6 6 8		SC SM	At 50 feet, same as above in sample 2A-13
16							Contact in sample 2A-14 with SILTY FINE SAND (SM), light olive brown (2.5Y 5/4) with some orange brown (oxide) mottling), moist, loose, silt 10 - 20 percent increasing with depth
							Color change in sample shoe to dark gray (5Y 4/1) but same SILTY FINE SAND (SM)
	55		2A-15	8 13 20		SW	At 55.0 feet, GRAVELLY SAND (SW) with trace silt, black (5Y 2.5/1) moist, medium dense, fine subround gravel to 1/2-inch diameter, fine to coarse sand (f,m,c = 40,30,10)
17							
18							
	60		2A-16	9 15 18		SW	Same GRAVELLY SAND (SW) as above in sample 2A-15, but dark gray (5Y 4/1) and medium dense
19							
	65		2A-17	9 18 22			No recovery in sample 2A-17
20			2A-18	9 19 31		SW	Same GRAVELLY SAND (SW) as above in sample 2A-15, but very dark greenish gray (GLEY 1 3/1) and medium dense
21							
	70						Total Depth = 68.0 feet
							(Northing 3553.346, Easting 3963.072)
22							NOTES:
							1. Drilled adjacent borehole hollow stem augers to collect bulk soil cuttings sample 2A-19 from 0 to 10.0 feet.
23	75						2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 2A-14 at 50 feet and for remainder of borehole. Hammers not used for Shelby tube samples.
24							3. 36-inch long Shelby tube samples were pushed 30 inches only.
	80						4. Shallow (Silt-Clay unit) groundwater encountered at 9.5 feet during drilling. Deep (Sand-Gravel unit) groundwater not encountered during drilling (no visible signs of saturated soils).
25							5. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
26	85						

Graphic Log

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-02B

Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. hammer; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
							Surface: Grass **ALLUVIUM**
			2B-1	---		CL	At 5.0 feet (bottom of Shelby tube sample 2B-1), SILTY CLAY (CL), brown (10YR 5/3), moist, faintly micaceous, low to medium plasticity
			2B-2	---			
			2B-3	1 2 2		ML	CLAYEY SILT (ML), brown (10YR 5/3), moist, faintly micaceous, low to medium plasticity
						CL/ML	Grades to SILTY CLAY / CLAYEY SILT (CL/ML), same color as above, wet, soft, low to medium plasticity
			2B-4	---		ML	At 15.0 feet (bottom of Shelby tube sample 2B-4, CLAYEY SILT (ML), brown (10YR 4/3), wet, faintly micaceous, trace sand, low to medium plasticity
			2B-5	---			
			2B-6	1 1 2		CL	SILTY CLAY (CL), grayish brown (2.5Y 5/2), wet, soft, medium plasticity
			2B-7	---		CL/ML	At 25.0 feet (bottom of Shelby tube sample 2B-7), SILTY CLAY / CLAYEY SILT (CL/ML), dark gray (5Y 4/1), wet, low to medium plasticity At approximately 27.0 feet, driller reported relatively more firm drilling than above
			2B-8	---		ML	At 30 feet (bottom of Shelby tube sample 2B-8), SILT (ML), dark gray (5Y 4/1), very moist, slightly micaceous, low to medium plasticity

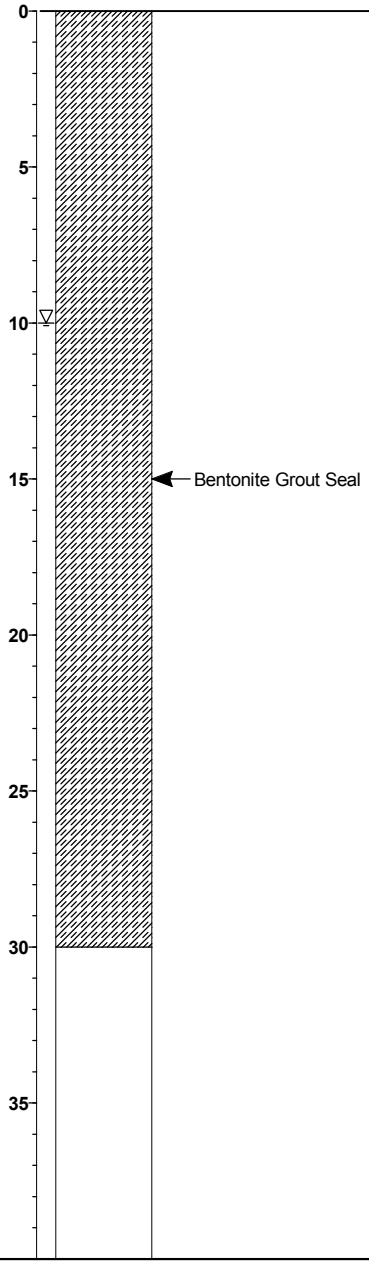
Total Depth = 30.0 feet

(Northing 3503.039, Easting 3901.078)

NOTES:

1. 36-inch long Shelby tube samples were pushed 30 inches only.
2. Used 140 lb. hammer throughout entire borehole for SPT sample collection.
3. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



Drilling Company:	**Major Drilling Environmental, LLC**
Drilling Method:	**Mud Rotary**
Logged By:	**David Lamadrid**
Sampling Method:	**See legend for explanation of sample types**

Date Started:	**2/1/12**	Elevation:	**148.9 ft.**
Date Ended:	**2/1/12**	Total Depth:	**30.0 ft.**
Boring Diameter:	**5.0"**		

STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-03A

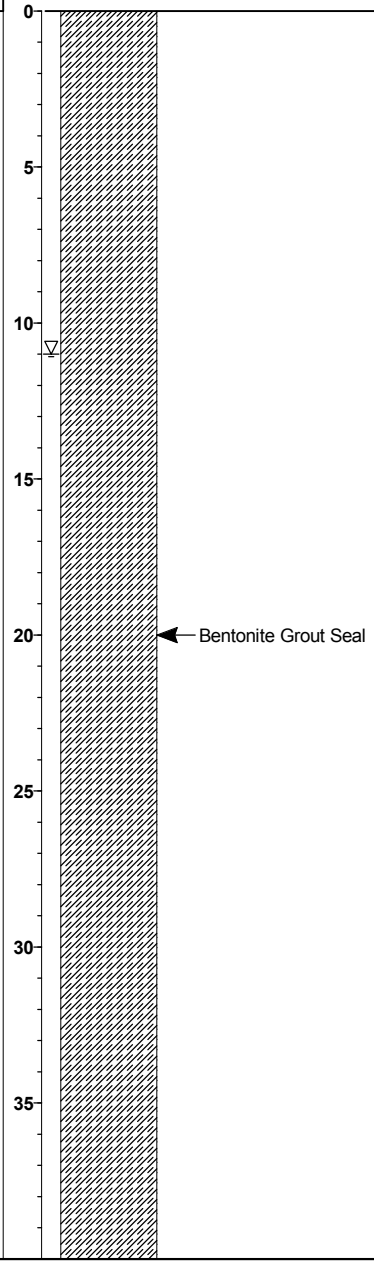
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0					FILL	Surface: gravel road base Initially used 140 lb. hammer and switched to 300 lb. hammer as noted below.
1		3A-1	---		ML	**ALLUVIUM** Shelby tube sample 3A-1 could only be pushed 12 inches. At bottom of sample CLAYEY SILT (ML), brown (10YR 4/3), moist, slightly micaceous, low to medium plasticity
		3A-2	---			
5					CL/ML	At 6.0 feet (bottom of Shelby tube sample 3A-2), SILTY CLAY / CLAYEY SILT (ML), brown (10YR 4/3), very moist, slightly micaceous, low to medium plasticity
2		3A-3	---			
		3A-4	---		ML	At 8.5 feet (bottom of Shelby tube sample 3A-3), slightly CLAYEY SILT (ML), brown (10YR 4/3), very moist, slightly micaceous, low to medium plasticity
3 / 10		3A-5	---		ML	At 11.0 feet (bottom of Shelby tube sample 3A-4), same CLAYEY SILT (ML) as above in sample 3A-3 but wet
4		3A-6	---		ML	At 13.5 feet (bottom of Shelby tube sample 3A-5), CLAYEY SILT (ML), brown (10YR 4/3), wet, medium plasticity
15 / 5					ML	At 16.0 feet (bottom of Shelby tube sample 3A-6), same CLAYEY SILT (ML) as above in sample 3A-5, with slight pale brown (10YR 6/3) mottling, few small (<1/8 inch) black flecks
6 / 20		3A-7	---			
7		3A-8	0 2 3		CL	SILTY CLAY (CL), dark gray (5Y 4/1), moist to wet, firm, bedded layers with varying silt content, beds up to 4 inches thick
25		3A-9	---			Shelby tube sample 3A-9 could only be pushed 7 inches
8		3A-10	3 4 5		ML	CLAYEY SILT (ML), dark gray (5Y 4/1), moist, stiff, grades quickly to trace clay at bottom of sample, faintly micaceous, low to medium plasticity
9 / 30		3A-11	---			
10					CL	At 32.5 feet (bottom of Shelby tube sample 3A-11), SILTY CLAY (CL), dark gray (5Y 4/1), moist, low to medium plasticity (driller reported firm push)
35 / 11		3A-12	---			
12 / 40		3A-13			CL	At 37.5 feet (bottom of Shelby tube sample 3A-12), same SILTY CLAY (CL) as above in sample 3A-11 (driller reported firm push)

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/30/12**
Date Ended: **1/30/12**
Boring Diameter: **5.0"**

Elevation: **147.8 ft.**
Total Depth: **71.5 ft.**

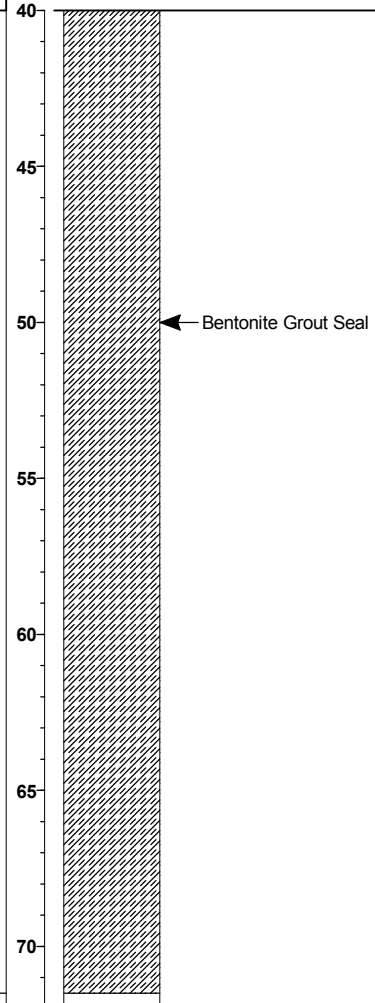
STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
	40					CL		**ALLUVIUM (Continued)** At 40 feet (bottom of Shelby tube sample 3A-13), CLAY (CL), dark gray (5Y 4/1), very moist, medium to high plasticity
13								Shelby tube sample 3A-14 could only be pushed 15 inches. Sample was disturbed and tube severly bent at bottom. Sample not retained. At bottom of sample
	45		3A-14			ML/SM		FINE SANDY SILT / SILTY FINE SAND (ML/SM), dark gray (5Y 4/1) with greenish tint, very moist.
14			3A-15	15 19 26		GC		At 46.5 feet, SANDY, CLAYEY GRAVEL (GC), yellowish brown (10YR 4/6), wet, dense, abundant mottling with gray and brown, fine to coarse sand (f,m,c = 10,30,60), fine to coarse subrounded gravel to 1-inch diameter
15								
	50		3A-16	14 25 34		GC		Switched to 300 lb. hammer for sample 3A-16 and for remainder of samples
16								At 50 feet, same SANDY, CLAYEY GRAVEL (GC) as above in sample 3A-15, but gravel up to 2.5 inch diameter
	55		3A-17	7 9 16		SW/GW		GRAVELLY SAND / SANDY GRAVEL (SW/GW), very dark gray (5Y 3/1), wet, medium dense, trace fines, fine to coarse sand (f,m,c = 20,40,40), fine to coarse subrounded gravel to 1 inch diameter
17								
18								
	60		3A-18	8 21 48		SW/GW		Same GRAVELLY SAND / SANDY GRAVEL (SW/GW) as above in sample 3A-17, but very moist, dense, gravels up to 2.5 inch diametr
19								
						SW		FINE TO MEDIUM SAND (SW), very dark gray (5Y 3/1), very moist, medium dense, predominantly fine sand, trace silt, few pebbles
	65		3A-19	7 14 18				
20						ML		Contact in sample with slightly SANDY SILT (ML), dark gray (5Y 4/1), moist, very stiff, some pebbles
21						SM		At 70.0 feet, SILTY SAND (SM), dark gray (5Y 4/1), moist, medium dense, silt 30 - 40 percent, fine to coarse sand, some pebbles
	70		3A-20	8 10 14		ML/SM		Grades with increasing silt content to SANDY SILT / SILTY SAND (ML/SM)
22								Total Depth = 71.5 feet (Northing 3082.638, Easting 3955.140) NOTES: 1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample from 0 to 10.0 feet. 2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collected sample 3A-16 and for remainder of borehole. Hammer not used for Shelby tube samples. 3. 36-inch long Shelby tube samples were pushed 30 inches only. 4. Shallow (Silt-Clay unit) groundwater encountered at 11.0 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 46.0 feet during drilling. 5. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
23	75							
24								
	80							
25								
26	85							

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-03B

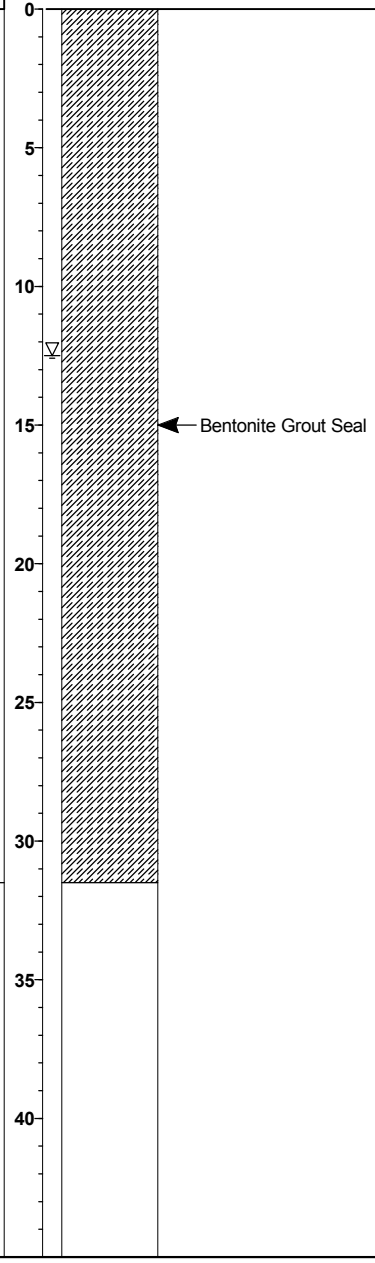
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. hammer; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0					FILL		Surface: gravel fill
1			3B-1	---				**ALLUVIUM** Shelby tube sample 3B-1 poor recovery and slightly disturbed; did not retain sample. At bottom of sample, SILTY CLAY (CL), dark yellowish brown (10YR 3/4), very moist to wet, medium plasticity
	5		3B-2	---		CL		
2			3B-3	1 2 3		ML		At 7.0 feet, slightly CLAYEY SILT (ML), yellowish brown (10YR 5/4), very moist, firm, irregular partings with some oxide filled, medium plasticity
3	10		3B-4	---				
4						CL/ML		At 12.5 feet (bottom of Shelby tube sample 3B-4), SILTY CLAY / CLAYEY SILT (CL/ML), brown (10YR 4/3), very moist to wet, low to medium plasticity
5	15		3B-5	---				
6			3B-6	1 2 2		CL		SILTY CLAY (CL), mottled yellowish brown (2.5Y 6/3) and brown (10YR 5/3), wet, soft
	20		3B-7	---				
7						CL		At 22.5 feet (bottom of Shelby tube sample 3B-7), SILTY CLAY (CL), light olive brown (2.5Y 5/3), wet, scattered small (<1/16 inch) hard granules
								At approximately 23 to 24 feet, driller reported relatively harder drilling
8	25		3B-10	2 4 5		ML		SILT (ML) with trace clay, dark grayish green (GLEY1 4/1), moist, firm, faintly micaceous, low to medium plasticity
9	30		3B-11	2 5 4		ML		Same SILT (ML) as above but slightly clayey
10								Total Depth = 31.5 feet
								(Northing 3126.117, Easting 3904.878)
11	35							NOTES: 1. 36-inch long Shelby tube samples were pushed 30 inches only.
								2. Used 140 lb. hammer throughout entire borehole for SPT and California modified sample collection.
12	40							3. Shelby tube sample collection was attempted at 25.0 feet (sample 3B-8) and 27.5 feet (sample 3B-9), but little or no recovery was obtained and the tube at 27.5 feet sheared off and remained in the borehole. Another adjacent borehole was drilled to collect California modified samples at 25.0 feet (sample 3B-10) and 30.0 feet (sample 3B-11).
13								4. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
	45							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **2/1/12**
Date Ended: **2/1/12**
Boring Diameter: **5.0"**

Elevation: **148.7 ft.**
Total Depth: **31.5 ft.**

STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-04A

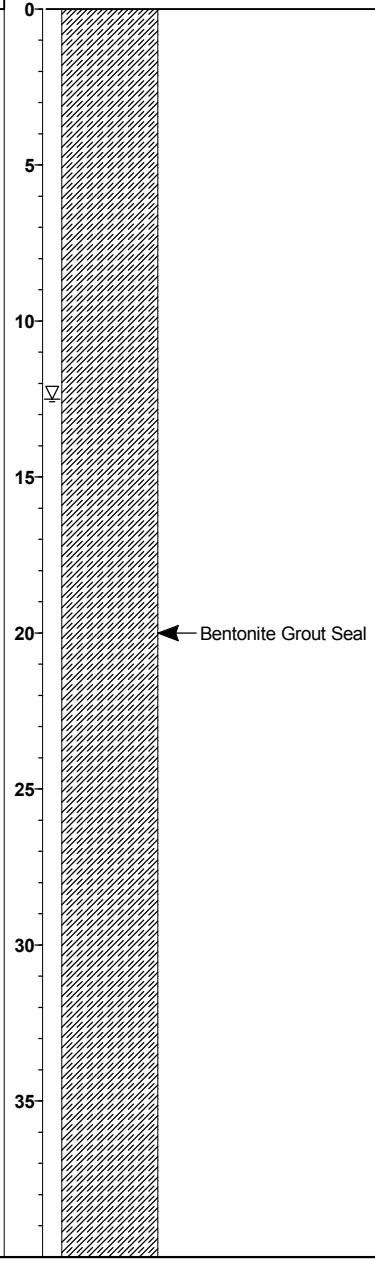
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0					FILL	Surface: gravel fill Note: Initially use 140 lb. hammer and switched to 300 lb. hammer as noted below. **ALLUVIUM**
1		4A-1	---			
5		4A-2	---		CL/ML	At 5.0 feet (bottom of Shelby tube sample 4A-1), SILTY CLAY / CLAYEY SILT (CL/ML), olive gray (5Y 4/2) with slight orange brown (oxide) mottling, moist, low to medium plasticity
2					CL/ML	At 7.5 feet (bottom of Shelby tube sample 4A-2), same SILTY CLAY / CLAYEY SILT (CL/ML) as above
3 / 10		4A-3	---			
4		4A-4	1 2 2		CL	Slightly SILTY CLAY (CL), yellowish brown (10YR 5/4), wet, soft, slightly micaceous, medium plasticity
15		4A-5	---			
5					CL	At 17.5 feet (bottom of Shelby tube sample 4A-5), same SILTY CLAY (CL) as above in sample 4A-4
6 / 20		4A-6	---			
7					CL	At 22.5 feet (bottom of Shelby tube sample 4A-6), SILTY CLAY (CL), light olive brown (2.5Y 5/3), moist to wet, rare fine gravels, medium plasticity
25		4A-7	---			
8		4A-8	---		ML	At 27.5 feet (bottom of Shelby tube sample 4A-7), SILT (ML), dark grayish olive (10YR 4/2), moist, slightly micaceous, low to medium plasticity
9 / 30		4A-9	3 4 5		CL	SILTY CLAY (CL), dark gray (5Y 4/1), moist, stiff, grades to more silt with depth
10						
35		4A-10	---			
11					CL	At 37.5 feet (bottom of Shelby tube sample 4A-10), CLAY (CL), dark greenish gray (GLEY1 4/1), moist, medium to high plasticity
12 / 40						

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/1/12**
Date Ended: **3/1/12**
Boring Diameter: **5.0"**

Elevation: **147.4 ft.**
Total Depth: **61.5 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
40 / 13		4A-12	3 5 6				**ALLUVIUM (Continued)** CLAY (CL), greenish gray (GLEY1 5/1), very moist, medium to high plasticity Sharp contact in sample 4A-12 with CLAY (CL), dark greenish gray (GLEY1 4/1) with minor orange brown (oxide) mottling, moist, stiff, medium to high plasticity (more relative firmness at bottom of sample)
45 / 14		4A-13	7 7 13		SW		Driller reported harder drilling at 43 feet At 45.0 feet, FINE TO MEDIUM SAND (SW), strong brown (7.5YR 4/6) with yellowish brown (10YR 5/6) motting, wet, medium dense, fine to medium sand, trace to some scattered fine gravels, with two 1-inch lenses with fines
50 / 15		4A-14	12 26 50		SW		- Switched to 300 lb. hammer for sample 4A-14 and for remainder of samples - At 50 feet, GRAVELLY SAND (SW) with fines, strong brown (7.5YR 4/6) with yellowish brown (10YR 5/6) mottling, very moist, dense, fine to coarse subrounded gravel to 2-inch diameter, fine to coarse sand (f:m:c = 40:40:20)
55 / 16		4A-15	18 32 50/3"		GW		- At 55.0 feet, CLAYEY, SANDY GRAVEL (GW), yellowish brown (10YR 5/6) with slight orange brown (oxide) mottling, moist, very dense, clay 10-20 percent, fine to coarse sand (f:m:c = 40:40:20), fine to coarse subrounded gravel to 2-inch diameter - At 60 feet, SANDY GRAVEL (GW), very dark gray (5Y 3/1), medium dense, fine to coarse sand, fine to coarse subrounded gravel to 1.5-inch diameter
60 / 17		4A-16	10 25 42		GW GC		- Contact in bottom ring with SANDY, CLAYEY GRAVEL (GC), dark gray (5Y 4/1), moist, predominantly medium and coarse sand, fine to coarse subrounded gravel to 2-inch diameter

Total Depth = 61.5 feet

(Northing 2888.126, Easting 4026.358)

NOTES:

1. Drilled adjacent borehole on 3/6/12 with hollow stem augers to collect bulk soil cuttings samples 4A-17 (from 2.0 to 5.0 feet) and 4A-18 (from 5.0 to 10.0 feet).

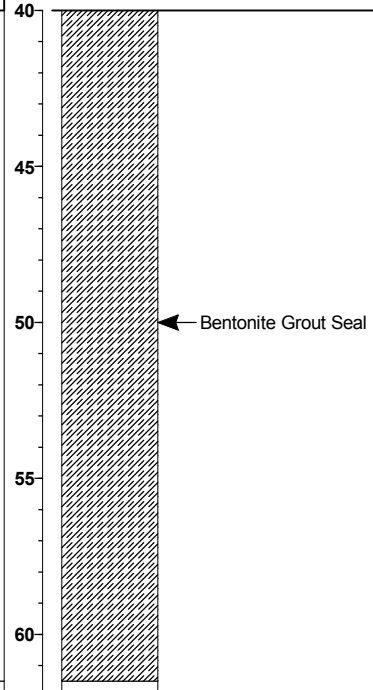
2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 4A-14 at 50 feet and for remainder of borehole. Hammers not used for Shelby tube samples.

3. 36-inch long Shelby tube samples were pushed 30 inches only.

4. Shallow (Silt-Clay unit) groundwater encountered at 12.5 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 45.0 feet during drilling.

5. Refer to compilation of labortaory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-04B

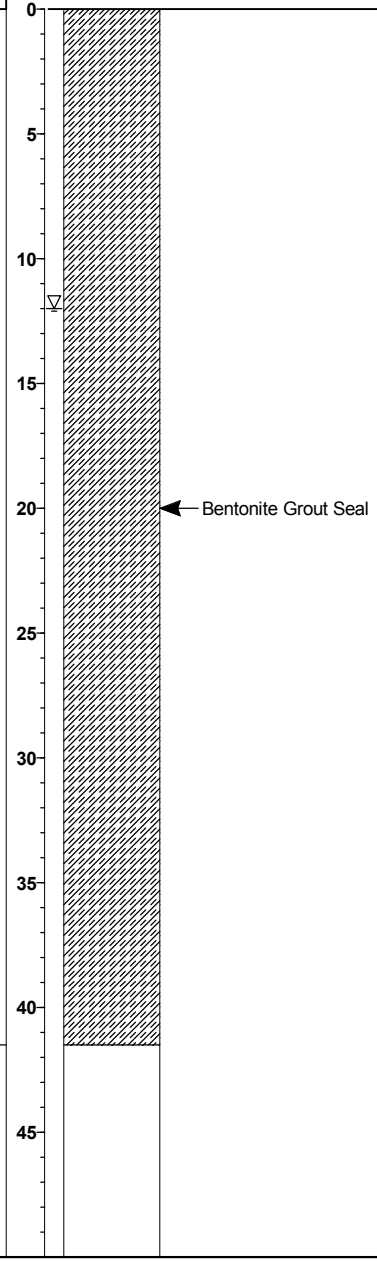
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. hammer; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
							Surface: gravel fill
							ALLUVIUM
			4B-1	---			
	5		4B-2	---		ML	5.0 feet (bottom of Shelby tube sample 4B-1), slightly CLAYEY SILT (ML), dark olive gray (5Y 3/2) with minor orange brown (oxide) mottling, moist, low to medium plasticity
						ML	At 7.5 feet (bottom of Shelby tube sample 4B-2), SILTY CLAY (CL), light olive brown (2.5Y 5/3) with orange brown (oxide) mottling, very moist, medium plasticity
	10		4B-3	---			
			4B-4	1 2 2		CL/ML	SILTY CLAY / CLAYEY SILT (ML/CL), dark yellowish brown (10YR 4/4), wet, soft, medium plasticity Grades to SILTY CLAY (CL) at bottom of sample
	15		4B-5	---			
						ML	At 17.5 feet (bottom of Shelby tube sample 4B-5), CLAYEY SILT (ML), dark yellowish brown (10YR 4/4), wet, faintly micaceous, low to medium plasticity
	20		4B-6	---			
						ML	At 22.5 feet (bottom of Shelby tube sample 4B-6), slightly CLAYEY SILT (ML), light olive brown (2.5Y 5/4), wet, slightly crumbly texture, low to medium plasticity
	25		4B-7	---			
			4B-8	3 4 8		ML	SILT (ML), dark greenish gray (GLEY1 4/1), wet at top of sample 4B-8 grading to very moist, stiff, low to medium plasticity
	30		4B-9	---			Could only push Shelby tube sample 4B-9 24 inches
			4B-10	---		ML	At 32.0 feet (bottom of Shelby tube sample 4B-9), CLAYEY SILT (ML), dark greenish gray (GLEY1 4/1), wet, very moist, low to medium plasticity
	35					ML	At 34.5 feet (bottom of Shelby tube sample 4B-10), same CLAYEY SILT (ML) as above in sample 4B-9
			4B-11	---			Only 4 inch recovery in Shelby tube sample 4B-11; did not retain sample
	40		4B-12	2 5 9		CL	CLAY (CL), very dark greenish gray (GLEY1 3/1) with slight orange brown (oxide) mottling), moist, stiff, medium to high plasticity
							Total Depth = 41.5 feet
							(Northing 2858.555, Easting 3904.450)
	45						NOTES: 1. 36-inch long Shelby tube samples were pushed 30 inches only. 2. Used 140 lb. hammer throughout entire borehole for SPT sample collection. 3. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
0	0						
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15	50						

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/2/12**
Date Ended: **3/2/12**
Boring Diameter: **5.0"**

Elevation: **146.3 ft.**
Total Depth: **41.5 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-05A

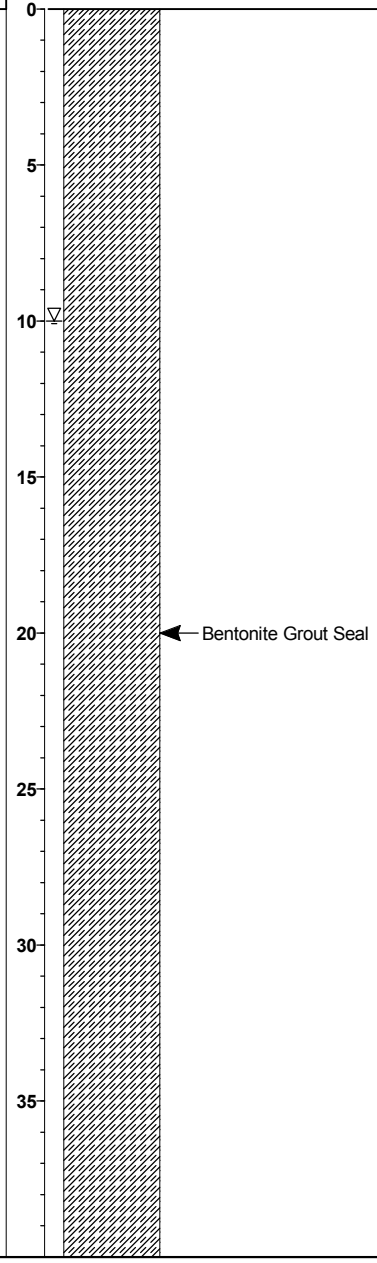
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0	0					FILL	Surface: gravel fill Initially used 140 lb. hammer and switched to 300 lb. hammer as noted below. **ALLUVIUM**
1			5A-1	---			
	5		5A-2	0 (push)		CL	SILTY CLAY (CL), mottled very dark grayish brown (10YR 3/2) and dark yellowish brown (10YR 4/6), very moist, soft, some black soft carbonaceous nodules, medium plasticity
2			5A-3	---			
3	10					CL	At 10.0 feet (bottom of Shelby tube sample 5A-3), same SILTY CLAY (CL) as above but only slight dark grayish brown mottling, wet
4			5A-4	---			
	15					ML	At 15.0 feet (bottom of Shelby tube sample 5A-4), CLAYEY SILT (ML), yellowish brown (10YR 5/4), wet, medium plasticity
5			5A-5	---			
6	20		5A-6	1 3 3		CL	Same SILTY CLAY (CL) as above in sample 5A-4, with 1.5-inch lens of clayey silt, firm
7			5A-7	---			
	25					ML	At 25 feet (bottom of Shelby tube sample 5A-7), CLAYEY SILT (ML), dark gray (5Y 4/1) with slight greenish tint, moist, low to medium plasticity
8			5A-8	---			
9	30					CL/ML	At 30 feet (bottom of Shelby tube sample 5A-8), SILTY CLAY / CLAYEY SILT (CL/ML), dark gray (5Y 4/1), moist, low to medium plasticity, crumbly texture
10			5A-9	---			
	35					CH	At 35.0 feet (bottom of Shelby tube sample 5A-9), CLAY (CL), dark greenish gray (GLEY1 4/1) with minor orange brown (oxide) mottling, moist, high plasticity
11			5A-10	---			Could only push Shelby tube sample 5A-10 22 inches.
12	40					SM	At bottom of sample, SILTY FINE SAND (SM), yellowish brown (10YR 5/4) with moderate orange brown (oxide) mottling, moist, silt 20 - 30 percent

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **2/29/12**
Date Ended: **3/1/12**
Boring Diameter: **5.0"**

Elevation: **139.1 ft.**
Total Depth: **70.3 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
12.8	40		5A-11	6 9 23		SM SW		**ALLUVIUM (Continued)** At 40 feet, same SILTY FINE SAND (SM) as above - Sharp contact with GRAVELLY SAND (SW) with fines, strong brown (7.5 YR 4/6) with abundant orange brown (oxide) mottling, very moist, dense, fine subrounded gravel 10 - 20 percent, fine to coarse sand, very weathered appearance
13.7	45		5A-12	26 50/4"		SC		- At 44 feet, driller reported abundant gravel encountered - At 45 feet, GRAVELLY, CLAYEY SAND (SC), mottled light olive brown (2.5Y 5/3) and yellowish brown (10YR 5/4) with abundant orange brown (oxide) mottling, moist, dense, fine to coarse subrounded gravel to 1-inch diameter 10 - 20 percent, fine to coarse sand (f:m:c = 60:30:10)
15.2	50		5A-13	14 21 36		GW		- Switched to 300 lb. hammer for sample 5A-13 and remaining samples - At 50 feet, SANDY GRAVEL (GW), brown (7.5Y 4/4) with abundant orange brown (oxide) mottling, wet, dense, fine to coarse sand (f:m:c = 60:30:10), fine to coarse subrounded gravel to 2-inch diameter, weathered appearance
16.8	55		5A-14	5 7 17		SM SW/GW		At 55 feet, SILTY FINE SAND (SM), dark gray (2.5Y 4/1), wet, medium dense, silty 20 - 30 percent, grades to fine to coarse sand Quickly grades to GRAVELLY SAND / SANDY GRAVEL (SW/GW), same color as above, fine to coarse sand (f:m:c = 20:40:40), fine to coarse subrounded gravel to 1-inch diameter
18.3	60		5A-15	9 9 12		SW/GW		At 60 feet, same GRAVELLY SAND / SANDY GRAVEL (SW/GW) as above Contact in sample with same SW/GW, but dark gray (2.5Y 4/1), fine to coarse sand (f:m:c = 40:40:20), gravels to 1/2-inch diameter, medium dense
19.8	65		5A-16	7 8 6		SW/GW		Same as above but loose. Primarily large piece of wood in sample shoe At 68 feet, driller reported much harder drilling
21.3	70		5A-17	50/3"		SLST		At 70 feet, SILTSTONE (SLST) with some fine sand, dark gray (2.5Y N4), moist, hard (moderately indurated), scattered white small nodules (1/16 to 1/8 inch)
22.8	75							
24.4	80							
25.9	85							

Total Depth = 70.3 feet
(Northing 2586.445, Easting 3967.732)

NOTES:
1. Drilled adjacent borehole on 3/2/12 with hollow stem augers to collect bulk soil cuttings samples 5A-18 (from 2.0 to 5.0 feet) and 5A-19 (from 5.0 to 10.0 feet).

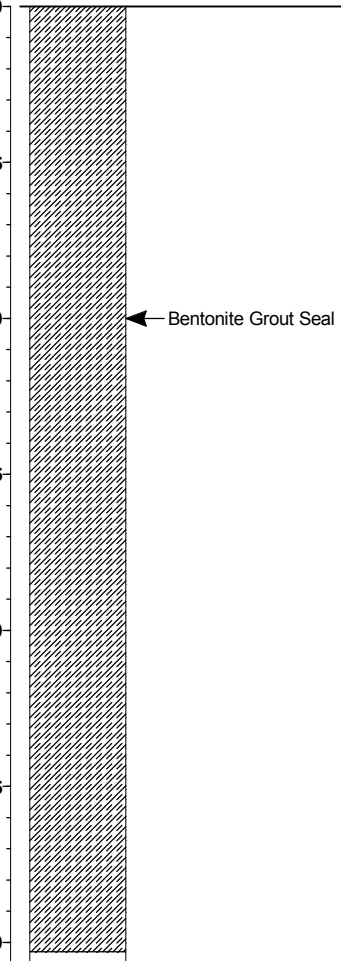
2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 5A-13 at 50 feet and for remainder of borehole. Hammers not used for Shelby tube samples.

3. 36-inch long Shelby tube samples were pushed 30 inches only.

4. Shallow (Silt-Clay unit) groundwater encountered at 12.5 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 50.0 feet during drilling.

5. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-05B

Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

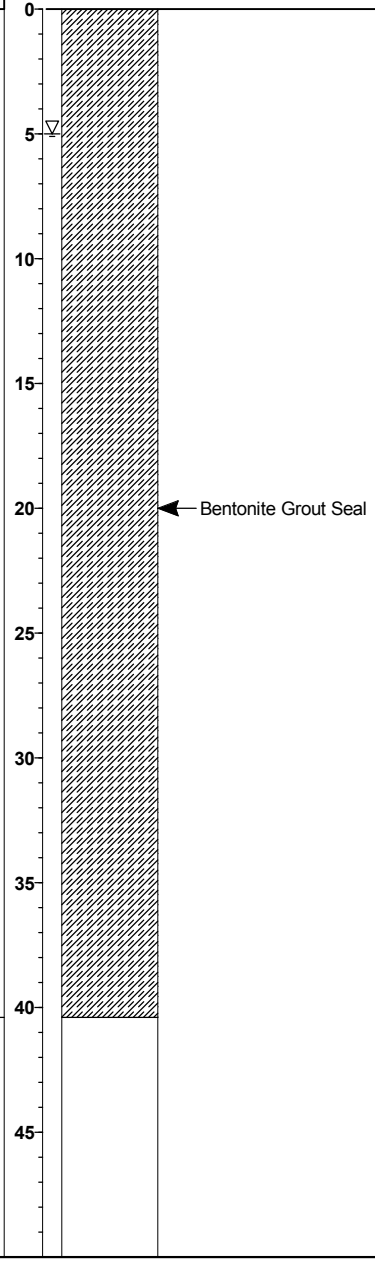
REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
							Surface: Grass **ALLUVIUM**
			5B-1	---			
			5B-2	0 2 3		CH	CLAY (CH) with sand, mottled dark yellowish brown (10YR 3/6) and dark grayish brown (2.5Y 4/2), wet, firm, high plasticity
			5B-3	---			
						CH	At 10.0 feet (bottom of Shelby tube sample 5B-3), CLAY (CH), grayish brown (2.5Y 5/2) with some orange brown (oxide) mottling, wet, high plasticity
			5B-4	---			
			5B-5	---		CH	At 15.0 feet (bottom of Shelby tube sample 5B-4), SILTY CLAY (CH), very dark greenish gray (GLEY1 3/1), very moist, high plasticity Drilled/sampled to 17.5 feet on 3/5/12, and completed remainder of borehole on 3/6/12
			5B-6	2 3 4		CH	At 17.5 feet, same SILTY CLAY (CH) as above but with few scattered rootlets, firm
			5B-7	---			
						CH	At 22.5 feet (bottom of Shelby tube sample 5B-7), SILTY CLAY (CH), dark greenish gray (GLEY1 4/1), very moist to wet, few scattered rootlets, high plasticity
			5B-8	---			- Driller reported last 3 inches of push for Shelby tube sample 5B-8 was hard, and tube was bent at the bottom
						GW	- At 27.5 feet (bottom of Shelby tube sample 5B-8), SANDY GRAVEL (GW), mottled dark yellowish brown (10YR 4/6) and olive gray (5Y 4/2), moist, fine to coarse sand (f:m:c = 20:40:40), fine to coarse subrounded gravel to 2-inch diameter - Switched to 300 lb. hammer for sample 5B-9 and for remainder of samples
			5B-9	13 26 50/4"			- At 32.0 feet, GRAVELLY SAND / SANDY GRAVEL (SW/GW) with clay, yellowish brown (10YR 5/6) with orange brown (oxide) mottling, very moist, very dense, fine to coarse sand (f:m:c = 40:40:20), fine to coarse subrounded gravel to 2-inch diameter
			5B-10	34 50/4"		SW/GW	- At 36.0 feet, same GRAVELLY SAND / SANDY GRAVEL (SW/GW) as above in sample 5B-9 - At 40 feet, SANDY GRAVEL (GW), dark greenish gray (GLEY1 3/1), wet, very dense, fine to coarse sand (f:m:c = 40:40:20), fine to coarse subrounded gravel to 1-inch diameter
			5B-11	50/5"		GW	

Total Depth = 40.4 feet (N. 2394.709, E. 3957.493)

NOTES:
1. 36-inch long Shelby tube samples were pushed 30 inches only.
2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer for sample 5B-9 and remaining samples.
3. Shallow (Silt-Clay unit) and deep (Sand-Gravel unit) groundwater encountered at 5.0 and 40 feet, respectively, during drilling.
4. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



Drilling Company:	**Major Drilling Environmental, LLC**
Drilling Method:	**Mud Rotary**
Logged By:	**David Lamadrid**
Sampling Method:	**See legend for explanation of sample types**

Date Started:	**3/5/12**	Elevation:	**125.9 ft.**
Date Ended:	**3/6/12**	Total Depth:	**40.4 ft.**
Boring Diameter:	**5.0"**		

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-06A

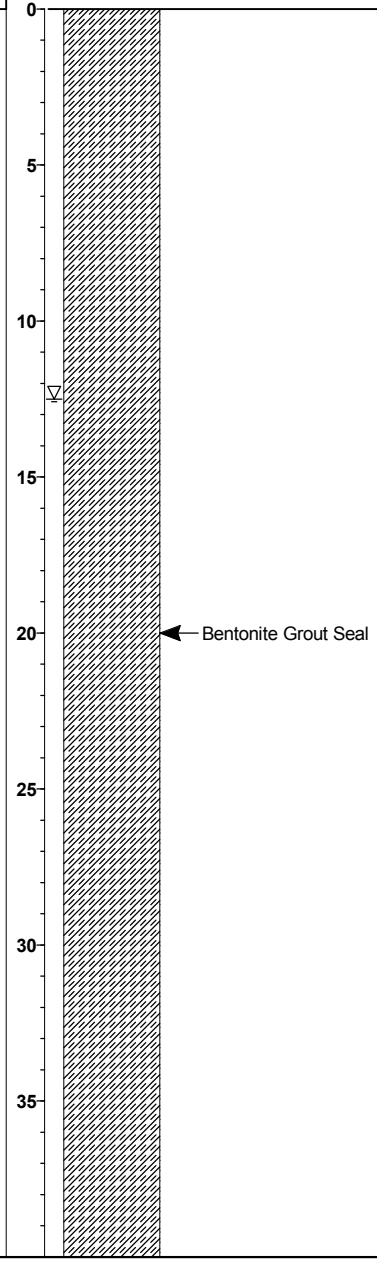
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
							Surface: Grass Note: Initially used 140 lb. hammer and switched to 300 lb. hammer as noted below.
1			6A-1	---			**ALLUVIUM**
	5		6A-2	---		CL	At 5.0 feet (bottom of Shelby tube sample 6A-1), SILTY CLAY (CL), brown (10YR 4/3) with pale brown (2.5Y 7/3) mottling, very moist, medium plasticity
2						CL	Can only push Shelby tube sample 6A-2 24.0 inches.
			6A-3	---			At bottom of sample, SILTY CLAY (CL), dark gray (2.5Y 4/1), very moist, medium plasticity
3	10		6A-4	---		CL	At 10.0 feet (bottom of Shelby tube sample 6A-3), SILTY CLAY (CL), dark gray (2.5Y 4/1) with slight orange brown (oxide) mottling, moist, noticeably more firm than above
4						CL	At 12.5 feet (bottom of Shelby tube ample 6A-4), SILTY CLAY (CL), very dark grayish brown (10YR 3/2), wet, low to medium plasticity
	15		6A-5	---			
5							
			6A-6	3 3 7		CL	SILTY CLAY (CL), light yellowish brown (2.5Y 6/3) with moderate orange brown (oxide) mottling, moist, stiff, low to medium plasticity
6	20		6A-7	---			
7						CL	At 22.5 feet (bottom of Shelby tube sample 6A-7), same SILTY CLAY (CL) as above in sample 6A-6
	25		6A-8	---			
8						CL	At 27.5 feet (bottom of Shelby tube sample 6A-8), SILTY CLAY (CL), dark grayish green (5GY 4/2), moist, low to medium plasticity, crumbly texture
9	30		6A-9	---			
10			6A-10	2 5 7		CL/CH	CLAY (CL/CH), dark greenish gray (GLEY 4/1), moist, stiff, medium to high plasticity
11	35		6A-11	---		CH	34-inch recovery in Shelby tube sample 6A-11 likely due to swelling. At top of sample, CLAY as above in sample 6A-10 but high plasticity
						ML	At bottom of sample 6A-11, SILT (ML) with clay, dark greenish gray (GLEY1 4/1) with some orange brown (oxide) mottling, slightly micaceous, low to medium plasticity
12	40						

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **2/28/12**
Date Ended: **2/29/12**
Boring Diameter: **5.0"**

Elevation: **140.0 ft.**
Total Depth: **67.3 ft.**

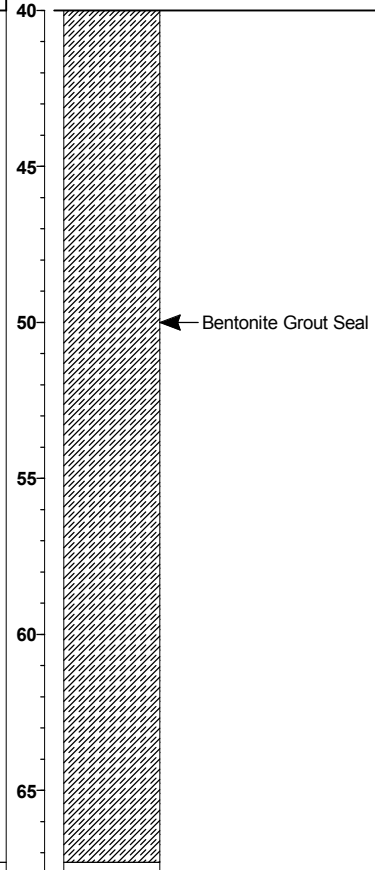
STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
	40		6A-12	---				**ALLUVIUM (Continued)**
13			6A-13	9 32 33		SM SM		SILTY FINE SAND (SM), yellowish brown (10YR 5/6), moist, silt 10 - 20 percent At 43.0 feet, sharp contact with SILTY SAND (SM) with fine gravel, strong brown (7.5YR 4/6) with orange brown (oxide) mottling, moist, hard, silt 10 - 20 percent, fine to coarse sand (f:m:c = 50:30:20), weathered appearance
14	45							At 46 feet, driller reported gravel encountered. Switched to 300 lb. hammer before collecting sample 6A-14 and for remainder of samples
15								
16	50		6A-14	20 40 50/2"		GC		SANDY, CLAYEY GRAVEL (GC), mottled dark grayish brown (10YR 4/2) and light yellowish brown (2.5Y 6/4), moist, hard, fine to medium sand 10 - 20 percent, fine to coarse subrounded gravel to 1.5-inch diameter
17	55		6A-15	23 16 16		GW SW		SANDY GRAVEL (GW), black (5Y 2.5/1), wet, medium dense, fine to coarse sand (f:m:c: = 20:40:40) 20 - 30 percent, fine to coarse subrounded gravel to 2.5-inch diameter Contact with GRAVELLY SAND (SW), dark yellowish brown (10YR 3/6), wet, medium dense, fine gravel to 1/2-inch diameter 10 - 20 percent, fine to medium sand (approximately 50/50)
18								
19	60		6A-16 6A-17	5 8 9 12 22 30		SM SM		Sample 6A-16, no recovery. In sample shoe is SILTY FINE SAND (SM), very dark gray (2.5Y 3/1), wet, silt 5 - 10 percent Sample 6A-17, same SILTY SAND (SM) as above but with 10 - 20 percent predominantly fine gravel to 1-inch diameter, increasing silt and gravel content with depth, medium dense to dense
20	65							At 67.0 feet, SILTSTONE (SLST) with some fine sand, dark gray (2.5Y N4), moist, hard (moderately indurated), scattered while small nodules (1/16 to 1/8 inch)
			6A-18	50/3"		SLST		
21								Total Depth = 67.3 feet (Northing 2550.768, Easting 4122.694)
22	70							NOTES: 1. Drilled adjacent borehole on 3/2/12 with hollow stem augers to collect bulk soil cuttings samples 6A-19 (0 to 5.0 feet) and 6A-20 (from 5.0 to 10.0 feet).
23	75							2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collected sample 6A-14 at 50 feet and for remainder of borehole. Hammer not used for Shelby tube samples. 3. 36-inch long Shelby tube samples were pushed 30 inches only.
24	80							4. Shallow (Silt-Clay unit) groundwater encountered at 12.5 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 55.0 feet during drilling.
25								5. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
26	85							

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-06B

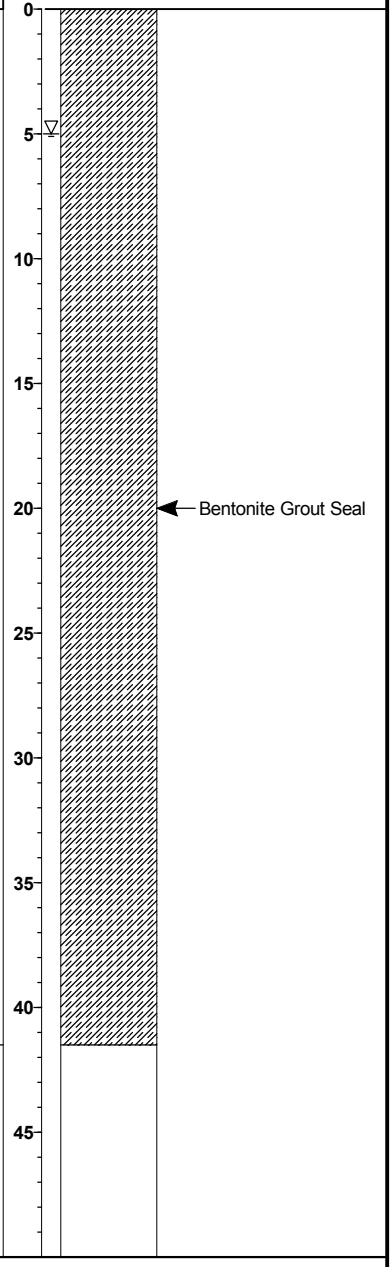
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0							Surface: grass Note: Initially used 140 lb. hammer and switched to 300 lb. hammer as noted below
1		6B-1	---				**ALLUVIUM**
5		6B-2	---		CL/CH		At 5.0 feet (bottom of Shelby tube sample 6B-1), CLAY (CL/CH), dark grayish brown (2.5Y 4/2) with minor minor orange brown (oxide) mottling, wet, medium to high plasticity
2					CL		At 7.5 feet (bottom of Shelby tube sample 6B-2), SILTY CLAY (CL), light olive brown (2.5Y 5/3) with moderate orange brown (oxide) mottling, wet, medium plasticity
3 / 10		6B-3	---				
4		6B-4	0 0 4		CH		At top of sample 6B-4, CLAY (CH), yellowish brown (10YR 5/4), wet, high plasticity
15		6B-5	---		CL		Sharp contact with CLAY (CL), dark gray (5Y 4/1), moist, noticeably more firm than above, medium plasticity
5		6B-6	---		CL		At 17.5 feet (bottom of Shelby tube sample 6B-5), SILTY CLAY (CL), dark greenish gray (GLEY1 4/1), moist, medium plasticity
6 / 20							At 20 feet (bottom of Shelby tube sample 6B-6), same SILTY CLAY (CL) but slightly crumbly texture
7							- Could only push Shelby tube sample 6B-7 20 inches. Disturbed gravels observed at bottom of sample. Switched to 300 lb. hammer for sample 6B-8 and remaining samples
25		6B-7	---		ML		- At 26.5 feet, CLAYEY GRAVELLY SAND / SANDY GRAVEL (SC/GC), strong brown (7.5YR 4/6) with abundant orange brown (oxide) mottling, moist, medium dense, clay 10 - 20 percent, fine to coarse sand (f:m:c = 40:30:30), fine to coarse subrounded gravel to 1.5-inch diameter, weathered appearance
8		6B-8	15 18 32		SC/GC		
9 / 30		6B-9	30 20 37		SC/GC		- At 30 feet, Same SC/GC as above - At 35.0 feet, SANDY CLAYEY GRAVEL (GC), mottled pale brown (2.5Y 8/4) and dark yellowish brown (10YR 4/4), very moist, dense, fine to coarse sand (f:m:c = 20:40:40) 10 - 20 percent, clay 10 - 20 percent, fine subrounded gravel to 3/4-inch diameter
10							- Sharp contact in sample 6B-10 with SANDY GRAVEL (GW) with fines, mottled strong brown (7.5YR 4/6) and light yellowish brown (2.5Y 6/4), very moist, dense, fine to coarse sand (f:m:c = 40:30:30), fine to coarse subrounded gravel to 2-inch diameter
35 / 11		6B-10	15 30 50/5"		GC GW		
12 / 40		6B-11	6 11 20		GW SW		- At 40 feet, same SANDY GRAVEL (GW) as above but with trace fines, wet. Sharp contact with GRAVELLY SAND (SW), dark greenish gray (GLEY1 3/1), wet, medium dense, trace fines, predominantly fine gravel, fine to coarse sand (f:m:c = 40:40:20)
13							Total Depth = 31.5 feet (N. 2413.173, E. 4135.229)
45 / 14							NOTES: 1. 36-in. long Shelby tubes were pushed 30 in. only. 2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 6B-8 and remaining samples. 3. Shallow and deep groundwater encountered at 5.0 and 40.0 feet, respectively, during drilling. 4. Refer to compilation of laboratory test data by Geosyntec consultants, Inc., for soil test information.
15 / 50							

Completion Detail



Drilling Company:	**Major Drilling Environmental, LLC**	Date Started:	**3/5/12**
Drilling Method:	**Mud Rotary**	Date Ended:	**3/5/12**
Logged By:	**David Lamadrid**	Boring Diameter:	**5.0"**
Sampling Method:	**See legend for explanation of sample types**	Elevation:	**124.5 ft.**
		Total Depth:	**41.5 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-07

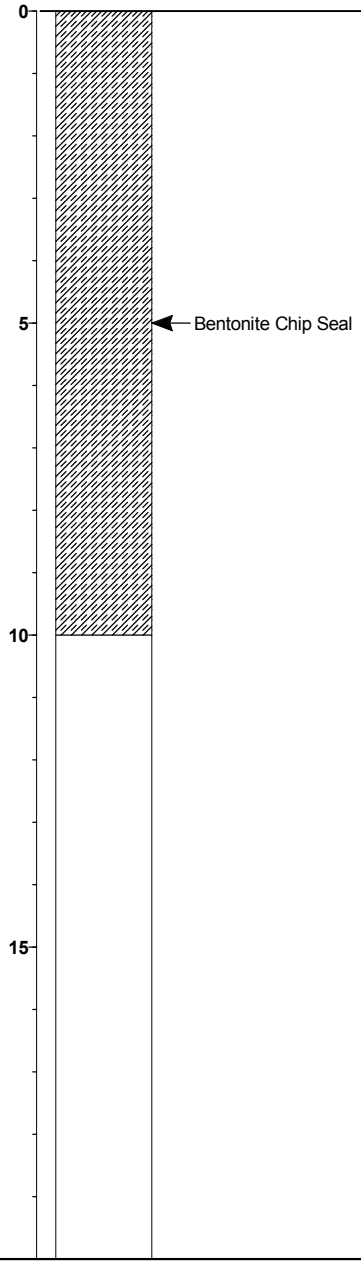
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0					FILL		Surface: gravel fill
1		7-1	---		CL		**ALLUVIUM** SILTY CLAY (CL), yellowish brown, very moist
5		7-2	---		CL		Grades to very moist to wet
10							Total Depth = 10.0 feet (Northing 3700.361, Easting 3967.166) NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc. for soil test information.

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/6/12**
Date Ended: **3/6/12**
Boring Diameter: **8.0"**

Elevation: **149.9 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-08

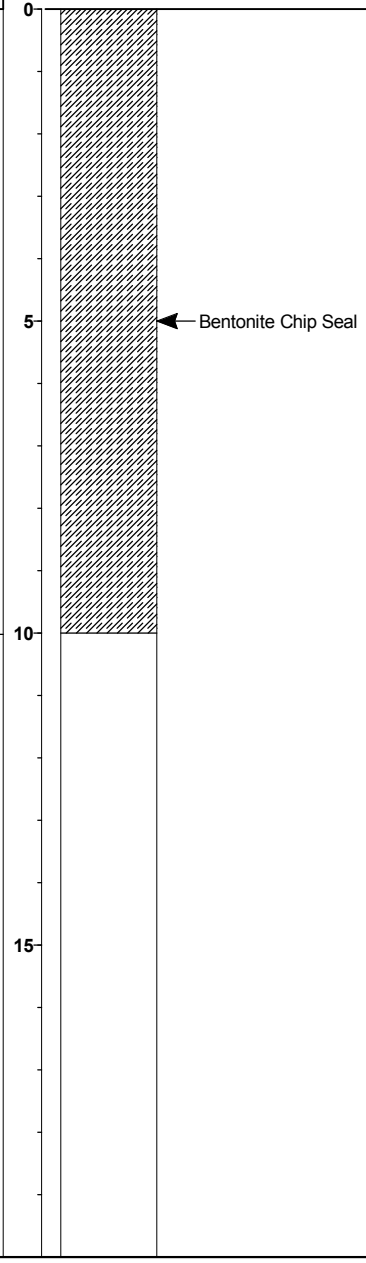
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0					FILL		Surface: gravel fill
	1		8-1	---		CL		**ALLUVIUM** SILTY CLAY (CL), grayish brown, very moist
	2							
	3							
1								
	4							Becomes very moist to wet
	5		8-2	---		CL		
	6							
2								
	7							
	8							
	9							
3	10							Total Depth = 10.0 feet (Northing 3300.262, Easting 3956.582)
	11							
	12							NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
4	13							
	14							
	15							
5	16							
	17							
	18							
	19							
6	20							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/6/12**
Date Ended: **3/6/12**
Boring Diameter: **8.0"**

Elevation: **149.2 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-09

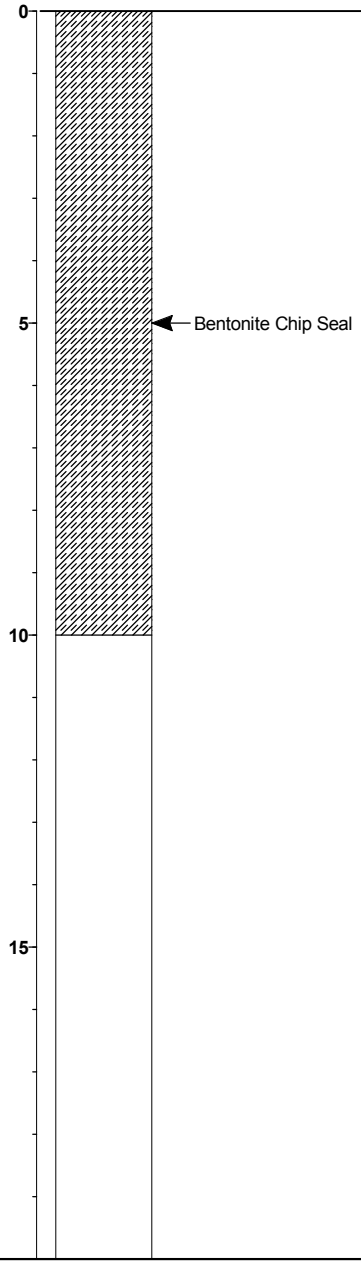
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0					FILL		Surface: gravel fill
2		9-1	---		ML		**ALLUVIUM** CLAYEY SILT (ML), yellowish brown, moist
5		9-2	---		ML		
							Grades to very moist to wet
10							Total Depth = 10.0 feet (Northing 3049.643, Easting 3999.323) NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/6/12**
Date Ended: **3/6/12**
Boring Diameter: **8.0"**

Elevation: **148.8 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-10

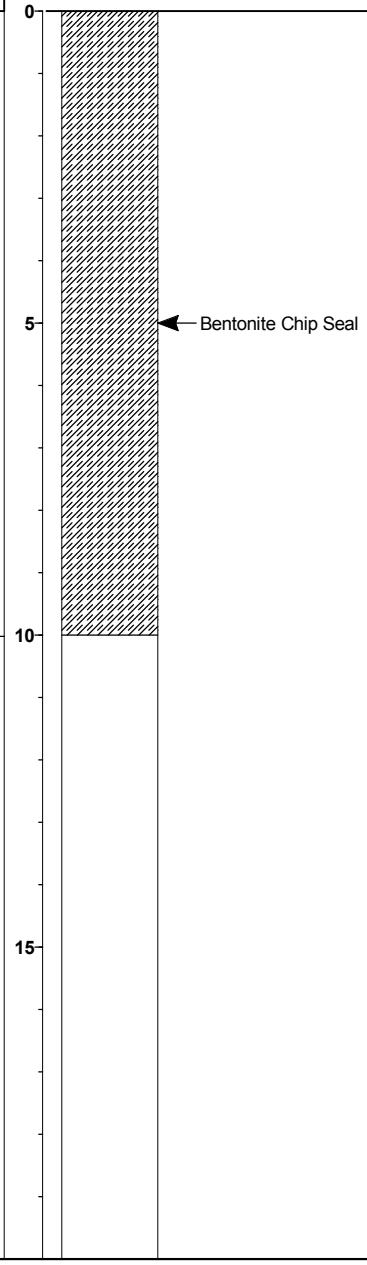
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0					FILL		Surface: gravel fill
	1		10-1	---		CL		**FILL** SILTY CLAY (CL), greenish gray, moist, apparent fill soil
	2							
	3							
1	4							
	5		10-2	---		CL		
	6							
2	7							At approximately 7.0 feet, minor plastics and organics in fill soil
	8							
	9							
3	10							Total Depth = 10.0 feet (Northing 2964.379, Easting 4106.519)
	11							
	12							NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
4	13							
	14							
	15							
5	16							
	17							
	18							
	19							
6	20							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/6/12**
Date Ended: **3/6/12**
Boring Diameter: **8.0"**

Elevation: **148.3 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-11

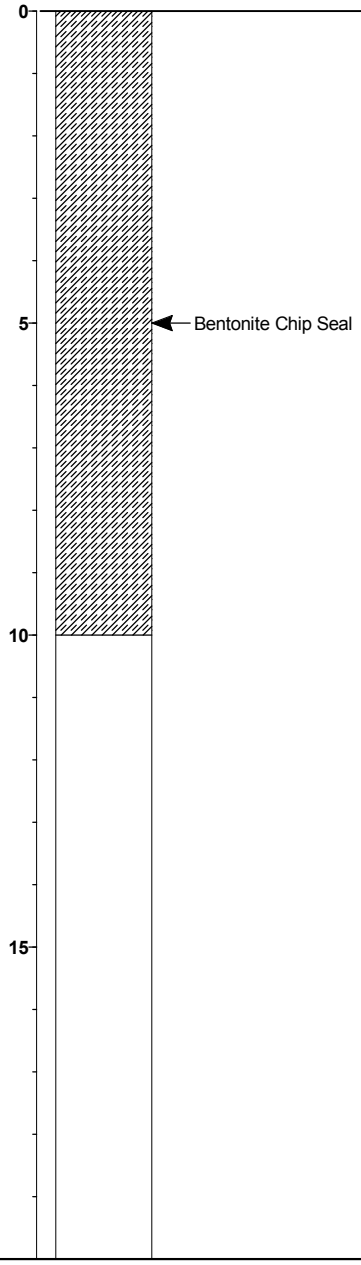
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0		11-1	---				Surface: Grass
	1					CL		**FILL** SILTY CLAY (CL), gray-brown, moist
	2					CL/ML		SILTY CLAY / CLAYEY SILT (CL/ML), greenish gray, moist, apparent fill soil
1	3							
	4							
	5		11-2	---		CL/ML		Grades to very moist
2	6							
	7							
	8							
	9							Plastic debris encountered in fill soil near bottom of borehole
3	10							Total Depth = 10.0 feet (Northing 2846.369, Easting 4129.031)
	11							
	12							NOTES: 1. Groundwater not encountered during drilling.
4	13							2. Refer to compilation of laboratory test data by Geosyntec, Inc., for soil test information.
	14							
	15							
5	16							
	17							
	18							
	19							
6	20							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/6/12**
Date Ended: **3/6/12**
Boring Diameter: **8.0"**

Elevation: **148.0 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-12

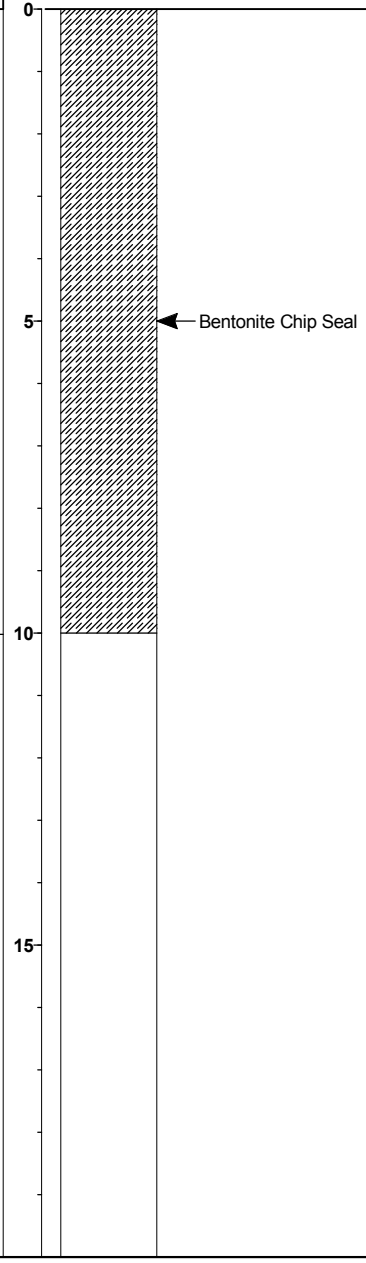
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0					FILL		Surface: gravel fill
	2		12-1	---		CL		**ALLUVIUM** SILTY CLAY (CL), light bronw, very moist
1	5		12-2	---		CL		
2	6							Grades to very moist to wet
3	10							Total Depth = 10.0 feet (Northing 2710.683, Easting 3994.257) NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
4	13							
5	15							
6	20							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/2/12**
Date Ended: **3/2/12**
Boring Diameter: **8.0"**

Elevation: **143.1 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-13

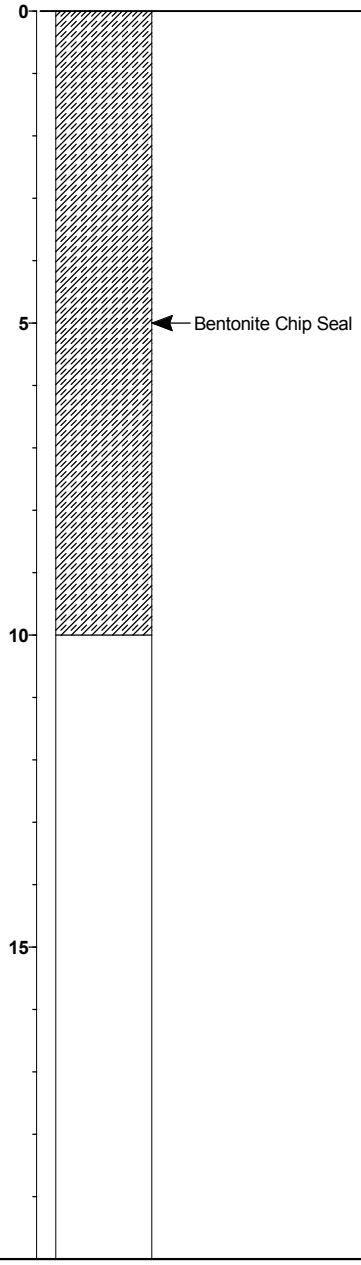
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0					FILL		Surface: gravel fill
	1		13-1	---		CH		**ALLUVIUM** SILTY CLAY (CL), brown, moist, high plasticity
1	2							
	3							
	4							
	5		13-2	---		CL		Grades to very moist, medium to high plasticity
2	6							
	7							
	8							
	9							
3	10							Total Depth = 10.0 feet (Northing 2624.516, Easting 4128.381)
	11							
	12							NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
4	13							
	14							
	15							
5	16							
	17							
	18							
	19							
6	20							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/2/12**
Date Ended: **3/2/12**
Boring Diameter: **8.0"**

Elevation: **141.6 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

APPENDIX B

Production Well PW-1 Documentation

WATER WELL REPORT
STATE OF OREGON

YAMH
7319

RECEIVED
OCT 13 1981
WATER RESOURCES DEPT.
SALEM, OREGON

State Well No. 5S/5W-1
State Permit No.

(1) OWNER:
Name River Bend Landfill Co
Address Po Box 509
City McMinnville State Ore

(2) TYPE OF WORK (check):
New Well ☑ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Air ☐ Driven ☐
Rotary Mud ☐ Dug ☐
Cable ☑ Bored ☐

(4) PROPOSED USE (check):
Domestic ☑ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐
Thermal: Withdrawal ☐ Reinjection ☐

(5) CASING INSTALLED: Steel ☑ Threaded ☐ Plastic ☐ Welded ☐
6" Diam. from 0 ft. to 77 ft. Gauge 250
" Diam. from ft. to ft. Gauge

LINER INSTALLED:
4" Diam. from 55 ft. to 97 ft. Gauge 160#

(6) PERFORATIONS: Perforated? ☑ Yes ☐ No
Type of perforator used Torch + Saw
Size of perforations 1/4 in. by 6 in.
120 perforations from 57 ft. to 97 ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☐ Yes ☑ No
Manufacturer's Name
Type Model No.
Diam. Slot Size Set from ft. to ft.
Diam. Slot Size Set from ft. to ft.

(8) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☑ No If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
Air test gal./min. with drill stem at ft. hrs.
Bailer test 30 gal./min. with 50 ft. drawdown after 2 hrs.
Artesian flow g.p.m.
Temperature of water Depth artesian flow encountered ft.

(9) CONSTRUCTION: Special standards: Yes ☐ No ☑
Well seal—Material used Cement grout
Well sealed from land surface to 20 ft.
Diameter of well bore to bottom of seal 11 in.
Diameter of well bore below seal 11 in.
Number of sacks of cement used in well seal 7 sacks
How was cement grout placed? Pumped
Was pump installed? no Type HP Depth ft.
Was a drive shoe used? ☐ Yes ☑ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☐ No
Type of Water? depth of strata
Method of sealing strata off
Was well gravel packed? ☑ Yes ☐ No Size of gravel: 3/8
Gravel placed from 20 ft. to 77 ft.

(10) LOCATION OF WELL:
County Yamhill Driller's well number 712.
¼ ¼ Section 1 T. 5S R. 5W W.M.
Tax Lot # Lot Blk Subdivision
Address at well location:

(11) WATER LEVEL: Completed well.
Depth at which water was first found 45 ft.
Static level 25 ft. below land surface. Date 10-9-81
Artesian pressure lbs. per square inch. Date

(12) WELL LOG: Diameter of well below casing 6
Depth drilled 97 ft. Depth of completed well 97 ft.
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Top Soil	0	1	
Brown Clay	1	15	
Blue Clay	15	40	
Cemented gravel	40	60	
Blue Clay	60	65	
Cemented gravel	65	77	
Blue Clay	77	97	

Work started 10-7 19 81 Completed 10-9 19 81
Date well drilling machine moved off of well 10-9 19 81

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] [illegible] (Drilling Machine Operator) Date 10-9 19 81
Drilling Machine Operator's License No. 1273

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name BLUE WATER DRILLING CO (Person, firm or corporation) (Type or print)
Address R1 Box 75 Dayton Ore
[Signed] Robert Schelburne (Water Well Contractor)
Contractor's License No. 417 Date 10-9, 19 81

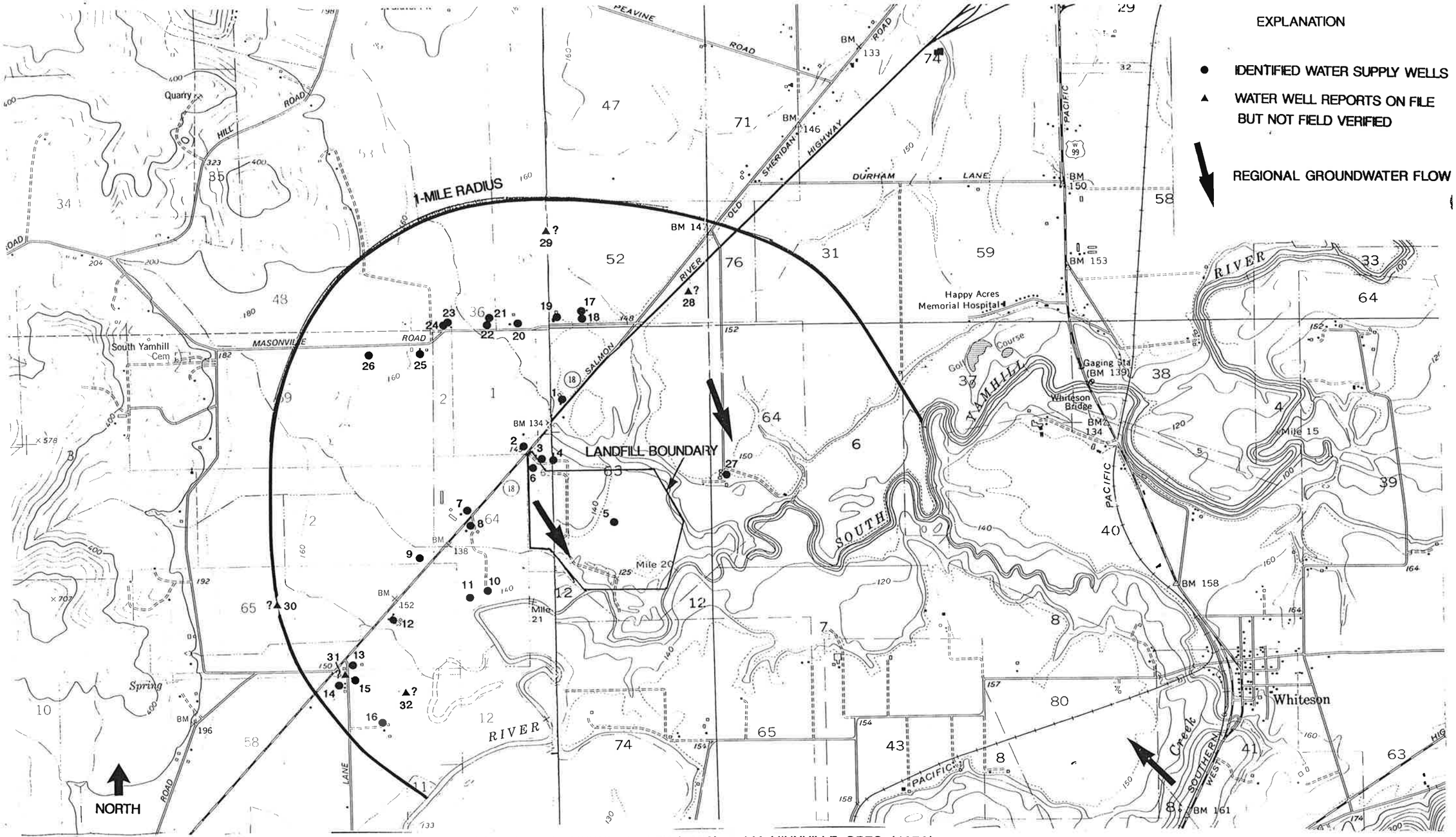
NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report [illegible] with the
WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310
within 30 days from the date of well completion

SP*12658-690

Table H-2-1a

Riverbend Landfill
Summary of Water Supply Well Information

EMCON Well No.	Oregon Water Resources Division Well No.	Owner/Tenant	Location of Well [a]	Land Surface Elevation [b] (feet; MSL [c])	Depth (feet; bgs [d])	Date Well Completed	Drilling Company	Well Construction Detail	Geologic Unit Screened	Use	Status	Water Level Measurements With Date	Other
1	NA [e]	Loulou Gregory	13130 SW Hwy. 18 McMinnville, OR	150	39	NA	NA	NA	NA	Domestic & Garden	Active	15.4 ft 06/29/93	Appears to be a hand-dug well
2	NA	Judee Ward	13450 SW Hwy. 18 McMinnville, OR	150	79	Since 1981	NA	NA	NA	Domestic	Active	15 ft 06/29/93	Tenant uses bottled drinking water. (Modern drilled well.)
3 [f]	NA	Mike Bernard	13465 SW Hwy. 18	150	100	1980s	Bluewater Drilling Co.	Casing: 0 to 100 ft Surface Seal: 0 to 20 ft Perforations: 50 to 100 ft Liner: 60 to 100 ft Gravel Pack: 20 to 65 ft	Clay and gravel	Domestic & Stock	Backup	NA	Owner reports constructed similar to their other well (see EMCON #4).
4	NA	Mike Bernard	13465 SW Hwy. 18	150	100	04/26/81	Bluewater Drilling Co.	Casing: 0 to 100 ft Surface Seal: 0 to 20 ft Perforations: 50 to 100 ft Liner: 60 to 100 ft Gravel Pack: 20 to 65 ft	Clay and gravel	Domestic & Stock	Active	NA	Also supplies water to 13445 SW Hwy 18.
5	5S/5W-1	Marvin Bernard (leased to Riverbend Landfill)	13469 SW Hwy. 18 McMinnville, OR	150	420	NA	Stephen Schneider (Abandonment)	NA	NA	Industrial	Decommissioned	40 ft 07/20/89	Abandonment log available
6	NA	Marvin Bernard (leased to Riverbend Landfill)	13469 SW Hwy. 18 McMinnville, OR	150	97	10/09/81	Bluewater Drilling Co.	Casing: 0 to 97 ft Surface Seal: 0 to 20 ft Perforations: 57 to 97 ft Liner: 55 to 97 ft Gravel Pack: 20 to 77 ft	Clay, gravels	Industrial	Active	25 ft 10/09/81	Near MW-1 monitoring well cluster
7	4S/4W-1	Tom Schmidt (formerly owned by Eugene Schmidt)	13940 SW Hwy. 18 McMinnville, OR	150	97	07/21/65	John Meeker Well Drilling	Casing: 0 to 95.5 ft Surface Seal: 0 to 20 ft Perforations: 35 to 55 ft 35 to 95 ft	Clay, clay with gravel; Sandy clayey gravel	Domestic	Active	15 ft 07/21/65	40 gpm [g] with 22 feet drawdown



Base Map From: USGS 7.5' quads. MUDDY VALLEY (1979) and McMINNVILLE, OREG. (1970)

EMCON Northwest, Inc.

Site
OREGON

0 2000 4000
Scale in Feet

DATE 4/93
DWN. CDF
APPR.
REVIS.
PROJECT NO. 0258001.24

Figure H-2-1
RIVERBEND LANDFILL
BENEFICIAL USE SURVEY
WATER WELL LOCATION MAP

ATTACHMENT 5

Geomorphic Analysis Memorandum
(Prepared by Waterways Consulting, Inc.)

TECHNICAL MEMORANDUM

To: Shane Latimer, Latimer Environmental, LLC.

From: John Dvorsky, Waterways Consulting, Inc.

Date: March 16, 2015

Re: Riverbend Landfill Geomorphic Analysis

Overview

Riverbend Landfill Co. (RLC), located in Yamhill County, Oregon (Figures 1 and 2), has proposed several projects at Riverbend Landfill including expansion of the landfill to the south, a floodplain enhancement project on land owned by RLC that abuts the South Yamhill River (South Yamhill), and stream and wetland restoration on a tributary to the South Yamhill. To support this effort Waterways Consulting, Inc. (Waterways) conducted an evaluation of geomorphic conditions of the South Yamhill in the vicinity of the project. The analysis included a geomorphic evaluation of the site, use of aerial photos to map changes in channel planform over time, and a general description of the form and function of the South Yamhill. This brief technical memorandum summarizes the results of the analysis and provides design approach recommendations for the channel-floodplain improvement elements.

Geomorphic Setting

The South Yamhill is a low gradient, meandering river that drains the east side of the Oregon Coast Range. The primary geomorphic influence on the form and function of the South Yamhill are the deep, fine grained sediments deposited by the Missoula Floods during the Pleistocene (Figure 3). Much of the Yamhill Valley was periodically inundated in the backwater of the Columbia River-derived Missoula Floods, which are known to have occurred many times over the last two million years. Following the passing of each flood, reincision of the unconsolidated, fine-grained deposits resulted in a moderately incised, meandering channel planform that was quickly recolonized by riparian vegetation. As this process repeated itself over the last two million years, a mosaic of terraces, oxbows, and floodplain channels formed, overlain by thin alluvial layers deposited by the South Yamhill. Consequently, alluvial features present along the modern Yamhill River consist of a combination of landforms that were generated in response to the Missoula Floods and those that were generated directly by the South Yamhill and its tributaries.

Geomorphic Evaluation

Due to soil characteristics, the lack of a significant supply of coarse bedload, and the natural density of vegetation lining the banks, the current planform of the South Yamhill, within the project area, has not changed significantly[1] from what it was historically. This hypothesis is supported by radiocarbon dating of a Native American archaeological site on a flood terrace within the project area that dates back to approximately 3,000 years before present[2]. This evidence suggests that the South Yamhill has not reworked these terrace features for at least the last 3,000 years.

To further test this hypothesis, an analysis of channel planform in the project area was conducted using historic aerial photos dating back to 1936 and extending to 2005 (Figures 4 and 5). Although 69 years of data does not definitively describe long-term changes to the form and function of the South Yamhill, it does provide an opportunity to evaluate changes to channel form during a period of rapid changes to adjacent land uses, and the watershed as a whole, and provides a sufficient amount of time to estimate rates of channel migration.

To roughly evaluate the rate of change of the local planform of the South Yamhill, five meander bends were assessed using the vegetated bank lines digitized from the georeferenced aerial photos from 1936, 1966, and 2005. The measured rates of channel migration ranged from 3.9 feet per year to 1.5 feet per year with a mean of 2.2 feet per year (see Figures 4 and 5). Although it was not analyzed quantitatively, a qualitative/observational evaluation suggested that the observed rates of bank erosion were associated with meander bend migration and/or translocation through a process of inner bend accretion and outer bend erosion, rather than wholesale widening of the channel.

The results of the analysis suggest that the planform of the South Yamhill has been fairly static over the past 69 years and rates of bank erosion are low, despite the degree of change that has occurred in the watershed. Much of the watershed has converted from natural land cover types to land uses dominated by agriculture, industrial forestry, and suburban and rural development.

---

[1] Several sections of the Yamhill have been straightened in the past century to accommodate anthropogenic activities on existing floodplain terraces. The associated meander cut-off was due to direct human action and not a result of a natural avulsion event.

[2] Radiocarbon dating of the archaeological site within the project area was conducted by ICF Jones & Stokes in 2009. Although a report was prepared, the information and the location of the site can not be shared with the public to protect the documented artifacts.

The primary effect of land use changes appears to have been to the profile stability of the South Yamhill, rather than the lateral stability. The primary result of impacts to profile stability has been increased rates of channel incision along the mainstem of the South Yamhill. Channel incision has been observed along many mainstem river systems draining the east side of the Oregon Coast Range including the Tualatin River, Chehalem, Luckiamute, Mary's River and others. The causes of channel incision vary but are primarily the result of changes to the downstream base level (e.g. – incised mainstem rivers downstream), changes to the hydrology (e.g. – higher peak flows, increased flashiness), direct channel modifications (e.g. – straightening, filling of floodplain channels, etc), and construction of levees along the top of bank.

Incision impacts channel function by reducing the frequency at which flows access the floodplain, thereby disconnecting the main channel from its floodplain and degrading the value of the floodplain. Incision can also result in further incision due to increases in shear stress on the bed of the channel as flow depths increase, creating a positive feedback loop that can eventually lead to bank erosion and channel widening. This process is more pronounced where the bank material is composed of sand or other coarser, unconsolidated sediments. But in all cases, channel incision has a direct impact on channel-floodplain interactions, degrades the value of the floodplain, and can eventually lead to bank erosion and channel widening.

Although land use impacts have led to moderate rates of channel incision on the South Yamhill in the recent past, it is unlikely that the channel will continue to incise. Because channel incision can have a significant impact on existing infrastructure, such as diversion structures, culverts, and bridges, efforts to arrest the incision (e.g. – grade control at bridges) occur over time to lessen the impact. The effect is a new base level for the river and a more stable channel profile. Where bank material is composed primarily of unconsolidated sediment (e.g. – sand, gravel, and cobble) or where bank vegetation has been removed, an incised channel with stable bed profiles often begin to migrate laterally. In the case of the South Yamhill in the vicinity of the project, moderate incision of the channel has not led to lateral instability because the bank material is comprised of cohesive sediments and a healthy riparian corridor has been maintained along the margins of the channel.

Design Approach Recommendations

In situations where channel-floodplain interactions have been impacted by channel incision, two potential enhancement approaches can be pursued. One approach involves measures to re-aggrade the channel, thereby forcing the bed of the channel back up to where there is a more frequent hydrologic connection with the floodplain. The techniques to accomplish this vary considerably from site to site but can include channel-spanning grade control structures, reducing the slope of the channel by forcing a more sinuous meander pattern, or other

measures to increase channel roughness. A major constraint associated with this approach is the fact that increases in the elevation of the channel bed are often accompanied by increases in flood elevations. In many cases, increases in flood elevations are not tolerated due to impacts to adjacent properties and infrastructure as well as upstream effects associated with backwatering at high flows.

An alternative approach to improving channel-floodplain interactions is to lower the elevation of the floodplain. This involves mass excavation of terrace deposits and is often accompanied by creation of lower terraces that flood more frequently, integration of floodplain wetland features, installation of habitat elements such as large wood, and a vigorous program of native revegetation. The specific approach taken at each site needs to consider the hydrology to define the proposed bench elevations, soil conditions to minimize erosion of the bench prior to vegetation establishment, upstream and downstream effects, and the potential impacts that localized changes in cross-section geometry and channel-floodplain dynamics might have on sediment transport continuity through the system. One of the primary constraints on using this approach to improve channel-floodplain dynamics is the cost associated with implementation. For the project to be effective it often requires that a large amount of material is removed from the disconnected floodplain terrace. In many cases the removed material needs to be hauled off site and a disposal site identified.

Given the conditions at the Riverbend site, forced aggradation of the South Yamhill is not a feasible option. Raising flood elevations would significantly impact adjacent and upstream farmland and common techniques used to aggrade streambeds are not practical for a river the size of the South Yamhill. Consequently, the preferred approach to improving channel-floodplain interactions is to lower adjacent terrace and floodplain elevations closer to the river elevation. To minimize potential impacts to sediment transport continuity along the South Yamhill, improvements to channel-floodplain interactions could best be achieved by mimicking a backwater/alcove landform rather than through direct benching. This approach also addresses bank erosion concerns by maintaining a buffer between the lowered floodplain/alcove and the main channel and protects existing mature riparian vegetation within that buffer.

Summary

The reach of the South Fork Yamhill River within the vicinity of Riverbend Landfill is characterized by a stable planform that has not moved appreciably from its current alignment for at least the past 70 years. Although the river does meander across the valley bottom, the current meandering planform is a result of Pleistocene-era flood events rather than modern geomorphic processes. The cohesive nature of the bank material, densely vegetated banks and floodplains, a lack of significant coarse bedload movement through the system, and low

velocity conditions during high flow event limits episodic changes in the channel planform. Similarly, the risk of a massive realignment of the channel, such as an avulsion, does not exist. Consequently, there is limited risk to the existing landfill and the proposed landfill expansion associated with meander bend migration or avulsion of the South Fork Yamhill River.

John Dvorsky, M.S.
Principal Scientist
Waterways Consulting, Inc.

John Dvorsky, MS, has sixteen years of experience in geomorphology, hydrology, and fisheries biology and specializes in watershed and stream restoration planning, site-specific project plan implementation, geomorphic and hydrologic assessments and coordination with state and federal resource and regulatory agencies. He has managed watershed assessments, salmonid enhancement planning projects, multidisciplinary monitoring programs, sediment source analyses, and reach-scale hydrologic and geomorphic assessments. His educational background, training, and "big-picture" understanding of both the biological and physical components of a project, allow him to synthesize the available information and make quality resource management decisions. Mr. Dvorsky works closely with Waterways engineers to make sure current geomorphic, hydrologic, and ecological principles are being integrated into ecological restoration design projects.

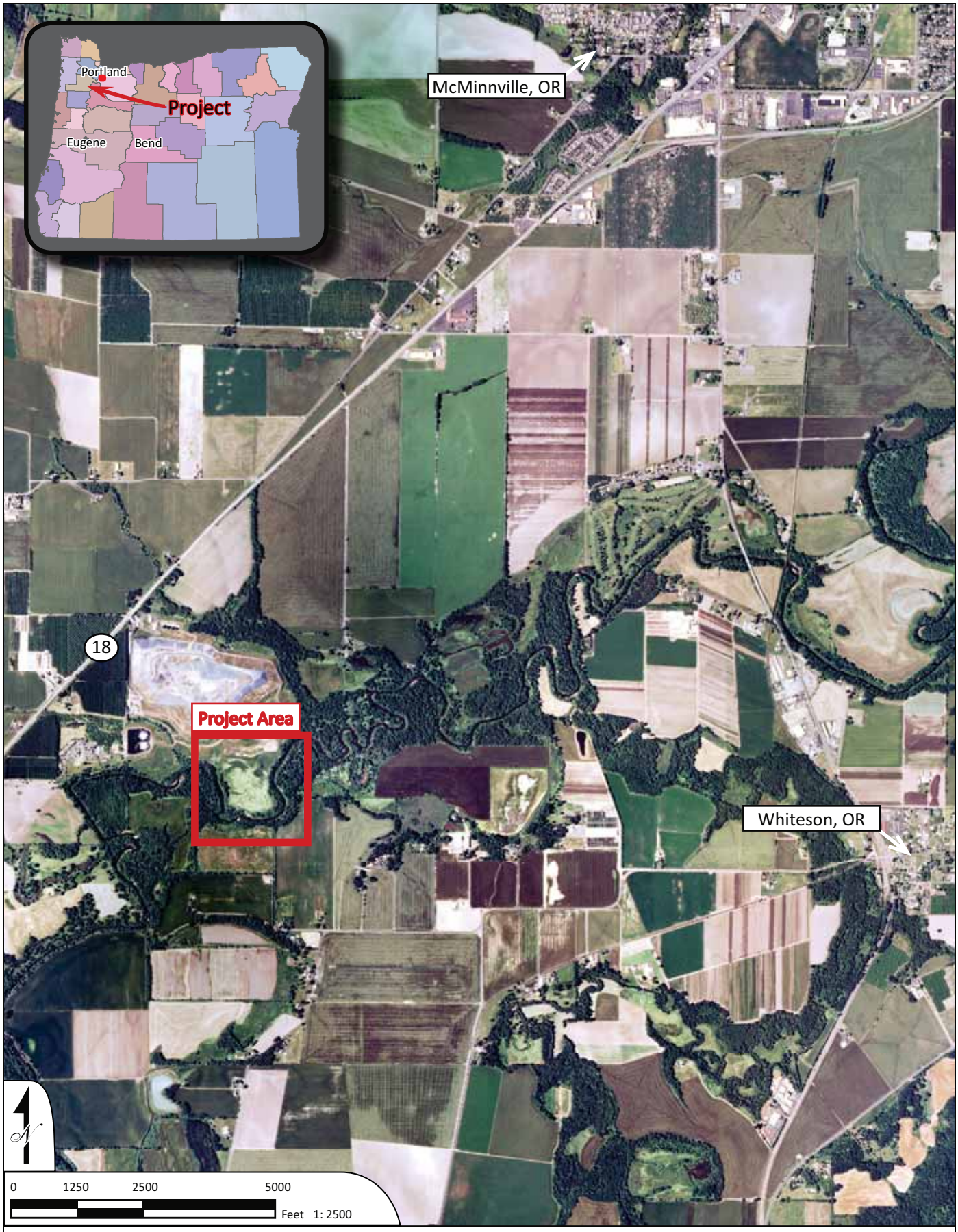


FIGURE 1

Project location for the Riverbend Landfill floodplain enhancement project on the South Yamhill River. The project is located south of McMinnville, Oregon.

WATERWAYS CONSULTING, INC.

Santa Cruz, CA | watways.com | Portland, OR

FIGURE 2

Existing project site conditions on the South Yamhill River. The project site is southeast of the existing landfill operation on Salmon River Highway 18.

WATERWAYS CONSULTING, INC.

Santa Cruz, CA | watways.com | Portland, OR

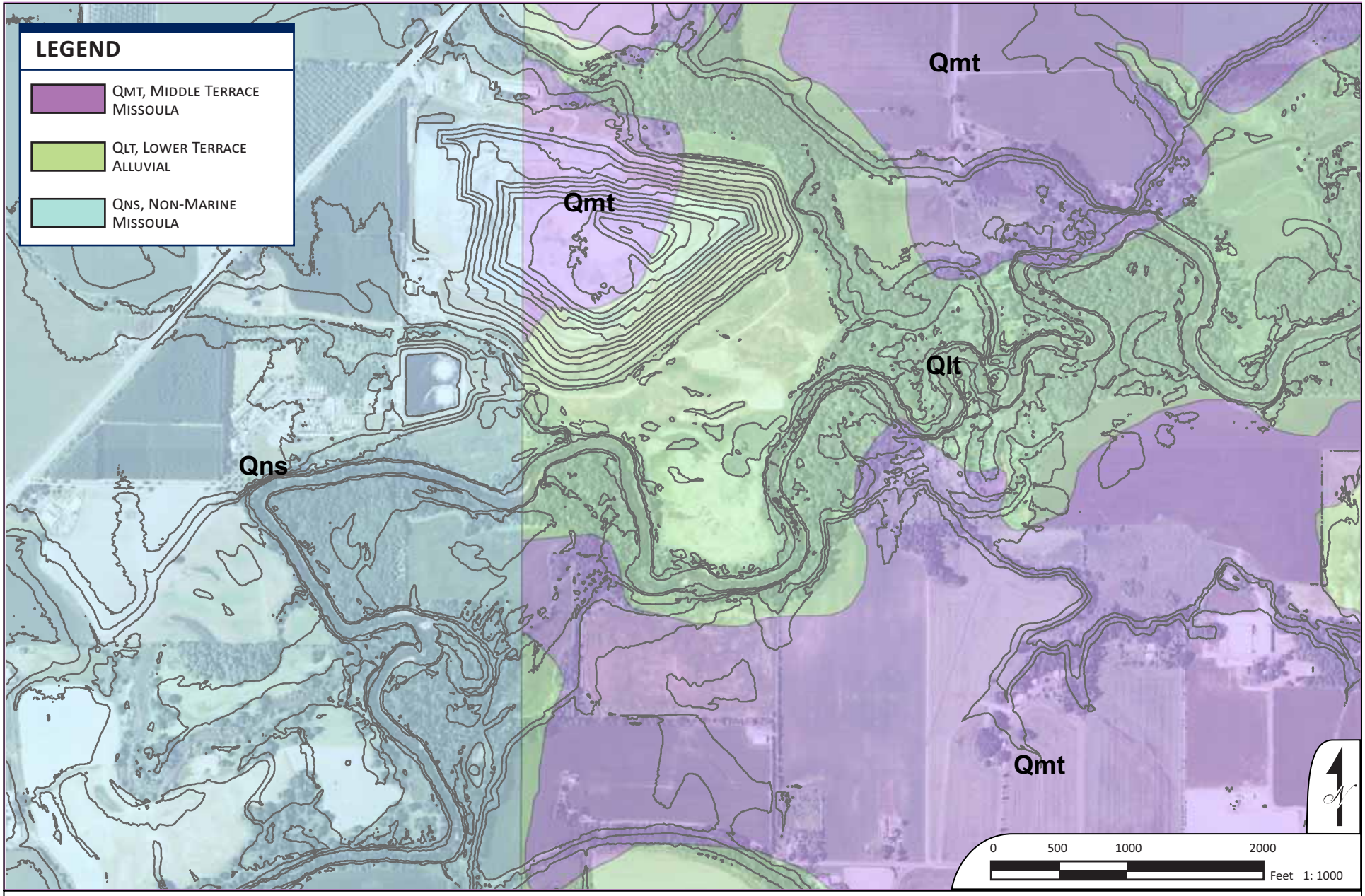
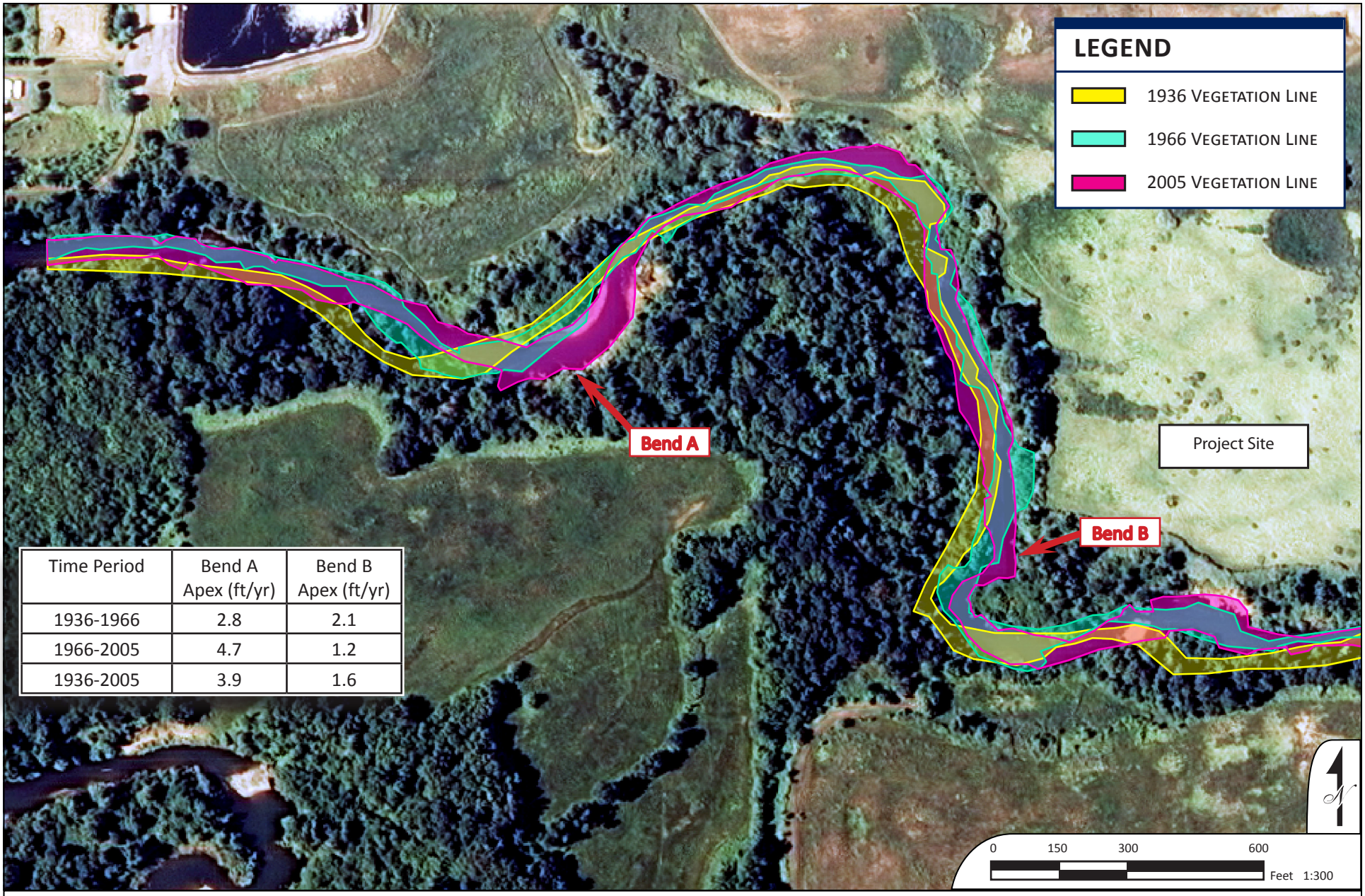


FIGURE 3

Geologic map in project vicinity with 10-foot contour lines, and aerial in background.
Geology map source: DOGAMI, 2012; Original source is from two mapping products.

WATERWAYS CONSULTING, INC.

Santa Cruz, CA | watways.com | Portland, OR



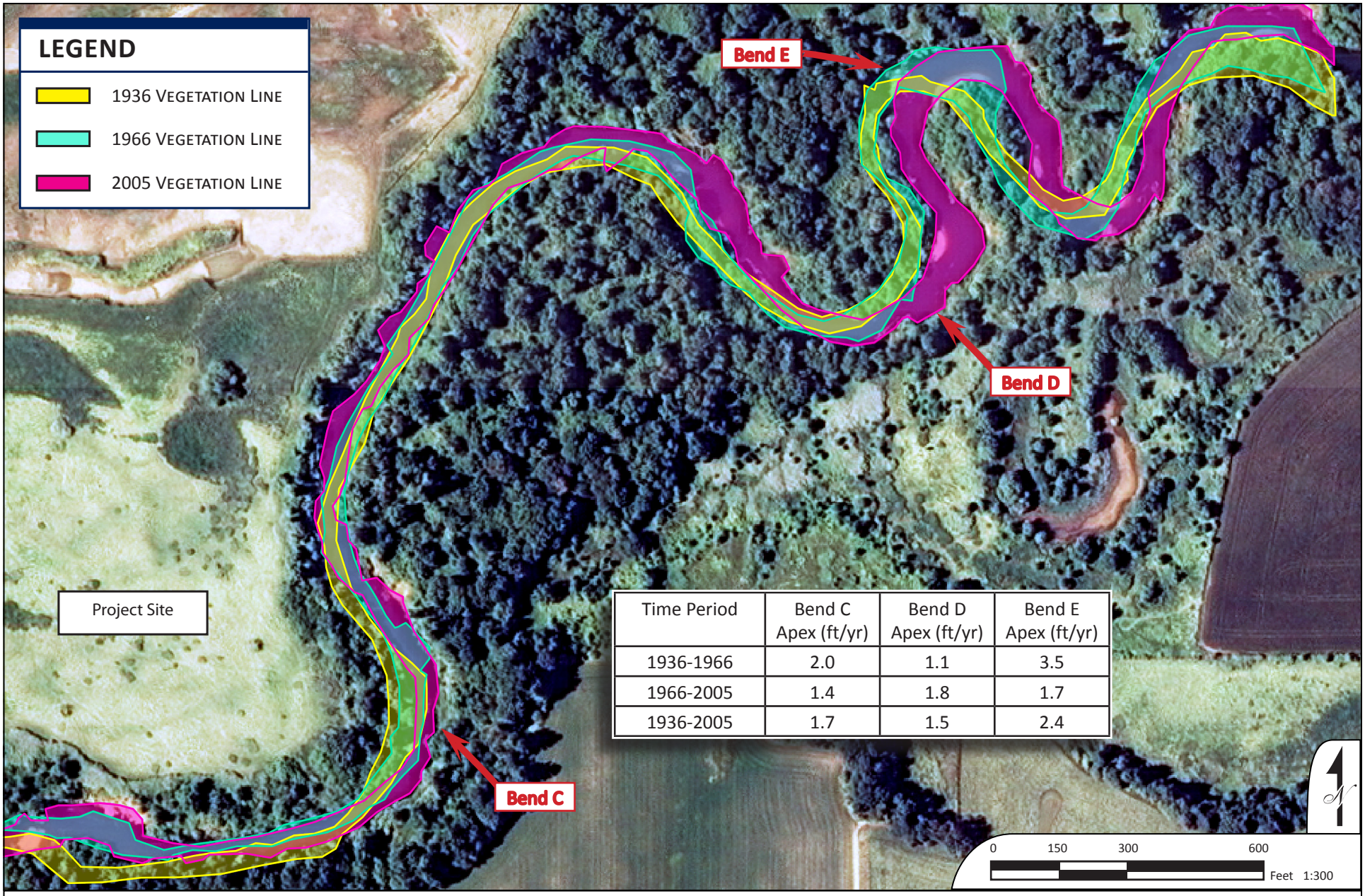
Time Period	Bend A Apex (ft/yr)	Bend B Apex (ft/yr)
1936-1966	2.8	2.1
1966-2005	4.7	1.2
1936-2005	3.9	1.6

FIGURE 4

Map depicting movement in vegetation line on the S. Yamhill River over time from historic aerial photograph analysis, shown overlaid on 2005 aerial with table of movement rates (ft/yr) at outside bends.

WATERWAYS CONSULTING, INC.

Santa Cruz, CA | watways.com | Portland, OR



Time Period	Bend C Apex (ft/yr)	Bend D Apex (ft/yr)	Bend E Apex (ft/yr)
1936-1966	2.0	1.1	3.5
1966-2005	1.4	1.8	1.7
1936-2005	1.7	1.5	2.4

FIGURE 5

Map depicting movement in vegetation line on the S. Yamhill River over time from historic aerial photograph analysis, shown overlaid on 2005 aerial with table of movement rates (ft/yr) at outside bends.

WATERWAYS CONSULTING, INC.

Santa Cruz, CA | watways.com | Portland, OR

ATTACHMENT 6

Module 11: Summary of Field Investigation and Laboratory Testing
(Prepared by Geosyntec Consultants)

Prepared for

Riverbend Landfill Company
13469 SW Highway 18
McMinnville, Oregon 97128

MODULE 11: SUMMARY OF FIELD INVESTIGATION AND LABORATORY TESTING PROGRAMS

RIVERBEND LANDFILL

Prepared by

Geosyntec consultants

engineers | scientists | innovators

1111 Broadway, 6th Floor
Oakland, California 94607

Project Number: WG1866

17 March 2015, Revised 22 April 2015

Module 11: Summary of Field Investigation and Laboratory Testing Programs

Riverbend Landfill

Prepared by

Geosyntec Consultants, Inc.
1111 Broadway, 6th Floor
Oakland, California 94607

Project Number: WG1866
17 March 2015, Revised 22 April 2015

Geosyntec consultants

TABLE OF CONTENTS

1. INTRODUCTION 1

2. FIELD INVESTIGATIONS 1

3. GEOTECHNICAL LABORATORY TESTING 4

4. GENERAL STRATIGRAPHY AND SUMMARY OF TEST RESULTS AND PRELIMINARY FINDINGS 5

5. ADDITIONAL FIELD INVESTIGATION: CPTS 5

LIST OF TABLES

Table 1: Summary of Laboratory Test Results: Module 11

LIST OF FIGURES

Figure 1: Module 11: Existing Boreholes and Proposed CPTs Location Plan

Figure 2: Soil Strength Profile: Module 11 Borings

LIST OF APPENDICES

Appendix A: 2010 Boring Logs

Appendix B: 2010 Energy Measurement

Appendix C: 2011 Boring Logs

Appendix D: 2011 Energy Measurement

Appendix E: 2012 Boring Logs

Appendix F: 2012 Energy Measurement

Appendix G: 2013 Boring Logs

Appendix H: 2013 Energy Measurement

Appendix I: 2014 Boring Logs

Appendix J: 2014 Energy Measurement

Appendix K: MASW Surveys

1. INTRODUCTION

Geosyntec Consultants, Inc. (Geosyntec) has prepared this summary of the geotechnical field investigation and laboratory testing programs at the Riverbend Landfill (Landfill) located in McMinnville, Oregon for Module 11 located to the West of the existing landfill. The Landfill is owned and operated by Riverbend Landfill Company (RLC).

Geotechnical field investigations applicable to the Module 11 area were conducted in 2010, 2011, 2012, 2013, and 2014. The purpose of these field investigations and tests was to characterize the subsurface soils with depth and to evaluate their engineering properties (i.e., grain size, Atterberg limits, dry density, moisture content, strength, and consolidation).

Based on review comments received from the Oregon Department of Environmental Quality (ODEQ), a supplemental field investigation program, using cone penetration tests (CPTs), is currently under way.

2. FIELD INVESTIGATIONS

Figure 1 shows the locations for the borings applicable to Module 11. The depth of the borings ranges between 10 feet and 99 feet below the ground surface.

Oregon-licensed drilling contractors performed the geotechnical field investigation in coordination with SCS Engineers in 2010, 2011, and 2012; and Geosyntec in 2013 and 2014. The final boring locations were surveyed by Lee MacDonald and Associates (LMA) of McMinnville, Oregon.

To evaluate subsurface conditions, the borings were drilled using mud rotary drilling or hollow-stem auger techniques. Deep holes were drilled to determine the stratigraphy with depth and the depth to firm/dense materials whereas shallower holes were drilled to determine the consistency of the deposits across the Module 11 area.

The mud rotary drilling method allows the collection of (i) high quality geotechnical samples in the clays and silts using Shelby tubes, and (ii) SPT information (using driven samples) for performing liquefaction evaluations where cohesionless layers (sands and silts) were encountered below the groundwater level.

Sampling of the clays and low- to high-plasticity silts was performed by pushing Shelby tubes or by using a Gregory Undisturbed (GUS) sampler with a Shelby tube. The Shelby tubes were 3-inch diameter, thin-walled, and 3-foot long.

Where materials were hard and the Shelby tube could not be pushed, a Modified California sampler (3-inch outside diameter, 2.5-inch inside diameter) with brass liners was driven. Each Shelby tube or bras liner was capped and labeled with the boring number and the depth interval. The end caps were taped so loss of moisture was minimal.

Sampling of the cohesionless soils such as sands and nonplastic silts was performed using the standard penetration test (SPT) sampling (ASTM D1586) without liners in the barrel. NWJ-rods were used regardless of depth. To drive the split spoon samplers, a 140-pound above-ground automatic hammer falling 30 inches was used. A 300-pound above ground slide hammer falling 30 inches was also used with a Modified California sampler with brass liners to obtain samples where gravelly soils were encountered.

The energy of the sampling setups used was measured by Robert Miner and Associates (RMA) of Manchester, Washington for the various field investigations.

The samples driven with the SPT were contained in plastic bags. The plastic bags were labeled with the boring number and the interval sampled. Sampling recovery and blowcount per 6 inches were recorded on the boring log.

Bulk soil samples were also collected at some boring locations. Bulk samples were contained in plastic buckets and labeled with their location and sampling interval.

After sample collection was finished, the drilling contractor grouted the holes as required by the Oregon regulations.

The boring logs and the energy measurement reports for the various field investigations are included in the various Appendices as listed below:

Year	Item	Appendix	Borings (See Figure 1 for Locations)
2010	Boring Logs	A	GT10-01, GT10-02, GT10-03, GT10-04, GT10-05
2010	Energy Measurement	B	Applicable to 2010 borings
2011	Boring Logs	C	GT11-01, GT11-02, GT11-03
2011	Energy Measurement	D	Applicable to 2011 borings
2012	Boring Logs	E	GT12-01A, GT12-01B, GT12-02A, GT12-02B, GT12-03A, GT12-03B, GT12-04A, GT12-04B, GT12-05A, GT12-05B, GT12-06A, GT12-06B, GT12-07, GT12-08, GT12-09, GT12-10, GT12-11, GT12-12, GT12-13
2012	Energy Measurement	F	Applicable to 2012 borings
2013	Boring Logs	G	GT13-01, GT13-02, GT13-03, GT13-04, GT13-05, GT13-06, GT13-16, GT13-17
2013	Energy Measurement	H	Applicable to 2013 borings
2014	Boring Logs	I	GT14-01, GT14-02, GT14-03, GT14-04, GT14-05, GT14-06, GT14-07, GT14-08, GT14-09, GT14-10, GT14-11, GT14-12, GT14-13, GT14-14
2014	Energy Measurement	J	Applicable to 2014 borings

Site-specific shear wave velocity surveys for the geotechnical evaluation were performed in 2012 and in 2013 by Zonge International using multichannel analysis of

surface waves (MASW) surveys. The location of the surveys is shown in Figure 1; Appendix K includes the data reports.

3. GEOTECHNICAL LABORATORY TESTING

To characterize the soils and determine their strength and deformation characteristics for permit-level design, the following geotechnical soils laboratory tests have been performed to date on samples collected during the field investigations:

- Grain Size Distribution (including Hydrometer) (ASTM D422)
- Atterberg Limits (ASTM D4318)
- Moisture Content/Dry Density (ASTM D2937)
- Consolidation (ASTM D2435)
- Unconsolidated Undrained (UU) Triaxial Tests (ASTM D2850)

The table below lists the purpose for each test type.

Laboratory Test	ASTM Designation	Purpose
Moisture Content/Dry Density	D2937	Subsurface characterization, slope stability analyses.
Grain size	D422	Subsurface characterization, liquefaction analyses.
Atterberg limits	D4318	Subsurface characterization, liquefaction analyses, consolidation settlement.
Consolidation	D2435	Consolidation settlement.
Unconsolidated Undrained Triaxial test	D2850	Strength of natural (subsurface) cohesive soils, slope stability analyses, and foundation design.

4. GENERAL STRATIGRAPHY AND SUMMARY OF TEST RESULTS AND PRELIMINARY FINDINGS

Field investigations indicated that generally, cohesive silts and clays were encountered below the ground surface to various depths underlain by sands and gravels over bedrock encountered at various depths.

Table 1 presents a summary of all laboratory test results performed on representative samples collected from the various boreholes applicable to Module 11. The laboratory test results performed to date on the cohesive soils indicate that:

- Soils are low to high plasticity silts and clays (i.e., Unified Soil Classification System (USCS) classification ML, MH, CL, and CH), the liquid limits (LL) range between 22 and 106 and the plasticity indices (PI) range between 3 and 72. The dry unit weights range between 60 and 102 pounds per cubic foot (pcf) approximately.
- Soils have an estimated compression index (C_c) ranging from 0.21 to 0.59; the void ratios (e_o) ranged between 0.65 and 1.41, and the average estimated compression ratio ($C_c/1+e_o$) of 0.18.
- Soils have an estimated recompression index (C_s) ranging from 0.03 to 0.11 and the average estimated recompression ratio ($C_s/1+e_o$) of 0.03.
- The undrained shear strength of the soils with depth is shown in Figure 2.

5. ADDITIONAL FIELD INVESTIGATION: CPTs

The Oregon Department of Environmental Quality (ODEQ) reviewed the previous version of this report entitled *Module 11: Summary of Field Investigation and Laboratory Testing Programs* prepared by Geosyntec dated 17 March 2015. The ODEQ requested that cone penetration testing be conducted at various locations across the Module 11 area to further characterize the subsurface stratigraphy across the Module 11 area.

The maximum depth of exploration of the CPTs would be to a firm and/or dense stratum, such as, the sands and gravels[1]. Accordingly, nine CPTs will be conducted for this work. Of the nine CPTs, four CPTs will collect information such as friction ratio and tip resistance which will then be interpreted, using industry-accepted methodologies; the remaining five CPTs will be seismic CPTs where shear wave velocities will also be measured. At three CPT locations pore water pressure dissipation (dissipation) tests will also be performed. At these three locations, one dissipation test will be conducted in the silt zone and the second dissipation test will be conducted in the clay zone, if encountered.

Figure 1 shows the proposed CPT locations. These locations may need to be adjusted depending on access or wetland impact issues if encountered in the field.

The purpose for each CPT is summarized in the table below:

CPT	Purpose
CPT14-01	Tip resistance, friction ratio, stratigraphy
CPT14-02	Tip resistance, friction ratio, stratigraphy
CPT14-03	Tip resistance, friction ratio, stratigraphy
CPT14-04	Tip resistance, friction ratio, stratigraphy
CPT14-05S	Tip resistance, friction ratio, stratigraphy, shear wave velocity
CPT14-06S	Tip resistance, friction ratio, stratigraphy, shear wave velocity, pore pressure dissipation
CPT14-07S	Tip resistance, friction ratio, stratigraphy, shear wave velocity
CPT14-08S	Tip resistance, friction ratio, stratigraphy, shear wave velocity, pore pressure dissipation

[1] The CPT may not be able to penetrate gravel layers; therefore, exploration will be stopped when, according to the CPT subcontractor, push pressures would damage the CPT equipment.

CPT	Purpose
CPT14-09S	Tip resistance, friction ratio, stratigraphy, shear wave velocity, pore pressure dissipation

TABLES

Table 1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	To (ft-BGS)	Average Depth (ft-BGS)	Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	Gravel Content (%)	Fines Content (%)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT11-01	152.07	66.5	5.0	6.5	5.8	146.3		40.6		CL	43.2	25.1	18.1	0.0	96.9							
GT11-01	152.07	66.5	7.5	10.0	8.8	143.3	87.5	39.7	122.2	ML	33.8	30.9	2.9			1469	Backpressure saturated	1.08				
GT11-01	152.07	66.5	12.5	14.0	13.3	138.8		40.3		ML	36.3	26.4	9.9	0.0	98.3							
GT11-01	152.07	66.5	15.0	16.5	15.8	136.3		41.0		ML	34.6	26.7	7.9	0.0	99.0							
GT11-01	152.07	66.5	20.0	22.5	21.3	130.8	87.5	34.2	117.4	ML	36.1	27.5	8.6			1566	Backpressure saturated	0.96	0.32	0.16	0.03	0.02
GT11-01	152.07	66.5	25.0	26.5	25.8	126.3		36.9		ML	36.3	25.7	10.6	0.0	99.5							
GT11-01	152.07	66.5	30.0	31.5	30.8	121.3		36.2		ML	38.4	26.0	12.4	0.0	99.4							
GT11-01	152.07	66.5	50.5	51.0	50.8	101.3				SM				26.5	37.6							
GT11-02	141.40	61.5	7.5	10.0	8.8	132.7	102.3	23.4	126.2	ML	36.2	23.8	12.4			1633	Backpressure saturated	0.65				
GT11-02	141.40	61.5	22.0	24.5	23.3	118.2	90.0	31.3	118.2	ML	47.1	30.2	16.9			2067	Backpressure saturated	0.91	0.34	0.18	0.04	0.02
GT11-02	141.40	61.5	32.5	35.0	33.8	107.7	81.7	37.9	112.7	CH	82.2	21.6	60.6					1.06	0.34	0.16	0.04	0.02
GT11-03	144.78	61.5	5.0	7.5	6.3	138.5	83.7	37.5	115.1	CH	76.4	32.3	44.1			1045	Backpressure saturated	1.01				
GT11-03	144.78	61.5	18.5	20.5	19.5	125.3	80.7	38.6	111.9	CH	70.3	30.4	39.9									
GT11-03	144.78	61.5	40.0	42.5	41.3	103.5	82.1	38.7	113.9	CH	63.0	29.8	33.2			1342	Backpressure saturated	1.05				
GT11-03	144.78	61.5	40.0	42.5	41.3	103.5	83.0	37.0	113.7	CH	60.9	29.3	31.6					1.03				
GT11-03	144.78	61.5	50.0	52.5	51.3	93.5	72.0	49.7	107.8	MH	55.1	32.6	22.5									
GT10-02	135.00	55.8	22.5	25.0	23.8	111.3	88.9	33.1	118.3	ML	42.5	30.2	12.3			1656	Backpressure saturated					
GT10-02	135.00	55.8	22.5	25.0	23.8	111.3	82.9	37.0	113.6	ML	42.5	30.2	12.3					1.11	0.47	0.22	0.05	0.02
GT10-03	130.50	60.3	17.0	20.0	18.5	112.0	70.9	47.9	104.9	CH	84.0	25.9	58.1					1.38	0.51	0.21	0.09	0.04
GT10-03	135.00	60.3	22.0	25.0	23.5	111.5				CH	56.6	25.1	31.5									
GT10-03	135.00	60.3	30.0	33.0	31.5	103.5	78.6	42.3	111.8	CL												
GT10-03	135.00	60.3	22.0	25.0	23.5	111.5	69.7	48.9	103.8	CH												
GT10-04	137.90	68.8	22.0	25.0	23.5	114.4	84.8	35.8	115.2	CL	39.8	28.2	11.6			2099	Backpressure saturated	1.02	0.35	0.17	0.07	0.03
GT10-04	137.90	68.8	37.0	40.0	38.5	99.4	80.4	39.9	112.5	CH	92.2	27.9	64.3			744	Backpressure saturated					
GT10-05	116.30	50.2	7.5	10.0	8.8	107.6	75.9	43.3	108.8	MH	64.2	28.6	35.6					1.22	0.38	0.17	0.07	0.03
GT10-05	116.30	50.2	17.5	20.0	18.8	97.6	64.2	58.2	101.6	CH	55.0	34.1	20.9									
GT10-05	116.30	50.2	17.5	20.0	18.8	97.6	59.9	63.6	98.0	CH	55.0	34.1	20.9									
GT12-01A	151.74	66.5	2.0	4.5	3.3	148.5	91.1	31.6	119.9	CL	43.0	19.2	23.8			1003	Backpressure saturated (see note Z)					
GT12-01A	151.74	66.5	2.0	4.5	3.3	148.5	92.7	28.9	119.5	CL	43.0	19.2	23.8			1545	UU (see note AA)					
GT12-01A	151.74	66.5	12.0	14.5	13.3	138.5	82.0	39.0	114.0	ML	36.7	25.1	11.6			1340	UU (see note AA)					
GT12-01A	151.74	66.5	20.0	22.5	21.3	130.5	83.8	34.6	112.8	ML	34.1	24.3	9.8					1.05	0.33	0.16	0.04	0.02
GT12-01A	151.74	66.5	25.0	27.5	26.3	125.5	87.8	34.1	117.7	CL	40.2	24.7	15.5			925	UU (see note AA)					
GT12-01A	151.74	66.5	35.0	37.5	36.3	115.5	80.8	40.0	113.1	CH	74.5	25.7	48.8			1390	UU (see note AA)					
GT12-01B	150.77	30.0	2.5	5.0	3.8	147.0	80.0	40.6	112.5	MH	52.0	30.0	22.0			1200	UU (see note AA)					
GT12-01B	150.77	30.0	7.5	10.0	8.8	142.0	82.5	38.4	114.2	ML	31.0	27.8	3.2			1341	Backpresure saturated (see note Z)					
GT12-01B	150.77	30.0	12.5	15.0	13.8	137.0	83.1	38.0	114.7	ML	39.4	28.6	10.8			1545	UU (see note AA)					

Table 1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	To (ft-BGS)	Average Depth (ft-BGS)	Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	Gravel Content (%)	Fines Content (%)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT12-02A	149.32	68.0	4.5	7.0	5.8	143.6	77.2	43.1	110.5	CL	48.4	24.6	23.8			1176	Backpresure saturated (see note Z)					
GT12-02A	149.32	68.0	4.5	7.0	5.8	143.6	78.0	42.9	111.5	CL	48.4	24.6	23.8			1160	UU (see note AA)					
GT12-02A	149.32	68.0	9.5	12.0	10.8	138.6	81.0	39.7	113.2	CL	41.2	24.9	16.3			1360	UU (see note AA)					
GT12-02A	149.32	68.0	25.0	27.5	26.3	123.1	94.5	29.0	121.9	CL	33.1	21.4	11.7			3420	UU (see note AA)					
GT12-02A	149.32	68.0	35.0	37.5	36.3	113.1	84.6	36.6	115.6	CH	71.8	24.2	47.6			2140	UU (see note AA)					
GT12-02B	148.89	30.0	2.5	5.0	3.8	145.1	81.7	39.2	113.7	CL	48.9	22.4	26.5			1250	UU (see note AA)					
GT12-02B	148.89	30.0	7.5	10.0	8.8	140.1	82.1	39.4	114.4	ML	37.5	26.7	10.8			1432	Backpresure saturated (see note Z)					
GT12-02B	148.89	30.0	12.5	15.0	13.8	135.1	82.7	38.4	114.5	ML	34.4	26.3	8.1			940	UU (see note AA)					
GT12-03A	147.77	71.5	13.5	16.0	14.8	133.0	78.6	39.5	109.6	ML	34.8	25.2	9.6					1.19	0.44	0.20	0.05	0.02
GT12-03A	147.77	71.5	20.0	22.5	21.3	126.5	81.0	39.0	112.6	CL	39.4	25.0	14.4				CU (see note DD)					
GT12-03A	147.77	71.5	20.0	22.5	21.3	126.5	84.6	36.7	115.7	CL	39.4	25.0	14.4									
GT12-03A	147.77	71.5	30.0	32.5	31.3	116.5	84.9	36.2	115.6	CL	41.4	21.6	19.8				CU (see note DD)					
GT12-03A	147.77	71.5	30.0	32.5	31.3	116.5	84.9	36.3	115.7	CL	41.4	21.6	19.8									
GT12-04A	147.36	61.5	15.0	17.5	16.3	131.1	83.4	37.2	114.4	CL	37.1	24.3	12.8					1.10	0.38	0.18	0	0.02
GT12-04A	147.36	61.5	30.0	31.5	30.8	116.6		39.8		CL	42.6	26.0	16.6	0.0	99.4						0.04	0.04
GT12-04A	147.36	61.5	35.0	37.5	36.3	111.1	86.7	33.9	116.1	CL	48.5	27.6	20.9					1.02	0.37	0.19	0.10	0.05
GT12-05A	139.06	70.3	2.5	5.0	3.8	135.3	80.2	30.5	104.7	CL	32.6	21.7	10.9			582	Backpresure saturated (see note Z)					
GT12-05A	139.06	70.3	2.5	5.0	3.8	135.3	93.7	22.7	115.0	CL	32.6	21.7	10.9			1550	UU (see note AA)					
GT12-05A	139.06	70.3	12.5	15.0	13.8	125.3	85.1	36.2	115.9	ML	37.6	30.0	7.6			1205	UU (see note AA)					
GT12-05A	139.06	70.3	22.5	25.0	23.8	115.3	83.7	37.5	115.1	ML	39.1	29.4	9.7			2130	UU (see note AA)					
GT12-05A	139.06	70.3	32.5	35.0	33.8	105.3	87.4	34.4	117.5	CH	64.5	23.1	41.4			1880	UU (see note AA)					
GT12-05B	125.91	40.4	2.5	5.0	3.8	122.2	77.3	41.7	109.5	CH	54.4	27.8	26.6			350	UU (see note AA)					
GT12-05B	125.91	40.4	7.5	10.0	8.8	117.2	91.7	30.6	119.8	CH	57.7	19.8	37.9			1038	Backpresure saturated (see note Z)					
GT12-05B	125.91	40.4	15.0	17.5	16.3	109.7	75.2	45.8	109.6	CH	70.5	24.4	46.1			1330	UU (see note AA)					
GT12-06A	140.03	67.3	17.5	19.0	18.3	121.8		34.9		CL	41.1	24.7	16.4	0.3	96.0							
GT12-06A	140.03	67.3	25.0	27.5	26.3	113.8	85.3	35.7	115.8	CL	45.3	26.5	18.8	0.0	99.8	1915	UU (see note AA)					
GT12-08	149.24	10.0	1.0	5.0	3.0	146.2				CL	47.0	25.6	21.4									
GT12-10	148.31	10.0	1.0	5.0	3.0	145.3				CL	41.1	23.2	17.9									
GT12-12	143.06	10.0	5.0	10.0	7.5	135.6				CL	39.3	23.0	16.3									
GT12-13	141.63	10.0	1.0	5.0	3.0	138.6				CH	53.2	23.2	30.0									
GT13-01	141.7	99.0	10.0	12.5	11.3	130.45	92.7	30.2	120.7	CL	40.1	25.1	15.0			1495	Backpressure saturated (see note Z)	0.82				
GT13-01	141.7	99.0	10.0	12.5	11.3	130.45	95.2	28.5	122.3	CL	40.1	25.1	15.0			2050	UU (see note AA)	0.77				
GT13-01	141.7	99.0	10.0	12.5	11.3	130.45	96.2	27.4	122.6	CL	40.1	25.1	15.0					0.79	0.21	0.12	0.03	0.02
GT13-01	141.7	99.0	20.0	22.5	21.3	120.45	95.8	28.1	122.7	CL	49.5	25.0	24.5			1860	UU (see note AA)	0.76				
GT13-01	141.7	99.0	30.0	32.5	31.3	110.45	87.9	33.9	117.7	ML	36.0	30.4	5.6			1955	UU (see note AA)	0.92				
GT13-01	141.7	99.0	30.0	32.5	31.3	110.45	85.7	35.1	115.8	ML	36.0	30.4	5.6					1.04	0.36	0.18	0.03	0.01

Table 1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	To (ft-BGS)	Average Depth (ft-BGS)	Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	Gravel Content (%)	Fines Content (%)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT13-01	141.7	99.0	40.0	41.5	40.8	100.95	88.9	33.1	118.3	CH	68.1	24.3	43.8			2315	UU (see note AA)	0.90				
GT13-01	141.7	99.0	55.0	56.5	55.8	85.95				SM				1.5	33.1							
GT13-01	141.7	99.0	70.0	71.5	70.8	70.95				SM				20.2	20.7							
GT13-02	148.3	73.5	10.0	12.5	11.3	137.1	95.0	28.1	121.7	ML	47.5	27.8	19.7				CU (see note CC)	0.84				
GT13-02	148.3	73.5	10.0	12.5	11.3	137.1	95.0	28.1	121.7	ML	47.5	27.8	19.7				CU (see note DD)	0.84				
GT13-02	148.3	73.5	10	12.5	11.25	137.05	98.0	25.9	123.4	ML	47.5	27.8	19.7					0.75	0.27	0.15	0.05	0.03
GT13-02	148.3	73.5	20	22.5	21.3	127.1																
GT13-02	148.3	73.5	30.0	32.5	31.3	117.1	88.2	30.1	114.7	CH	81.8	33.2	48.6			1480	Backpressure saturated (see note Z)	0.91				
GT13-02	148.3	73.5	30.0	32.5	31.3	117.1	83.5	37.4	114.7	CH	81.8	33.2	48.6			1865	UU (see note AA)	1.02				
GT13-02	148.3	73.5	40	42.5	41.3	107.1																
GT13-02	148.3	73.5	50	52.5	51.3	97.1																
GT13-03	145.5	72.5	15.0	17.5	16.3	129.3	97.3	27.1	123.7	CL	43.8	25.9	17.9			2250	UU (see note AA)	0.73				
GT13-03	145.5	72.5	15.0	17.5	16.3	129.3	89.0	33.4	118.7	CL	43.8	25.9	17.9					0.93	0.33	0.17	0.06	0.03
GT13-03	145.5	72.5	20	22	21.0	124.5																
GT13-03	145.5	72.5	30.0	32.5	31.3	114.3	94.0	24.7	117.2	CH	66.4	30	36.4			2915	UU (see note AA)	0.79				
GT13-03	145.5	72.5	40.0	42.5	41.3	104.3	86.4	34.0	115.8	CH	60.9	27.8	33.1			1735	UU (see note AA)	0.95				
GT13-03	145.5	72.5	40.0	42.5	41.3	104.3	91.2	30.2	118.7	CH	60.9	27.8	33.1					0.92	0.29	0.15	0.07	0.04
GT13-03	145.5	72.5	51.5	53.0	52.3	93.25				CL				4.2	65.6							
GT13-03	145.5	72.5	53.0	54.5	53.8	91.75				SM				0.0	41.1							
GT13-04	144.1	68.5	5.0	7.5	6.3	137.9	77.8	41.8	110.3	CH	68.3	31.4	36.9			990	UU (see note AA)	1.17				
GT13-04	144.1	68.5	5.0	7.5	6.3	137.9	79.4	39.6	110.8	CH	68.3	31.4	36.9					1.16	0.46	0.21	0.10	0.05
GT13-04	144.1	68.5	10.0	12.5	11.3	132.9	86.7	34.0	116.2	CH	68.2	32.0	36.2				CU (see note CC)	0.94				
GT13-04	144.1	68.5	10.0	12.5	11.3	132.9	86.7	34.0	116.2	CH	68.2	32.0	36.2				CU (see note DD)	0.94				
GT13-04	144.1	68.5	10.0	12.5	11.3	132.9	85.0	35.0	114.8	CH	68.2	32.0	36.2					1.02	0.36	0.18	0.09	0.04

Table 1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	Sample Location To (ft-BGS)	Sample Location Average Depth (ft-BGS)	Sample Location Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	Gravel Content (%)	Fines Content (%)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT13-04	144.1	68.5	25.0	27.5	26.3	117.85	86.6	34.6	116.6	MH	53.4	30.1	23.3			1685	UU (see note AA)	0.95				
GT13-04	144.1	68.5	35.0	37.5	36.3	107.9																
GT13-04	144.1	68.5	45.0	47.5	46.3	97.85	74.2	47.0	109.1	MH	62.8	32.9	29.9			1350	UU (see note AA)	1.27				
GT13-04	144.1	68.5	50.0	51.5	50.8	93.35				SM				0.0	18.7							
GT13-04	144.1	68.5	55.0	56.5	55.8	88.35				SM				18.3	22.6							
GT13-05	144.8	66.5	10.0	12.5	11.3	133.6																
GT13-05	144.8	66.5	20.0	22.5	21.3	123.6	82.3	38.5	114.0	MH	70.3	34.6	35.7			2470	UU (see note AA)	1.05				
GT13-05	144.8	66.5	20.0	22.5	21.3	123.6	86.6	34.5	116.5	MH	70.3	34.6	35.7					1.02	0.31	0.15	0.06	0.03
GT13-05	144.8	66.5	35.0	37.5	36.3	108.55	76.6	44.0	110.3	MH	51.1	30.8	20.3			570	UU (see note AA)	1.20				
GT13-05	144.8	66.5	45.0	47.5	46.3	98.6	80.8	40.2	113.3	CH	56.3	29.1	27.2			1035	UU (see note AA)	1.09				
GT13-05	144.8	66.5	45.0	47.5	46.3	98.6	80.3	40.2	112.6	CH	56.3	29.1	27.2					1.18	0.44	0.20	0.06	0.03
GT13-06	144.5	66.5	10.0	12.5	11.3	133.3	90.4	31.9	119.2	CH	67.6	26.7	40.9			2370	UU (see note AA)	0.86				
GT13-06	144.5	66.5	10.0	12.5	11.3	133.3	89.5	32.4	118.5	CH	67.6	26.7	40.9					0.95	0.30	0.15	0.07	0.04
GT13-06	144.5	66.5	20.0	22.5	21.3	123.25	83.4	37.7	114.8	MH	66.9	36.4	30.5			2685	UU (see note AA)	1.02				
GT13-06	144.5	66.5	30.0	32.5	31.3	113.25	83.0	38.0	114.5	CH	68.5	33.0	35.5			2120	UU (see note AA)	1.03				
GT13-06	144.5	66.5	45.0	47.5	46.3	98.3																
GT13-16	126.9	51.5	5.0	7.5	6.3	120.65	80.8	37.0	110.7	CH	66.7	30.9	35.8			1520	UU (see note AA)	1.09				
GT13-16	126.9	51.5	15.0	17.5	16.3	110.7																
GT13-16	126.9	51.5	20.0	22.5	21.3	105.65	84.4	36.2	115.0	CH	63.3	25.8	37.5			1625	UU (see note AA)	1.00				
GT13-16	126.9	51.5	31.5	34.0	32.8	94.15				CH				0.0	69.0							
GT13-17	126.6	52.5	5.0	7.5	6.3	120.4																
GT13-17	126.6	52.5	10.0	12.5	11.3	115.4																
GT13-17	126.6	52.5	20.0	22.5	21.3	105.35	77.7	43.1		CL	48.4	27.5	20.9			495	UU (see note AA)	1.17				
GT14-01	148.35	77.5	5	7.5	6.25	142.1	81.7	39.3	113.8	ML	31	24	7			1325	UU (see note AA)					

Table 1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	Sample Location To (ft-BGS)	Sample Location Average Depth (ft-BGS)	Sample Location Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	Gravel Content (%)	Fines Content (%)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT14-01	148.35	77.5	10	12.5	11.25	137.1				ML												
GT14-01	148.35	77.5	15	16.5	15.75	132.6				CL												
GT14-01	148.35	77.5	20	22	21	127.35	86.6	34.5	116.5	CL	40	23	17			1280	UU (see note AA)					
GT14-01	148.35	77.5	22.5	24	23.25	125.1				CH												
GT14-01	148.35	77.5	25	26.5	25.75	122.6				CH												
GT14-01	148.35	77.5	30	32.5	31.25	117.1	90.4	32.1	119.4	CL	45	21	24			1495	UU (see note AA)	0.98	0.41	0.21	0.07	0.04
GT14-01	148.35	77.5	60	61.5	60.75	87.6				SW-SM												
GT14-01	148.35	77.5	65	65.5	65.25	83.1		64.4		CH	106	34	72	0.0	98.7							
GT14-01	148.35	77.5	70	71.5	70.75	77.6		93.1		MH	85	44	41	0.0	98.5							
GT14-01	148.35	77.5	75	77.5	76.25	72.1				MH												
GT14-02	144.01	81.5	5	6.5	5.75	138.26				MH												
GT14-02	144.01	81.5	6.5	9	7.75	136.26	83.4	37.7	114.8	MH	35	25	10			900	UU (see note AA)					
GT14-02	144.01	81.5	10	11.5	10.75	133.26				MH												
GT14-02	144.01	81.5	15	17.5	16.25	127.76				CL												
GT14-02	144.01	81.5	17.5	19	18.25	125.76				CL												
GT14-02	144.01	81.5	20	21.5	20.75	123.26				CL-CH												
GT14-02	144.01	81.5	25	27.5	26.25	117.76	89.3	33.7	119.4	CL	39	25	14					0.96				
GT14-02	144.01	81.5	30	31.5	30.75	113.26				CL												
GT14-02	144.01	81.5	65	66.5	65.75	78.26		43.4		ML	48	38	10	1.0	61.7							
GT14-02	144.01	81.5	70.5	71	70.75	73.26		44.0		SM	44	34	10	0.0	46.7							
GT14-03	136.86	50.5	5	7.5	6.25	130.61	87.8	34.9	118.4	CL	37	21	16			1190	UU (see note AA)					
GT14-03	136.86	50.5	10	11.5	10.75	126.11				ML												
GT14-03	136.86	50.5	15	17.5	16.25	120.61				CL												
GT14-03	136.86	50.5	17.5	19	18.25	118.61				CL												

Table 1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	Sample Location To (ft-BGS)	Sample Location Average Depth (ft-BGS)	Sample Location Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	Gravel Content (%)	Fines Content (%)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT14-03	136.86	50.5	20	21.5	20.75	116.11				CH												
GT14-03	136.86	50.5	25	27.5	26.25	110.61	80.6	41.1	113.7	CH	82	29	53			1260	UU (see note AA)					
GT14-03	136.86	50.5	25	27.5	26.25	110.61	78.8	42.6	112.4	CH	95	32	63			1065	UU (see note AA)					
GT14-03	136.86	50.5	30	31.5	30.75	106.11				CL												
GT14-04	139.70	51.5	5	7.5	6.25	133.45				ML												
GT14-04	139.70	51.5	10	12.5	11.25	128.45	83.8	38.4	116.0	CL	30	22	8					1.09				
GT14-04	139.70	51.5	15	16.5	15.75	123.95				ML												
GT14-04	139.70	51.5	20	22.5	21.25	118.45	80.8	40.8	113.8	CL	39	22	17					1.16				
GT14-04	139.70	51.5	25	26.5	25.75	113.95				ML												
GT14-05	133.82	50.5	5	7.5	6.25	127.57	96.7	28.0	123.8	CL	47	24	23			1265	UU (see note AA)					
GT14-05	133.82	50.5	10	11.5	10.75	123.07				CL												
GT14-05	133.82	50.5	15	17.5	16.25	117.57				CH												
GT14-05	133.82	50.5	20	22.5	21.25	112.57				CH												
GT14-05	133.82	50.5	25	26.5	25.75	108.07		35.8		ML	37	27	10	0.0	98.8							
GT14-05	133.82	50.5	45	47.5	46.25	87.57		57.5		SM	47	41	6	0.0	44.6							
GT14-06	133.52	57.5	5	7.5	6.25	127.27				CL												
GT14-06	133.52	57.5	10	11.5	10.75	122.77				ML												
GT14-06	133.52	57.5	15	17.5	16.25	117.27				CL												
GT14-06	133.52	57.5	20	22.5	21.25	112.27				CH or MH												
GT14-06	133.52	57.5	22.5	24	23.25	110.27				CH or MH												
GT14-06	133.52	57.5	25	26.5	25.75	107.77				CH												
GT14-06	133.52	57.5	30	32.5	31.25	102.27	79.2	42.0	112.5	MH	74	41	33			2800	UU (see note AA)	1.31	0.59	0.26	0.10	0.04
GT14-07	133.20	65.5	5	7.5	6.25	126.95				CL												
GT14-07	133.20	65.5	10	11.5	10.75	122.45				CL												

Table 1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	Sample Location To (ft-BGS)	Sample Location Average Depth (ft-BGS)	Sample Location Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	Gravel Content (%)	Fines Content (%)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT14-07	133.20	65.5	15	17.5	16.25	116.95	83.2	38.3	115.1	CL	48	27	21			1550	UU (see note AA)					
GT14-07	133.20	65.5	20	21.5	20.75	112.45				CH												
GT14-07	133.20	65.5	25	27.5	26.25	106.95	78.6	43.6	112.9	CH	84	27	57			1015	UU (see note AA)	1.18	0.47	0.22	0.11	0.05
GT14-07	133.20	65.5	30.5	31	30.75	102.45		45.3		SM	62	34	28	3.1	33							
GT14-08	128.7	24.0	5	7.5	6.25	122.45				CL												
GT14-08	128.7	24.0	7.5	9	8.25	120.45				ML												
GT14-08	128.7	24.0	10	12.5	11.25	117.45				ML												
GT14-08	128.7	24.0	15	16.5	15.75	112.95				ML												
GT14-08	128.7	24.0	20	22.5	21.25	107.45	72.7	49.5	108.7	CH	85	26	59					1.41				
GT14-08	128.7	24.0	22.5	24	23.25	105.45				CH												
GT14-09	141.1	21.5	5	7.5	6.25	134.85				ML												
GT14-09	141.1	21.5	10	11.5	10.75	130.35				CL												
GT14-09	141.1	21.5	15	17.5	16.25	124.85	87.0	32.7	115.4	CL	35	21	14					0.94				
GT14-09	141.1	21.5	20	21.5	20.75	120.35				ML												
GT14-10	147.0	26.5	5	6.5	5.75	141.25				ML												
GT14-10	147.0	26.5	10	12.5	11.25	135.75				CL/ML												
GT14-10	147.0	26.5	15	16.5	15.75	131.25				ML												
GT14-10	147.0	26.5	20	22.5	21.25	125.75	83.5	34.7	112.5	CL	35	17	18					1.02				
GT14-10	147.0	26.5	25	26.5	25.75	121.25				ML												
GT14-11	149.1	26.5	5	6.5	5.75	143.35				ML												
GT14-11	149.1	26.5	10	12.5	11.25	137.85				CL/ML												
GT14-11	149.1	26.5	15	16.5	15.75	133.35				CL/ML												
GT14-11	149.1	26.5	20	22.5	21.25	127.85	89.5	33.8	119.8	CL	40	25	15					0.95				
GT14-11	149.1	26.5	25	26.5	25.75	123.35				ML												

Table 1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	Sample Location To (ft-BGS)	Sample Location Average Depth (ft-BGS)	Sample Location Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	Gravel Content (%)	Fines Content (%)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT14-12	147.9	26.5	5	6.5	5.75	142.15				ML												
GT14-12	147.9	26.5	10	12.5	11.25	136.65				ML												
GT14-12	147.9	26.5	15	17.5	16.25	131.65	88.9	34.3	119.4	CL-ML	22	17	5					0.97				
GT14-12	147.9	26.5	20	21.5	20.75	127.15				CL												
GT14-12	147.9	26.5	25	26.5	25.75	122.15				ML												
GT14-13	144.6	46.5	5	7.5	6.25	138.35				MH												
GT14-13	144.6	46.5	6.5	9	7.75	136.85				MH												
GT14-13	144.6	46.5	10	12.5	11.25	133.35				ML												
GT14-13	144.6	46.5	15	16.5	15.75	128.85				CL												
GT14-13	144.6	46.5	20	22.5	21.25	123.35				MH												
GT14-13	144.6	46.5	25	27.5	26.25	118.35	89.2	33.8	119.3	CL	44	26	18			1475	UU (see note AA)					
GT14-13	144.6	46.5	30	31.5	30.75	113.85				CH												
GT14-13	144.6	46.5	35	36.5	35.75	108.85				GM	66	45	21	48.6	15.4							
GT14-13	144.6	46.5	40	41.5	40.75	103.85				GC												
GT14-13	144.6	46.5	45	46.5	45.75	98.85				GC												
GT14-14	145.4	51.5	5	7.5	6.25	139.15				MH												
GT14-14	145.4	51.5	7.5	9	8.25	137.15				MH												
GT14-14	145.4	51.5	10	12.5	11.25	134.15				CL												
GT14-14	145.4	51.5	15	17.5	16.25	129.15				ML	28	23	5					1.14	0.40	0.19	0.05	0.02
GT14-14	145.4	51.5	17.5	19	18.25	127.15				MH												
GT14-14	145.4	51.5	20	21.5	20.75	124.65				MH												
GT14-14	145.4	51.5	25	27.5	26.25	119.15				ML	47	28	19					0.91	0.34	0.18	0.05	0.03
GT14-14	145.4	51.5	27.5	29	28.25	117.15				MH												
GT14-14	145.4	51.5	30	31.5	30.75	114.65	90.2	31.3	118.4	CL	38	23	15					0.87				

Table 1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	To (ft-BGS)	Average Depth (ft-BGS)	Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	Gravel Content (%)	Fines Content (%)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT14-14	145.4	51.5	35	36.5	35.75	109.65				CH												
GT14-14	145.4	51.5	40	41.5	40.75	104.65				MH				0.0	68.7							
GT14-14	145.4	51.5	45	46.5	45.75	99.65				GM	67	37	30	8.0	70.4							
GT14-14	145.4	51.5	50	51.5	50.75	94.65				GM												

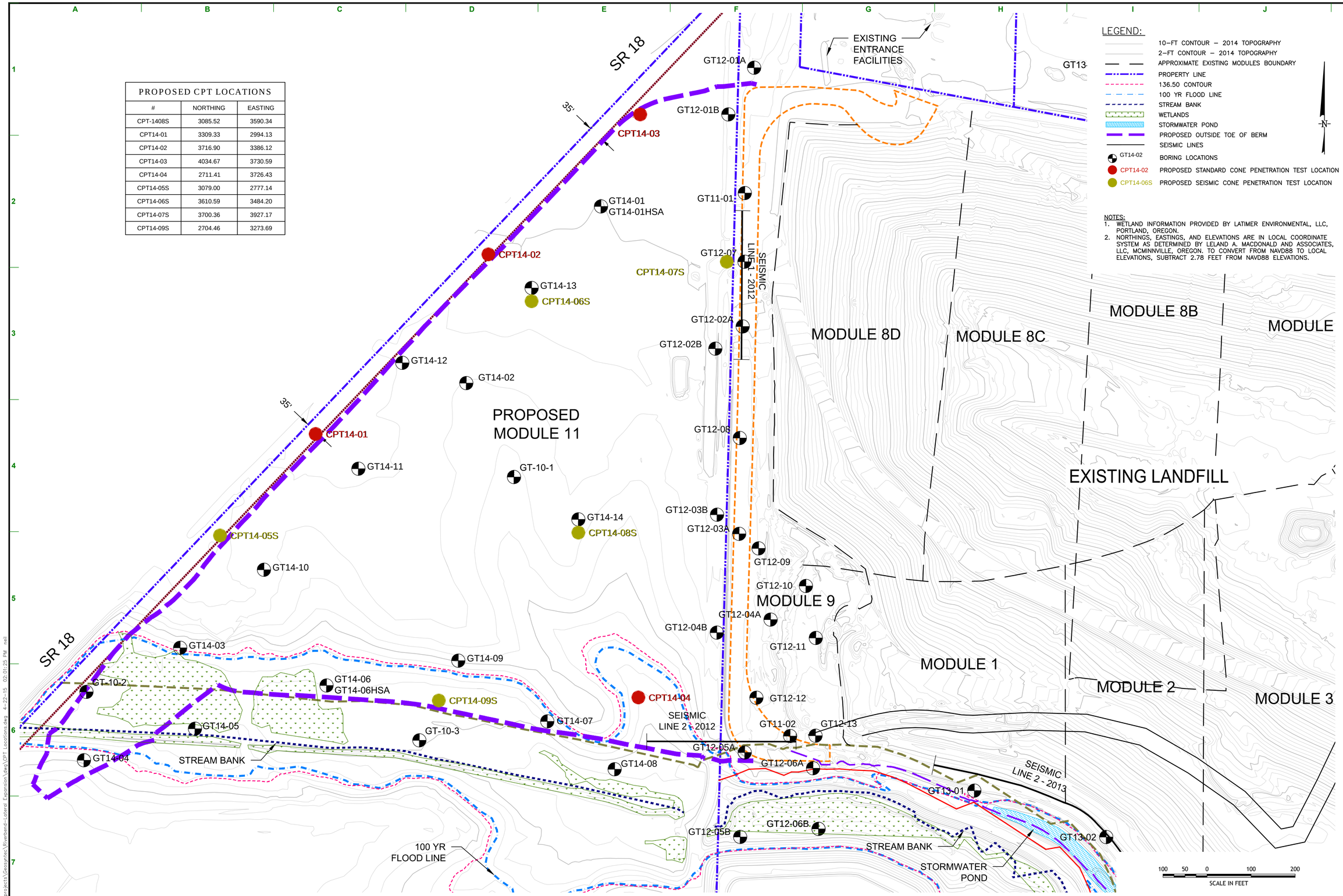
USCS: Unified Soil Classification System
LL: Liquid Limit (Atterberg Limits)
PL: Plastic Limit (Atterberg Limits)
PI: Plasticity Index (PI = LL - PL)

MSL: Mean S e_0: from moisture/density, consolidation, or triaxial test on relatively undisturbed sample.
BGS: Below Ground Surface
psi: Pounds per square inch
psf: Pounds per square foot

Note Z: S_u at 10% strain were estimated from the data.
Note AA: sample tested at natural density and moisture content. S_u at 5% and 10% strain were estimated from the data.

FIGURES

PROPOSED CPT LOCATIONS		
#	NORTHING	EASTING
CPT-1408S	3085.52	3590.34
CPT14-01	3309.33	2994.13
CPT14-02	3716.90	3386.12
CPT14-03	4034.67	3730.59
CPT14-04	2711.41	3726.43
CPT14-05S	3079.00	2777.14
CPT14-06S	3610.59	3484.20
CPT14-07S	3700.36	3927.17
CPT14-09S	2704.46	3273.69



REVISIONS

NO.	DESCRIPTION	DATE

SHEET TITLE
MODULE 11: EXISTING BOREHOLE AND PROPOSED CPT'S LOCATION PLAN

PROJECT TITLE
SITE DESIGN REVIEW APPLICATION
RIVERBEND EXPANSION - MODULE 11
RIVERBEND LANDFILL - CONDA WAY
YAMHILL COUNTY, OREGON

WASTE MANAGEMENT

PRELIMINARY DRAWINGS

DES BY:	FWS	DATE:	APRIL 2015
DRN BY:	NTB	SCALE:	AS NOTED
CHK BY:	FWS	PROJECT:	WG1866
REV BY:	FWS	DOCUMENT:	
APP BY:	HDS	FILE:	

Geosyntec consultants
1111 Broadway
Sixth Floor
Oakland, CA 94607

FIGURE NO.
1

T:\projects\Geosyntec\Riverbend-Lateral Expansion\dwg\CPT Locations.dwg 4-22-15 02:01:25 PM neil

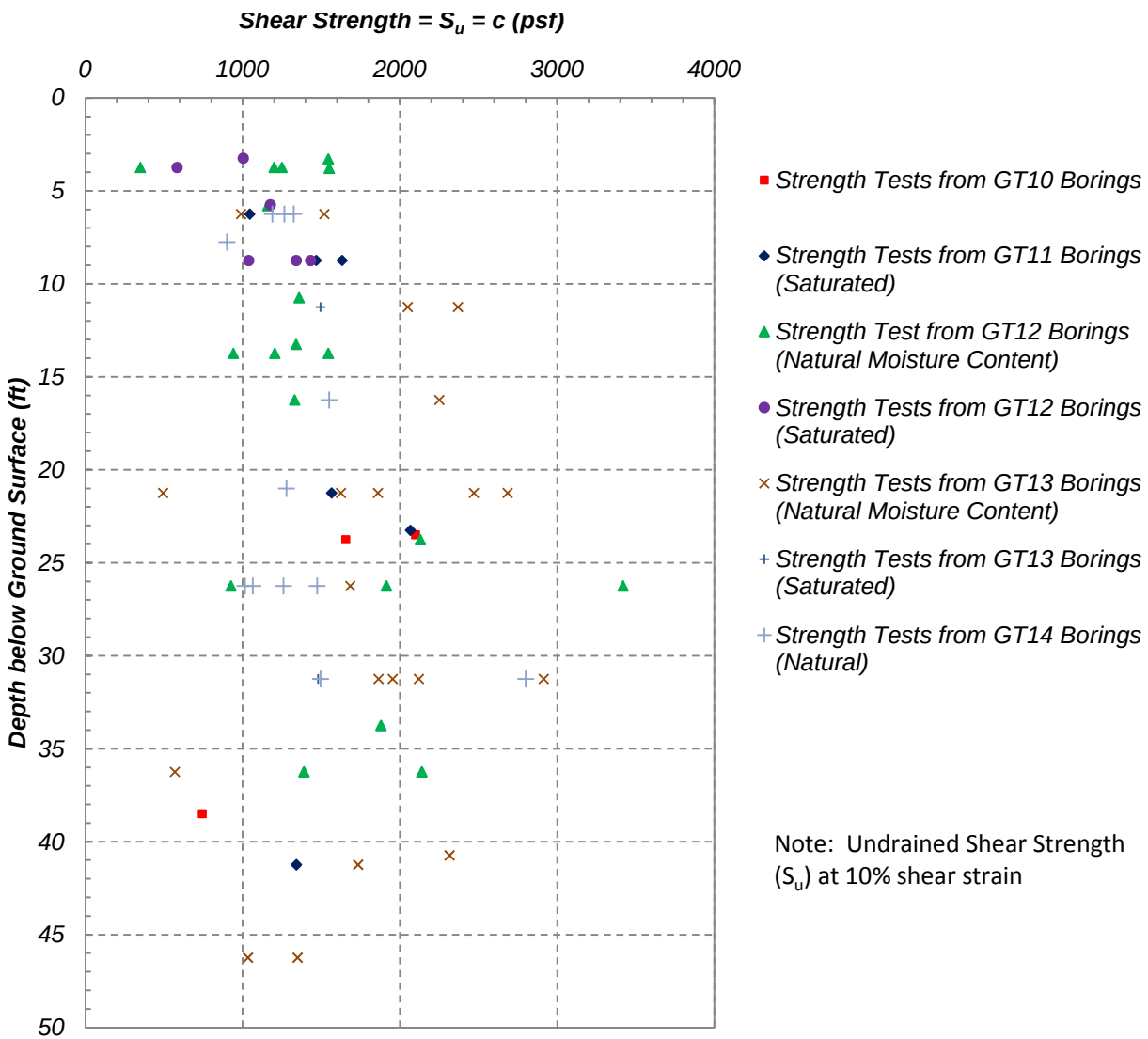


Figure 2. Soil Strength Profile - Module 11 Borings

APPENDICES

APPENDIX A

2010 Boring Logs

LEGEND FOR BORING LOGS

SAMPLE LOCATION / TYPE

Sampled Interval

Sample Recovery

Standard Penetration Test (SPT) sample (1.4-inch I.D.)

Shelby tube sample (thin wall, 3-inch I.D.)

Bulk drill cuttings sample (> 3 ft. interval)

California Modified split spoon sample (2.5-inch I.D.)

Continuous core barrel sample (3-inch I.D., 5 feet long)

Grab drill cuttings sample (< 3 ft. interval)

BLOW COUNTS

Refers to number of blows by standard 140 pound hammer (unless otherwise indicated on log) per 6 inches of driven depth.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) DESCRIPTION (common terms used)

MOISTURE CONDITION

Dry - apparent absence of moisture, dry to the touch
Damp - slight moisture but does not adhere to hand
Moist - optimum water content but no visible water
Wet - visible free water

CONSISTENCY

Very Soft - thumb will penetrate more than 1 inch
Soft - thumb will penetrate about 1 inch
Firm or Stiff - thumb will indent soil about 1/4 inch
Hard or Very Stiff - thumb will not indent soil but readily indented by thumbnail
Very Hard - thumbnail will not indent soil

PLASTICITY

Non-plastic - an 1/8-inch thread cannot be rolled at any water content
Low - a thread can barely be rolled
Medium - a thread is easy to roll but can't be rerolled below the plastic limit
High - considerable rolling effort to reach the plastic limit; thread can be rerolled below the plastic limit

DENSITY (SANDY SOIL)

Sand consistency described using terms ranging from Very Loose to Very Dense

OTHER TERMS

Standard terms (as per ASTM D2488) are used to describe the size range, sorting, angularity, and shape of particles making up the soil
Standard terms may be used to described such soil properties as dilatancy and toughness if called for by the project

OTHER SYMBOLS

WATER - First depth at which free water (wet soil conditions) encountered (▽), static water level (▼).

CONTACTS:

———— Contact between different lithologies directly observed.
Horizontal line indicates sharp contact; slant line indicates gradational contact.

– – – – Inferred contact (contact between different lithologies not observed).

UNIFIED SOIL CLASSIFICATION SYSTEM CHART

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW		Well-graded gravels, gravels, gravel/sand mixtures, little or no fines.
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GM		Silty gravels, gravel-sand-silt mixtures
			GC		Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL		Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH		Inorganic clays of medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH		Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTES: No. 4 size = 5mm (0.25 in); No. 200 size = 0.0075 mm (0.0003 in)

Dual symbols are used to indicate borderline soil classifications

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-01

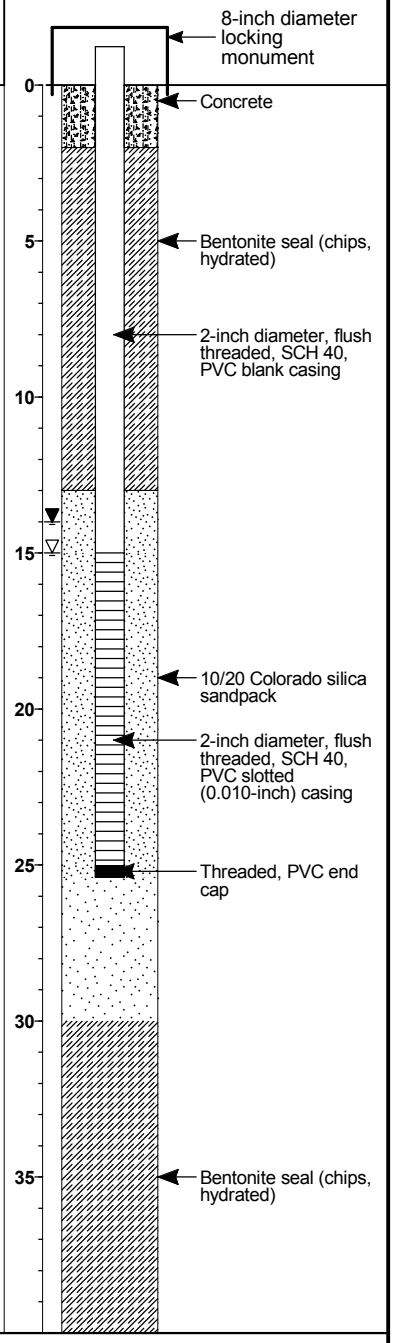
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04210010.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0		1-1	---		ML		Surface: natural ground surface (grass)
1								
2	5		1-2	3 3 5	0.5			SILT (ML), light olive brown (2.5Y 5/3) with some orange brown oxide (iron) mottling, moist to wet, firm, trace clay, low plasticity
			1-3	---				
3	10				0.75			At 10.0 feet (bottom of Shelby tube sample), FINE SANDY SILT (ML), dark yellowish brown (10YR 4/6), moist, sand 10-20 percent, slightly micaceous
4								
5	15		1-4	3 2 4	0.25	CL ML		- At 15 feet, same as above but wet At 15.8 feet, 2-inch thick CLAY (CL) seam, very dark gray (5Y 3/1), wet, apparent soft consistency, high plasticity
			1-5	---				At 16.0 feet, SILT (ML), very dark gray (5Y 3/1), wet, firm, faintly micaceous, low to medium plasticity
6	20				0.75			- At 20.0 feet (bottom of Shelby tube sample), same silt at above
7			1-6	5 5 5	0.25	ML		Thinly bedded SILT (ML) and CLAYEY SILT (ML), very dark gray (5Y 3/1), moist, stiff, 2- to 4-inch thick beds with varying clay content from 0 to 10-20 percent, moist, stiff, with two clay lenses (1.5 inch thick)
8	25		1-7	---		CL		At 27.5 feet (bottom of Shelby tube sample), SILTY CLAY (CL), very dark gray (5Y 3/1), moist, medium to high plasticity
9	30		1-8	0 3 7	1.5			CLAY (CL), dark gray (5Y 4/1), moist, very soft, massive - At 30.7 feet, sharp color change to very dark gray (5Y 3/1) with greenish tint, damp to moist, stiff, faintly micaceous, more apparent firmness than above, medium to high plasticity
10								
11	35		1-9	0 3 4	1.0			- Same as above but greenish gray, firm, faint oxide (iron) mottling
			1-10	---				
12	40							Driller reports harder push last approximately 4 inches of Shelby tube sample No. 1-10

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **9/9/10**
Date Ended: **9/10/10**
Boring Diameter: **5.9" (to 26.0 ft.); 4.9" (from 26.0 - 66.5 ft.)**
Elevation: **143.8 ft.**
Depth to Water: **14.0 ft.**
Total Depth: **66.5 ft.**

STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-01

Riverbend Landfill Company

JOB NUMBER: 04210010.00

Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
40		1-11	12 15 22	1.0	CL	At 40.0 feet, CLAY (CL) with fine sand and gravel, mottled light olive brown (2.5Y 5/3) and orange brown (iron oxide), moist, hard, very weathered appearance, fine subrounded gravel 5-15 percent at top of sample, fine to coarse subrounded gravel 20-30 percent to 1-inch diameter at bottom 3 inches of sample
45		1-12	15 28 32		GC	SANDY, CLAYEY GRAVEL (GC), mottled very pale brown (10YR 7/4), light olive brown (2.5Y 5/3), and orange brown (iron oxide), wet, dense, fine to coarse sand (f:m:c = 20:40:40), fine to coarse subrounded gravel to 2-inch diameter, weathered appearance
50		1-13	15 21 33		SW/GW	GRAVELLY SAND/SANDY GRAVEL (SW/GW), dark yellowish brown (10YR 3/4), wet, dense, trace fines, weathered appearance, fine to coarse sand (f:m:c = 10:40:50), fine to coarse subrounded gravel to 2-inch diameter
55		1-14	13 20 22			- Same as above but black (7.5YR N2/), medium dense, fine to coarse sand (f:m:c = 30:40:30), fine to coarse gravel to 1-inch diameter, predominantly fine gravel
						At 59.0 feet, driller reports softer drilling
60		1-15	3 4 4		SP	SAND (SP), black (7.5YR N2/), wet, loose, very fine to fine sand, few scattered fine gravels to 1/4-inch diameter, trace medium grained sand, wood layer at least 4 inches thick observed at bottom of upper ring and top of lower ring samples - At 63.0 feet, driller reports harder drilling - At 65.0 feet, GRAVELLY SAND / SANDY GRAVEL (SW/GW), black (7.5YR N2/), wet, medium dense, fine to coarse sand (f:m:c = 40:30:30) but coarsening with depth, fine to coarse subrounded gravel to 1-inch diameter, predominantly fine gravel
65		1-16	9 14 17		SW/GW	

Total Depth = 66.5 feet

NOTES:

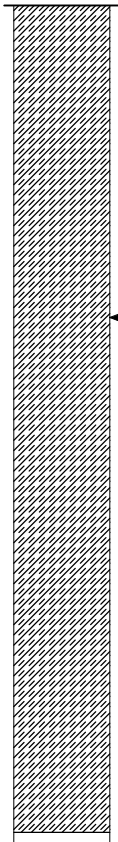
1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample from 0 to 5.0 feet.

2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 1-12 at 45 feet and for remainder of borehole. Hammers not used for Shelby tube samples.

3. Pushed 36-inch Shelby tube sample 30 inches only.

4. Static groundwater level measured on September 13, 2010.

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-02

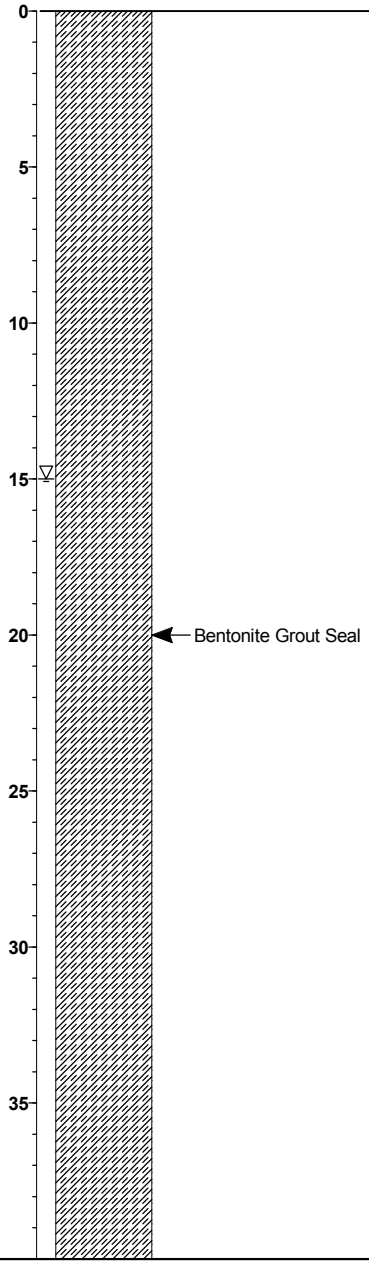
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04210010.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0		2-1	---		CL		Surface: natural ground surface (grass)
1								
2	5		2-2	2 3 5	1.0			CLAY (CL), mottled dark grayish brown (2.5Y 4/2) and orange brown (iron oxide), moist, firm, medium plasticity
3			2-3	---				
4	10				0.25			At 10.0 feet (bottom of Shelby tube sample), same as above
5	15		2-4	1 3 4	1.0			Becomes dark gray (2.5Y N4) with slight greenish tint, moist to wet
6	20		2-5	0	0.0	CH		CLAY (CH), dark gray (2.5Y N4), wet, soft, (sample 2-5 pushed by weight of rods), minor orange brown oxide (iron) mottling, scattered small (less than 1/4 inch) wood fragments; with 4-inch thick slightly silty clay lens, black (2.5YN2), moist, abundant wood fragments, organic odor
7			2-6	---	0.75	CL		
8	25							At 25.0 feet (bottom of Shelby tube sample), CLAY (CL), dark gray (2.5Y N4), medium plasticity
9			2-7	2 3 4	0.75			CLAY (CL), green-gray with slight oxide (iron) mottling, moist, firm, rare scattered fine gravel, minor scattered small wood fragments, medium plasticity
10	30							
11			2-8	---				Shelby tube sample 2-8 slightly damaged at bottom during sampling
12	35		2-9	4 7 13	1.75	SP SW		- At 35 feet, FINE SAND (SP) with clay, mottled yellowish brown (10YR 5/6) and light yellowish brown (2.5Y 6/3), moist to wet, medium dense, rare fine rounded gravels, grades with depth to trace or no fines - At 36.4 feet, sharp contact with FINE TO COARSE SAND (SW), wet, same color as above, medium dense, fine to coarse sand (f:m:c = 20:40:40), single rounded gravel to 3/4-inch diameter
	40							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **9/13/10**
Date Ended: **9/13/10**
Boring Diameter: **4.9 inches**
Elevation: **135.0 ft.**
Total Depth: **55.8 ft.**

STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-02

Riverbend Landfill Company

JOB NUMBER: 04210010.00

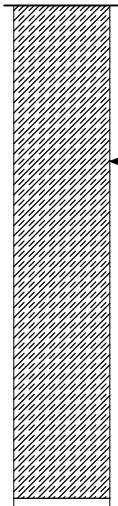
Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
40		2-10	12 22 37	3.25	SW	GRAVELLY SAND (SW), strong brown (7.5 YR 4/6), wet, very dense, very weathered appearance, fine to coarse sand (f:m:c = 40:40:20), fine to coarse subrounded gravel 20-30% to 1-inch diameter (predominantly fine), some thin lenses (less than 3 inches) with trace fines
45		2-11	14 17 14			At 45 feet, same as above
					ML	SILT (ML), dark yellowish brown (10YR 4/6), damp, very stiff to hard
50		2-12	5 6 14		SW	At 50 feet, GRAVELLY SAND (SW) with trace fines, black (2.5Y N2/), wet, loose to medium dense, fine to coarse sand (f:m:c = 50:30:20), fine to coarse subrounded gravel 15-25 percent to 1-inch diameter
					SLTST	- At 51.2, SILTSTONE (SLTST), dark gray (10YR 4/1), dry, indurated
55		2-13	24 50/4"			SILTSTONE (SLTST) as above

Total Depth = 55.8 feet

NOTES:

1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample from 0 to 5.0 feet.
2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 2-11 at 45 feet and for remainder of borehole. Hammers not used for Shelby tube samples.
3. Pushed 36-inch Shelby tube sample 30 inches only.

Completion Detail



STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-03

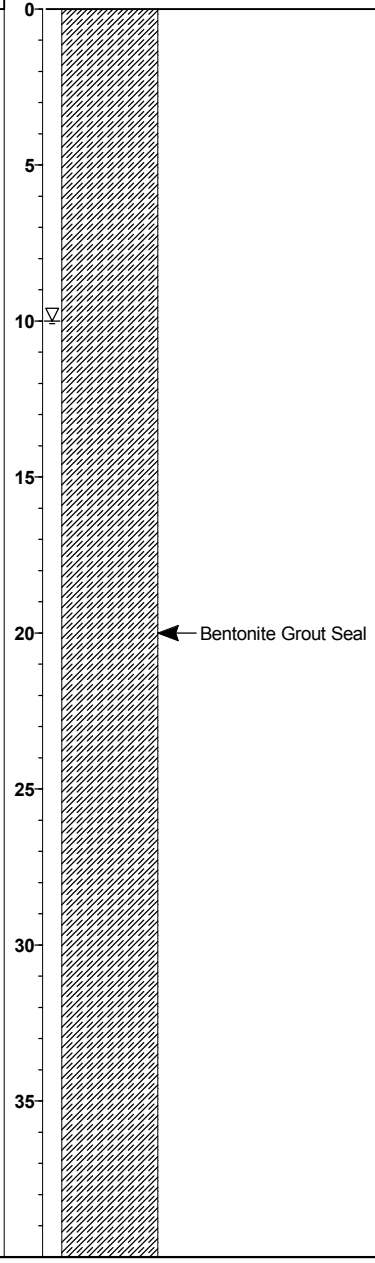
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04210010.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0		3-1	---		CL		Surface: natural ground surface (grass)
5		3-2	3 5 7				CLAY (CL), mottled dark brown (10YR 4/3) and gray (2.5Y N5/), moist, stiff, medium plasticity
		3-3	---				
10		3-4	1 3 6				Same as above, but with black carbonized (possibly remnant wood fragments) scattered nodules and flecks, moist to wet
15		3-5	2 5 6				CLAY (CL), dark gray (2.5Y N4/), damp, stiff, massive, medium to high plasticity
		3-6	---				
20		3-7	0				Same as above, but very soft (sample 3-7 pushed by weight of rods), wet, scattered coarse sand grains; high plasticity; sample is disturbed and does not stay intact in sampler
		3-8	---				
25		3-9	0/12" 3/6"				CLAY (CL) as above, but no sand and more apparent firmness (first 12 inches pushed by weight of rods)
					SM		SILTY FINE SAND (SM), dark gray (5Y 4/1) with greenish tint, moist to wet, very loose, some olive (5Y 4/3) mottling, silt 10-20 percent
		3-10	3 3 5		ML		FINE SANDY SILT (ML), mottled yellowish brown (10YR 5/8) and light olive brown (2.5Y 5/3), moist, firm, sand 20-30 percent, low plasticity; with 1-inch thick gray clayey silt lens
30		3-11	---				
		3-12	9 6 7		CL		SANDY CLAY (CL), olive gray (5Y 4/2) with greenish tint, moist, stiff, fine sand 20-30 percent, abundant wood fragments at top of sample, rare fine gravels, low plasticity - At 34.1 feet, becomes mottled yellowish brown (10YR 5/8) and light olive brown (2.5Y 5/6), moist, stiff, fine to medium sand (f:m = 90:10) 30-40 percent, low plasticity
35		3-13	24 33 35				At 37.5 feet, SANDY, GRAVELLY CLAY (CL), yellowish brown (10YR 5/8), moist, very dense, weathered appearance, fine to coarse sand (f:m:c = 40:40:20), fine to coarse subangular gravel 20-30 percent to 1-inch diameter, matrix supported
40							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary (Hollow Stem Auger 0 - 5.0 ft.)**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **9/3/10**
Date Ended: **9/7/10**
Boring Diameter: **4.9 inches**
Elevation: **130.5 ft.**
Total Depth: **60.3 ft.**

STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-03

Riverbend Landfill Company

JOB NUMBER: 04210010.00

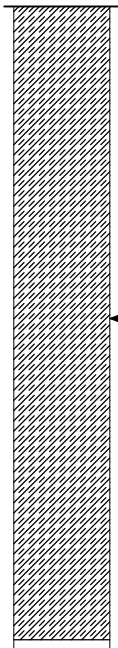
Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
40		3-14	11 14 15		CL	Same as above, but moist to wet, medium dense, predominantly fine subrounded gravel
45		3-15	17 34 50/4"		GW	SANDY GRAVEL (GW) with clay, mottled yellowish brown (10YR 5/8) and dark yellowish brown (10YR 4/4), moist to wet, very dense, weathered appearance, fine to coarse sand (f:m:c = 20:40:40), fine to coarse subgrounded gravel to 1-inch diameter
50		3-16	7 10 19		ML GW	At 50.0 feet, same as above CLAYEY SILT (ML) lens, dark gray (2.5Y N4/), moist At 51.5 feet, SANDY GRAVEL (GW) as above
55		3-17	24 50/5"		CL BASALT	At 55.3 feet, CLAYSTONE (CLST), light olive brown (2.5Y 5/4), dry, hard, cemented, some fine to coarse rounded gravel mixed in matrix At 55.6 feet, BASALT, black, some orange-brown oxide mottling, massive, fine grained, calcite or zeolite filled vein, few open vesicles, crumbly due to weathering
60		3-18	50/4"			BASALT, black, massive, fine grained, unweathered

Total Depth = 60.3 feet

NOTES:

1. Initially drilled borehole with hollow stem augers to collect bulk soil cuttings sample from 0 to 5.0 feet, then switched to mud rotary drilling.
2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 3-14 at 40 feet and for remainder of borehole. Hammers not used for Shelby tube samples.
3. 36-inch Shelby tube used; applied 36-inch push.

Completion Detail



STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-04

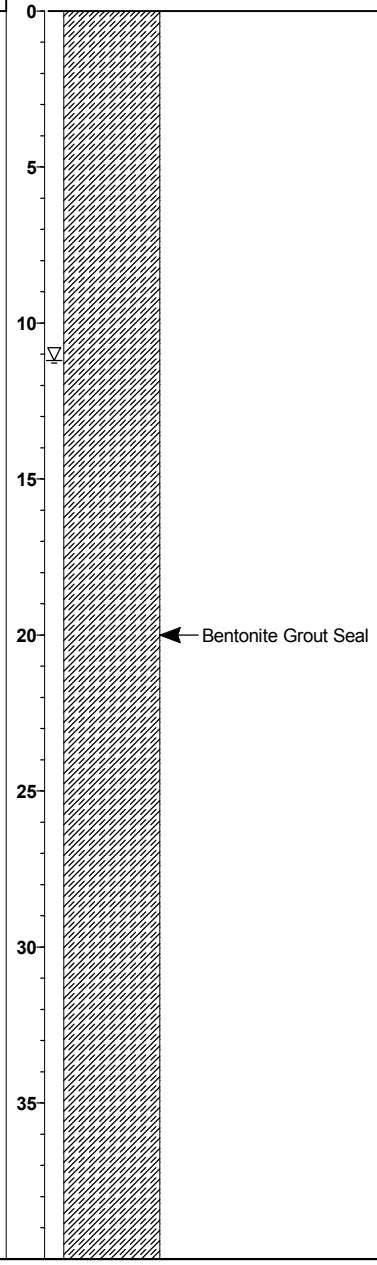
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04210010.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0		4-1	---		ML	Surface: natural ground surface (grass)
						Samples 4-1 (from 0-5 feet) and 4-2 (from 5-10 feet) are bulk soil cuttings samples drilled with hollow stem augers
5		4-2	---			
		4-3	2 3 4			CLAYEY SILT (ML), dark yellowish brown (10YR 4/4), damp, firm, clay 10-20 percent, faintly micaceous, medium plasticity (with water added), few filled micropores
		4-4	---			
10		4-5	1 2 2			Same as above, but slightly more clay (20-30 percent), moist, soft
		4-6	---			
15		4-7	2 2 2			Same as at 5 feet, but bedded, beds up to 6 inches thick with varying clay content (10-30 percent), visibly wet in beds with less clay
		4-8	---			
20		4-9	1 2 2			At 20.0 feet, same as at 15 feet
		4-10	---		CL/ML	At 20.6 feet, SILTY CLAY / CLAYEY SILT (CL/ML), dark yellowish brown (10YR 4/4), moist to wet, soft, faint light olive brown (2.5Y 5/3) and orange brown oxide (iron) mottling, few filled micropores, faintly micaceous, medium plasticity
25		4-11	3 5 4			At 25.0 feet, same as above
		4-12	---		CL	- At 25.4 feet, SILTY CLAY (CL), mottled light olive brown (2.5Y 5/4) and dark yellowish brown (10YR 4/6), damp, stiff, some orange brown oxide (iron) mottling, few black flecks (manganese oxide?), medium plasticity
30		4-13	2 3 5		ML	- At 30.0 feet, SILT (ML) with clay, dark yellowish brown (10YR 4/4), moist to wet, faintly micaceous, low to medium plasticity
		4-14	---		CH	- At 30.5 feet, 5-inch thick CLAY (CH) lens, mottled dark yellowish brown (10YR 4/4) and light olive brown (2.5Y 5/4), very soft, high plasticity; too soft to maintain and observe structure
					CL	- At 30.9 feet, CLAY (CL), very dark gray (2.5Y N3/), damp, apparent firm consistency, massive, medium to high plasticity
35		4-15	2 6 6			Becomes very dark gray with faint orange brown oxide (iron) mottling, very faintly micaceous, stiff
		4-16	---			
40						

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary (Hollow Stem Auger 0-10 ft.)**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **9/2/10**
Date Ended: **9/3/10**
Boring Diameter: **4.9 inches**
Elevation: **137.9 ft.**
Total Depth: **68.8 ft.**

STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

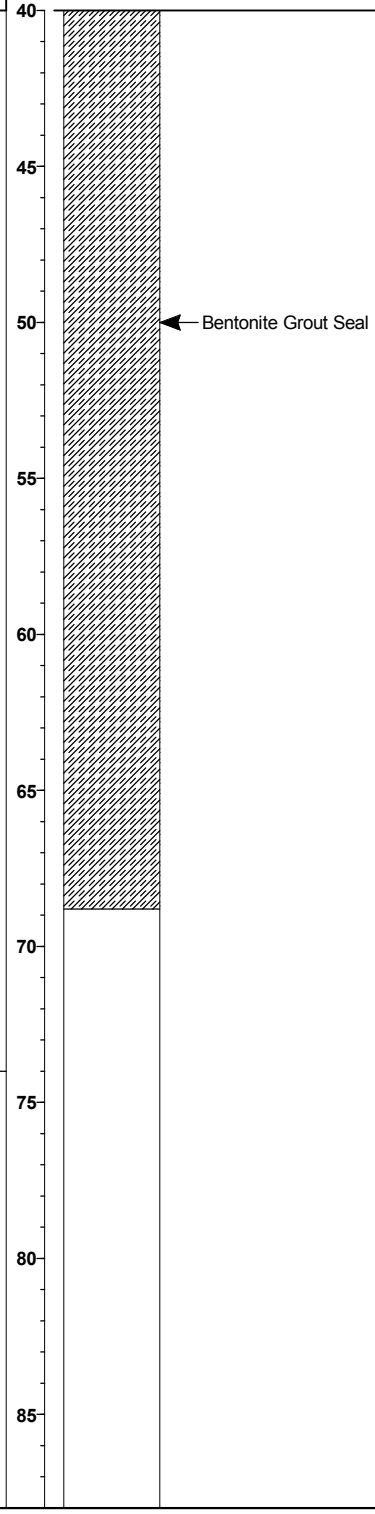
BORING NUMBER: GT10-04

Riverbend Landfill Company

JOB NUMBER: 04210010.00

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
	40		4-17	2 5 4		CL		CLAY, very dark gray (2.5Y N3/) with faint orange brown oxide (iron) mottling, damp, stiff, massive, medium to high plasticity
13			4-18	---				At 42.0 feet, can only push Shelby tube sample 4-18 24 inches
	45		4-19	32 50/5"		SP CL		VERY FINE TO FINE SAND (SP), mottled dark olive brown (2.5Y 3/3) and very dark gray (5Y 3/1), moist to wet, very dense, trace fines, slightly friable - At 44.8 feet, GRAVELLY CLAY (CL), very dark gray (2.5Y N3/), moist, hard, fine to coarse subrounded gravel 10-20 percent to 1-inch diameter, low to medium plasticity
14								
			4-20	9 43 50/5"				- At 47.5 feet, SANDY, GRAVELLY CLAY (CL), dark yellowish brown (10YR 3/6) with abundant orange brown oxide (iron) mottling, moist, hard, fine to meidum sand 10-20 percent, fine to coarse rounded gravel 20-30 percent up to 1.5-inch diameter, matrix supported, very weathered appearance (very disturbed sample, collected bag sample only)
15								
	50		4-21	12 39 42				Slow drilling
16			4-22	13 27 50/5"		SW		- At 52.5 feet, GRAVELLY, CLAYEY SAND (SC), same appearance as above, clay 10-20 percent, fine to coarse sand (f:m:c = 20:40:40), very dense, moist
	55		4-23	14 20 21		CL		SANDY GRAVELLY CLAY (CL) similar to above at 47.5 feet, medium dense, gravels to 2-inch diameter
17			4-24 (N.R.)	14 6 7				No recovery in sample 4-24
18								At 60.0 feet, CLAY (CL), very dark gray (5Y 3/1), damp to moist, firm, trace to some silt, massive
	60		4-25	3 4 5		ML		At 60.7 feet, SILT (ML), very dark gray (5Y 3/1), damp to moist, firm, trace clay, massive, low to medium plasticity
19			4-26	5 5 4		SM		- Attempted Shelby tube sample at 62.0 feet but could only push it 2 inches. - At 62.0 feet, SILTY SAND (SM), dark gray (5Y 4/1), moist to wet, loose to medium dense, fine to medium sand (f:m = 80:20), silt 25-35 percent, few subrounded gravels to 0.5-inch diameter, pieces of remnant wood fragments (slightly to very carbonized)
	65		4-27	13 19 14		SM		- Grades to fine to coarse sand content (f:m:c = 20:60:20), increased fine gravels to 10-20 percent, medium dense
20			4-28	3 7 50/4"		ML BASALT		- At 66.7 feet, SILTY FINE SAND (SM), dark gray (5Y 4/1), moist, medium dense, silt 10-20 percent, few fine gravels, scattered small wood fragments - At 67 feet, Quickly grades to SILT (ML), dark gray (5Y 4/1), moist, stiff to very stiff, small wood fragments, low plasticity - At 68.5 feet, BASALT, gray (2.5Y N4/), dry, fine grained (limited volume)
21								
	70							
22								
	75							Total Depth = 68.8 feet
23								NOTES: 1. Initially drilled borehole with hollow stem augers to collect bulk soil cuttings sample from 0-5 and 5-10 feet, then switched to mud rotary drilling.
24								
	80							2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 4-20 at 47.5 feet and for remainder of borehole. Hammers not used for Shelby tube samples.
25								
								3. 36-inch Shelby tube used; applied 36-inch push.
26	85							

Completion Detail



STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-05

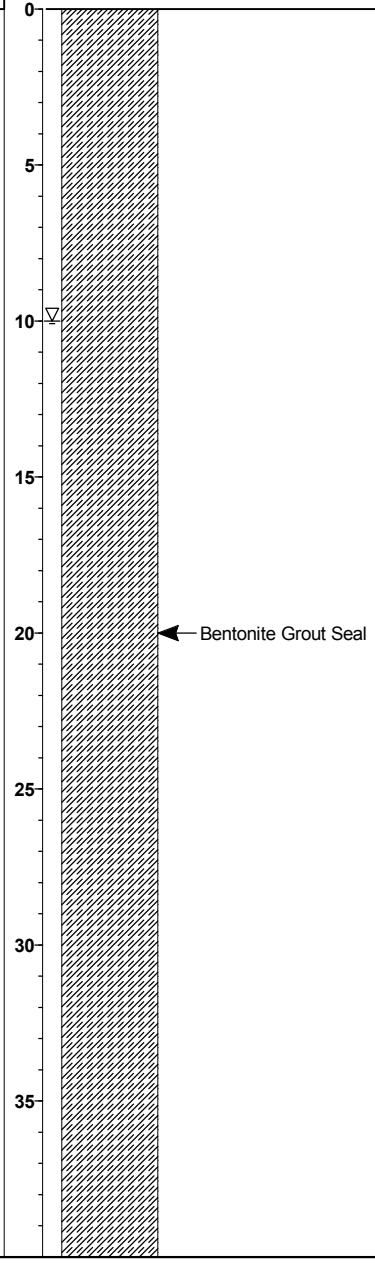
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04210010.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0		5-1	---		CL		Surface: natural ground surface (grass)
5		5-2	3 3 3	0.75			SILTY CLAY (CL), dark brown (7.5Y 3/2), moist, firm, slight orange brown oxide (iron) mottling, silt 10-20 percent, medium plasticity
		5-3	---				
10				0.0			At 10.0 feet (bottom of Shelby tube sample), CLAY (CL), very dark gray (7.5 Y N3/), moist to wet, medium plasticity
15		5-4	0	0.0			CLAY (CL), olive gray (5Y 4/2) with greenish tint, moist, very soft (sample 5-4 pushed by weight of rods), some orange brown oxide (iron) mottling, scattered oxidized rootlets throughout sample, trace to some silt, medium plasticity
		5-5	---				
20		5-6	0	0.0			SILTY CLAY (CL), dark gray (5Y 4/1) with slight greenish tint, moist to wet, very soft (sample 5-6 pushed by weight of rods), scattered rootlets throughout sample, silt 20-30 percent, medium plasticity
25		5-7	4 6 7				At 25.0 feet, same as above, but silt 25-35 percent, wet
		5-8	26 26 42		SW/GW		At 26.0 feet, SANDY GRAVEL / GRAVELLY SAND (SW/GW), dark gray (5Y 4/1) with slight greenish tint, wet, dense to very dense, fine to coarse sand (f:m:c = 20:40:40), fine to coarse subrounded gravel to 1-inch diameter, trace fines - At 27.5 feet, same as above, but clay content 5-15% - At 28.5 feet, sharp color change to dark yellowish brown (10YR 4/4) with orange brown oxide (iroin) mottling, dense - At 30.0 feet, lacks oxide mottling
30		5-9	15 27 38				
35		5-10	11 14 19		SC SW GW		At approx. 33.0 feet, GRAVELLY, CLAYEY SAND (SC), dark yellowish brown (10YR 4/6) with orange brown oxide (iron) and light olive brown (2.5Y 5/4) mottling, wet, medium dense, fine subrounded gravel 10-20 percent, clay 10-20 percent, fine to coarse sand (f:m:c = 25:50:25), very weathered appearance GRAVELLY SAND (SW), dark yellowish brown (10YR 3/4) with reddish brown oxide (iron) mottling, wet, medium dense, fine subgrounded gravel 20-30 percent, fine to coarse sand (f:m:c = 40:50:10), very weathered appearance
40							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **9/27/10**
Date Ended: **9/27/10**
Boring Diameter: **4.9 inches**
Elevation: **116.3 ft.**
Total Depth: **50.2 ft.**

STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT10-05

Riverbend Landfill Company

JOB NUMBER: 04210010.00

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
	40		5-11	12 19 24		GW		SANDY GRAVEL (GW), dark yellowish brown (10YR 3/4) with reddish brown oxide (iron) mottling, wet, medium dense, fine to coarse sand (f:m:c = 20:40:40) 25-35 percent, fine subrounded gravels with few coarse gravels, very weathered appearance
13								
	45		5-12	14 12 15		SW		GRAVELLY SAND (SW) with fines, dark olive gray (5Y 3/2), wet, medium dense, fine to coarse subrounded gravel 40-45 percent to 1.5-inch diameter, fine to coarse sand (f:m:c = 40:40:20) Grades to less gravel (fine, 10-20 percent), fine to coarse sand (f:m:c = 40:50:10) At 49.0 feet, driller reports harder drilling
14								
15								
	50		5-13	50/2"		BASALT		BASALT, dark gray (2.5Y N4/), hard, fine grained, with calcite or zeolite (?) nodules
16								
	55							
17								
18								
	60							
19								
	65							
20								
21								
	70							
22								
	75							
23								
24								
	80							
25								
26	85							

Total Depth = 50.2 feet

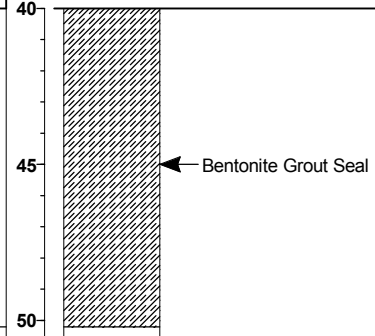
NOTES:

1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample from 0 to 10.0 feet.

2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 5-9 at 30.0 feet and for remainder of borehole. Hammers not used for Shelby tube samples.

3. 36-inch Shelby tube used; applied 30-inch push.

Completion Detail



STANDARD_LOG RLF_HSC GEOTECHNICAL BOREHOLE LOGS_V0.3.GPJ STD_LOG.GDT 2/23/11

APPENDIX B

2010 Energy Measurement

Robert Miner Dynamic Testing, Inc.
Dynamic Measurements and Analyses for Deep Foundations

October 11, 2010

Mr. Terry Jacques
Major Drilling Environmental, LLC
13565 SW Tualitin Sherwood Rd, STE 700
Sherwood, OR 77140

Re: Penetration Test Energy Measurements
Major Drilling B-54 Rig, Mobile Automatic Hammer, September 8, 2010
River Bend Landfill, Borehole GT10-11, McMinnville, OR

RMDT Job No. 10F32

Dear Mr. Jacques,

This letter presents energy transfer measurements made Standard Penetration Tests and California Modified Samples for the drill hole and drill rig referenced above. Robert Miner Dynamic Testing, Inc. (RMDT) made dynamic measurements with a Pile Driving Analyzer® as a hammer advanced the NW rod during sampling with a split spoon sampler and a California Modified sampler.

The purpose of RMDT's testing was the measurement of energy transferred to the drill rods. Measurements were made on a section of NW gauge rod at the top of the drill rod. Strain gages and accelerometers on the rod were connected to a Pile Driving Analyzer® (PDA) which generally processed acceleration and strain measurements from each hammer blow and stored both the measurements and computed results. Measurements and data processing generally followed the ASTM D 4633-10 standard. Energy transfer past the gage location, EFV, was computed by the PDA using force and velocity records as follows:

$$EFV = \int_a^b F(t)\ v(t)\ dt$$

The value "a" corresponds to the start of the record which is when the energy transfer begins and *"b"* is the time at which energy transferred to the rod reaches a maximum value. Appendix A contains more information on our measurement equipment and methods of analysis. The EFV energy calculation is identical to the EMX energy result discussed in Appendix A. The EFV and EMX values apply to the sensor location near the top of the rod.

TEST DETAILS

Testing occurred on September 8, 2010. Boring GT10-11 was advanced in the tree farm section of the River Bend Landfill facility located in McMinnville, OR. An NW size rod was used to advance both samplers. The automatic hammer in use during our testing was manufactured

Mailing Address: P.O. Box 340, Manchester, WA, 98353, USA **Phone:** 360-871-5480
Location: 2288 Colchester Dr. E., Ste A, Manchester, WA, 98353 **Fax:** 360-871-5483

by Foremost Mobile (Mobile) and was reported to use either a 140 lb or a 300 lb ram. The drill rig was a new track-mounted Mobile B-54.

RESULTS

Tables 1 and 2 summarizes RMDT's field results and Appendix B contains detailed numeric results. The tabulated records include the starting sample depth, the penetration resistance, the number of hammers blows in our data set, measured energy transfer, EFV, the computed transfer efficiency, ETR, and the hammer blow rate, BPM.

Energy measurements must be divided by the theoretical free fall energy of the hammer to obtain an efficiency. In anticipation of future site demands measurements were made with 140 lb and 300 lb rams in the Mobile Automatic Hammer. A 140 lb ram raised 30 inches above an impact surface has 350 lb-ft of potential energy. A 300 lb ram raised 30 inches above an impact surface has 750 lb-ft of potential energy. Thus, the transfer energy results for sampling with the 140 and 300 lb rams may be divided by 350 or 750 lb-ft to yield the ratio of the delivered energy to the nominal potential energy. This efficiency ratio, ETR, is given for each sample interval as a percent efficiency.

Table 1. Summary of Test Details and Results for the 140-lb ram

Start Sample Depth (ft)	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
5	5/1ft	5	261	75	21
15	6/1ft	6	305	87	21
30	5/1ft	5	331	95	21
45	14/1ft	14	336	96	22
50	37/1ft	37	334	95	21
55	98/8"	98	317	91	20
60	50/5"	50	320	91	20
		Average:	324	**92**	**21**

Excluding the data for the 5 ft sample depth, the average of ETR values within each of the six sample intervals from 15 ft to 60 ft ranged from 87 to 96 percent, and the overall average ETR

value was 92 percent. When computing the overall average value we excluded the results for the 5 ft sample depth because it is our opinion that the short rod length had a very substantial effect on transfer energy.

Table 2. Summary of Test Details and Results for the 300-lb ram

Start Sample Depth (ft)	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
20	6/1ft	6	674	90	23
40*	11/1ft	11	713	95	21
		Average:	693	**92**	**22**

*RMDT's field notes indicated sample taken at 35ft. Reviewers requested the sample depth be changed to 40ft.

Two tests were preformed during use of the 300 lb ram. In general, the variability of the recorded values is similar to that recorded with the 140 lb ram.

The consistency in BPM and ETR values for the two ram weights suggests the hammer is operating in a consistent manner regardless of ram size. Moreover, it is our opinion that these levels of transfer energy are consistent with observations on other occasions with automatic hammers manufactured by Mobile operating at similar blow rates.

It was a pleasure to assist you and to participate on this project with the staff of Major Drilling Environmental, LLC. Please do not hesitate to contact us if you or your client have any questions about this report.

Sincerely,

Robert Miner Dynamic Testing, Inc.

Andrew Banas
Staff Engineer

Robert Miner
Senior Engineer

Appendix A

APPENDIX A
AN INTRODUCTION INTO DYNAMIC PILE TESTING METHODS

The following has been written by Goble Rausche Likins and Associates, Inc. and may only be copied with its written permission.

BACKGROUND

Modern procedures of design and construction control require verification of bearing capacity and integrity of deep foundations during preconstruction test programs and also production installation. Dynamic pile testing methods meet this need economically and reliably, and therefore, form an important part of a quality assurance program when deep foundations are executed. Several dynamic pile testing methods exist; they have different benefits and limitations and different requirements for proper execution.

The Case Method of dynamic pile testing, named after the Case Institute of Technology where it was developed between 1964 and 1975, requires that a substantial ram mass (such as that of a pile driving hammer) impacts the pile top such that the pile undergoes at least a small permanent set. The method is therefore also referred to as a "High Strain Method". The Case Method requires dynamic measurements on the pile or shaft under the ram impact and then an evaluation of various quantities based on closed form solutions of the wave equation, a partial differential equation describing the motion of a rod under the effect of an impact. Conveniently, measurements and analyses are done by a single piece of equipment: the Pile Driving Analyzer® (PDA). However, for bearing capacity evaluations an important additional method is CAPWAP® which performs a much more rigorous analysis of the dynamic records than the simpler Case Method.

A related analysis method is the "Wave Equation Analysis" which calculates a relationship between bearing capacity and pile stress and field blow count. The GRLWEAP™ program performs this analysis and provides a complete set of helpful information and input data.

The following description deals primarily with the Case Method or "High Strain Test" Method of pile testing, however, for the sake of completeness, the "Low Strain Test" performed with the Pile Integrity Test™ (PIT), mainly for pile integrity evaluation, will also be described.

RESULTS FROM DYNAMIC TESTING

There are two main objectives of high strain dynamic pile testing:

- *Dynamic Pile Monitoring* and
- *Dynamic Load Testing*.

Dynamic pile monitoring is conducted during the installation of impact driven piles to achieve a safe and economical pile installation. Dynamic load testing, on the other hand, has as its primary goal the assessment of pile bearing capacity. It is applicable to both cast *insitu* piles or drilled shafts and impact driven piles during restrike.

Dynamic Pile Monitoring

During pile installation, the sensors attached to the pile measure pile top force and velocity. A PDA conditions and processes these signals and calculates or evaluates:

- Bearing capacity at the time of testing, including an assessment of shaft resistance development and driving resistance. This information supports formulation of a driving criterion.

- Dynamic pile stresses, axial and averaged over the pile cross section, both tensile and compressive, during pile driving to limit the potential of damage either near the pile top or along its length. Bending stresses can be evaluated at the point of sensor attachment.

- Pile integrity assessment by the PDA is based on the recognition of certain wave reflections from along the pile. If detected early enough, a pile may be saved from complete destruction. On the other hand, once damage is recognized measures can be taken to prevent reoccurrence.

- Hammer performance parameters including the energy transferred to the pile, the hammer speed in blows per minute and the stroke of open ended diesel hammers.

© 1999, Goble Rausche Likins and Associates, Inc.

Dynamic Pile Load Testing

Bearing capacity testing of either driven piles or drilled shafts applies the same basic measurement approach of dynamic pile monitoring. However, the test is done independent of the pile installation process and therefore a pile driving hammer or other dynamic loading device may not be available. If a special ram has to be mobilized then its weight should be between 0.8 and 2% of the test load (e.g. between 4 and 10 tons for a 500 ton test load) to assure sufficient soil resistance activation.

For a successful test, it most important that the test is conducted after a sufficient waiting time following pile installation for soil properties approaching their long term condition or concrete to properly set. During testing, PDA results of pile/shaft stresses and transferred energy are used to maintain safe stresses and assure sufficient resistance activation. For safe and sufficient testing of drilled shafts, ram energies are often increased from blow to blow until the test capacity has been activated. On the other hand, restrike tests on driven piles may require a warm hammer so that the very first blow produces a complete resistance activation. Data must be evaluated by CAPWAP for bearing capacity.

After the dynamic load test has been conducted with sufficient energy and safe stresses, the CAPWAP analysis provides the following results:

- Bearing capacity i.e. the mobilized capacity present at the time of testing
- Resistance distribution including shaft resistance and end bearing components
- Stresses in pile or shaft calculated for both the static load application and the dynamic test. These stresses are averages over the cross section and do not include bending effects or nonuniform contact stresses, e.g. when the pile toe is on uneven rock.
- Shaft impedance vs depth; this is an estimate of the shaft shape if it differs substantially from the planned profile
- Dynamic soil parameters for shaft and toe, i.e. damping factors and quakes (related to the dynamic stiffness of the resistance at the pile/soil interface.)

MEASUREMENTS

PDA

The basis for the results calculated by the PDA are pile top strain and acceleration measurements which are converted to force and velocity records, respectively. The PDA conditions, calibrates and displays these signals and immediately computes average pile force and velocity thereby eliminating bending effects. Using closed form Case Method solutions, based on the one-dimensional linear wave equation, the PDA calculates the results described in the analytical solutions section below.

HPA

The ram velocity may be directly obtained using radar technology in the Hammer Performance Analyzer™. For this unit to be applicable, the ram must be visible. The impact velocity results can be automatically processed with a PC or recorded on a strip chart.

Saximeter™

For open end diesel hammers, the time between two impacts indicates the magnitude of the ram fall height or stroke. This information is not only measured and calculated by the PDA but also by the convenient, hand-held Saximeter.

PIT

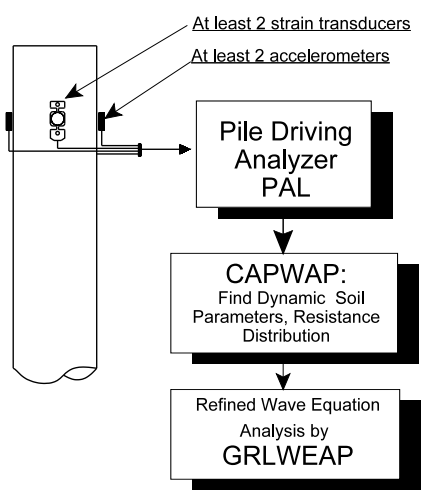
The Pile Integrity Tester™ (PIT) can be used to evaluate defects in concrete piles or shafts which may have occurred during driving or casting. Also timber piles of limited length can be tested in that manner. This so-called "Low Strain Method" or “Pulse-Echo Method” of integrity testing requires only the measurement of acceleration at the pile top. The stress wave producing impact is then generated by a small hand-held hammer and the records interpreted in the time domain. PIT also supports the so-called “Transient Response Method” which requires the additional measurement of the hammer force and an analysis in the frequency domain. This method may also be used to evaluate the unknown length of deep foundations under existing structures.

ANALYTICAL SOLUTIONS
BEARING CAPACITY

Wave Equation

GRL has written the GRLWEAP™ program which calculates a relationship between bearing capacity, pile stress and blow count. This relationship is often called the "bearing graph." Once the blow count is known from pile installation logs, the bearing graph yields the bearing capacity. This approach requires no measurements and therefore can be performed during the design stage of a project, for example for the selection of hammer, cushion and pile size.

After dynamic pile monitoring and/or dynamic load testing has been performed, the "Refined Wave Equation Analysis" or RWEA (see schematic below) is often performed by inputting the PDA and CAPWAP calculated parameters. Then the bearing graph from the RWEA is the basis for a safe and sufficient driving criteria.



Case Method

The Case Method is a closed form solution based on a few simplifying assumptions such as ideal plastic soil behavior and an ideally elastic and uniform pile. Given the measured pile top force F(t) and pile top velocity v(t), the total soil resistance is

$$R(t) = \tfrac{1}{2}\{[F(t) + F(t_2)] + Z[v(t) - v(t_2)]\} \qquad (1)$$

where

- t = a point in time after impact
- t_2 = time $t + 2L/c$
- L = pile length below gages
- c = $(E/\rho)^{1/2}$ is the speed of the stress wave
- ρ = pile mass density
- Z = EA/c is the pile impedance
- E = elastic modulus of the pile (ρc^2)
- A = pile cross sectional area

The total soil resistance consists of a dynamic (R_d) and a static (R_s) component. The static component is therefore

$$R_s(t) = R(t) - R_d(t) \qquad (2)$$

The dynamic component may be computed from a soil damping factor, J, and a pile toe velocity, $v_t(t)$ which is conveniently calculated for the pile toe. Using wave considerations, this approach leads immediately to the dynamic resistance

$$R_d(t) = J[F(t) + Zv(t) - R(t)] \qquad (3)$$

and finally to the static resistance by means of Equation 2.

There are a number of ways in which Eq. 1 through 3 can be evaluated. Most commonly, t_2 is set to that time at which the static resistance becomes maximum. The result is the so-called **RMX** capacity. Damping factors for RMX typically range between 0.5 for coarse grained materials to 1.0 for clays. The **RSP** capacity (this method is most commonly referred to in the literature, yet it is not very frequently used) requires damping factors between 0.1 for sand and 1.0 for clay. Another capacity, **RA2**, determines the capacity at a time when the pile is essentially at rest and thus damping is small; RA2

therefore requires no damping parameter. In any event, the proper Case Method and its associated damping parameter is most conveniently found after a CAPWAP analysis has been performed.

The static resistance calculated by Case Method or CAPWAP is the mobilized resistance at the time of testing. Consideration therefore has to be given to soil setup or relaxation effects and whether or not a sufficient set has been achieved under the test loading that would correspond to a full activation of the ultimate soil resistance.

The PDA also calculates an estimate of shaft resistance as the difference between force and velocity times impedance at the time immediately prior to the return of the stress wave from the pile toe. This shaft resistance is not reduced by damping effects and is therefore called the total shaft resistance **SFT**. A correction for damping effects produces the static shaft resistance estimate, **SFR**.

The Case Method solution is simple enough to be evaluated "in real time," i.e. between hammer blows, using the PDA. It is therefore possible to calculate all relevant results for all hammer blows and plot these results as a function of depth or blow number. This is done in the PDAPLOT program.

CAPWAP

The CAse Pile Wave Analysis Program combines the wave equation pile and soil model with the Case Method measurements. Thus, the solution includes not only the total and static bearing capacity values but also the shaft resistance, end bearing, damping factors and soil stiffnesses. The method iteratively calculates a number of unknowns by signal matching. While it is necessary to make hammer performance assumptions for a GRLWEAP analysis, the CAPWAP program works with the pile top measurements. Furthermore, while GRLWEAP and Case Method require certain assumptions regarding the soil behavior, CAPWAP calculates these soil parameters.

STRESSES

During pile monitoring, it is important that compressive stress maxima at pile top and toe and tensile stress maxima somewhere along the pile be calculated for each hammer blow.

At the pile top (location of sensors) both the maximum compression stress, **CSX**, and the maximum stress from individual strain transducers, **CSI**, are directly obtained from the measurements. Note that CSI is greater than or equal to CSX and the difference between CSI and CSX is a measure of bending in the plane of the strain transducers. Note also that all stresses calculated for locations below the sensors are averaged over the pile cross section and therefore do not include components from either bending or eccentric soil resistance effects.

The PDA calculates the compressive stress at the pile bottom, **CSB**, assuming (a) a uniform pile and (b) that the pile toe force is the maximum value of the total resistance R(t) minus the total shaft resistance, SFT. Again, for this stress estimation uniform resistance force are assumed (e.g. not a sloping rock.)

For concrete piles, the maximum tension stress, **TSX**, is also of great importance. It occurs at some point below the pile top. The maximum tension stress can be computed from the pile top measurements by finding the maximum tension wave (either traveling upward, W_U, or downward, W_d) and reducing it by the minimum compressive wave traveling in opposite direction.

$$W_u = ½[F(t) - Zv(t)] \quad (4)$$

$$W_d = ½[F(t) + Zv(t)] \quad (5)$$

CAPWAP also calculates tensile and compressive stresses along the pile and, in general, more accurately than the PDA. In fact, for non-uniform piles or piles with joints, cracks or other discontinuities, the closed form solutions from the PDA may be in error.

PILE INTEGRITY

High Strain Tests (PDA)

Stress waves in a pile are reflected wherever the pile impedance, $Z = EA/c = \rho cA = A \sqrt{(E \rho)}$, changes. Therefore, the pile impedance is a measure of the quality of the pile material (E, ρ, c) and the size of its cross section (A). The reflected waves arrive at the pile top at a time which is greater the farther away from the pile top the reflection occurs. The

magnitude of the change of the upward traveling wave (calculated from the measured force and velocity, Eq. 4) indicates the extent of the cross sectional change. Thus, with β_i (**BTA**) being a relative integrity factor which is unity for no impedance change and zero for the pile end, the following is calculated by the PDA.

$$\beta_i = (1 - \alpha_i)/(1 + \alpha_i) \tag{6}$$

with

$$\alpha_i = ½(W_{UR} - W_{UD})/(W_{Di} - W_{UR}) \tag{7}$$

where

W_{UR} is the upward traveling wave at the onset of the reflected wave. It is caused by resistance.

W_{UD} is the upwards traveling wave due to the damage reflection.

W_{Di} is the maximum downward traveling wave due to impact.

It can be shown that this formulation is quite accurate as long as individual reflections from different pile impedance changes have no overlapping effects on the stress wave reflections.

Without rigorous derivation, it has been proposed to consider as slight damage when β is above 0.8 and a serious damage when β is less than 0.6.

Low Strain Tests (PIT)

The pile top is struck with a held hand hammer and the resulting pile top velocity is measured, displayed and interpreted for signs of wave reflections. In general, a comparison of the reflected acceleration leads to a relative measure of extent of damage, again the location of the problem is indicated by the arrival time of the reflection. PIT records can also be interpreted by the β-Method. However, low strain tests do not activate much resistance which simplifies Eq. 7 since W_{UR} is then equal to zero.

For drilled shafts and PIT records that clearly show a toe reflection, an approximate shaft profile can be calculated from low strain records using the PITSTOP program's PROFILE routine.

HAMMER PERFORMANCE

The PDA calculates the energy transferred to the pile top from:

$$E(t) = \int_0^t F(t)v(t)\,dt \tag{8a}$$

The maximum of the E(t) curve is the most important information for an overall evaluation of the performance of a hammer and driving system. This **EMX** value allows for a classification of the hammer's performance when presented as the rated transfer efficiency, also called energy transfer ratio (**ETR**) or global efficiency

$$e_T = EMX/E_R \tag{8b}$$

where

E_R is the manufacturer's rated energy value.

Both Saximeter and PDA calculate the stroke (**STK**) of an open end diesel hammer using

$$STK = (g/8)\,T_B^2 - h_L \tag{9}$$

where

g is the earth's gravitational acceleration,
T_B is the time between two hammer blows,
h_L is a stroke loss value due to gas compression and time losses during impact (usually 0.3 ft or 0.1 m).

DETERMINATION OF WAVE SPEED

An important facet of dynamic pile testing is an assessment of pile material properties. Since in general force is determined from strain by multiplication with elastic modulus, E, and cross sectional area, A, the dynamic elastic modulus has to be determined for pile materials other than steel. In general, the records measured by the PDA clearly indicate a pile toe reflection as long as pile penetration per blow is greater than 1 mm or .04 inches. The time between the onset of the force and velocity records at impact and the onset of the reflection from the toe (usually apparent by a local maximum of the wave up curve) is the so-called wave travel time, T. Dividing 2L (L is here the length of the pile below sensors) by T leads to the stress wave speed in the pile:

$$c = 2L/T \tag{10}$$

The elastic modulus of the pile material is related to the wave speed according to the linear elastic wave equation theory by

$$E = c^2\rho \tag{11}$$

Since the mass density of the pile material, ρ, is usually well known (an exception is timber for which samples should be weighed), the elastic modulus is easily found from the wave speed. Note, however, that this is a dynamic modulus which is generally higher than the static one and that the wave speed depends to some degree on the strain level of the stress wave. For example, experience shows that the wave speed from PIT is roughly 5% higher than the wave speed observed during a high strain test.

Other Notes:

- If the pile material is nonuniform then the wave speed c, according to Eq. 10, is an average wave speed and does not necessarily reflect the pile material properties of the location where the strain sensors are attached to the pile top. For example, pile driving often causes fine tension cracks some distance below the top of concrete piles. Then the average c is slower than that at the pile top. It is therefore recommended to determine E in the beginning of pile driving and not adjust it when the average c changes.

- If the pile has such a high resistance that there is no clear indication of a toe reflection then the wave speed of the pile material must be determined either by assumption or by taking a sample of the concrete and measuring its wave speed in a simple free column test. Another possibility is to use the proportionality relationship, discussed under "DATA QUALITY CHECKS" to find c as the ratio between the measured velocity and measured strain.

DATA QUALITY CHECKS

Quality data is the first and foremost requirement for accurate dynamic testing results. It is therefore important that the measurement engineer performing PDA or PIT tests has the experience necessary to recognize measurement problems and take appropriate corrective action should problems develop. Fortunately, dynamic pile testing allows for certain data quality checks because two independent measurements are taken that have to conform to certain relationships.

Proportionality

As long as there is only a wave traveling in one direction, as is the case during impact when only a downward traveling wave exists in the pile, force and velocity measured at the pile top are proportional

$$F = v\,Z = v\,(EA/c) \tag{12a}$$

This relationship can also be expressed in terms of stress

$$\sigma = v\,(E/c) \tag{12b}$$

or strain

$$\epsilon = v / c \tag{12c}$$

This means that the early portion of strain times wave speed must be equal to the velocity unless the proportionality is affected by high friction near the pile top or by a pile cross sectional change not far below the sensors. Checking the proportionality is an excellent means of assuring meaningful measurements.

Measurements are always taken at opposite sides of the pile as a means of calculating the average force and velocity in the pile. The velocity on the two sides of the pile is very similar even when high bending exists. Thus, an independent check of the velocity measurements is easy and simple.

Strain measurements may differ greatly between the two sides of the pile when bending exists. It is even possible that tension is measured on one side while very high compression exists on the other side of the pile. In extreme cases, bending might be so high that it leads to a nonlinear stress distribution. The averaging of the two strain signals does then not lead to the average pile force and proportionality will not be achieved.

When testing drilled shafts, measurements of strain may also be affected by local concrete quality variations. It is then often necessary to use four strain transducers spaced at 90 degrees around the pile for an improved strain data quality. The use of four transducers is also recommended for large pile

diameters, particularly when it is difficult to mount the sensors at least two pile widths or diameters below the pile top.

LIMITATIONS, ADDITIONAL CONSIDERATIONS

Mobilization of capacity

Estimates of pile capacity from dynamic testing indicate the **mobilized pile capacity at the time of testing**. At very high blow counts (low set per blow), dynamic test methods tend to produce lower bound capacity estimates as not all resistance (particularly at and near the toe) is fully activated.

Time dependent soil resistance effects

Static pile capacity from dynamic method calculations provide an estimate of the axial pile capacity. Increases and decreases in the pile capacity with time typically occur (soil setup/relaxation). Therefore, **restrike testing usually yields a better indication of long term pile capacity than a test at the end of pile driving**. Often a wait period of one or two days between end of driving and restrike is satisfactory for a realistic prediction of pile capacity but this waiting time depends, among other factors, on the permeability of the soil.

(A) Soil setup

Because excess positive pore pressures often develop during pile driving in fine grained soil (clays, silts or even fine sands), the capacity of a pile at the time of driving may often be less than the long term pile capacity. These pore pressures reduce the effective stress acting on the pile thereby reducing the soil resistance to pile penetration, and thus the pile capacity at the time of driving. As these pore pressures dissipate, the soil resistance acting on the pile increases as does the axial pile capacity. This phenomena is routinely called soil setup or soil freeze.

(*B) Relaxation*

Relaxation (capacity reduction with time) has been observed for piles driven into weathered shale, and may take several days to fully develop. Pile capacity estimates based upon initial driving or short term restrike tests can significantly overpredict long term pile capacity. Therefore, piles driven into shale should be tested after a minimum one week wait either statically or dynamically (with particular emphasis than on the first few blows). Relaxation has also been observed for displacement piles driven into dense saturated silts or fine sands due to a negative pore pressure effect at the pile toe. Again, restrike tests should be used, with great emphasis on early blows.

Capacity results for open pile profiles

Larger diameter open ended pipe piles (or H-piles which do not bear on rock) may behave differently under dynamic and static loading conditions. Under dynamic loads the soil inside the pile or between its flanges may slip and produce internal friction while under static loads the plug may move with the pile, thereby creating end bearing over the full pile cross section. As a result both friction and end bearing components may be different under static and dynamic conditions.

CAPWAP Analysis Results

A portion of the soil resistance calculated on an individual soil segment in a CAPWAP analysis can usually be shifted up or down the shaft one soil segment without significantly altering the match quality. Therefore, use of the CAPWAP resistance distribution for uplift, downdrag, scour, or other geotechnical considerations should be made with an understanding of these analysis limitations.

Stresses

PDA and CAPWAP calculated stresses are average values over the cross section. Additional allowance has to be made for bending or non-uniform contact stresses. To prevent damage it is therefore important to maintain good hammer-pile alignment and to protect the pile toes using appropriate devices or an increased cross sectional area.

In the United States is has become generally acceptable to limit the dynamic installation stresses of driven piles to the following levels:

- 90% of yield strength for steel piles
- 85% of the concrete compressive strength - after subtraction of the effective prestress - for concrete piles in compression

100% of effective prestress plus ½ of the concrete's tension strength for prestressed piles in tension

70% of the reinforcement strength for regularly reinforced concrete piles in tension

300% of the static design allowable stress for timber

Note that the dynamic stresses may either be directly measured at the pile top by the PDA or calculated by the PDA for other locations along the pile based on the pile top measurements.

Additional design considerations

Numerous factors have to be considered in pile foundation design. Some of these considerations include

- additional pile loading from downdrag or negative skin friction,
- lateral and uplift loading requirements
- effective stress changes (due to changes in water table, excavations, fills or other changes in overburden),
- long term settlements in general and settlement from underlying weaker layers and/or pile group effects,

These factors have not been evaluated by GRL and have not been considered in the interpretation of the dynamic testing results. The foundation designer should determine if these or any other considerations are applicable to this project and the foundation design.

Wave equation analysis results

The results calculated by the wave equation analysis program depend on a variety of hammer, pile and soil input parameters. Although attempts have been made to base the analysis on the best available information, actual field conditions may vary and therefore stresses and blow counts may differ from the predictions reported. Capacity predictions derived from wave equation analyses should use restrike information. However, because of the uncertainties associated with restrike blow counts and restrike hammer energies, correlations of such results with static test capacities with have often displayed considerable scatter.

As for PDA and CAPWAP, the theory on which GRLWEAP is based is the one-dimensional wave equation. For that reason, stress predictions by the wave equation analysis can only be averages over the pile cross section. Thus, bending stresses or stress concentrations due to non-uniform impact or uneven soil or rock resistance are not considered in these results. Stress maxima calculated by the wave equation are usually subjected to the same limits as those measured directly or calculated from measurements by the PDA.

Appendix B

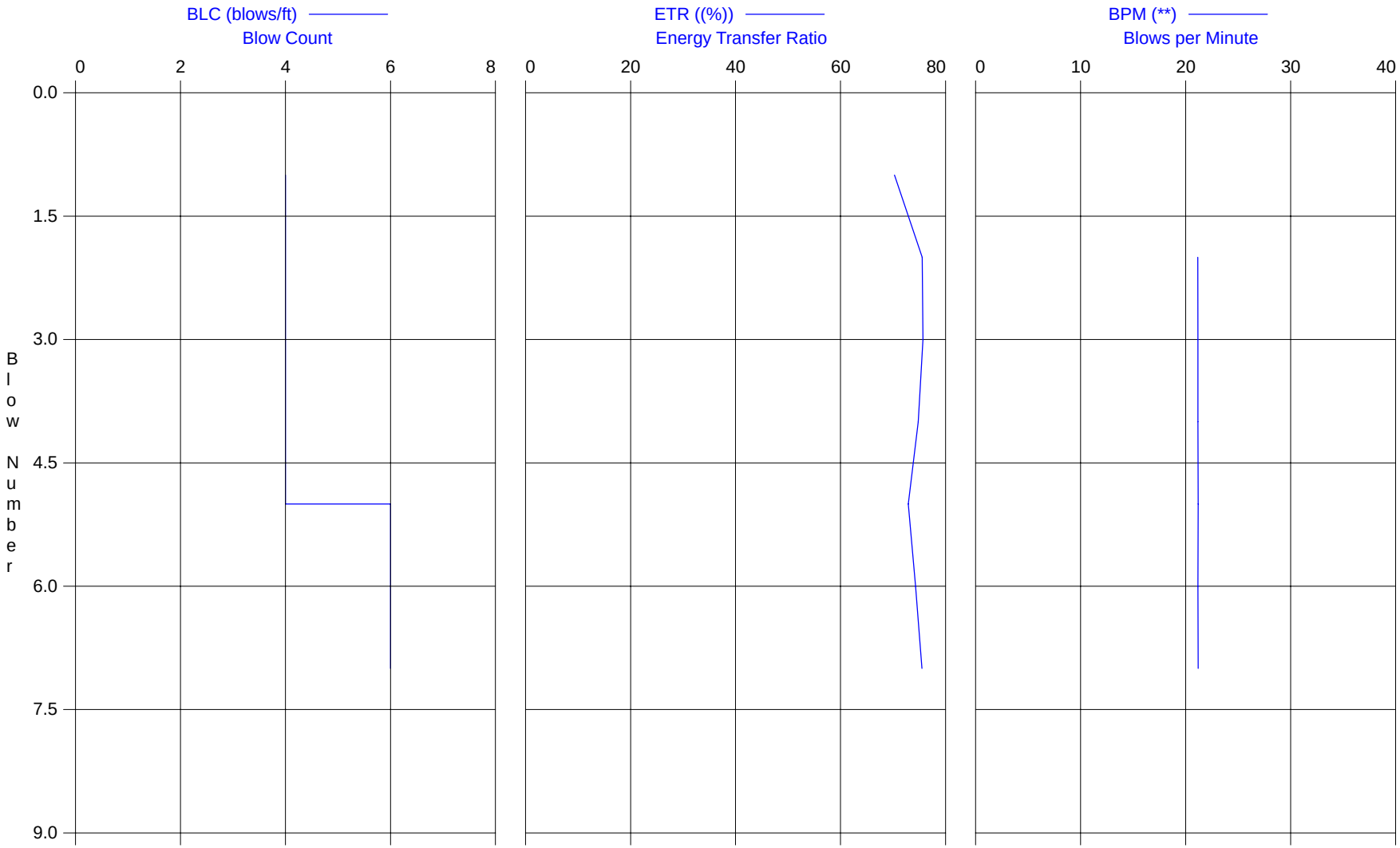
Summary of Case Method Field Results

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

Test date: 8-Sep-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-2



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-2
OP: RMDT-A. BANAS

SPT NW ROD
Test date: 8-Sep-2010

AR: 1.42 in^2
LE: 8.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.30

CSX: Max Measured Compr. Stress
FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total
DMX: Maximum Displacement

BL#	depth	BLC	CSX	FMX	VMX	EFV	ETR	BPM	EF2	SFT	DMX
	ft	bl/ft	ksi	kips	f/s	k-ft	(%)	**	k-ft	kips	in
3	5.75	4	25.5	36	16.1	0.3	75.7	21.2	0.3	13	2.75
4	6.00	4	25.6	36	15.8	0.3	74.8	21.2	0.3	12	2.46
5	6.17	6	25.3	36	15.4	0.3	72.9	21.2	0.3	11	2.36
6	6.33	6	25.1	36	15.7	0.3	74.3	21.2	0.3	11	2.25
7	6.50	6	25.1	36	15.7	0.3	75.5	21.2	0.3	11	2.13
		Average	25.3	36	15.7	0.3	74.6	21.2	0.3	11	2.39
		Std. Dev.	0.2	0	0.2	0.0	1.0	0.0	0.0	1	0.21
		Maximum	25.6	36	16.1	0.3	75.7	21.2	0.3	13	2.75
		@ Blow#	4	4	3	3	3	7	3	3	3

Total number of blows analyzed: 5

Time Summary

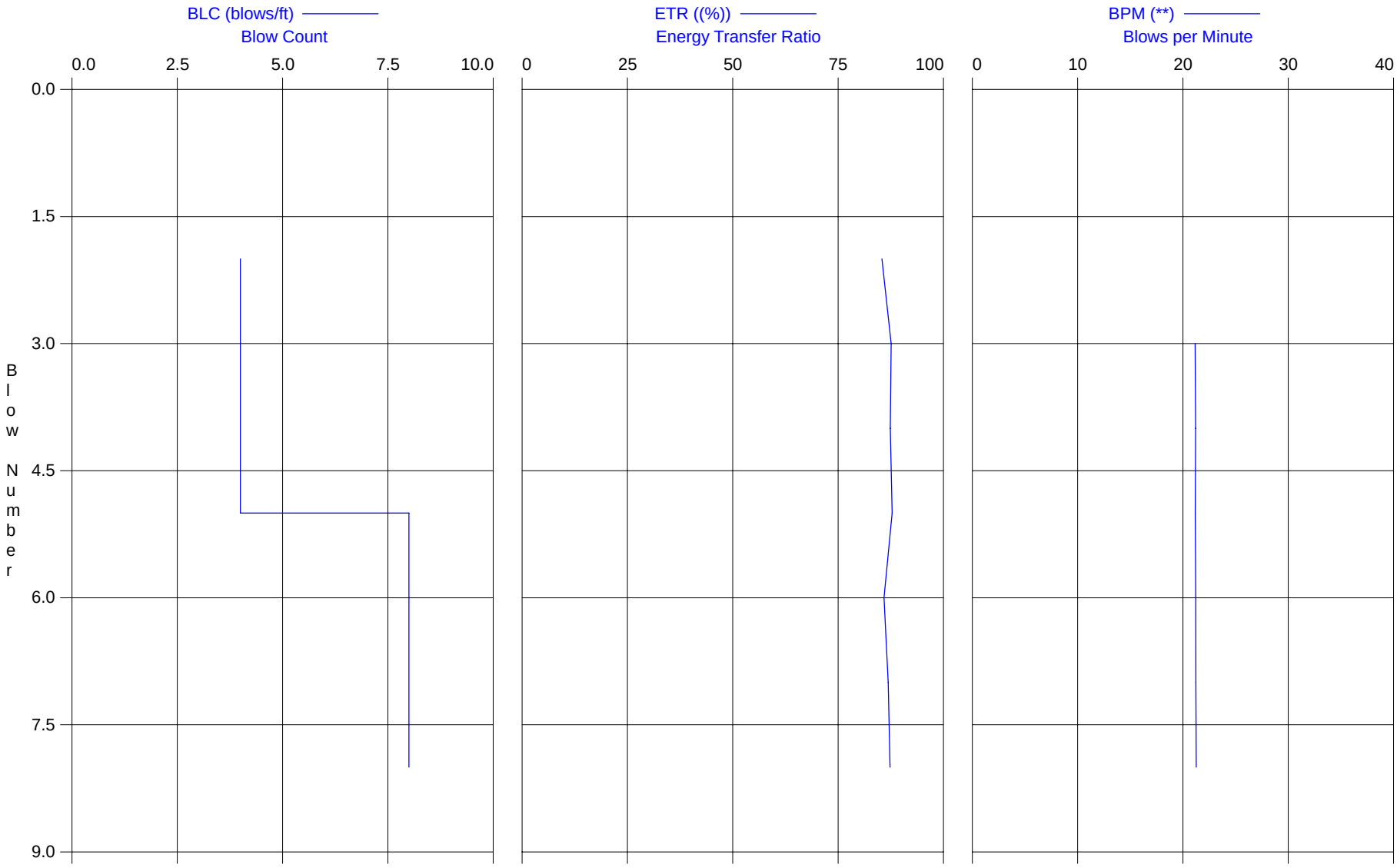
Drive 17 seconds 9:52:14 AM - 9:52:31 AM (9/8/2010) BN 1 - 7

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

Test date: 8-Sep-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-4



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-4
OP: RMDT-A. BANAS

SPT NW ROD
Test date: 8-Sep-2010

AR: 1.42 in^2
LE: 18.60 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.30

CSX: Max Measured Compr. Stress
FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total
DMX: Maximum Displacement

BL#	depth	BLC	CSX	FMX	VMX	EFV	ETR	BPM	EF2	SFT	DMX
	ft	bl/ft	ksi	kips	f/s	k-ft	(%)	**	k-ft	kips	in
3	15.75	4	26.7	38	16.4	0.3	87.6	21.2	0.4	15	2.65
4	16.00	4	26.5	38	16.4	0.3	87.4	21.2	0.4	14	2.37
5	16.13	8	25.8	37	16.0	0.3	87.8	21.2	0.4	15	2.30
6	16.25	8	26.2	37	15.7	0.3	85.9	21.2	0.4	14	2.16
7	16.38	8	25.7	36	15.8	0.3	86.9	21.2	0.4	15	1.97
8	16.50	8	26.3	37	15.7	0.3	87.3	21.3	0.4	14	1.72
		Average	26.2	37	16.0	0.3	87.2	21.2	0.4	14	2.19
		Std. Dev.	0.4	1	0.3	0.0	0.6	0.0	0.0	0	0.30
		Maximum	26.7	38	16.4	0.3	87.8	21.3	0.4	15	2.65
		@ Blow#	3	3	3	3	5	8	4	7	3

Total number of blows analyzed: 6

Time Summary

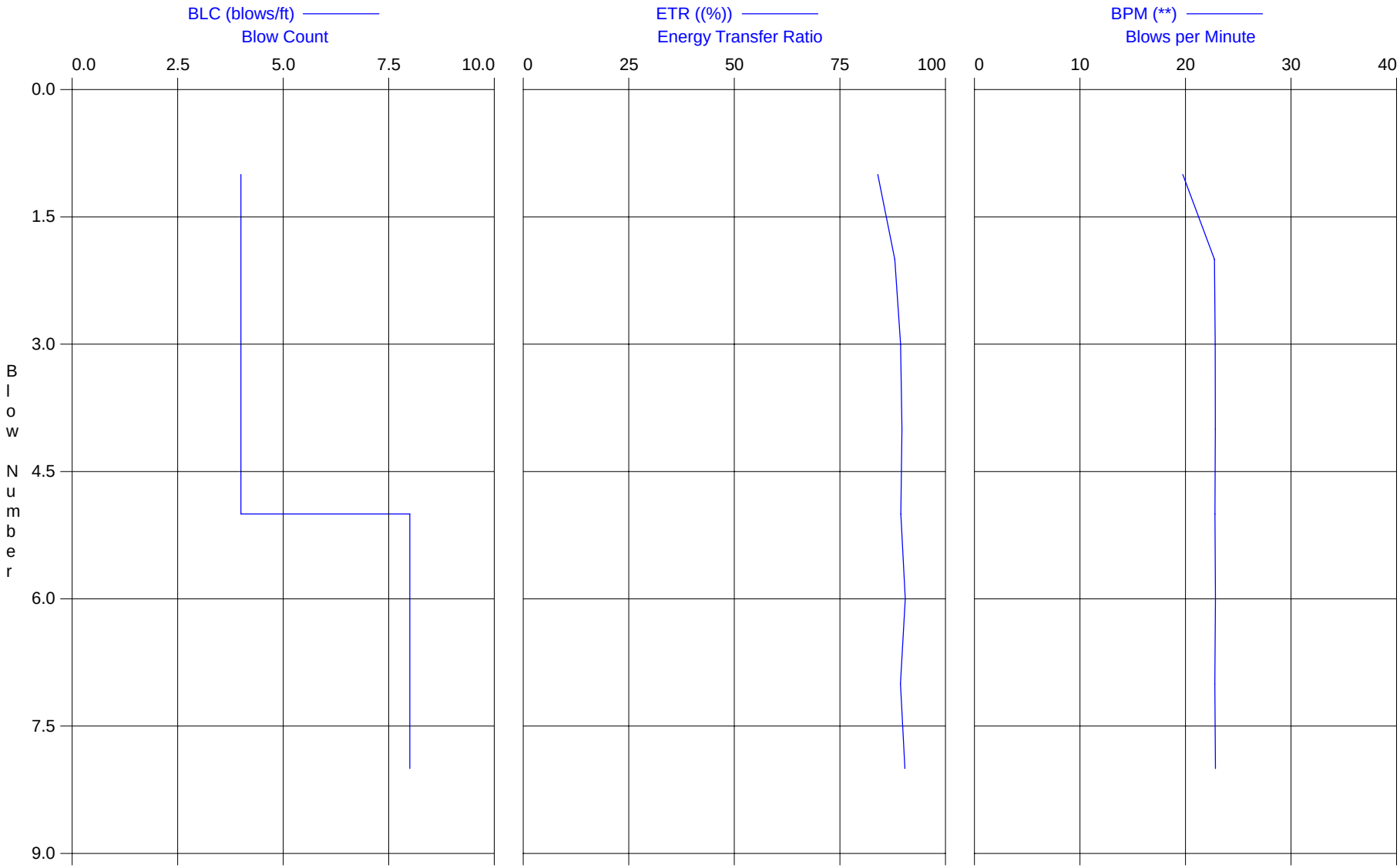
Drive 17 seconds 10:27:37 AM - 10:27:54 AM (9/8/2010) BN 2 - 8

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

Test date: 8-Sep-2010

WM-MAJOR DRILL SPT, OREGON - GT-10-11-5



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

WM-MAJOR DRILL SPT, OREGON - GT-10-11-5

SPT NW ROD

OP: RMDT-A. BANAS

Test date: 8-Sep-2010

AR: 1.42 in^2
LE: 26.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.30

CSX: Max Measured Compr. Stress
RX7: Max Case Method Capacity (JC=0.7)
BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total
DMX: Maximum Displacement

BL#	depth	BLC	CSX	RX7	BPM	EFV	ETR	BPM	EF2	SFT	DMX
	ft	bl/ft	ksi	kips	**	k-ft	(%)	**	k-ft	kips	in
3	20.75	4	27.5	6	22.8	0.7	89.4	22.8	0.8	24	2.14
4	21.00	4	27.8	6	22.8	0.7	89.7	22.8	0.8	21	2.07
5	21.13	8	28.0	5	22.8	0.7	89.4	22.8	0.8	25	2.17
6	21.25	8	27.6	6	22.8	0.7	90.5	22.8	0.8	25	2.06
7	21.38	8	27.9	6	22.8	0.7	89.4	22.8	0.8	25	1.94
8	21.50	8	27.7	6	22.8	0.7	90.4	22.8	0.8	22	2.01
		Average	27.7	6	22.8	0.7	89.8	22.8	0.8	24	2.06
		Std. Dev.	0.2	0	0.0	0.0	0.5	0.0	0.0	2	0.08
		Maximum	28.0	6	22.8	0.7	90.5	22.8	0.8	25	2.17
		@ Blow#	5	6	8	6	6	8	5	7	5

Total number of blows analyzed: 6

Time Summary

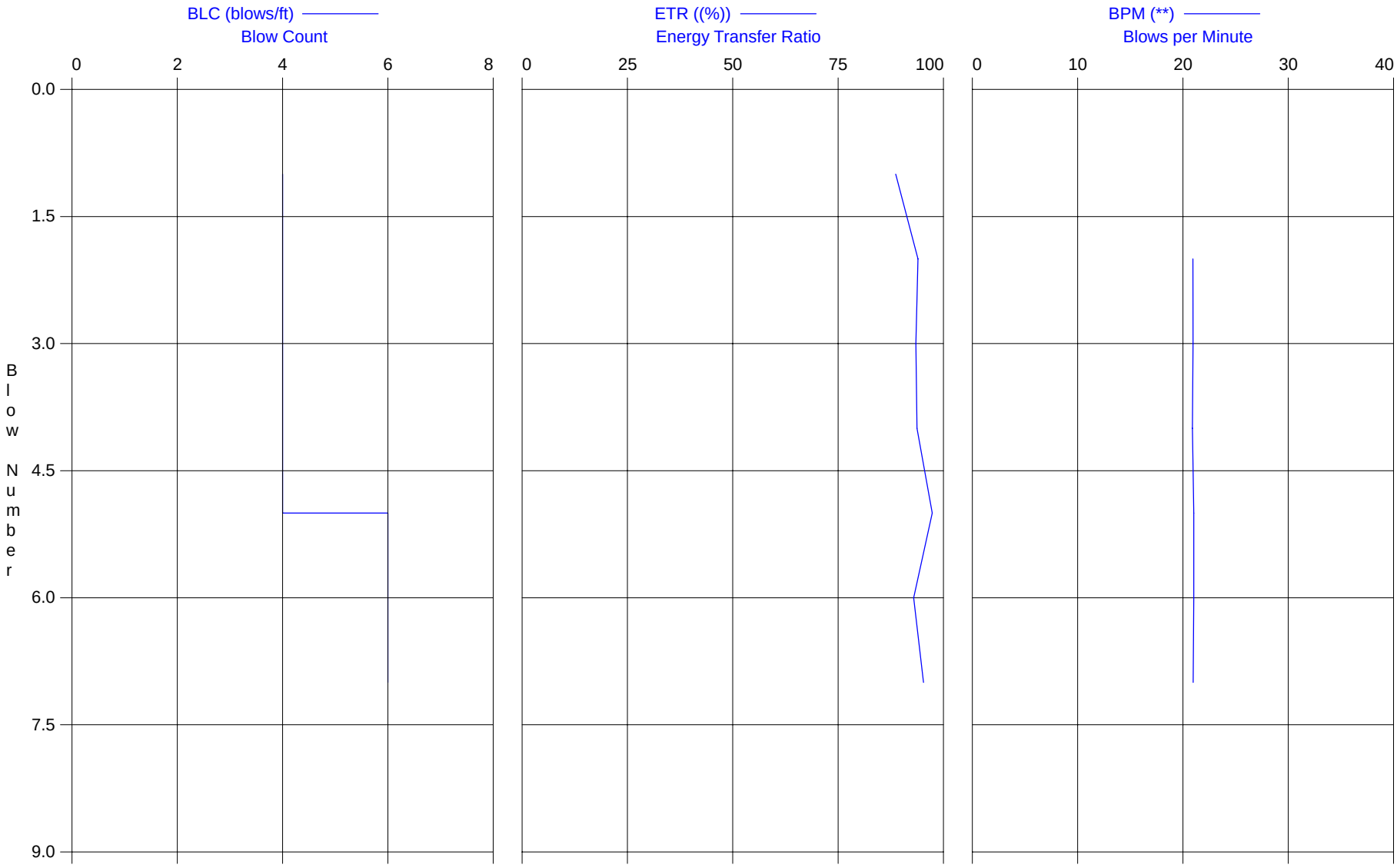
Drive 19 seconds 10:56:50 AM - 10:57:09 AM (9/8/2010) BN 1 - 8

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

Test date: 8-Sep-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-7



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-7
OP: RMDT-A. BANAS

SPT NW ROD
Test date: 8-Sep-2010

AR: 1.42 in^2
LE: 34.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.30

CSX: Max Measured Compr. Stress
FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total
DMX: Maximum Displacement

BL#	depth	BLC	CSX	FMX	VMX	EFV	ETR	BPM	EF2	SFT	DMX
	ft	bl/ft	ksi	kips	f/s	k-ft	(%)	**	k-ft	kips	in
3	30.75	4	26.7	38	16.0	0.3	93.5	21.0	0.4	17	2.26
4	31.00	4	25.9	37	15.9	0.3	93.7	20.9	0.4	18	1.85
5	31.17	6	26.1	37	15.8	0.3	97.3	21.0	0.4	18	1.73
6	31.33	6	26.7	38	15.6	0.3	93.0	21.0	0.4	18	1.83
7	31.50	6	26.7	38	15.6	0.3	95.3	21.0	0.4	18	1.76
		Average	26.4	38	15.8	0.3	94.6	21.0	0.4	18	1.89
		Std. Dev.	0.3	0	0.1	0.0	1.6	0.0	0.0	1	0.19
		Maximum	26.7	38	16.0	0.3	97.3	21.0	0.4	18	2.26
		@ Blow#	7	7	3	5	5	5	5	5	3

Total number of blows analyzed: 5

Time Summary

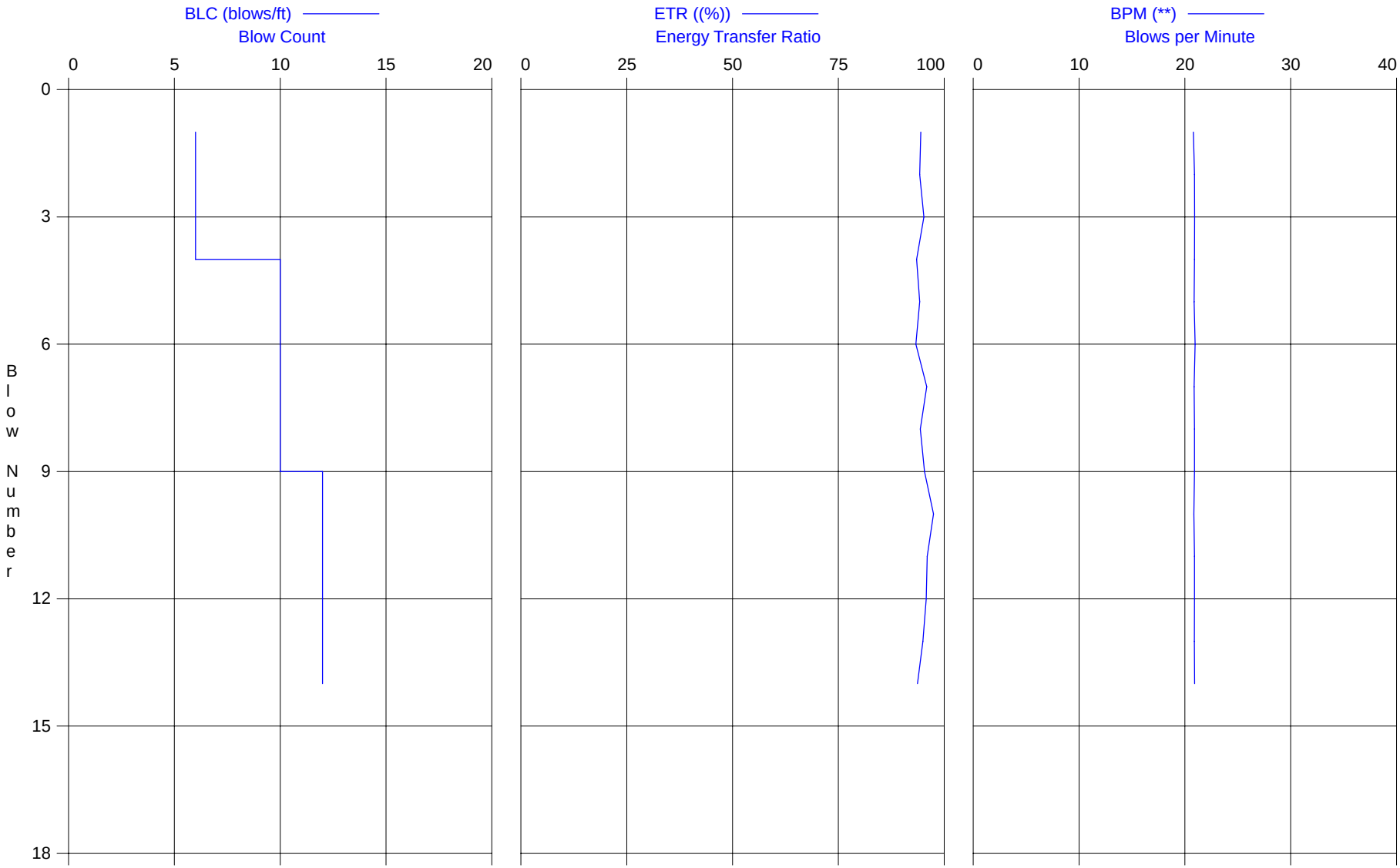
Drive 17 seconds 11:41:10 AM - 11:41:27 AM (9/8/2010) BN 1 - 7

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

Test date: 8-Sep-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-9



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-9
OP: RMDT-A. BANAS

SPT NW ROD
Test date: 8-Sep-2010

AR: 1.42 in^2
LE: 44.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.30

CSX: Max Measured Compr. Stress
EF2: Energy of F^2
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

DMX: Maximum Displacement
FMX: Maximum Force
RX7: Max Case Method Capacity (JC=0.7)
SFT: Skin friction total

BL#	depth	BLC	CSX	EF2	EFV	ETR	BPM	DMX	FMX	RX7	SFT
	ft	bl/ft	ksi	k-ft	k-ft	(%)	**	in	kips	kips	kips
4	40.60	10	27.6	0.9	0.7	93.5	20.9	1.51	39	17	15
5	40.70	10	27.7	0.9	0.7	94.2	20.9	1.53	39	17	15
6	40.80	10	27.9	0.9	0.7	93.3	21.0	1.39	40	18	14
7	40.90	10	28.1	0.9	0.7	95.9	20.9	1.33	40	18	15
8	41.00	10	28.2	0.9	0.7	94.4	20.9	1.23	40	18	15
9	41.08	12	28.2	0.9	0.7	95.4	20.9	1.19	40	18	15
10	41.17	12	28.1	0.9	0.7	97.5	20.8	1.17	40	18	16
11	41.25	12	28.2	0.9	0.7	96.0	20.9	1.11	40	18	15
12	41.33	12	28.1	0.9	0.7	95.7	20.9	1.05	40	18	15
13	41.42	12	28.6	0.9	0.7	95.0	20.9	0.99	41	20	15
14	41.50	12	28.3	0.9	0.7	93.7	20.9	0.95	40	19	14
		Average	28.1	0.9	0.7	95.0	20.9	1.22	40	18	15
		Std. Dev.	0.2	0.0	0.0	1.2	0.0	0.19	0	1	1
		Maximum	28.6	0.9	0.7	97.5	21.0	1.53	41	20	16
		@ Blow#	13	10	10	10	6	5	13	13	10

Total number of blows analyzed: 11

Time Summary

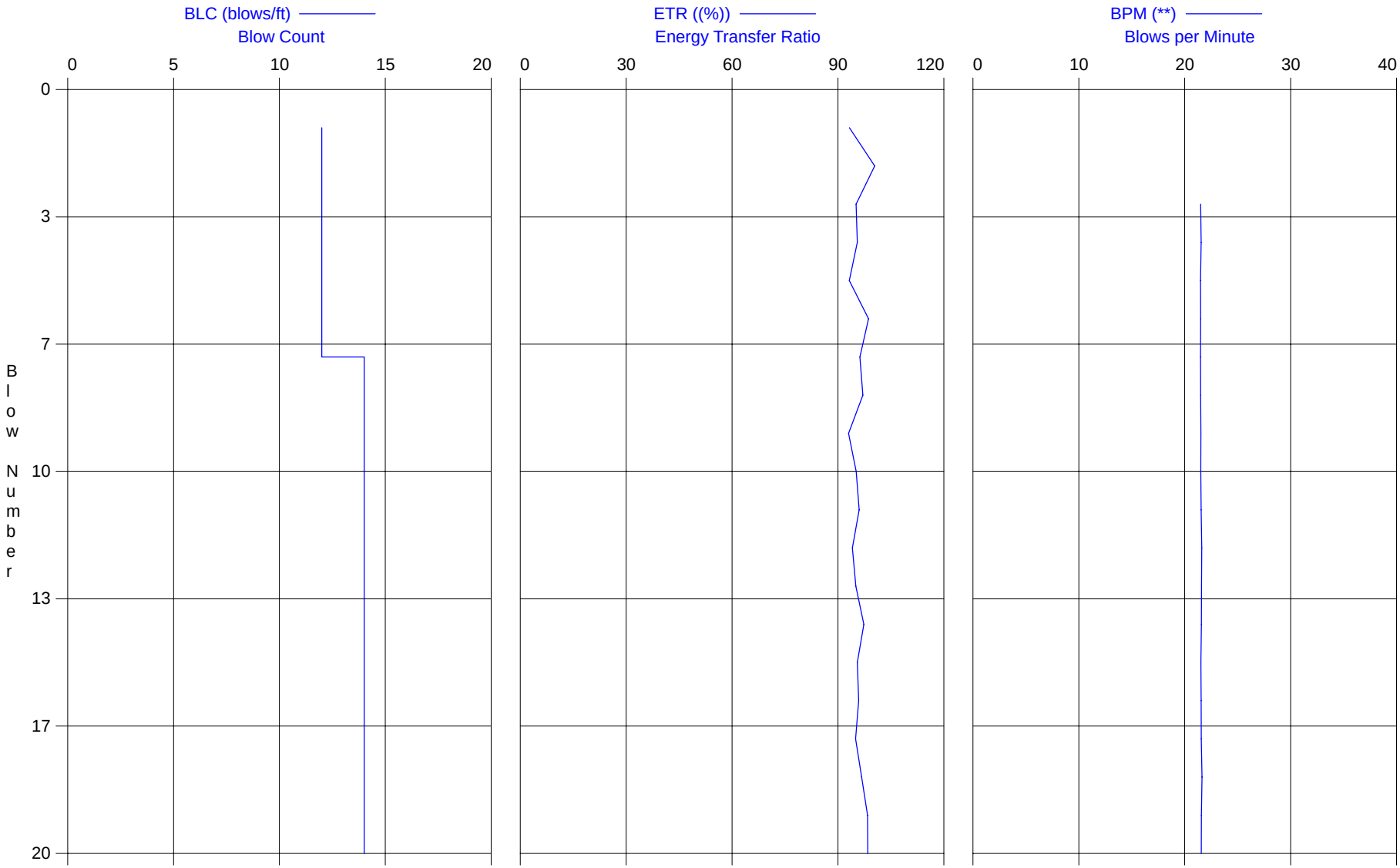
Drive 37 seconds 12:51:46 PM - 12:52:23 PM (9/8/2010) BN 1 - 14

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

Test date: 8-Sep-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-10



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-10
OP: RMDT-A. BANAS

SPT NW ROD
Test date: 8-Sep-2010

AR: 1.42 in^2
LE: 49.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.30

CSX: Max Measured Compr. Stress
RX7: Max Case Method Capacity (JC=0.7)
BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total
DMX: Maximum Displacement

BL#	depth	BLC	CSX	RX7	BPM	EFV	ETR	BPM	EF2	SFT	DMX
	ft	bl/ft	ksi	kips	**	k-ft	(%)	**	k-ft	kips	in
7	45.57	14	26.4	9	21.5	0.3	96.2	21.5	0.4	14	1.10
8	45.64	14	25.8	10	21.5	0.3	97.1	21.5	0.4	15	1.03
9	45.71	14	26.1	10	21.5	0.3	93.0	21.5	0.4	14	1.15
10	45.79	14	26.5	9	21.5	0.3	95.2	21.5	0.4	15	1.35
11	45.86	14	26.2	9	21.6	0.3	96.0	21.6	0.4	15	1.18
12	45.93	14	25.8	10	21.6	0.3	94.1	21.6	0.4	15	1.13
13	46.00	14	26.4	10	21.6	0.3	95.1	21.6	0.4	15	1.22
14	46.07	14	26.0	9	21.6	0.3	97.3	21.6	0.4	16	1.22
15	46.14	14	25.5	9	21.5	0.3	95.5	21.5	0.4	16	1.21
16	46.21	14	26.9	9	21.6	0.3	95.9	21.6	0.4	14	1.14
17	46.29	14	26.2	9	21.6	0.3	95.0	21.6	0.4	15	1.15
18	46.36	14	26.7	9	21.6	0.3	96.7	21.6	0.4	15	0.81
19	46.43	14	26.8	9	21.6	0.3	98.4	21.6	0.4	15	0.67
20	46.50	14	26.2	8	21.6	0.3	98.4	21.6	0.4	15	0.67
		Average	26.2	9	21.6	0.3	96.0	21.6	0.4	15	1.07
		Std. Dev.	0.4	1	0.0	0.0	1.5	0.0	0.0	0	0.20
		Maximum	26.9	10	21.6	0.3	98.4	21.6	0.4	16	1.35
		@ Blow#	16	12	18	19	20	18	11	15	10

Total number of blows analyzed: 14

Time Summary

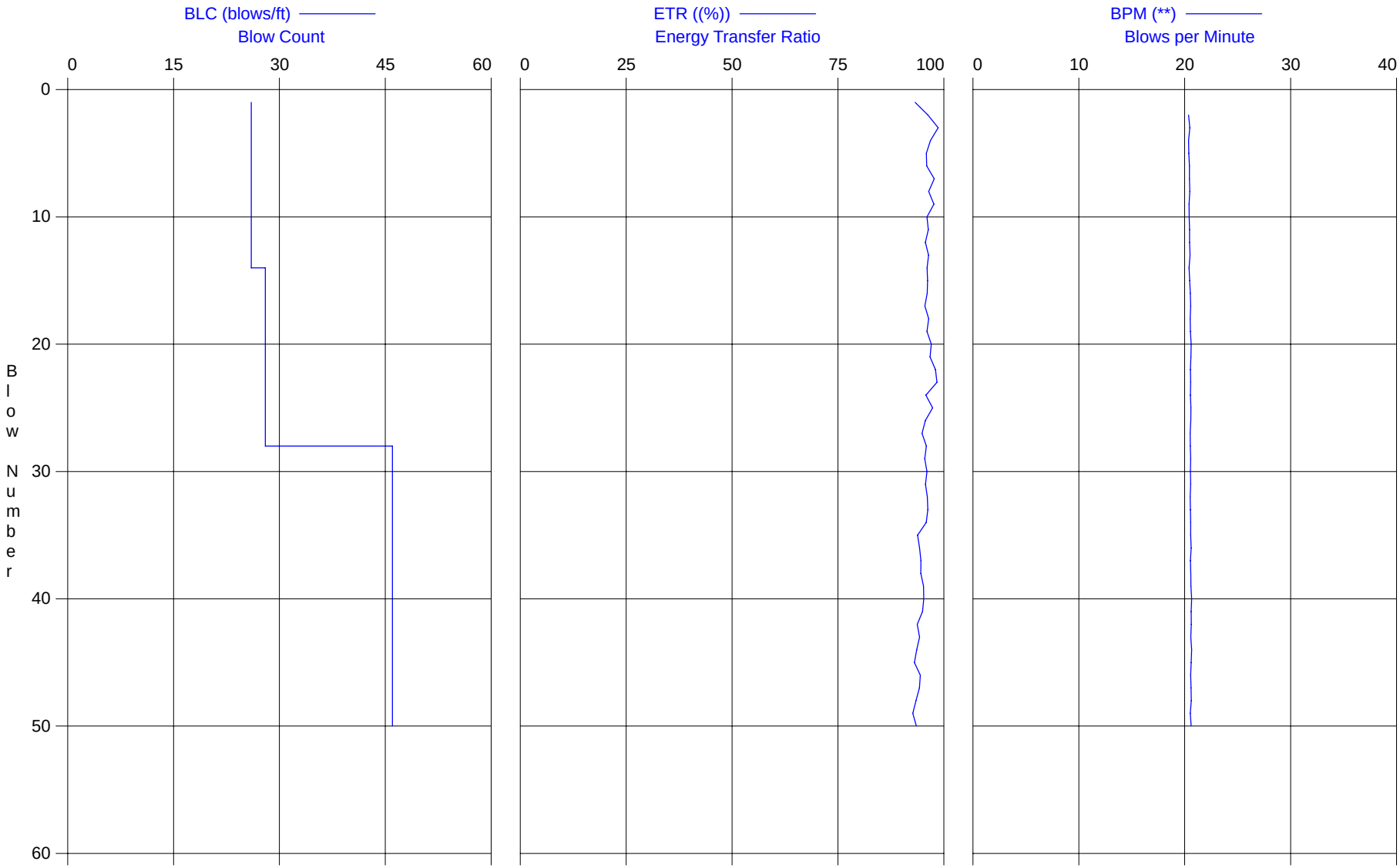
Drive 1 minute 24 seconds 1:31:47 PM - 1:33:11 PM (9/8/2010) BN 1 - 20

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

Test date: 8-Sep-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-12



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-12
OP: RMDT-A. BANAS

SPT NW ROD
Test date: 8-Sep-2010

AR: 1.42 in^2
LE: 54.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.30

CSX: Max Measured Compr. Stress
FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total
DMX: Maximum Displacement

BL#	depth	BLC	CSX	FMX	VMX	EFV	ETR	BPM	EF2	SFT	DMX
	ft	bl/ft	ksi	kips	f/s	k-ft	(%)	**	k-ft	kips	in
14	50.54	28	26.5	38	13.1	0.3	96.1	20.4	0.4	12	0.51
15	50.57	28	25.7	36	12.6	0.3	96.2	20.5	0.4	13	0.57
16	50.61	28	25.9	37	12.8	0.3	96.1	20.5	0.4	13	0.49
17	50.64	28	25.9	37	12.8	0.3	95.5	20.6	0.4	13	0.51
18	50.68	28	26.0	37	12.8	0.3	96.4	20.5	0.4	13	0.54
19	50.71	28	26.2	37	13.0	0.3	96.0	20.5	0.4	13	0.55
20	50.75	28	25.5	36	12.9	0.3	97.0	20.6	0.4	13	0.59
21	50.79	28	25.9	37	12.8	0.3	96.7	20.6	0.4	13	0.51
22	50.82	28	26.2	37	13.0	0.3	98.0	20.5	0.4	13	0.59
23	50.86	28	26.3	37	13.2	0.3	98.4	20.6	0.4	13	0.61
24	50.89	28	25.7	37	12.3	0.3	95.7	20.5	0.4	12	0.61
25	50.93	28	25.5	36	12.6	0.3	97.3	20.6	0.4	13	0.52
26	50.96	28	27.0	38	13.4	0.3	95.6	20.6	0.4	12	0.59
27	51.00	28	25.5	36	12.3	0.3	94.9	20.5	0.4	12	0.58
28	51.02	46	25.5	36	12.5	0.3	95.9	20.5	0.4	13	0.56
29	51.04	46	25.2	36	12.4	0.3	95.5	20.6	0.4	12	0.50
30	51.07	46	26.2	37	13.1	0.3	96.0	20.5	0.4	12	0.50
31	51.09	46	26.8	38	13.4	0.3	95.7	20.6	0.4	13	0.49
32	51.11	46	25.9	37	12.6	0.3	96.1	20.5	0.4	14	0.46
33	51.13	46	26.3	37	12.7	0.3	96.2	20.5	0.4	14	0.42
34	51.15	46	25.9	37	12.9	0.3	95.8	20.6	0.4	13	0.38
35	51.17	46	26.6	38	12.9	0.3	93.8	20.6	0.4	12	0.38
36	51.20	46	25.9	37	12.6	0.3	94.3	20.6	0.4	12	0.38
37	51.22	46	26.4	37	12.9	0.3	94.6	20.5	0.4	12	0.36
38	51.24	46	25.7	36	12.6	0.3	94.5	20.6	0.4	13	0.36
39	51.26	46	26.2	37	12.8	0.3	95.2	20.6	0.4	14	0.37
40	51.28	46	25.6	36	12.5	0.3	95.2	20.7	0.4	13	0.47
41	51.30	46	25.8	37	12.5	0.3	95.0	20.6	0.4	13	0.44
42	51.33	46	25.6	36	12.7	0.3	93.7	20.6	0.4	13	0.44
43	51.35	46	26.1	37	12.7	0.3	94.3	20.6	0.4	13	0.45
44	51.37	46	26.1	37	12.8	0.3	93.6	20.7	0.4	12	0.45
45	51.39	46	25.4	36	12.3	0.3	93.1	20.6	0.4	12	0.34
46	51.41	46	25.5	36	12.9	0.3	94.4	20.6	0.4	13	0.36
47	51.44	46	27.1	38	13.4	0.3	94.2	20.6	0.4	12	0.43
48	51.46	46	25.9	37	12.6	0.3	93.4	20.6	0.4	13	0.42
49	51.48	46	27.2	39	13.2	0.3	92.7	20.5	0.4	12	0.43
50	51.50	46	25.9	37	13.0	0.3	93.5	20.6	0.4	13	0.36
		Average	26.0	37	12.8	0.3	95.3	20.6	0.4	13	0.47
		Std. Dev.	0.5	1	0.3	0.0	1.3	0.0	0.0	1	0.08
		Maximum	27.2	39	13.4	0.3	98.4	20.7	0.4	14	0.61
		@ Blow#	49	49	31	23	23	40	43	32	23

Total number of blows analyzed: 37

Time Summary

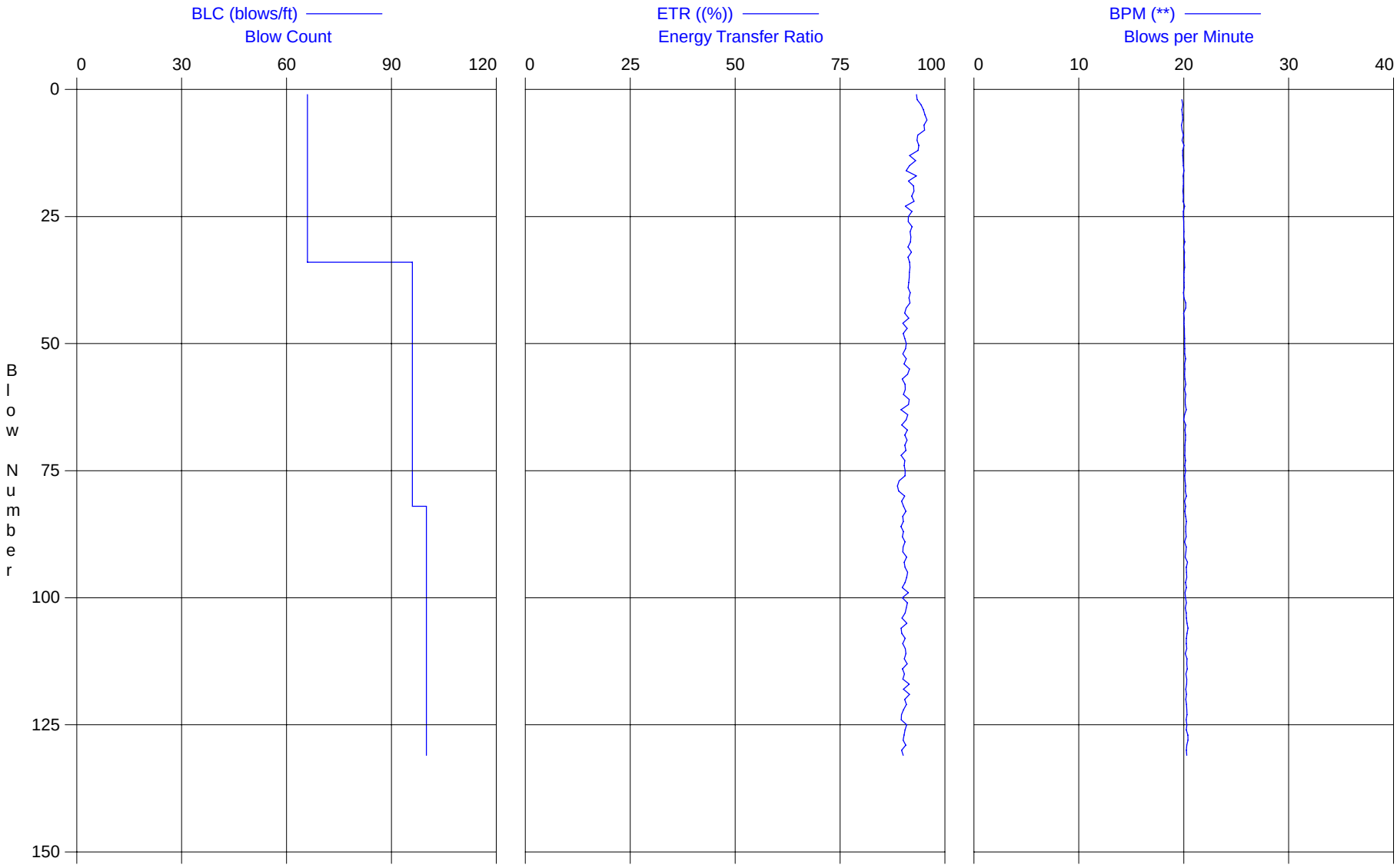
Drive 2 minutes 23 seconds 2:15:30 PM - 2:17:53 PM (9/8/2010) BN 1 - 50

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

Test date: 8-Sep-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-13



WM-MAJOR DRILL SPT, OREGON - GT10-11-13
OP: RMDT-A. BANAS

SPT NW ROD
Test date: 8-Sep-2010

AR: 1.42 in^2
LE: 59.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.30

CSX: Max Measured Compr. Stress
FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total
DMX: Maximum Displacement

BL#	depth	BLC	CSX	FMX	VMX	EFV	ETR	BPM	EF2	SFT	DMX
	ft	bl/ft	ksi	kips	f/s	k-ft	(%)	**	k-ft	kips	in
34	55.51	96	25.9	37	12.6	0.3	91.6	20.1	0.4	14	0.41
36	55.53	96	25.6	36	12.4	0.3	91.5	20.0	0.4	14	0.44
38	55.55	96	25.8	37	12.2	0.3	91.4	20.0	0.4	14	0.38
40	55.57	96	25.5	36	12.3	0.3	91.7	20.0	0.4	14	0.46
42	55.59	96	25.8	37	12.5	0.3	91.7	20.2	0.4	13	0.43
44	55.62	96	26.5	38	12.7	0.3	90.4	20.0	0.4	13	0.34
46	55.64	96	26.3	37	12.7	0.3	90.0	20.0	0.4	13	0.33
48	55.66	96	26.9	38	12.9	0.3	90.1	20.1	0.4	12	0.32
50	55.68	96	26.2	37	12.7	0.3	90.8	20.1	0.4	12	0.37
52	55.70	96	25.7	36	12.5	0.3	90.0	20.1	0.4	13	0.30
54	55.72	96	26.4	37	12.4	0.3	90.3	20.1	0.4	13	0.40
56	55.74	96	25.7	36	12.5	0.3	91.1	20.1	0.4	14	0.41
58	55.76	96	25.8	37	12.3	0.3	90.5	20.2	0.4	13	0.36
60	55.78	96	25.8	37	12.5	0.3	90.1	20.2	0.4	13	0.39
62	55.80	96	26.9	38	12.9	0.3	91.3	20.1	0.4	11	0.45
64	55.82	96	26.2	37	12.6	0.3	91.2	20.1	0.4	12	0.41
66	55.84	96	25.9	37	12.3	0.3	89.7	20.2	0.4	12	0.34
68	55.87	96	26.7	38	12.6	0.3	90.4	20.2	0.4	12	0.29
70	55.89	96	26.2	37	12.4	0.3	90.5	20.1	0.4	12	0.25
72	55.91	96	25.3	36	12.3	0.3	89.6	20.1	0.4	12	0.25
74	55.93	96	25.7	36	12.2	0.3	90.3	20.1	0.4	11	0.25
76	55.95	96	25.4	36	12.4	0.3	90.5	20.1	0.4	11	0.26
78	55.97	96	25.6	36	12.3	0.3	88.7	20.2	0.4	11	0.25
80	55.99	96	26.4	37	12.9	0.3	90.4	20.3	0.4	12	0.24
82	56.01	100	25.9	37	12.5	0.3	90.2	20.2	0.4	13	0.24
84	56.03	100	25.6	36	12.4	0.3	89.9	20.2	0.4	13	0.25
86	56.05	100	26.3	37	12.5	0.3	89.5	20.2	0.4	13	0.25
88	56.07	100	25.4	36	12.3	0.3	89.9	20.2	0.4	13	0.24
90	56.09	100	26.6	38	12.7	0.3	90.0	20.2	0.4	13	0.23
92	56.11	100	26.0	37	12.6	0.3	90.9	20.1	0.4	13	0.24
94	56.13	100	26.0	37	12.4	0.3	90.5	20.2	0.4	12	0.23
96	56.15	100	26.4	38	12.7	0.3	90.9	20.3	0.4	12	0.24
98	56.17	100	26.0	37	12.5	0.3	89.8	20.3	0.4	12	0.24
100	56.19	100	24.9	35	11.9	0.3	89.9	20.2	0.4	11	0.24
102	56.21	100	25.8	37	12.6	0.3	90.8	20.2	0.4	11	0.24
104	56.23	100	25.4	36	12.3	0.3	89.8	20.3	0.4	13	0.26
106	56.25	100	25.4	36	12.2	0.3	89.6	20.4	0.4	13	0.25
108	56.27	100	25.4	36	12.4	0.3	90.5	20.3	0.4	13	0.24
110	56.29	100	26.0	37	12.7	0.3	90.6	20.3	0.4	13	0.27
112	56.31	100	26.1	37	12.7	0.3	90.3	20.3	0.4	14	0.29
114	56.33	100	26.0	37	12.6	0.3	89.9	20.3	0.4	13	0.24
116	56.35	100	26.3	37	12.8	0.3	90.0	20.3	0.4	13	0.33
118	56.37	100	25.4	36	12.3	0.3	90.1	20.2	0.4	12	0.26
120	56.39	100	25.6	36	12.4	0.3	90.4	20.2	0.4	12	0.27
122	56.41	100	25.5	36	12.5	0.3	90.2	20.3	0.4	12	0.23
124	56.43	100	24.8	35	12.2	0.3	89.6	20.2	0.4	13	0.28
126	56.45	100	25.4	36	12.6	0.3	90.5	20.2	0.4	12	0.31
128	56.47	100	25.2	36	12.5	0.3	90.0	20.4	0.4	13	0.27
130	56.49	100	25.8	37	12.7	0.3	89.7	20.3	0.4	13	0.31
		Average	25.9	37	12.5	0.3	90.5	20.2	0.4	13	0.31
		Std. Dev.	0.5	1	0.2	0.0	0.7	0.1	0.0	1	0.08
		Maximum	26.9	38	12.9	0.3	91.7	20.4	0.4	14	0.48
		@ Blow#	48	48	35	34	40	128	47	36	35

Total number of blows analyzed: 98

Time Summary

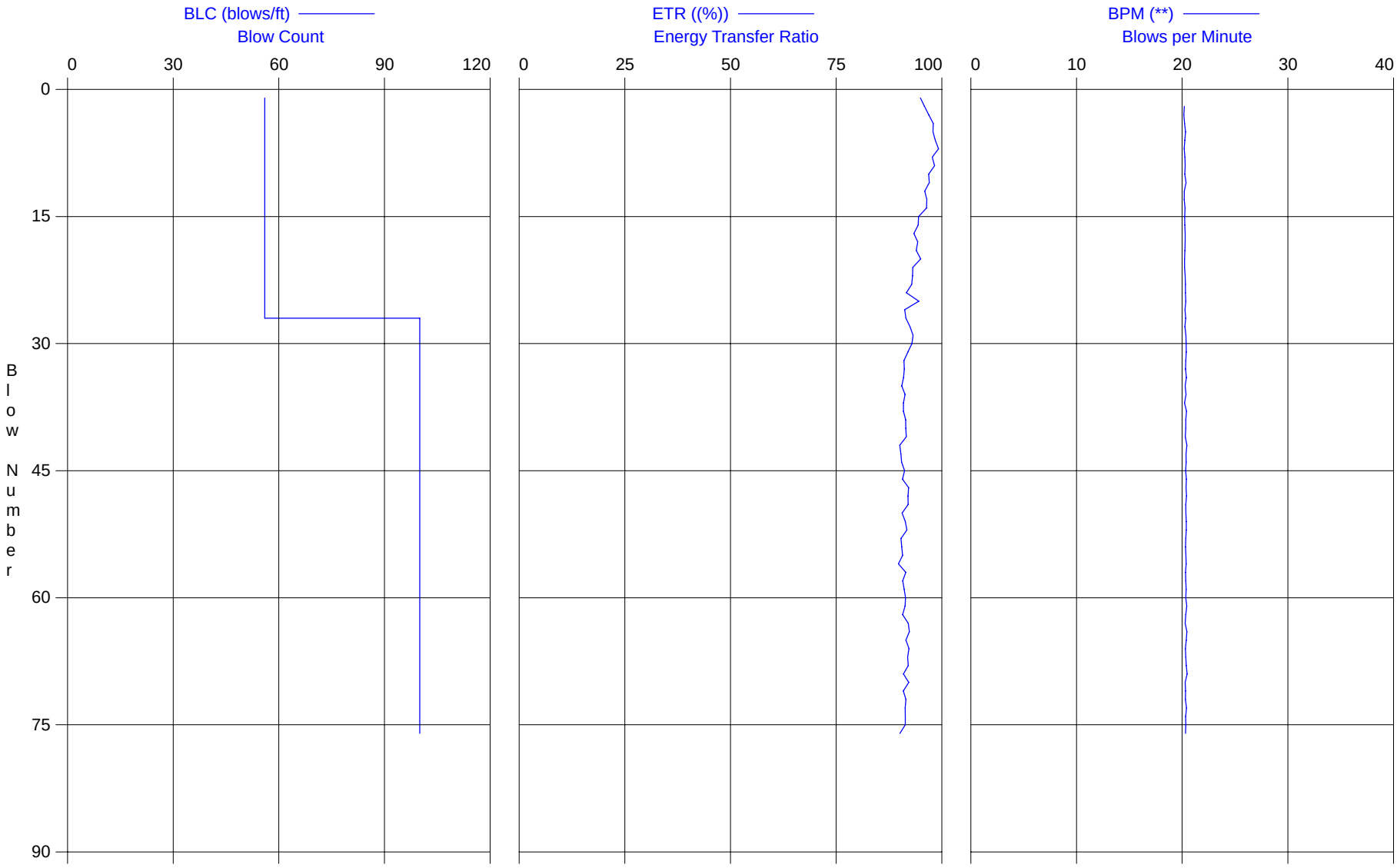
Drive 6 minutes 28 seconds 2:49:36 PM - 2:56:04 PM (9/8/2010) BN 1 - 131

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

Test date: 8-Sep-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-14



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2009.1 - Printed: 8-Oct-2010

WM-MAJOR DRILL SPT, OREGON - GT10-11-14
OP: RMDT-A. BANAS

SPT NW ROD
Test date: 8-Sep-2010

AR: 1.42 in^2
LE: 64.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.30

CSX: Max Measured Compr. Stress
FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total
DMX: Maximum Displacement

BL#	depth	BLC	CSX	FMX	VMX	EFV	ETR	BPM	EF2	SFT	DMX
	ft	bl/ft	ksi	kips	f/s	k-ft	(%)	**	k-ft	kips	in
27	60.51	100	25.7	36	12.6	0.3	91.5	20.3	0.4	11	0.32
28	60.52	100	24.9	35	12.5	0.3	92.4	20.3	0.4	12	0.33
29	60.53	100	26.4	37	13.1	0.3	93.2	20.4	0.4	12	0.33
30	60.54	100	26.2	37	12.9	0.3	92.9	20.4	0.4	11	0.33
31	60.55	100	26.6	38	12.9	0.3	92.0	20.4	0.4	11	0.31
32	60.56	100	26.0	37	12.4	0.3	91.0	20.3	0.4	12	0.31
33	60.57	100	25.8	37	12.7	0.3	91.1	20.3	0.4	11	0.31
34	60.58	100	26.6	38	13.0	0.3	91.0	20.4	0.4	11	0.31
35	60.59	100	25.5	36	12.6	0.3	90.5	20.3	0.4	12	0.30
36	60.60	100	25.3	36	12.6	0.3	91.3	20.4	0.4	12	0.37
37	60.61	100	27.0	38	12.9	0.3	90.9	20.2	0.4	11	0.42
38	60.62	100	26.0	37	12.8	0.3	90.9	20.4	0.4	12	0.35
39	60.63	100	26.5	38	13.1	0.3	91.4	20.3	0.4	11	0.44
40	60.64	100	26.8	38	13.2	0.3	91.5	20.3	0.4	12	0.39
41	60.65	100	26.7	38	13.1	0.3	91.6	20.3	0.4	12	0.33
42	60.66	100	26.7	38	13.0	0.3	90.0	20.4	0.4	11	0.28
43	60.67	100	26.5	38	13.1	0.3	90.3	20.4	0.4	11	0.27
44	60.68	100	26.4	37	12.9	0.3	90.5	20.4	0.4	12	0.33
45	60.69	100	27.0	38	13.2	0.3	91.2	20.3	0.4	12	0.36
46	60.70	100	26.3	37	12.9	0.3	90.7	20.4	0.4	11	0.26
47	60.71	100	26.0	37	13.0	0.3	92.1	20.4	0.4	12	0.48
48	60.72	100	25.8	37	12.9	0.3	92.0	20.4	0.4	12	0.42
49	60.73	100	26.1	37	12.9	0.3	92.0	20.3	0.4	11	0.47
50	60.74	100	25.6	36	12.7	0.3	90.6	20.4	0.4	12	0.40
51	60.75	100	25.9	37	12.8	0.3	91.3	20.4	0.4	12	0.36
52	60.76	100	25.5	36	12.9	0.3	91.7	20.4	0.4	12	0.37
53	60.77	100	26.0	37	12.7	0.3	90.3	20.3	0.4	11	0.33
54	60.78	100	26.0	37	12.7	0.3	90.5	20.3	0.4	12	0.30
55	60.79	100	25.5	36	12.7	0.3	90.7	20.4	0.4	12	0.29
56	60.80	100	26.5	38	13.0	0.3	89.7	20.4	0.4	12	0.28
57	60.81	100	25.9	37	12.8	0.3	91.5	20.3	0.4	12	0.29
58	60.82	100	25.7	36	12.7	0.3	90.7	20.3	0.4	12	0.24
59	60.83	100	25.5	36	12.6	0.3	91.1	20.4	0.4	11	0.23
60	60.84	100	26.7	38	13.0	0.3	91.4	20.3	0.4	12	0.24
61	60.85	100	26.2	37	13.0	0.3	91.3	20.4	0.4	12	0.24
62	60.86	100	26.3	37	13.0	0.3	90.7	20.3	0.4	11	0.24
63	60.87	100	26.3	37	12.8	0.3	92.1	20.3	0.4	12	0.24
64	60.88	100	26.7	38	13.2	0.3	92.3	20.4	0.4	12	0.24
65	60.89	100	26.0	37	12.7	0.3	91.5	20.4	0.4	11	0.24
66	60.90	100	26.7	38	13.1	0.3	92.2	20.3	0.4	11	0.24
67	60.91	100	26.0	37	12.8	0.3	91.9	20.3	0.4	11	0.24
68	60.92	100	26.0	37	12.9	0.3	92.0	20.4	0.4	12	0.24
69	60.93	100	25.9	37	12.7	0.3	90.9	20.5	0.4	12	0.24
70	60.94	100	26.4	37	13.0	0.3	92.2	20.3	0.4	12	0.24
71	60.95	100	25.2	36	12.6	0.3	90.9	20.3	0.4	12	0.24
72	60.96	100	25.7	36	12.8	0.3	91.5	20.3	0.4	11	0.24
73	60.97	100	26.1	37	13.0	0.3	91.3	20.4	0.4	12	0.24
74	60.98	100	26.3	37	12.9	0.3	91.4	20.3	0.4	11	0.24
75	60.99	100	26.0	37	12.9	0.3	91.3	20.3	0.4	12	0.24
76	61.00	100	25.6	36	12.5	0.3	90.1	20.3	0.4	12	0.24
		Average	26.1	37	12.9	0.3	91.3	20.4	0.4	12	0.30
		Std. Dev.	0.5	1	0.2	0.0	0.7	0.0	0.0	0	0.07
		Maximum	27.0	38	13.2	0.3	93.2	20.5	0.4	12	0.48
		@ Blow#	45	45	64	29	29	69	41	44	47

Total number of blows analyzed: 50

Time Summary

Drive 3 minutes 41 seconds 3:22:09 PM - 3:25:50 PM (9/8/2010) BN 1 - 76

APPENDIX C

2011 Boring Logs

LEGEND FOR BORING LOGS

SAMPLE LOCATION / TYPE

Sampled Interval

Sample Recovery

Standard Penetration Test (SPT) sample (1.4-inch I.D.)

Shelby tube sample (thin wall, 3-inch I.D.)

Bulk drill cuttings sample (> 3 ft. interval)

California Modified split spoon sample (2.5-inch I.D.)

Continuous core barrel sample (3-inch I.D., 5 feet long)

Grab drill cuttings sample (< 3 ft. interval)

BLOW COUNTS

Refers to number of blows by standard 140 pound hammer (unless otherwise indicated on log) per 6 inches of driven depth.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) DESCRIPTION (common terms used)

MOISTURE CONDITION

Dry - apparent absence of moisture, dry to the touch
Damp - slight moisture but does not adhere to hand
Moist - optimum water content but no visible water
Wet - visible free water

CONSISTENCY

Very Soft - thumb will penetrate more than 1 inch
Soft - thumb will penetrate about 1 inch
Firm or Stiff - thumb will indent soil about 1/4 inch
Hard or Very Stiff - thumb will not indent soil but readily indented by thumbnail
Very Hard - thumbnail will not indent soil

PLASTICITY

Non-plastic - an 1/8-inch thread cannot be rolled at any water content
Low - a thread can barely be rolled
Medium - a thread is easy to roll but can't be rerolled below the plastic limit
High - considerable rolling effort to reach the plastic limit; thread can be rerolled below the plastic limit

DENSITY (SANDY SOIL)

Sand consistency described using terms ranging from Very Loose to Very Dense

OTHER TERMS

Standard terms (as per ASTM D2488) are used to describe the size range, sorting, angularity, and shape of particles making up the soil
Standard terms may be used to described such soil properties as dilatancy and toughness if called for by the project

OTHER SYMBOLS

WATER - First depth at which free water (wet soil conditions) encountered (▽), static water level (▼).

CONTACTS:

———— Contact between different lithologies directly observed.
Horizontal line indicates sharp contact; slant line indicates gradational contact.

– – – – Inferred contact (contact between different lithologies not observed).

UNIFIED SOIL CLASSIFICATION SYSTEM CHART

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW		Well-graded gravels, gravels, gravel/sand mixtures, little or no fines.
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GM		Silty gravels, gravel-sand-silt mixtures
			GC		Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL		Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH		Inorganic clays of medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH		Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTES: No. 4 size = 5mm (0.25 in); No. 200 size = 0.0075 mm (0.0003 in)

Dual symbols are used to indicate borderline soil classifications

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT11-01

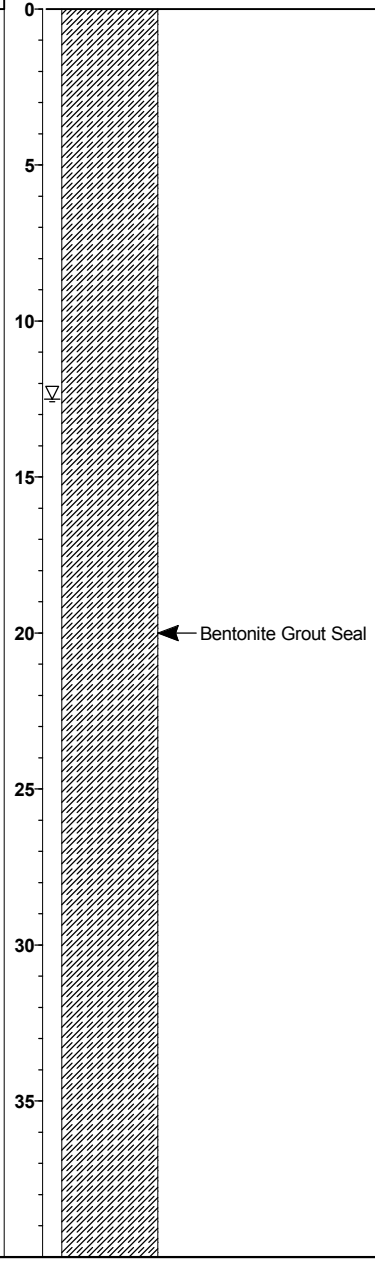
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0	0					FILL	Surface: gravel fill Note: Initially use 140 lb. hammer and switch to 300 lb. hammer as noted below
1							**ALLUVIUM**
2	5		1-1	1 2 3		CL	SILTY CLAY (CL), yellowish brown (10YR 5/4) with some olive gray (5Y 4/2) mottling, moist to wet, firm, medium plasticity
			1-2	---			
3	10					ML	At 10.0 feet (bottom of Shelby tube sample 1-2), CLAYEY SILT (ML), yellowish brown (10YR 5/4), moist, firm, low to medium plasticity
4			1-3	0 1 2			Same as above but wet, soft (first 6 inches pushed by weight of rods)
5	15		1-4	1 2 3		ML	At 15.0 feet, same as above Becomes mottled yellowish brown as above and light yellowish brown (10YR 6/4), wet, firm, low to medium plasticity
6	20		1-5	---			
7						ML	At 22.5 feet (bottom of Shelby tube sample 1-5), SILT (ML) with trace sand, dark gray (5Y 4/1) with greenish tint, wet, low to medium plasticity
8	25		1-6	3 3 4		ML	CLAYEY SILT (ML), same color as above, moist to wet, firm, bedded zones with varying clay content from 10 - 40 percent, beds up to 5 inches thick, zones with less clay are visibly wet, low to medium plasticity
9	30		1-7	1 5 6			Same as above but stiff
10							
11	35		1-8	---		CL	At 37.5 feet, SILTY CLAY (CL) with fine gravel, grayish green, moist to wet, apparent hard, low to medium plasticity
12	40		1-9	12 25 33		CL	- At 38.0 feet, SANDY, GRAVELLY CLAY (CL), mottled grayish green, light green, and very dark gray (5Y 3/1), moist to wet, hard, coarse sand and fine gravel 30 - 40 percent

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/26/11**
Date Ended: **1/26/11**
Elevation: **152.1 ft.**
Total Depth: **66.5 ft.**
Boring Diameter: **4.9" (to 45.0 ft.); 3.9" (from 45.0 - 66.5 ft.)**

STANDARD_LOG RLF_MSE BERM GEOTECHNICAL BOREHOLE LOGS_V2.0.GPJ STD_LOG.GDT 7/7/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT11-01

Riverbend Landfill Company

JOB NUMBER: 04211001.00

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
							Abundant gravels in drill cuttings
							Switch to 300 lb. hammer before collecting sample 1-10 and for remainder of borehole
45		1-10	15 26 50		GW		SANDY GRAVEL (GW) with clay, strong brown (6.5Y 4/6), moist, very dense, fine to coarse sand (f:m:c = 20:40:40) 30 - 40 percent, fine and coarse (50:50) subrounded gravel with oxidized surfaces, slightly weathered appearance
50		1-11	9 8 9		SW SM		At 50.0 feet, GRAVELLY SAND (SW) with trace fines, strong brown as above, wet, fine gravel 20 - 30 percent, medium to coarse sand (m:c = 30:60), weathered appearance - Contact in ring sample with SILTY FINE SAND (SM), dark gray (5Y 4/1) with bluish tint, silt 20 - 30 percent, medium dense, wet - At 53.5 feet, driller reports gravels encountered
55		1-12	7 13 16		SW/GW		At 55.0 feet, GRAVELLY SAND / SANDY GRAVEL (SW/GW), very dark gray (5Y 3/1), wet , medium dense to dense, fine to coarse sand (f:m:c = 20:40:40), fine subrounded gravel - At 57.5 feet, driller reports harder drilling - At 59.0 feet, driller reports softer drilling - At 60.0 feet, GRAVELLY SILTY SAND (SM), dark gray (5Y 4/1) with greenish tint, wet, fine to coarse sand (f:m:c = 60:20:20), silt 30 - 40 percent, fine gravel 10 - 20 percent, rare small wood fragments
60		1-13	7 8 11		SM SM		- Contact in ring sample with SILTY FINE SAND (SM), dark gray as above, silt 30 - 40 percent, wet, medium dense, faintly micaceous, rare small wood fragments - At 63.0 feet, driller reports harder drilling
65		1-14	10 15 22		SC		- At 65.0 feet, GRAVELLY CLAYEY SAND (SC), grayish green, moist to wet, dense, fine to coarse sand (f:m:c = 40:30:30), clay 20 - 30 percent, predominantly fine gravel but 2.5-inch gravel in sample shoe

Total Depth = 66.5 feet

(Northing 3856.08, Easting 3967.99)

NOTES:

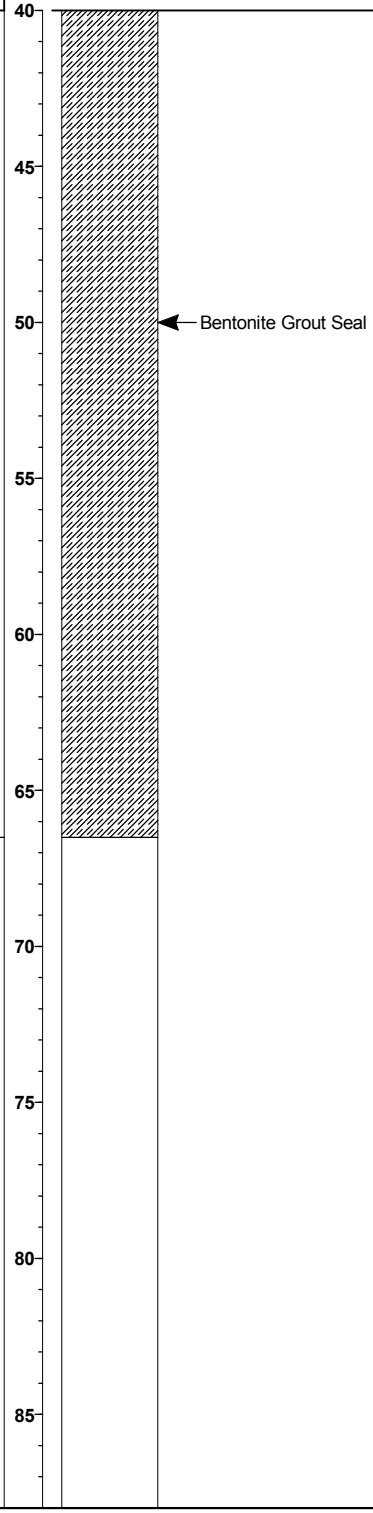
1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample 1-15 from 0 to 10.0 feet.

2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 1-10 at 45 feet and for remainder of borehole. Hammers not used for Shelby tube samples.

3. 36-inch long Shelby tube samples were pushed 30 inches only.

4. Shallow (Silt-Clay unit) groundwater encountered at 12.5 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 50.0 feet during drilling.

Completion Detail



STANDARD_LOG RLF_MSE BERM GEOTECHNICAL BOREHOLE LOGS_V2.0.GPJ STD_LOG.GDT 7/7/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT11-02

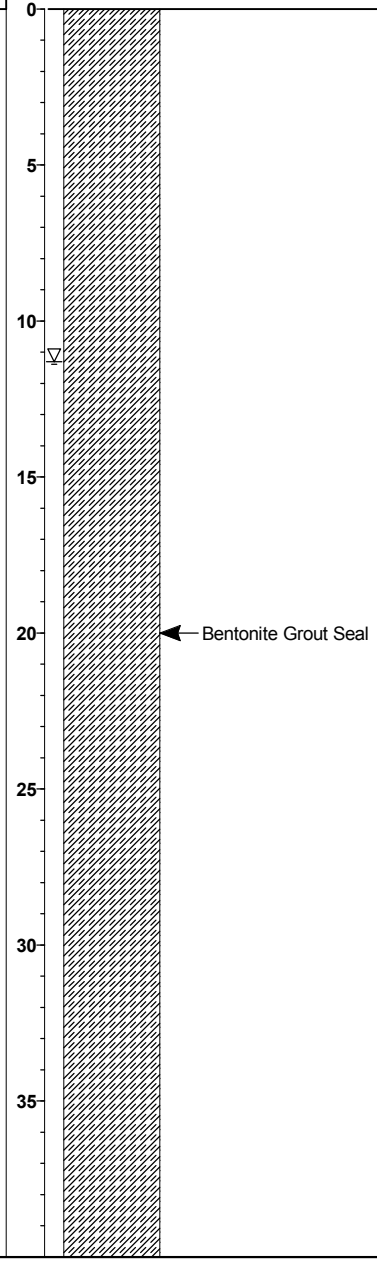
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0					FILL	Surface: gravel fill Note: Initially use 140 lb. hammer and switch to 300 lb. hammer as noted below. **ALLUVIUM**
5		2-1	0 3 4		CL	SILTY CLAY (CL), mottled very dark grayish brown (2.5Y 3/3) and dark yellowish brown (10YR 4/4), quickly grades to dark gray (5Y 4/1) with depth, moist to wet, firm, low to medium plasticity
		2-2	---			
10		2-3	2 3 5			At 10.0 feet, SILTY CLAY (CL), very dark gray (5Y 3/1), moist, firm, low to medium plasticity
					ML	At 11.3 feet, contact with CLAYEY SILT (ML), olive (2.5Y 4/3), wet, firm, clay 20 - 30 percent, low plasticity
15		2-4	1 2 3		CL	Very limited sample recovery, SILTY CLAY (CL), same appearance as above, firm
						Switch to 300 lb. hammer before collecting sample 2-5 at 20.0 feet
20		2-5	1 1 2		ML	SILT (ML), yellowish brown (10YR 5/4) with minor black (manganese?) mottling, moist, soft, trace clay, low to medium plasticity
		2-6	---			
25						At 24.5 feet (bottom of Shelby tube sample 2-6), CLAYEY SILT (ML), dark gray (5Y 4/1), moist, clay 20-30 percent, low to medium plasticity
						Switch to 140 lb. hammer before collecting sample 2-7 at 30.0 feet
30		2-7	3 4 5		CH	SILTY CLAY (CH), same color as above, moist, stiff, silt 10 - 20 percent, high plasticity
		2-8	---			
35						At 35.0 feet (bottom of Shelby tube sample 2-8), CLAY (CH), dark gray (5Y 4/1) with greenish tint, moist, trace silt, medium to high plasticity
40					CL/ML	

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/24/11**
Date Ended: **1/24/11**
Elevation: **141.4 ft.**
Total Depth: **61.5 ft.**
Boring Diameter: **4.9" (to 45.0 ft.); 3.9" (from 45.0 - 61.5 ft.)**

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT11-02

Riverbend Landfill Company

JOB NUMBER: 04211001.00

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
40		2-9	3 5 19		CL/ML		At 40.0 feet, SILTY CLAY / CLAYEY SILT (CL/ML), greenish gray, moist to wet, firm to stiff, slight orange brown oxide (iron) mottling
					ML		- At 41.3 feet, contact with SILT (ML) with fine sand, same color as above but with abundant oxide mottling
							- Switch to 300 lb. hammer before collecting sample 2-10 at 45.0 feet and for remainder of borehole
45		2-10	19 50/6"		GC		- At 45.0 feet, CLAYEY SANDY GRAVEL (GC), dark yellowish brown (10YR 4/4) with slight yellowish and orange brown oxide (iron) mottling, moist, very dense, clay 10 - 20 percent, fine to coarse sand (f:m:c = 20:40:40) 10 - 20 percent, subrounded gravel to 1.5-inch diameter, predominantely fine gravel
50		2-11	21 50/6"		GC		Same as above but mottled olive brown (2.5Y 4/3) with abundant orange brown oxide (iron) mottling, gravel to 2.5-inch diameter, large gravel stuck in sample shoe
55		2-12	2 31 50		ML		SILT (ML), greenish gray with minor orange brown oxide (iron) mottling, moist, hard, few scattered gravels to 2-inch diameter
60		2-13	11 15 22		SW/GW		GRAVELLY SAND / SANDY GRAVEL (SW/GW), black (5Y 2.5/1), wet, dense, trace to some fines, fine to coarse sand (f:m:c = 10:30:60), predominantely fine gravel

Total Depth = 61.5 feet

(Northing 2623.68, Easting 4070.74)

NOTES:

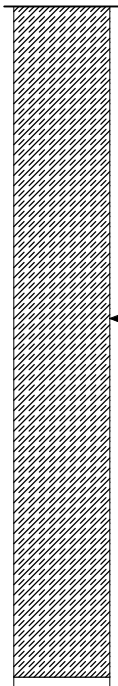
1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample 2-14 from 0 to 10.0 feet.

2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer for samples 2-5 (at 20 feet) and 2-10 (at 45 feet) through 2-13 (at 60 feet). Hammers not used for Shelby tube samples.

3. 36-inch long Shelby tube samples were pushed 30 inches only.

4. Shallow (Silt-Clay unit) groundwater encountered at 11.3 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 60.0 feet during drilling.

Completion Detail



STANDARD_LOG RLF_MSE BERM GEOTECHNICAL BOREHOLE LOGS_V2.0.GPJ STD_LOG.GDT 7/7/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT11-03

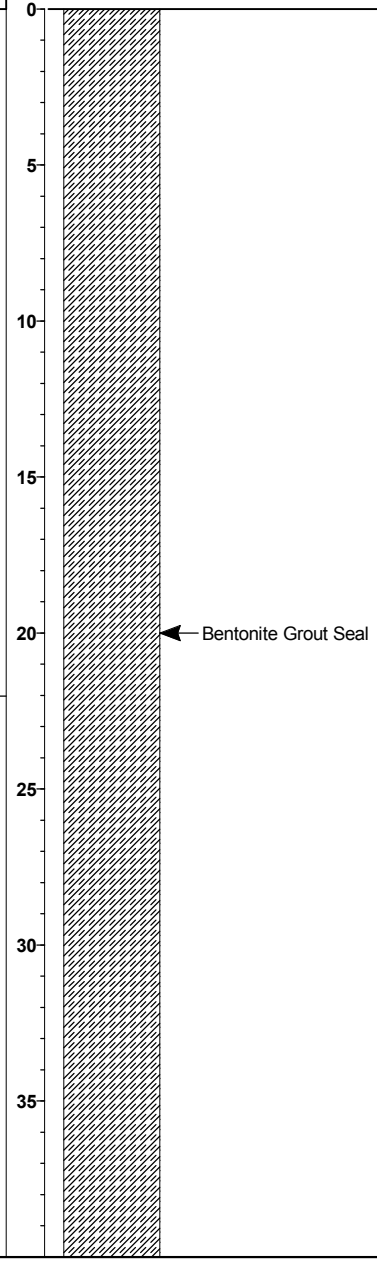
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.00

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. hammer; 30-inch drop).
NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0					FILL		Surface: gravel road base
							BERM FILL
		3-1	6 7				No recovery in sample 3-1
1		3-2	6 3		CH		CLAY (CH), mottled dark gray (5Y 4/1) and olive brown (2.5Y 4/4), moist, stiff, medium to high plasticity
5		3-3	6 5 ---				
2		3-4	---				At 7.5 feet (bottom of Shelby tube sample 3-3), same as above
3 / 10							At 10.0 feet (bottom of Shelby tube sample 3-4), CLAY (CH), dark yellowish brown (10YR 4/4) with some gray (5Y 4/1) mottling, moist, high plasticity (more apparent plasticity than above), sticky
		3-5	1 4 8				At 12.0 feet, same as above, but moist to wet, stiff
4 / 15		3-6	1 5 9				At 14.4 feet, same as above, but less apparent plasticity (medium to high), stiff
5		3-7	---				At 18.5 feet (bottom of Shelby tube sample 3-7), same as above. Shelby tube not retained due to very low recovery.
6 / 20		3-8	---				- Gus sampler used to collect Shelby tube sample 3-8. Can only push Shelby tube 24 inches.
		3-9	4 5 6		CH		- At 20.5 feet, CLAY (CH), dark yellowish brown (10YR 4/6) with slight dark gray (5Y 4/1) mottling, moist, stiff, high plasticity
7		3-10	4 6				**ALLUVIUM**
		3-11	9 2 3 7		CL		At 22.0 feet, SLIGHTLY SILTY CLAY (CL), mottled dark yellowish brown (10YR 4/4) with abundant dark gray (5Y 4/1) mottling, moist, stiff, medium to high plasticity
8 / 25							
9 / 30		3-12	4 6 10				SLIGHTLY SILTY CLAY (CL), dark yellowish brown (10YR 4/4) with minor brown (10YR 5/3) mottling, moist, very stiff, few scattered black (manganese?) nodules to 1/8-inch diameter, medium to high plasticity
10							
11 / 35		3-12b	4 5 7		CH		Same as above. Sample not retained due to poor recovery, apparent high plasticity (CH)
12 / 40							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/25/11**
Date Ended: **1/27/11**
Elevation: **144.8 ft.**
Total Depth: **61.5 ft.**
Boring Diameter: **4.9" (to 45.0 ft.); 3.9" (from 45.0 - 61.5 ft.)**

STANDARD_LOG RLF_MSE BERM GEOTECHNICAL BOREHOLE LOGS_V2.0.GPJ STD_LOG.GDT 7/7/11

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

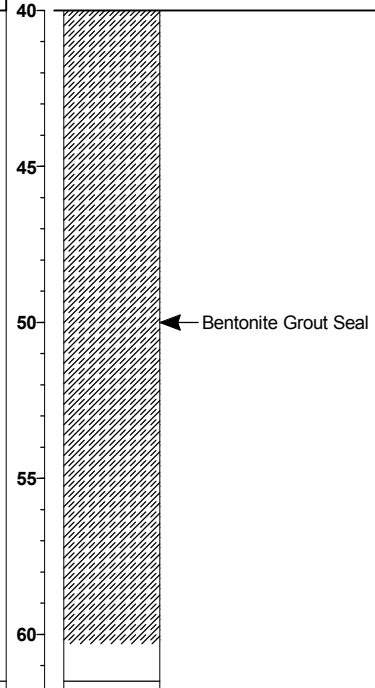
BORING NUMBER: GT11-03

Riverbend Landfill Company

JOB NUMBER: 04211001.00

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
	40		3-13	---				
13						CH		At 42.5 feet (bottom of Shelby tube sample 3-13), CLAY (CH), mottled olive brown (2.5Y 4/3) and dark gray (5Y 4/1) with greenish tint, moist to wet, medium to high plasticity, sticky
	45		3-14	0 1 4				CLAY (CH), dark gray (5Y 4/1) with greenish tint, minor orange brown oxide (iron) mottling quickly grading to no mottling at bottom of sample, moist to wet, soft to firm, medium to high plasticity, sticky (first 6 inches pushed by weight of rods)
14								
			3-15	0 1 3		CH		- At 48.0 feet, same as above but soft, high plasticity (first 6 inches pushed by weight of rods)
15								
	50		3-16	---				Gus sampler used to collect Shelby tube sample 3-16
16						MH		At 52.5 feet (bottom of Shelby tube sample 3-16), CLAYEY SILT (MH), very dark gray (5Y 3/1) with greenish tint, moist to wet, apparent soft, high plasticity
	55		3-17	0 0 2				At 55.0 feet, no recovery, soft (first 12 inches pushed by weight of rods)
17								
18								At 57.0 feet, driller reports gravels encountered - At 58.5 feet, driller reports no gravels - At 60.0 feet, CLAYEY SAND (SC) with gravel, dark olive gray (5Y 3/2) with greenish tint, with moderate orange brown oxide (iron) mottling, moist to wet, very dense, clay 10 - 20 percent, fine to coarse sand (f:m:c = 40:40:20), scattered fine gravels
	60		3-18	19 24 44		SC		
19								Total Depth = 61.5 feet (Northing 2223.69, Easting 5663.49)
	65							NOTES: 1. Mud rotary drilling completed on 1/25/11. Drilled adjacent borehole on 1/27/11 with hollow stem augers to collect bulk soil cuttings samples 3-19 (from 0 - 10.0 feet) and 3-20 (from 10.0 to 20.0 feet).
20								
21								2. Used 140 lb. hammer throughout entire borehole. Hammer not used for Shelby tube samples.
	70							
22								3. 36-inch long Shelby tube samples were pushed 30 inches only.
	75							4. Shallow (Silt-Clay unit) groundwater depth was undetermined due to fine-grained soils without visible free water or wet conditions. Deep (Sand-Gravel unit) groundwater was not encountered during drilling.
23								
24								
	80							
25								
26	85							

Completion Detail



STANDARD_LOG RLF_MSE BERM GEOTECHNICAL BOREHOLE LOGS_V2.0.GPJ STD_LOG.GDT 7/7/11

APPENDIX D

2011 Energy Measurement

Robert Miner Dynamic Testing, Inc.

Dynamic Measurements and Analyses for Deep Foundations

January 31, 2011

Mr. Terry Jacques
Major Drilling Environmental, LLC
13565 SW Tualitin Sherwood Rd, STE 700
Sherwood, OR 77140

Re: Penetration Test Energy Measurements
Major Drilling B-54 Rig, Mobile Automatic Hammer
Borehole GT11-02, January 24, 2011
River Bend Landfill, McMinnville, OR

RMDT Job No. 11F06

Dear Mr. Jacques,

This letter presents energy transfer measurements made durring Standard Penetration Tests and California Modified Samples for the drill hole and drill rig referenced above. Robert Miner Dynamic Testing, Inc. (RMDT) made dynamic measurements with a Pile Driving Analyzer® as a hammer advanced the NW rod during sampling with a split spoon sampler and a California Modified sampler.

The purpose of RMDT's testing was the measurement of energy transferred to the drill rods. Measurements were made on a section of NW gauge rod at the top of the drill rod. Strain gages and accelerometers on the rod were connected to a Pile Driving Analyzer® (PDA) which generally processed acceleration and strain measurements from each hammer blow and stored both the measurements and computed results. Measurements and data processing generally followed the ASTM D 4633-10 standard. Energy transfer past the gage location, EFV, was computed by the PDA using force and velocity records as follows:

$$EFV = \int_a^b F(t)\ v(t)\ dt$$

The value "a" corresponds to the start of the record which is when the energy transfer begins and *"b"* is the time at which energy transferred to the rod reaches a maximum value. Appendix A contains more information on our measurement equipment and methods of analysis. The EFV energy calculation is identical to the EMX energy result discussed in Appendix A. The EFV and EMX values apply to the sensor location near the top of the rod.

TEST DETAILS

Testing occurred on January 24, 2011. Boring GT11-02 was advanced in the maintenance yard of the River Bend Landfill facility located in McMinnville, OR. An NW size rod was used to advance both samplers. The automatic hammer in use during our testing was manufactured

Mailing Address: P.O. Box 340, Manchester, WA, 98353, USA **Phone:** 360-871-5480
Location: 2288 Colchester Dr. E., Ste A, Manchester, WA, 98353 **Fax:** 360-871-5483

by Foremost Mobile (Mobile) and was reported to use either a 140 lb or a 300 lb ram. The drill rig was a track-mounted Mobile B-54.

RESULTS

Tables 1 and 2 summarize RMDT's field records and Appendix B contains detailed numeric results. The tabulated results include the starting sample depth, the penetration resistance, the number of hammers blows in our data set, measured energy transfer, EFV, the computed transfer efficiency, ETR, and the hammer blow rate, BPM.

Energy measurements must be divided by the theoretical free fall energy of the hammer to obtain an efficiency. In anticipation of future site demands measurements were made with 140 lb and 300 lb rams in the Mobile Automatic Hammer. A 140 lb ram raised 30 inches above an impact surface has 350 lb-ft of potential energy. A 300 lb ram raised 30 inches above an impact surface has 750 lb-ft of potential energy. Thus, the transfer energy results for sampling with the 140 and 300 lb rams may be divided by 350 or 750 lb-ft to yield the ratio of the delivered energy to the nominal potential energy. This efficiency ratio, ETR, is given for each sample interval as a percent efficiency.

Table 1. Summary of Test Details and Results for the 140-lb ram and Split Spoon Sampler

Sample Name and Sample Start Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
02-1 @5ft	7/1ft	7	219	63	24
02-3 @10ft	8/1ft	8	247	71	24
02-4 @15ft	5/1ft	5	256	73	24
02-7 @30ft	9/1ft	9	327	93	24
02-9 @40ft	24/1ft	24	334	95	21
Average for 30ft and 40ft samples:			**330**	**94**	**22**

When computing the overall average value we excluded the results for the 5ft, 10ft and 15ft sample depths because it is our opinion that the short rod lengths had a very substantial effect on transfer energy. The limited data collected suggests that the relationship between rod length and ETR stabilizes after approximately 20ft to 30ft. Excluding the data for the 5ft, 10ft and 15ft

sample depths the average ETR values between the sample intervals of 30ft to 40ft was 94 percent.

Table 2. Summary of Test Details and Results for the 300-lb ram and California Modified Sampler

Sample Name and Sample Start Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
02-5 @20ft	3/1ft	3	633	84	24
02-10 @45ft	50/6in	50	717	96	23
02-11 @50ft	50/6in	50	698	93	23
02-12 @55ft	81/1ft	79	724	97	23
02-13 @60ft	37/1ft	37	715	95	23
		Average:	**697**	**93**	**23**

Five tests were preformed with the 300 lb ram and California Modified Sampler. In general, the variability of the recorded values is similar to that recorded with the 140 lb ram. The average ETR values within each of the five sample intervals from 20 ft to 60 ft ranged from 84 to 97 percent, and the overall average ETR value was 93 percent.

The consistency in BPM and ETR values for the two ram weights suggests the hammer is operating in a consistent manner regardless of ram size. These levels of transfer energy are consistent with energy measurements completed on September 8, 2010 for the same Mobile hammer operating at similar blow rates.

It was a pleasure to assist you and to participate on this project with the staff of Major Drilling Environmental, LLC. Please do not hesitate to contact us if you or your client have any questions about this report.

Sincerely,

Robert Miner Dynamic Testing, Inc.

Andrew Banas
Staff Engineer

APPENDIX A
AN INTRODUCTION INTO DYNAMIC PILE TESTING METHODS

The following has been written by Goble Rausche Likins and Associates, Inc. and may only be copied with its written permission.

BACKGROUND

Modern procedures of design and construction control require verification of bearing capacity and integrity of deep foundations during preconstruction test programs and also production installation. Dynamic pile testing methods meet this need economically and reliably, and therefore, form an important part of a quality assurance program when deep foundations are executed. Several dynamic pile testing methods exist; they have different benefits and limitations and different requirements for proper execution.

The Case Method of dynamic pile testing, named after the Case Institute of Technology where it was developed between 1964 and 1975, requires that a substantial ram mass (such as that of a pile driving hammer) impacts the pile top such that the pile undergoes at least a small permanent set. The method is therefore also referred to as a "High Strain Method". The Case Method requires dynamic measurements on the pile or shaft under the ram impact and then an evaluation of various quantities based on closed form solutions of the wave equation, a partial differential equation describing the motion of a rod under the effect of an impact. Conveniently, measurements and analyses are done by a single piece of equipment: the Pile Driving Analyzer® (PDA). However, for bearing capacity evaluations an important additional method is CAPWAP® which performs a much more rigorous analysis of the dynamic records than the simpler Case Method.

A related analysis method is the "Wave Equation Analysis" which calculates a relationship between bearing capacity and pile stress and field blow count. The GRLWEAP™ program performs this analysis and provides a complete set of helpful information and input data.

The following description deals primarily with the Case Method or "High Strain Test" Method of pile testing, however, for the sake of completeness, the "Low Strain Test" performed with the Pile Integrity Test™ (PIT), mainly for pile integrity evaluation, will also be described.

RESULTS FROM DYNAMIC TESTING

There are two main objectives of high strain dynamic pile testing:

- *Dynamic Pile Monitoring* and
- *Dynamic Load Testing*.

Dynamic pile monitoring is conducted during the installation of impact driven piles to achieve a safe and economical pile installation. Dynamic load testing, on the other hand, has as its primary goal the assessment of pile bearing capacity. It is applicable to both cast *insitu* piles or drilled shafts and impact driven piles during restrike.

Dynamic Pile Monitoring

During pile installation, the sensors attached to the pile measure pile top force and velocity. A PDA conditions and processes these signals and calculates or evaluates:

- Bearing capacity at the time of testing, including an assessment of shaft resistance development and driving resistance. This information supports formulation of a driving criterion.

- Dynamic pile stresses, axial and averaged over the pile cross section, both tensile and compressive, during pile driving to limit the potential of damage either near the pile top or along its length. Bending stresses can be evaluated at the point of sensor attachment.

- Pile integrity assessment by the PDA is based on the recognition of certain wave reflections from along the pile. If detected early enough, a pile may be saved from complete destruction. On the other hand, once damage is recognized measures can be taken to prevent reoccurrence.

- Hammer performance parameters including the energy transferred to the pile, the hammer speed in blows per minute and the stroke of open ended diesel hammers.

© 1999, Goble Rausche Likins and Associates, Inc.

Dynamic Pile Load Testing

Bearing capacity testing of either driven piles or drilled shafts applies the same basic measurement approach of dynamic pile monitoring. However, the test is done independent of the pile installation process and therefore a pile driving hammer or other dynamic loading device may not be available. If a special ram has to be mobilized then its weight should be between 0.8 and 2% of the test load (e.g. between 4 and 10 tons for a 500 ton test load) to assure sufficient soil resistance activation.

For a successful test, it most important that the test is conducted after a sufficient waiting time following pile installation for soil properties approaching their long term condition or concrete to properly set. During testing, PDA results of pile/shaft stresses and transferred energy are used to maintain safe stresses and assure sufficient resistance activation. For safe and sufficient testing of drilled shafts, ram energies are often increased from blow to blow until the test capacity has been activated. On the other hand, restrike tests on driven piles may require a warm hammer so that the very first blow produces a complete resistance activation. Data must be evaluated by CAPWAP for bearing capacity.

After the dynamic load test has been conducted with sufficient energy and safe stresses, the CAPWAP analysis provides the following results:

- Bearing capacity i.e. the mobilized capacity present at the time of testing
- Resistance distribution including shaft resistance and end bearing components
- Stresses in pile or shaft calculated for both the static load application and the dynamic test. These stresses are averages over the cross section and do not include bending effects or nonuniform contact stresses, e.g. when the pile toe is on uneven rock.
- Shaft impedance vs depth; this is an estimate of the shaft shape if it differs substantially from the planned profile
- Dynamic soil parameters for shaft and toe, i.e. damping factors and quakes (related to the dynamic stiffness of the resistance at the pile/soil interface.)

MEASUREMENTS

PDA

The basis for the results calculated by the PDA are pile top strain and acceleration measurements which are converted to force and velocity records, respectively. The PDA conditions, calibrates and displays these signals and immediately computes average pile force and velocity thereby eliminating bending effects. Using closed form Case Method solutions, based on the one-dimensional linear wave equation, the PDA calculates the results described in the analytical solutions section below.

HPA

The ram velocity may be directly obtained using radar technology in the Hammer Performance Analyzer™. For this unit to be applicable, the ram must be visible. The impact velocity results can be automatically processed with a PC or recorded on a strip chart.

Saximeter™

For open end diesel hammers, the time between two impacts indicates the magnitude of the ram fall height or stroke. This information is not only measured and calculated by the PDA but also by the convenient, hand-held Saximeter.

PIT

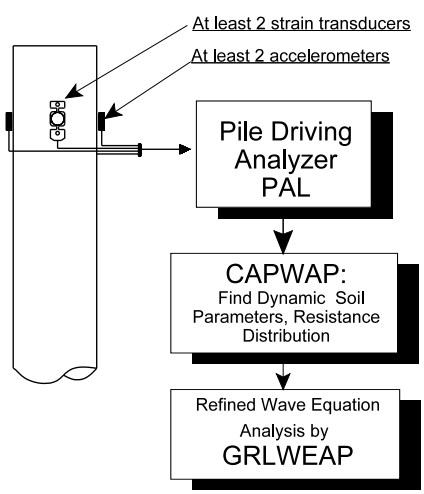
The Pile Integrity Tester™ (PIT) can be used to evaluate defects in concrete piles or shafts which may have occurred during driving or casting. Also timber piles of limited length can be tested in that manner. This so-called "Low Strain Method" or “Pulse-Echo Method” of integrity testing requires only the measurement of acceleration at the pile top. The stress wave producing impact is then generated by a small hand-held hammer and the records interpreted in the time domain. PIT also supports the so-called “Transient Response Method” which requires the additional measurement of the hammer force and an analysis in the frequency domain. This method may also be used to evaluate the unknown length of deep foundations under existing structures.

ANALYTICAL SOLUTIONS
BEARING CAPACITY

Wave Equation

GRL has written the GRLWEAP™ program which calculates a relationship between bearing capacity, pile stress and blow count. This relationship is often called the "bearing graph." Once the blow count is known from pile installation logs, the bearing graph yields the bearing capacity. This approach requires no measurements and therefore can be performed during the design stage of a project, for example for the selection of hammer, cushion and pile size.

After dynamic pile monitoring and/or dynamic load testing has been performed, the "Refined Wave Equation Analysis" or RWEA (see schematic below) is often performed by inputting the PDA and CAPWAP calculated parameters. Then the bearing graph from the RWEA is the basis for a safe and sufficient driving criteria.



Case Method

The Case Method is a closed form solution based on a few simplifying assumptions such as ideal plastic soil behavior and an ideally elastic and uniform pile. Given the measured pile top force F(t) and pile top velocity v(t), the total soil resistance is

$$R(t) = \tfrac{1}{2}\{[F(t) + F(t_2)] + Z[v(t) - v(t_2)]\} \qquad (1)$$

where

- t = a point in time after impact
- t_2 = time $t + 2L/c$
- L = pile length below gages
- c = $(E/\rho)^{1/2}$ is the speed of the stress wave
- ρ = pile mass density
- Z = EA/c is the pile impedance
- E = elastic modulus of the pile (ρc^2)
- A = pile cross sectional area

The total soil resistance consists of a dynamic (R_d) and a static (R_s) component. The static component is therefore

$$R_s(t) = R(t) - R_d(t) \qquad (2)$$

The dynamic component may be computed from a soil damping factor, J, and a pile toe velocity, $v_t(t)$ which is conveniently calculated for the pile toe. Using wave considerations, this approach leads immediately to the dynamic resistance

$$R_d(t) = J[F(t) + Zv(t) - R(t)] \qquad (3)$$

and finally to the static resistance by means of Equation 2.

There are a number of ways in which Eq. 1 through 3 can be evaluated. Most commonly, t_2 is set to that time at which the static resistance becomes maximum. The result is the so-called **RMX** capacity. Damping factors for RMX typically range between 0.5 for coarse grained materials to 1.0 for clays. The **RSP** capacity (this method is most commonly referred to in the literature, yet it is not very frequently used) requires damping factors between 0.1 for sand and 1.0 for clay. Another capacity, **RA2**, determines the capacity at a time when the pile is essentially at rest and thus damping is small; RA2

therefore requires no damping parameter. In any event, the proper Case Method and its associated damping parameter is most conveniently found after a CAPWAP analysis has been performed.

The static resistance calculated by Case Method or CAPWAP is the mobilized resistance at the time of testing. Consideration therefore has to be given to soil setup or relaxation effects and whether or not a sufficient set has been achieved under the test loading that would correspond to a full activation of the ultimate soil resistance.

The PDA also calculates an estimate of shaft resistance as the difference between force and velocity times impedance at the time immediately prior to the return of the stress wave from the pile toe. This shaft resistance is not reduced by damping effects and is therefore called the total shaft resistance **SFT**. A correction for damping effects produces the static shaft resistance estimate, **SFR**.

The Case Method solution is simple enough to be evaluated "in real time," i.e. between hammer blows, using the PDA. It is therefore possible to calculate all relevant results for all hammer blows and plot these results as a function of depth or blow number. This is done in the PDAPLOT program.

CAPWAP

The CAse Pile Wave Analysis Program combines the wave equation pile and soil model with the Case Method measurements. Thus, the solution includes not only the total and static bearing capacity values but also the shaft resistance, end bearing, damping factors and soil stiffnesses. The method iteratively calculates a number of unknowns by signal matching. While it is necessary to make hammer performance assumptions for a GRLWEAP analysis, the CAPWAP program works with the pile top measurements. Furthermore, while GRLWEAP and Case Method require certain assumptions regarding the soil behavior, CAPWAP calculates these soil parameters.

STRESSES

During pile monitoring, it is important that compressive stress maxima at pile top and toe and tensile stress maxima somewhere along the pile be calculated for each hammer blow.

At the pile top (location of sensors) both the maximum compression stress, **CSX**, and the maximum stress from individual strain transducers, **CSI**, are directly obtained from the measurements. Note that CSI is greater than or equal to CSX and the difference between CSI and CSX is a measure of bending in the plane of the strain transducers. Note also that all stresses calculated for locations below the sensors are averaged over the pile cross section and therefore do not include components from either bending or eccentric soil resistance effects.

The PDA calculates the compressive stress at the pile bottom, **CSB**, assuming (a) a uniform pile and (b) that the pile toe force is the maximum value of the total resistance R(t) minus the total shaft resistance, SFT. Again, for this stress estimation uniform resistance force are assumed (e.g. not a sloping rock.)

For concrete piles, the maximum tension stress, **TSX**, is also of great importance. It occurs at some point below the pile top. The maximum tension stress can be computed from the pile top measurements by finding the maximum tension wave (either traveling upward, W_U, or downward, W_d) and reducing it by the minimum compressive wave traveling in opposite direction.

$$W_u = ½[F(t) - Zv(t)] \quad (4)$$

$$W_d = ½[F(t) + Zv(t)] \quad (5)$$

CAPWAP also calculates tensile and compressive stresses along the pile and, in general, more accurately than the PDA. In fact, for non-uniform piles or piles with joints, cracks or other discontinuities, the closed form solutions from the PDA may be in error.

PILE INTEGRITY

High Strain Tests (PDA)

Stress waves in a pile are reflected wherever the pile impedance, $Z = EA/c = \rho cA = A \sqrt{(E \rho)}$, changes. Therefore, the pile impedance is a measure of the quality of the pile material (E, ρ, c) and the size of its cross section (A). The reflected waves arrive at the pile top at a time which is greater the farther away from the pile top the reflection occurs. The

magnitude of the change of the upward traveling wave (calculated from the measured force and velocity, Eq. 4) indicates the extent of the cross sectional change. Thus, with β_i (**BTA**) being a relative integrity factor which is unity for no impedance change and zero for the pile end, the following is calculated by the PDA.

$$\beta_i = (1 - \alpha_i)/(1 + \alpha_i) \tag{6}$$

with

$$\alpha_i = ½(W_{UR} - W_{UD})/(W_{Di} - W_{UR}) \tag{7}$$

where

W_{UR} is the upward traveling wave at the onset of the reflected wave. It is caused by resistance.

W_{UD} is the upwards traveling wave due to the damage reflection.

W_{Di} is the maximum downward traveling wave due to impact.

It can be shown that this formulation is quite accurate as long as individual reflections from different pile impedance changes have no overlapping effects on the stress wave reflections.

Without rigorous derivation, it has been proposed to consider as slight damage when β is above 0.8 and a serious damage when β is less than 0.6.

Low Strain Tests (PIT)

The pile top is struck with a held hand hammer and the resulting pile top velocity is measured, displayed and interpreted for signs of wave reflections. In general, a comparison of the reflected acceleration leads to a relative measure of extent of damage, again the location of the problem is indicated by the arrival time of the reflection. PIT records can also be interpreted by the β-Method. However, low strain tests do not activate much resistance which simplifies Eq. 7 since W_{UR} is then equal to zero.

For drilled shafts and PIT records that clearly show a toe reflection, an approximate shaft profile can be calculated from low strain records using the PITSTOP program's PROFILE routine.

HAMMER PERFORMANCE

The PDA calculates the energy transferred to the pile top from:

$$E(t) = \int_0^t F(t)v(t)\,dt \tag{8a}$$

The maximum of the E(t) curve is the most important information for an overall evaluation of the performance of a hammer and driving system. This **EMX** value allows for a classification of the hammer's performance when presented as the rated transfer efficiency, also called energy transfer ratio (**ETR**) or global efficiency

$$e_T = EMX/E_R \tag{8b}$$

where

E_R is the manufacturer's rated energy value.

Both Saximeter and PDA calculate the stroke (**STK**) of an open end diesel hammer using

$$STK = (g/8)\,T_B^2 - h_L \tag{9}$$

where

g is the earth's gravitational acceleration,
T_B is the time between two hammer blows,
h_L is a stroke loss value due to gas compression and time losses during impact (usually 0.3 ft or 0.1 m).

DETERMINATION OF WAVE SPEED

An important facet of dynamic pile testing is an assessment of pile material properties. Since in general force is determined from strain by multiplication with elastic modulus, E, and cross sectional area, A, the dynamic elastic modulus has to be determined for pile materials other than steel. In general, the records measured by the PDA clearly indicate a pile toe reflection as long as pile penetration per blow is greater than 1 mm or .04 inches. The time between the onset of the force and velocity records at impact and the onset of the reflection from the toe (usually apparent by a local maximum of the wave up curve) is the so-called wave travel time, T. Dividing 2L (L is here the length of the pile below sensors) by T leads to the stress wave speed in the pile:

$$c = 2L/T \tag{10}$$

The elastic modulus of the pile material is related to the wave speed according to the linear elastic wave equation theory by

$$E = c^2\rho \tag{11}$$

Since the mass density of the pile material, ρ, is usually well known (an exception is timber for which samples should be weighed), the elastic modulus is easily found from the wave speed. Note, however, that this is a dynamic modulus which is generally higher than the static one and that the wave speed depends to some degree on the strain level of the stress wave. For example, experience shows that the wave speed from PIT is roughly 5% higher than the wave speed observed during a high strain test.

Other Notes:

- If the pile material is nonuniform then the wave speed c, according to Eq. 10, is an average wave speed and does not necessarily reflect the pile material properties of the location where the strain sensors are attached to the pile top. For example, pile driving often causes fine tension cracks some distance below the top of concrete piles. Then the average c is slower than that at the pile top. It is therefore recommended to determine E in the beginning of pile driving and not adjust it when the average c changes.

- If the pile has such a high resistance that there is no clear indication of a toe reflection then the wave speed of the pile material must be determined either by assumption or by taking a sample of the concrete and measuring its wave speed in a simple free column test. Another possibility is to use the proportionality relationship, discussed under "DATA QUALITY CHECKS" to find c as the ratio between the measured velocity and measured strain.

DATA QUALITY CHECKS

Quality data is the first and foremost requirement for accurate dynamic testing results. It is therefore important that the measurement engineer performing PDA or PIT tests has the experience necessary to recognize measurement problems and take appropriate corrective action should problems develop. Fortunately, dynamic pile testing allows for certain data quality checks because two independent measurements are taken that have to conform to certain relationships.

Proportionality

As long as there is only a wave traveling in one direction, as is the case during impact when only a downward traveling wave exists in the pile, force and velocity measured at the pile top are proportional

$$F = v\,Z = v\,(EA/c) \tag{12a}$$

This relationship can also be expressed in terms of stress

$$\sigma = v\,(E/c) \tag{12b}$$

or strain

$$\epsilon = v / c \tag{12c}$$

This means that the early portion of strain times wave speed must be equal to the velocity unless the proportionality is affected by high friction near the pile top or by a pile cross sectional change not far below the sensors. Checking the proportionality is an excellent means of assuring meaningful measurements.

Measurements are always taken at opposite sides of the pile as a means of calculating the average force and velocity in the pile. The velocity on the two sides of the pile is very similar even when high bending exists. Thus, an independent check of the velocity measurements is easy and simple.

Strain measurements may differ greatly between the two sides of the pile when bending exists. It is even possible that tension is measured on one side while very high compression exists on the other side of the pile. In extreme cases, bending might be so high that it leads to a nonlinear stress distribution. The averaging of the two strain signals does then not lead to the average pile force and proportionality will not be achieved.

When testing drilled shafts, measurements of strain may also be affected by local concrete quality variations. It is then often necessary to use four strain transducers spaced at 90 degrees around the pile for an improved strain data quality. The use of four transducers is also recommended for large pile

diameters, particularly when it is difficult to mount the sensors at least two pile widths or diameters below the pile top.

LIMITATIONS, ADDITIONAL CONSIDERATIONS

Mobilization of capacity

Estimates of pile capacity from dynamic testing indicate the **mobilized pile capacity at the time of testing**. At very high blow counts (low set per blow), dynamic test methods tend to produce lower bound capacity estimates as not all resistance (particularly at and near the toe) is fully activated.

Time dependent soil resistance effects

Static pile capacity from dynamic method calculations provide an estimate of the axial pile capacity. Increases and decreases in the pile capacity with time typically occur (soil setup/relaxation). Therefore, **restrike testing usually yields a better indication of long term pile capacity than a test at the end of pile driving**. Often a wait period of one or two days between end of driving and restrike is satisfactory for a realistic prediction of pile capacity but this waiting time depends, among other factors, on the permeability of the soil.

(A) Soil setup

Because excess positive pore pressures often develop during pile driving in fine grained soil (clays, silts or even fine sands), the capacity of a pile at the time of driving may often be less than the long term pile capacity. These pore pressures reduce the effective stress acting on the pile thereby reducing the soil resistance to pile penetration, and thus the pile capacity at the time of driving. As these pore pressures dissipate, the soil resistance acting on the pile increases as does the axial pile capacity. This phenomena is routinely called soil setup or soil freeze.

(*B) Relaxation*

Relaxation (capacity reduction with time) has been observed for piles driven into weathered shale, and may take several days to fully develop. Pile capacity estimates based upon initial driving or short term restrike tests can significantly overpredict long term pile capacity. Therefore, piles driven into shale should be tested after a minimum one week wait either statically or dynamically (with particular emphasis than on the first few blows). Relaxation has also been observed for displacement piles driven into dense saturated silts or fine sands due to a negative pore pressure effect at the pile toe. Again, restrike tests should be used, with great emphasis on early blows.

Capacity results for open pile profiles

Larger diameter open ended pipe piles (or H-piles which do not bear on rock) may behave differently under dynamic and static loading conditions. Under dynamic loads the soil inside the pile or between its flanges may slip and produce internal friction while under static loads the plug may move with the pile, thereby creating end bearing over the full pile cross section. As a result both friction and end bearing components may be different under static and dynamic conditions.

CAPWAP Analysis Results

A portion of the soil resistance calculated on an individual soil segment in a CAPWAP analysis can usually be shifted up or down the shaft one soil segment without significantly altering the match quality. Therefore, use of the CAPWAP resistance distribution for uplift, downdrag, scour, or other geotechnical considerations should be made with an understanding of these analysis limitations.

Stresses

PDA and CAPWAP calculated stresses are average values over the cross section. Additional allowance has to be made for bending or non-uniform contact stresses. To prevent damage it is therefore important to maintain good hammer-pile alignment and to protect the pile toes using appropriate devices or an increased cross sectional area.

In the United States is has become generally acceptable to limit the dynamic installation stresses of driven piles to the following levels:

- 90% of yield strength for steel piles
- 85% of the concrete compressive strength - after subtraction of the effective prestress - for concrete piles in compression

100% of effective prestress plus ½ of the concrete's tension strength for prestressed piles in tension

70% of the reinforcement strength for regularly reinforced concrete piles in tension

300% of the static design allowable stress for timber

Note that the dynamic stresses may either be directly measured at the pile top by the PDA or calculated by the PDA for other locations along the pile based on the pile top measurements.

Additional design considerations

Numerous factors have to be considered in pile foundation design. Some of these considerations include

- additional pile loading from downdrag or negative skin friction,
- lateral and uplift loading requirements
- effective stress changes (due to changes in water table, excavations, fills or other changes in overburden),
- long term settlements in general and settlement from underlying weaker layers and/or pile group effects,

These factors have not been evaluated by GRL and have not been considered in the interpretation of the dynamic testing results. The foundation designer should determine if these or any other considerations are applicable to this project and the foundation design.

Wave equation analysis results

The results calculated by the wave equation analysis program depend on a variety of hammer, pile and soil input parameters. Although attempts have been made to base the analysis on the best available information, actual field conditions may vary and therefore stresses and blow counts may differ from the predictions reported. Capacity predictions derived from wave equation analyses should use restrike information. However, because of the uncertainties associated with restrike blow counts and restrike hammer energies, correlations of such results with static test capacities with have often displayed considerable scatter.

As for PDA and CAPWAP, the theory on which GRLWEAP is based is the one-dimensional wave equation. For that reason, stress predictions by the wave equation analysis can only be averages over the pile cross section. Thus, bending stresses or stress concentrations due to non-uniform impact or uneven soil or rock resistance are not considered in these results. Stress maxima calculated by the wave equation are usually subjected to the same limits as those measured directly or calculated from measurements by the PDA.

Appendix B

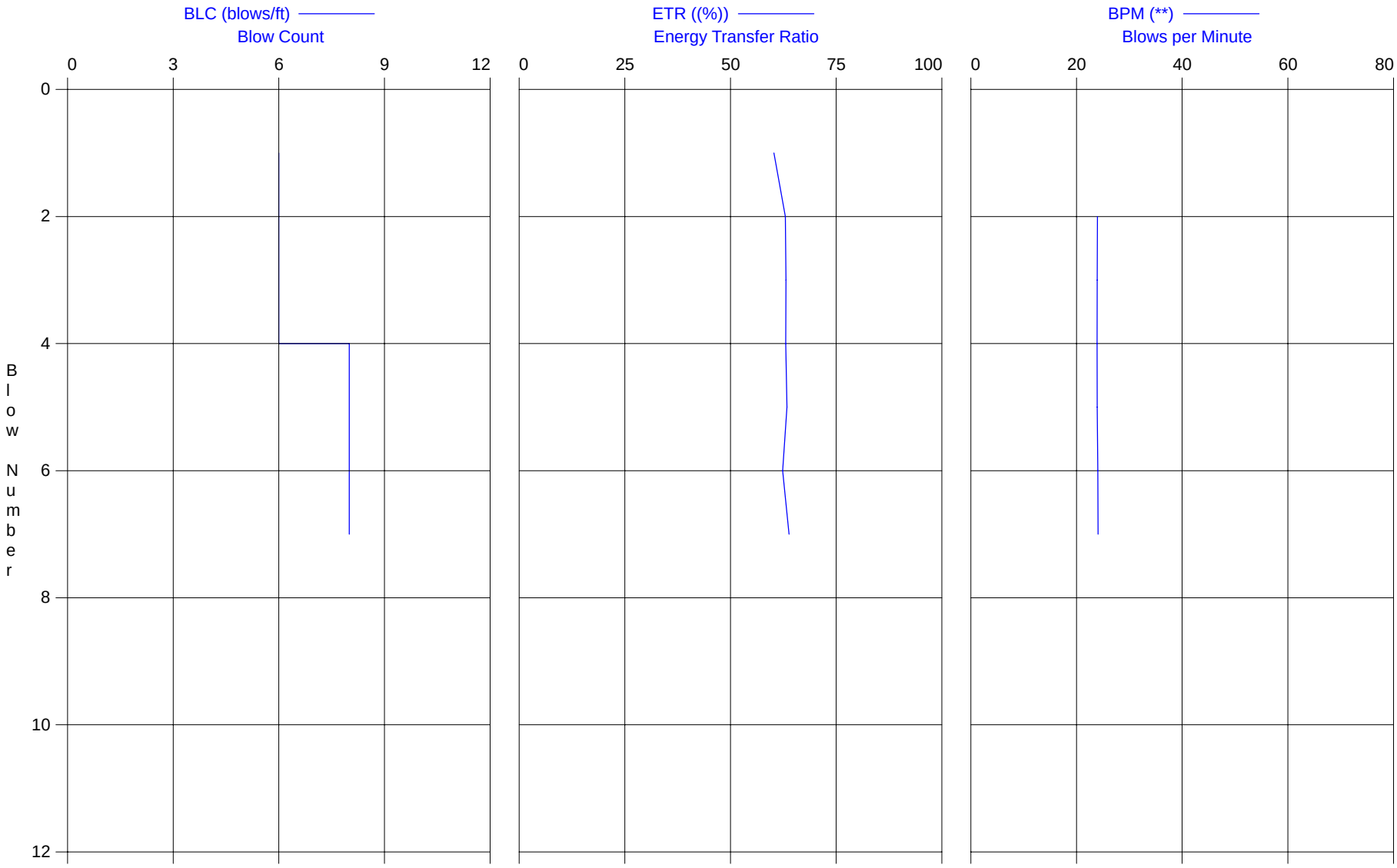
Summary of Case Method Field Results

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

Test date: 24-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-1 @5FT, SS W/140LB



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-1 @5FT, SS W/140LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

AR: 1.42 in^2
LE: 8.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.40

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio
DMX: Maximum Displacement

RAT: SPT Length Ratio
BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
1	5.67	6	34	13.2	0.211	60.3	2.17	1.8	0.0	0.3	15
2	5.83	6	35	13.5	0.220	63.0	2.11	2.0	24.0	0.3	0
3	6.00	6	34	13.3	0.221	63.1	2.04	2.0	23.9	0.3	0
4	6.13	8	34	13.2	0.221	63.1	1.79	2.0	23.9	0.3	0
5	6.25	8	34	13.1	0.222	63.4	1.63	2.0	23.9	0.3	0
6	6.38	8	34	13.2	0.218	62.3	1.50	2.0	24.0	0.3	0
7	6.50	8	34	13.2	0.223	63.8	1.52	2.0	24.1	0.3	0
		Average	34	13.2	0.219	62.7	1.82	2.0	24.0	0.3	2
		Std. Dev.	0	0.1	0.004	1.1	0.26	0.1	0.1	0.0	5
		Maximum	35	13.5	0.223	63.8	2.17	2.0	24.1	0.3	15
		@ Blow#	2	2	7	7	1	2	7	7	1

Total number of blows analyzed: 7

Time Summary

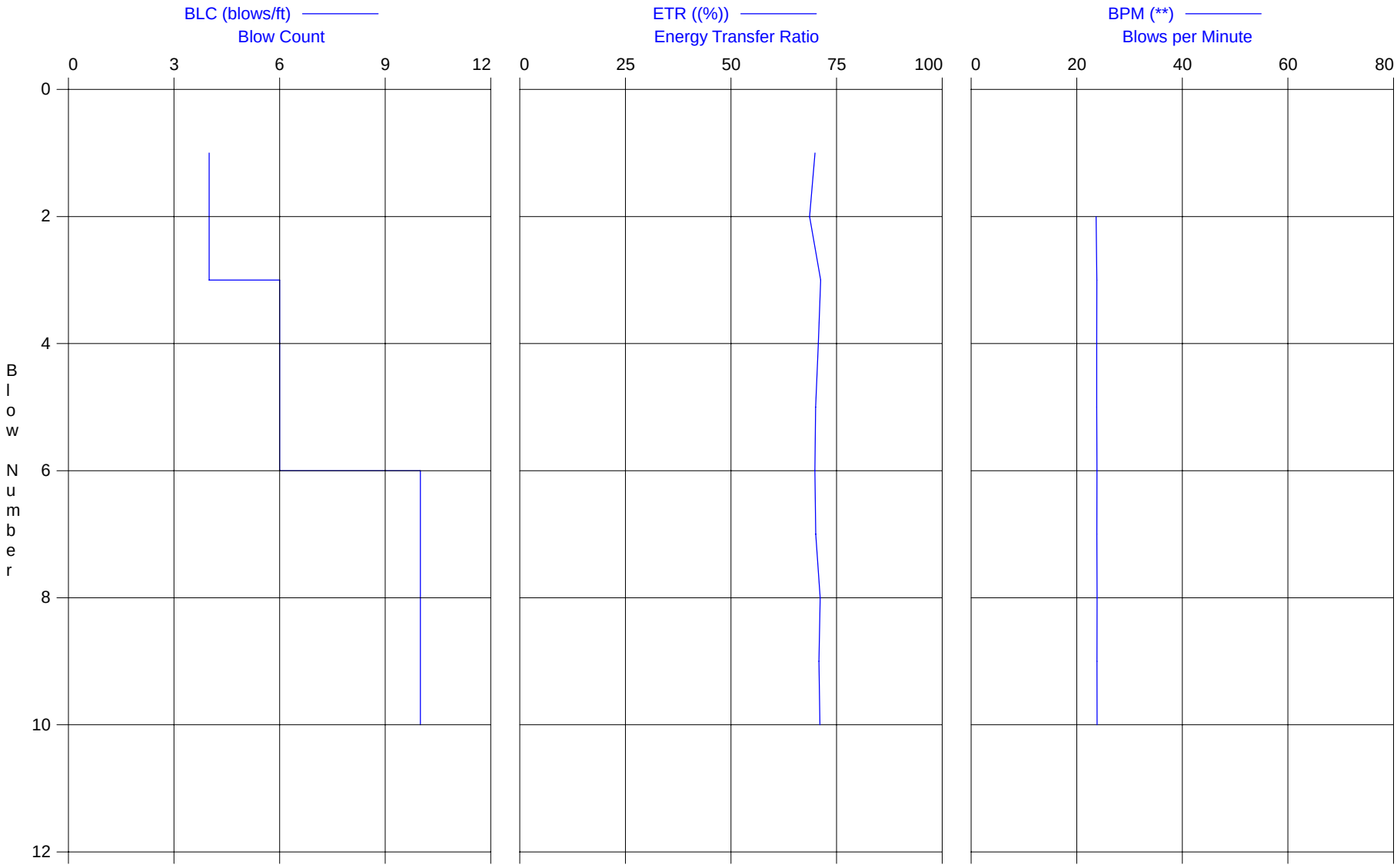
Drive 15 seconds 8:31:28 AM - 8:31:43 AM (1/24/2011) BN 1 - 7

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

Test date: 24-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-3 @10FT, SS W/140LB



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-3 @10FT, SS W/140LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

AR: 1.42 in^2
LE: 13.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.40

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio
DMX: Maximum Displacement

RAT: SPT Length Ratio
BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
3	10.67	6	33	14.2	0.249	71.2	2.10	1.5	23.8	0.3	9
4	10.83	6	33	13.9	0.247	70.7	2.00	1.5	23.8	0.3	9
5	11.00	6	35	14.2	0.245	70.0	2.00	1.5	23.8	0.3	10
6	11.10	10	35	13.6	0.244	69.8	1.36	1.5	23.8	0.3	11
7	11.20	10	35	13.2	0.245	70.1	1.40	1.5	23.8	0.3	11
8	11.30	10	35	13.7	0.249	71.1	1.46	1.5	23.8	0.3	11
9	11.40	10	34	13.1	0.248	70.8	1.35	1.5	23.8	0.3	10
10	11.50	10	35	13.2	0.249	71.1	1.44	1.5	23.8	0.3	10
		Average	34	13.6	0.247	70.6	1.64	1.5	23.8	0.3	10
		Std. Dev.	1	0.4	0.002	0.5	0.31	0.0	0.0	0.0	1
		Maximum	35	14.2	0.249	71.2	2.10	1.5	23.8	0.3	11
		@ Blow#	7	3	3	3	3	3	10	3	7

Total number of blows analyzed: 8

Time Summary

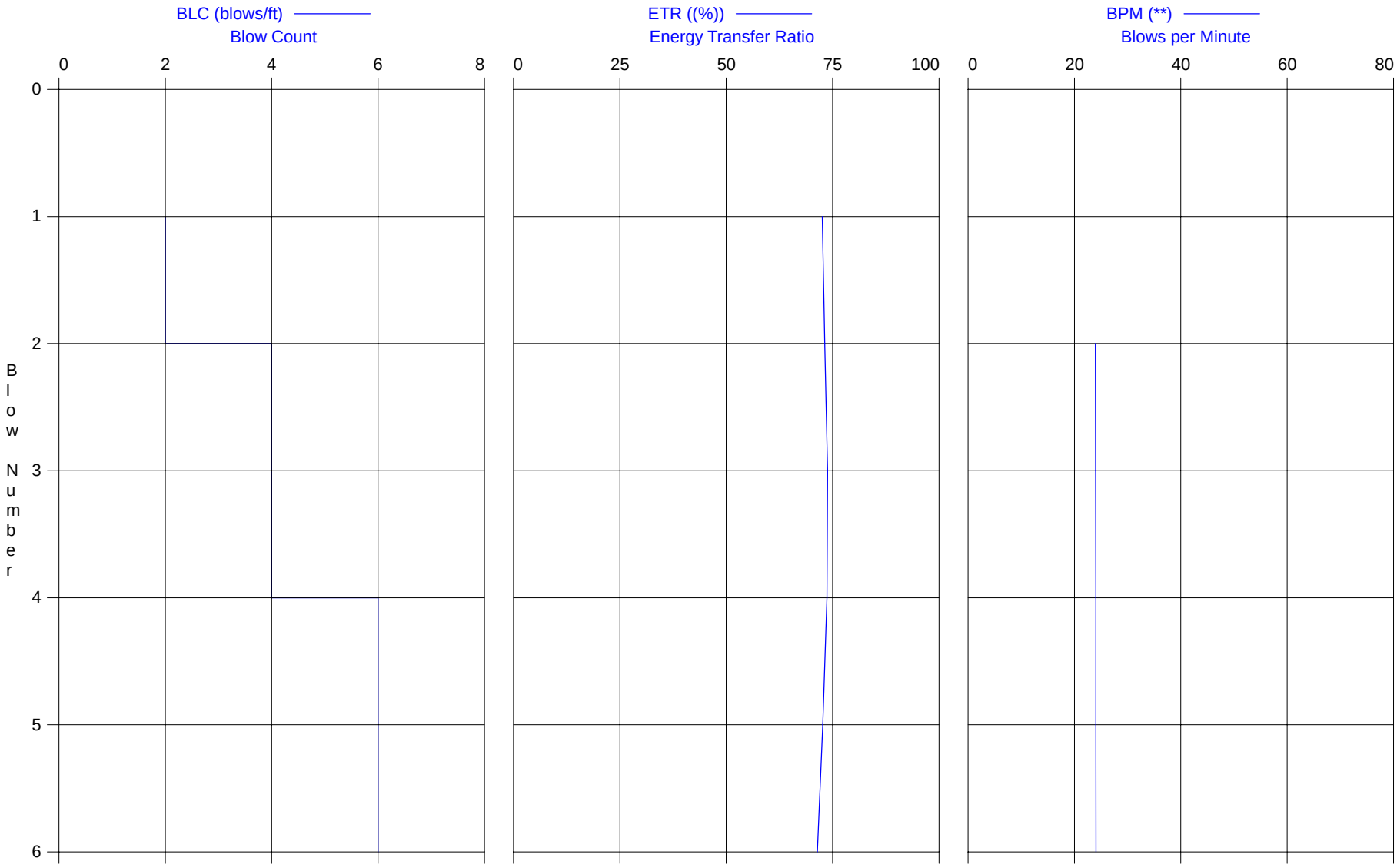
Drive 23 seconds 8:46:23 AM - 8:46:46 AM (1/24/2011) BN 1 - 10

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

Test date: 24-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-4 @15FT, SS W/140LB



Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-4 @15FT, SS W/140LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

AR: 1.42 in^2
LE: 18.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.40

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio
DMX: Maximum Displacement

RAT: SPT Length Ratio
BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
2	15.75	4	35	14.0	0.256	73.2	3.00	1.4	24.0	0.3	12
3	16.00	4	34	13.9	0.258	73.8	3.00	1.4	24.0	0.3	11
4	16.17	6	34	13.7	0.258	73.7	2.42	1.4	24.0	0.3	11
5	16.33	6	34	13.8	0.254	72.7	2.21	1.4	24.0	0.3	10
6	16.50	6	34	13.5	0.250	71.4	2.15	1.4	24.1	0.3	13
		Average	34	13.8	0.255	73.0	2.56	1.4	24.0	0.3	12
		Std. Dev.	0	0.2	0.003	0.9	0.37	0.0	0.0	0.0	1
		Maximum	35	14.0	0.258	73.8	3.00	1.4	24.1	0.3	13
		@ Blow#	2	2	3	3	3	2	6	6	6

Total number of blows analyzed: 5

Time Summary

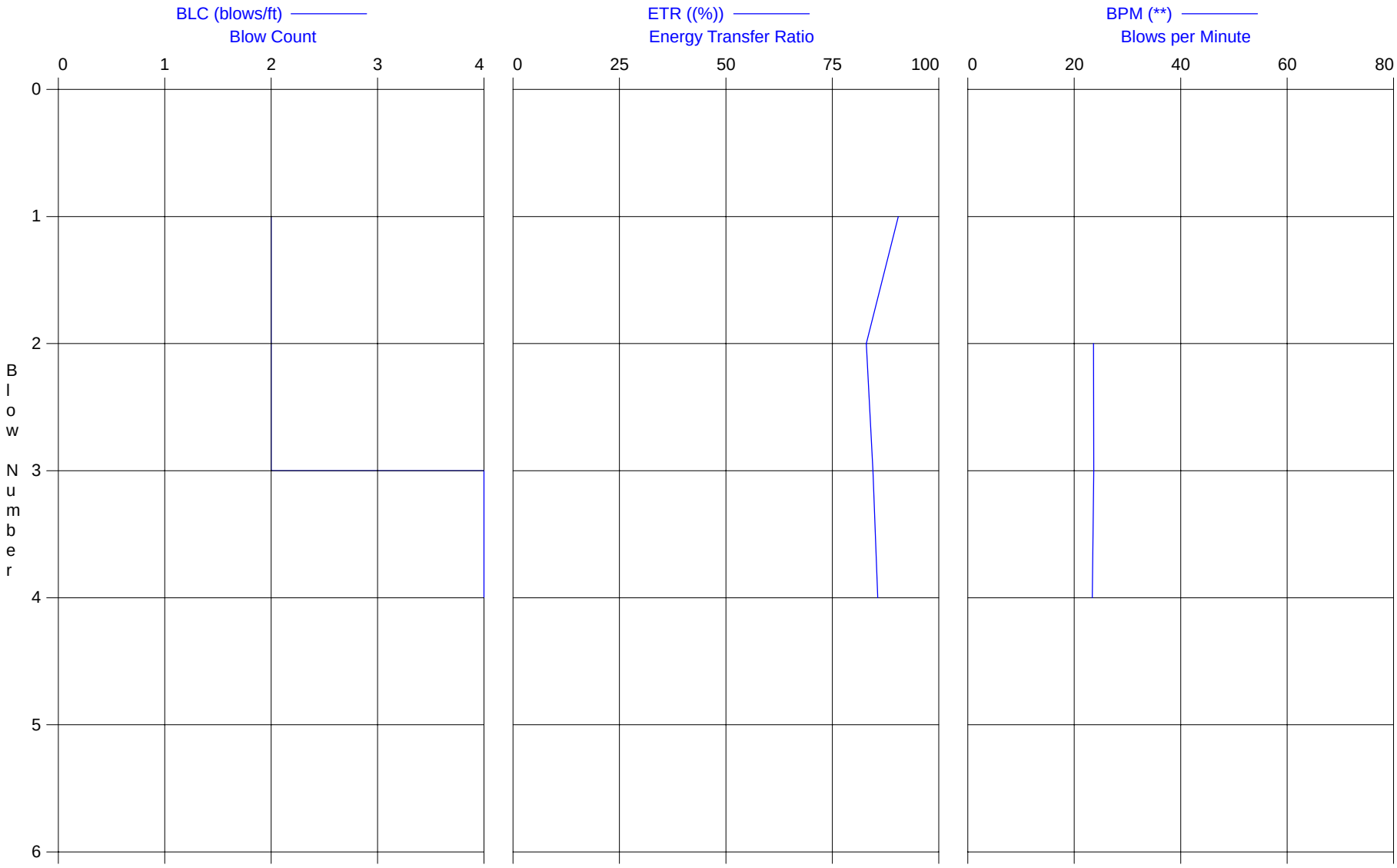
Drive 13 seconds 9:00:44 AM - 9:00:57 AM (1/24/2011) BN 1 - 6

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

Test date: 24-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-5 @20FT, CALF.MOD W/300LB



MAJOR DRILLING, WM SPT - SAMPLE 02-5 @20FT, CALF.MOD W/300LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

AR: 1.42 in^2
LE: 23.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.40

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio
DMX: Maximum Displacement

RAT: SPT Length Ratio
BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
2	21.00	2	43	15.6	0.622	83.0	6.00	1.4	23.6	0.8	6
3	21.25	4	42	15.6	0.634	84.5	3.16	1.4	23.7	0.8	7
4	21.50	4	42	15.2	0.643	85.7	3.00	1.4	23.4	0.8	14
		Average	42	15.5	0.633	84.4	4.05	1.4	23.6	0.8	9
		Std. Dev.	0	0.2	0.009	1.1	1.38	0.0	0.1	0.0	3
		Maximum	43	15.6	0.643	85.7	6.00	1.4	23.7	0.8	14
		@ Blow#	2	3	4	4	2	2	3	3	4

Total number of blows analyzed: 3

Time Summary

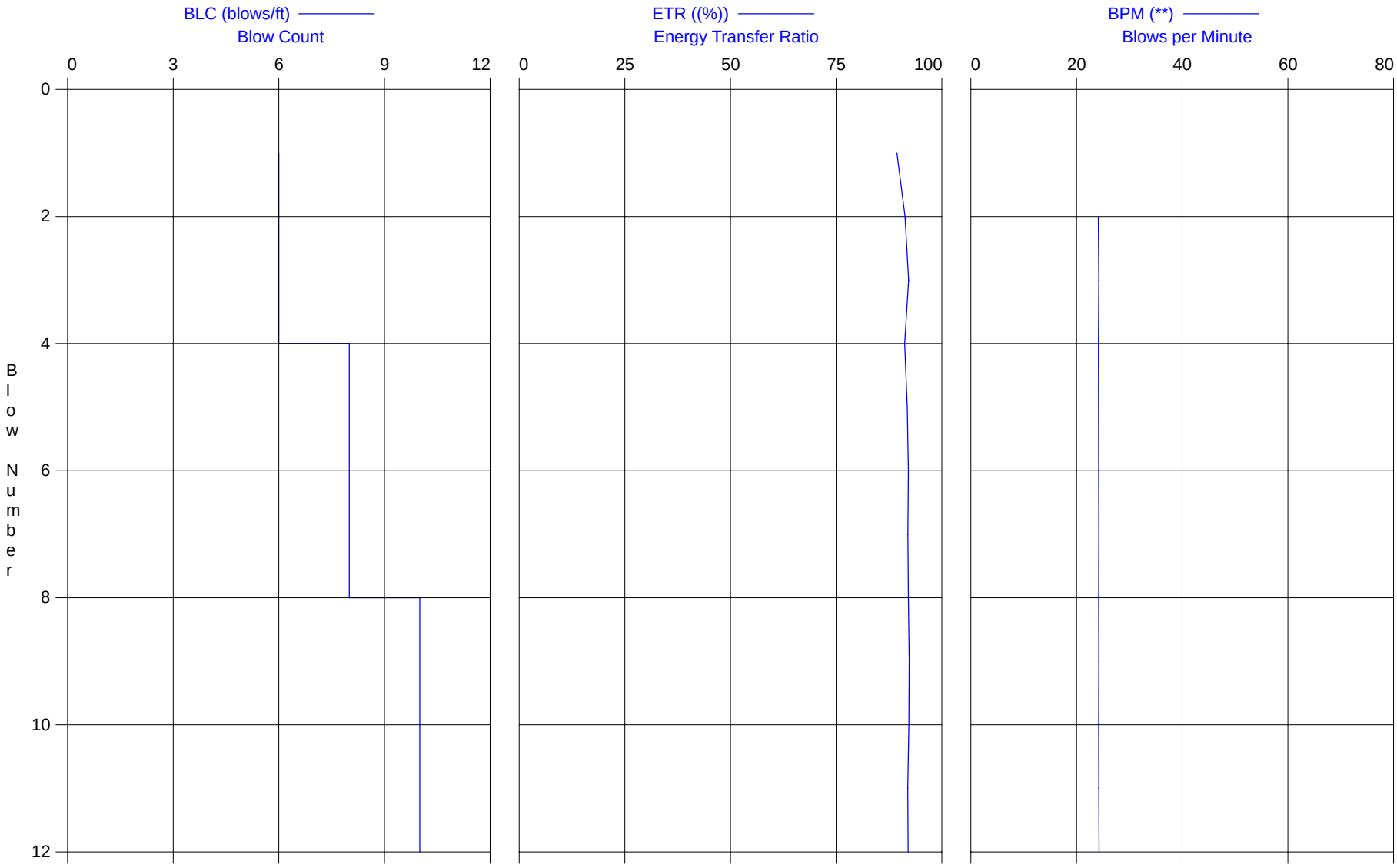
Drive 8 seconds 9:21:57 AM - 9:22:05 AM (1/24/2011) BN 1 - 4

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

Test date: 24-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-7 @30FT, SS W/140LB



MAJOR DRILLING, WM SPT - SAMPLE 02-7 @30FT, SS W/140LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

AR: 1.42 in^2
LE: 34.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.40

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio
DMX: Maximum Displacement

RAT: SPT Length Ratio
BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
4	30.63	8	38	14.0	0.319	91.2	1.76	1.2	24.2	0.4	12
5	30.75	8	38	13.8	0.321	91.8	1.69	1.2	24.2	0.4	12
6	30.88	8	39	13.5	0.322	92.1	1.65	1.2	24.2	0.4	13
7	31.00	8	38	13.5	0.322	92.0	1.58	1.2	24.2	0.5	13
8	31.10	10	39	13.3	0.322	92.1	1.47	1.2	24.2	0.4	13
9	31.20	10	38	13.4	0.323	92.3	1.51	1.2	24.2	0.5	12
10	31.30	10	39	13.3	0.323	92.2	1.51	1.2	24.2	0.4	13
11	31.40	10	38	13.2	0.322	91.9	1.52	1.2	24.2	0.4	12
12	31.50	10	38	13.0	0.322	92.0	1.36	1.2	24.3	0.4	13
		Average	38	13.4	0.322	92.0	1.56	1.2	24.2	0.4	13
		Std. Dev.	0	0.3	0.001	0.3	0.12	0.0	0.0	0.0	0
		Maximum	39	14.0	0.323	92.3	1.76	1.2	24.3	0.5	13
		@ Blow#	6	4	9	9	4	4	12	7	10

Total number of blows analyzed: 9

Time Summary

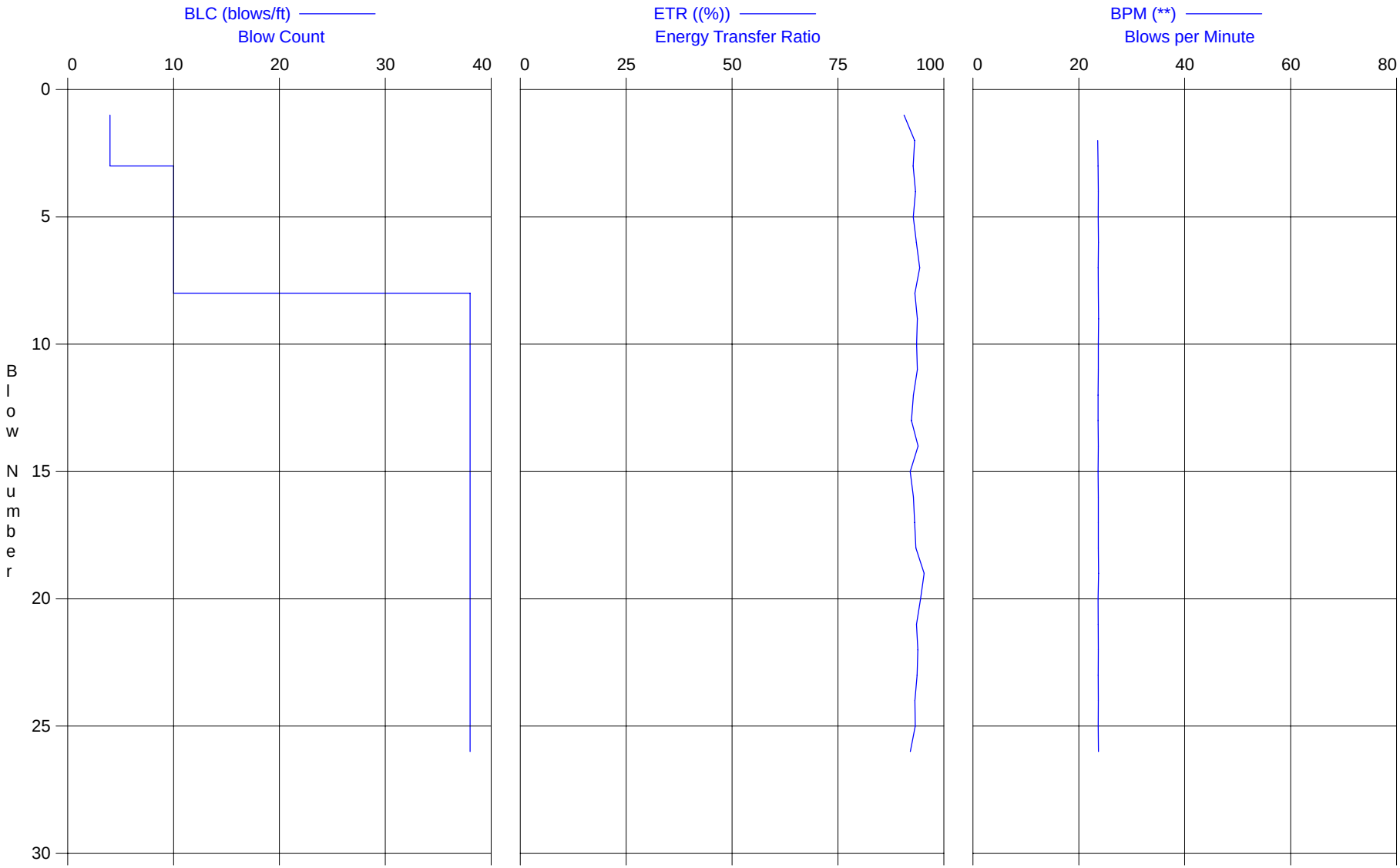
Drive 27 seconds 10:02:13 AM - 10:02:40 AM (1/24/2011) BN 1 - 12

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

Test date: 24-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-9 @40FT, SS W/140LB



MAJOR DRILLING, WM SPT - SAMPLE 02-9 @40FT, SS W/140LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

AR: 1.42 in^2
LE: 43.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.40

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio
DMX: Maximum Displacement

RAT: SPT Length Ratio
BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
3	40.60	10	37	14.4	0.325	92.7	1.78	1.2	23.6	0.4	10
4	40.70	10	37	14.4	0.327	93.3	1.78	1.2	23.7	0.4	9
5	40.80	10	37	14.3	0.325	92.8	1.61	1.2	23.7	0.4	10
6	40.90	10	37	14.0	0.327	93.5	1.55	1.2	23.7	0.4	10
7	41.00	10	37	13.9	0.330	94.3	1.47	1.2	23.7	0.4	10
8	41.03	38	37	13.3	0.326	93.2	1.16	1.2	23.7	0.4	10
9	41.05	38	38	12.0	0.328	93.7	0.81	1.2	23.7	0.4	10
10	41.08	38	38	11.1	0.328	93.6	0.65	1.2	23.7	0.4	11
11	41.11	38	37	10.7	0.328	93.8	0.54	1.2	23.7	0.4	10
12	41.13	38	37	10.6	0.325	92.8	0.59	1.2	23.6	0.4	11
13	41.16	38	36	10.4	0.323	92.3	0.44	0.9	23.6	0.4	10
14	41.18	38	36	10.5	0.329	93.9	0.46	0.9	23.7	0.4	10
15	41.21	38	36	10.5	0.322	92.0	0.43	1.2	23.6	0.4	11
16	41.24	38	37	10.6	0.325	92.8	0.59	1.2	23.7	0.4	12
17	41.26	38	36	10.5	0.326	93.1	0.47	0.9	23.7	0.4	10
18	41.29	38	37	10.7	0.327	93.4	0.48	1.2	23.7	0.4	11
19	41.32	38	37	10.8	0.334	95.3	0.52	0.9	23.7	0.4	11
20	41.34	38	36	10.7	0.331	94.5	0.43	1.2	23.6	0.4	10
21	41.37	38	37	10.7	0.327	93.5	0.46	1.2	23.7	0.4	10
22	41.40	38	38	10.8	0.329	93.9	0.48	1.2	23.7	0.4	11
23	41.42	38	39	10.8	0.328	93.7	0.51	1.2	23.7	0.4	11
24	41.45	38	37	10.7	0.326	93.2	0.47	1.2	23.7	0.4	10
25	41.47	38	38	10.9	0.326	93.2	0.56	1.0	23.7	0.4	11
26	41.50	38	38	10.7	0.322	92.1	0.47	1.2	23.7	0.4	11
		Average	37	11.6	0.327	93.4	0.78	1.1	23.7	0.4	10
		Std. Dev.	1	1.5	0.003	0.7	0.47	0.1	0.0	0.0	1
		Maximum	39	14.4	0.334	95.3	1.78	1.2	23.7	0.4	12
		@ Blow#	23	3	19	19	3	3	9	7	16

Total number of blows analyzed: 24

Time Summary

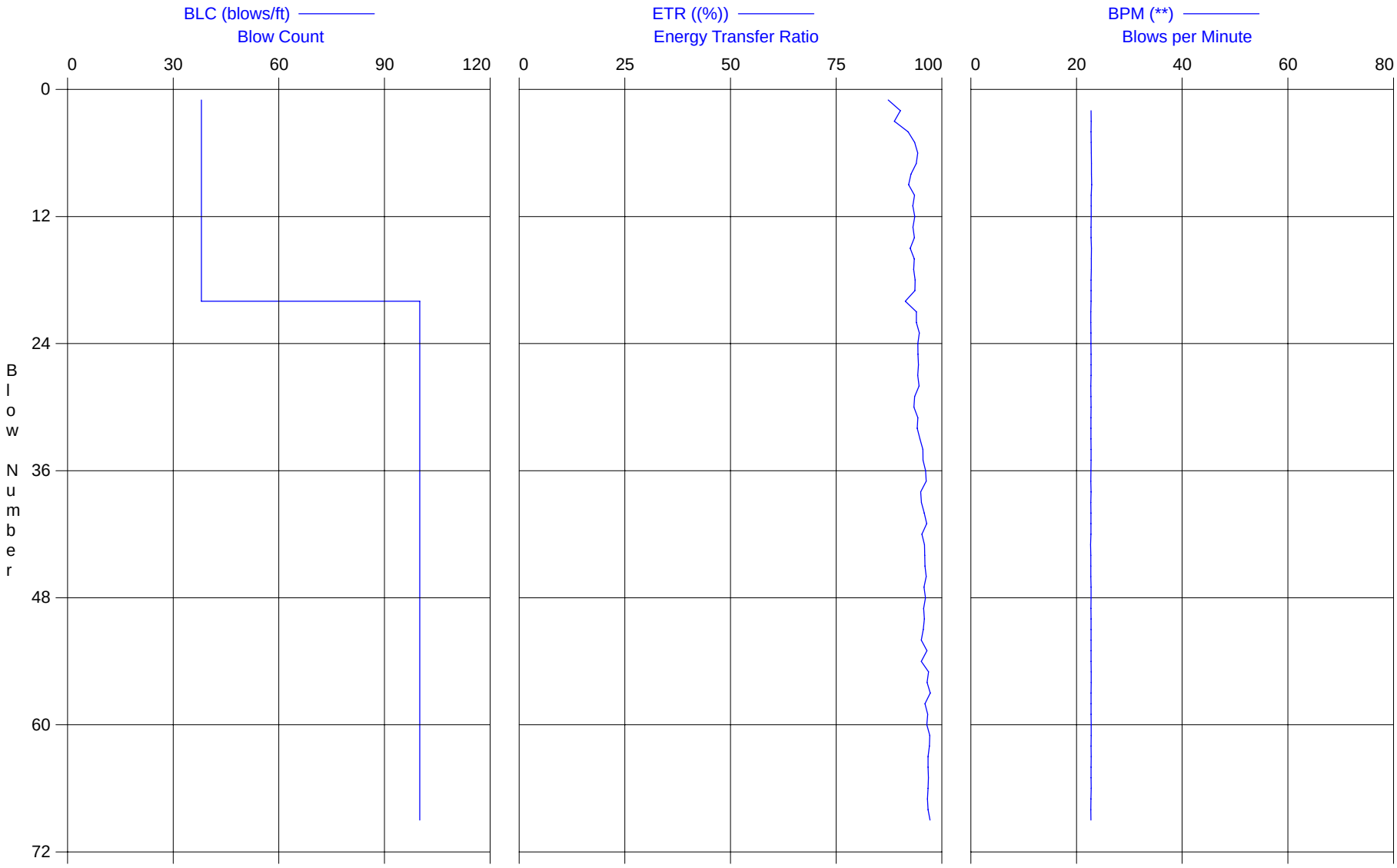
Drive 1 minute 3 seconds 10:41:46 AM - 10:42:49 AM (1/24/2011) BN 1 - 26

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

Test date: 24-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-10 @45FT, CALF.MOD W/300LB



MAJOR DRILLING, WM SPT - SAMPLE 02-10 @45FT, CALF.MOD W/300LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

AR: 1.42 in^2
LE: 48.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.40

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio
DMX: Maximum Displacement

RAT: SPT Length Ratio
BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
20	45.51	100	42	11.3	0.685	91.4	0.44	1.2	22.7	0.9	9
21	45.52	100	42	11.5	0.705	94.0	0.46	1.2	22.7	0.9	15
22	45.53	100	42	11.5	0.705	94.0	0.46	1.2	22.7	0.9	15
23	45.54	100	42	11.6	0.710	94.7	0.47	1.2	22.7	0.9	15
24	45.55	100	42	11.6	0.707	94.3	0.46	1.2	22.7	0.9	16
25	45.56	100	42	11.5	0.708	94.3	0.45	1.2	22.8	0.9	14
26	45.57	100	42	11.6	0.708	94.5	0.46	1.2	22.7	0.9	16
27	45.58	100	42	11.5	0.707	94.3	0.46	1.2	22.8	0.9	16
28	45.59	100	43	11.5	0.710	94.6	0.45	1.2	22.7	0.9	14
29	45.60	100	42	11.4	0.702	93.6	0.45	1.2	22.7	0.9	14
30	45.61	100	42	11.4	0.701	93.4	0.45	1.2	22.7	0.9	13
31	45.62	100	42	11.7	0.707	94.3	0.45	2.4	22.7	1.3	13
32	45.63	100	42	11.5	0.706	94.2	0.45	2.4	22.7	1.3	16
33	45.64	100	42	11.6	0.711	94.8	0.45	2.4	22.7	1.3	16
34	45.65	100	43	11.5	0.716	95.5	0.45	1.2	22.8	0.9	14
35	45.66	100	42	11.7	0.716	95.5	0.45	2.4	22.7	1.3	16
36	45.67	100	42	11.7	0.721	96.1	0.44	2.4	22.7	1.3	16
37	45.68	100	42	11.6	0.722	96.3	0.52	2.4	22.7	1.3	15
38	45.69	100	42	11.6	0.712	95.0	0.44	2.4	22.8	1.3	16
39	45.70	100	42	11.6	0.714	95.2	0.47	2.1	22.7	1.3	15
40	45.71	100	42	11.6	0.719	95.8	0.51	2.1	22.7	1.3	15
41	45.72	100	42	11.7	0.723	96.4	0.53	2.1	22.7	1.3	16
42	45.73	100	42	11.7	0.715	95.3	0.43	2.1	22.7	1.4	16
43	45.74	100	42	11.7	0.719	95.9	0.44	2.1	22.7	1.4	14
44	45.75	100	42	11.8	0.720	95.9	0.44	2.1	22.7	1.4	15
45	45.76	100	42	11.8	0.720	96.0	0.44	2.1	22.7	1.4	15
46	45.77	100	42	11.8	0.722	96.3	0.44	2.1	22.7	1.4	14
47	45.78	100	42	11.8	0.718	95.8	0.44	2.1	22.7	1.4	15
48	45.79	100	42	11.8	0.721	96.1	0.44	2.1	22.7	1.4	15
49	45.80	100	42	11.8	0.718	95.7	0.44	2.1	22.7	1.4	15
50	45.81	100	42	11.8	0.719	95.9	0.44	2.1	22.7	1.4	15
51	45.82	100	42	11.7	0.717	95.6	0.44	2.1	22.8	1.4	14
52	45.83	100	42	11.7	0.714	95.1	0.43	2.1	22.8	1.4	14
53	45.84	100	42	11.8	0.724	96.5	0.43	2.1	22.7	1.5	15
54	45.85	100	42	11.7	0.714	95.1	0.43	2.1	22.8	1.4	15
55	45.86	100	42	11.9	0.726	96.9	0.44	2.1	22.8	1.5	16
56	45.87	100	42	11.8	0.724	96.5	0.44	2.1	22.8	1.4	15
57	45.88	100	42	11.8	0.730	97.3	0.44	2.1	22.7	1.4	16
58	45.89	100	42	11.9	0.720	96.0	0.47	2.1	22.7	1.4	15
59	45.90	100	42	11.8	0.725	96.6	0.49	2.1	22.7	1.4	16
60	45.91	100	44	11.7	0.723	96.5	0.44	2.1	22.8	1.4	18
61	45.92	100	42	11.8	0.729	97.1	0.44	2.1	22.8	1.5	14
62	45.93	100	42	11.8	0.728	97.1	0.47	2.1	22.8	1.5	16
63	45.94	100	42	11.8	0.725	96.7	0.44	2.0	22.8	1.5	14
64	45.95	100	42	11.7	0.726	96.8	0.46	2.0	22.7	1.5	15
65	45.96	100	42	11.8	0.726	96.8	0.47	2.0	22.7	1.5	15
66	45.97	100	42	11.8	0.726	96.8	0.44	2.0	22.8	1.5	16
67	45.98	100	43	11.9	0.724	96.6	0.43	2.1	22.7	1.5	17
68	45.99	100	43	11.8	0.725	96.7	0.43	2.0	22.7	1.5	16
69	46.00	100	43	11.8	0.729	97.2	0.44	2.1	22.7	1.5	16
		Average	42	11.7	0.717	95.6	0.45	1.9	22.7	1.3	15
		Std. Dev.	0	0.1	0.009	1.2	0.02	0.4	0.0	0.2	1
		Maximum	44	11.9	0.730	97.3	0.53	2.4	22.8	1.5	18
		@ Blow#	60	58	57	57	41	31	55	65	60

Total number of blows analyzed: 50

Time Summary

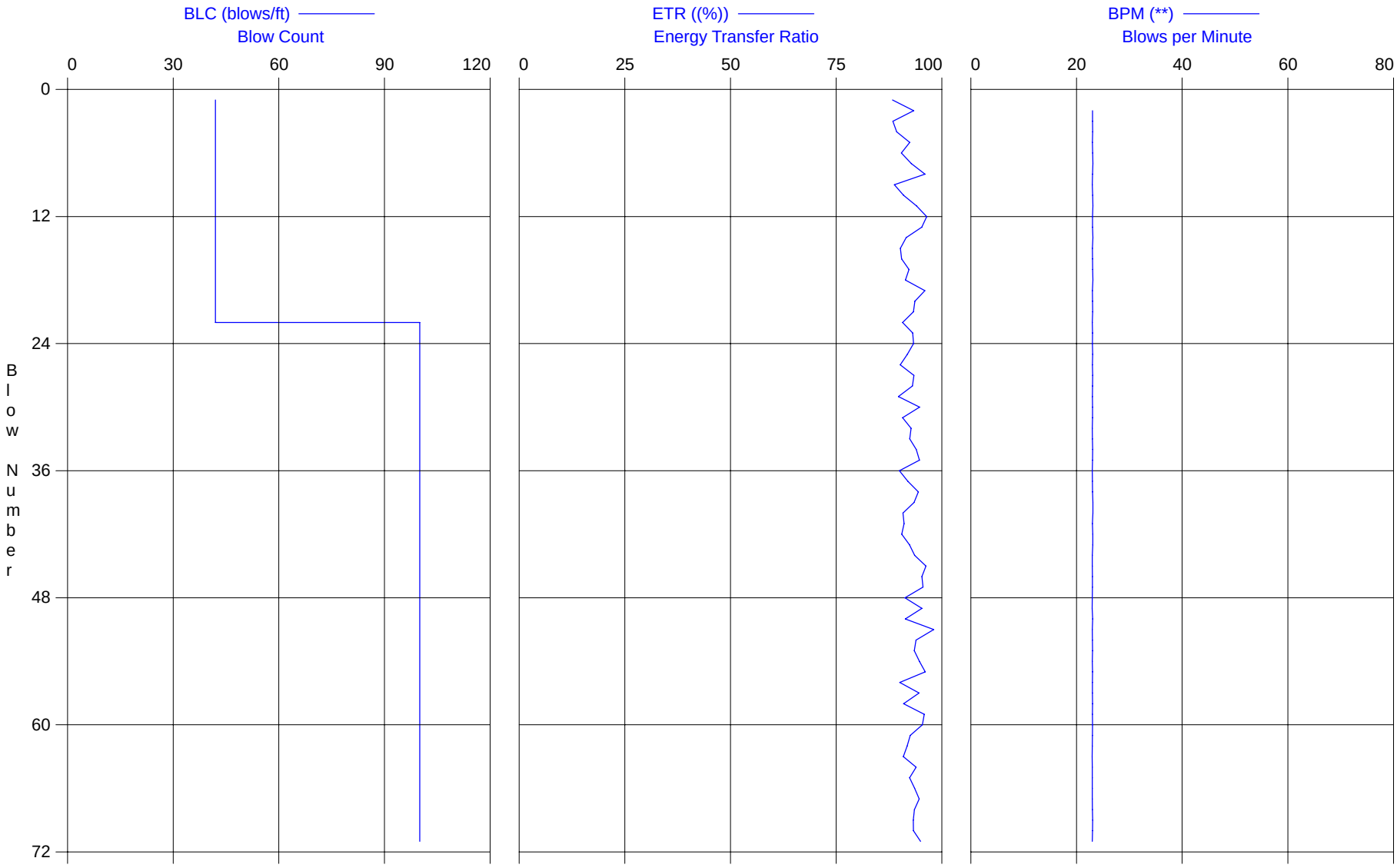
Drive 3 minutes 11:10:49 AM - 11:13:49 AM (1/24/2011) BN 1 - 69

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

Test date: 24-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-11 @50FT, CALF.MOD W/300LB



MAJOR DRILLING, WM SPT - SAMPLE 02-11 @50FT, CALF.MOD W/300LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

AR: 1.42 in^2
LE: 53.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.40

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio
DMX: Maximum Displacement

RAT: SPT Length Ratio
BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
22	50.51	100	41	11.9	0.680	90.7	0.45	1.2	23.0	0.8	11
23	50.52	100	42	11.9	0.698	93.1	0.44	1.2	23.0	0.9	12
24	50.53	100	41	11.9	0.700	93.3	0.45	1.2	23.0	0.9	11
25	50.54	100	42	12.0	0.689	91.9	0.43	1.2	23.1	0.9	11
26	50.55	100	42	12.0	0.676	90.2	0.42	1.2	23.0	0.9	11
27	50.56	100	42	12.0	0.700	93.4	0.46	1.2	23.1	0.9	11
28	50.57	100	41	11.8	0.698	93.0	0.45	1.2	23.0	0.9	11
29	50.58	100	41	11.9	0.673	89.7	0.41	1.2	23.0	0.9	11
30	50.59	100	41	12.1	0.711	94.7	0.47	1.2	23.0	0.9	11
31	50.60	100	42	12.0	0.680	90.7	0.42	1.2	23.0	0.9	11
32	50.61	100	42	12.0	0.695	92.7	0.44	1.2	23.0	0.9	11
33	50.62	100	42	11.9	0.693	92.4	0.44	1.2	23.0	0.9	12
34	50.63	100	42	12.0	0.704	93.9	0.44	1.2	23.1	0.9	11
35	50.64	100	42	12.1	0.710	94.7	0.46	1.2	23.0	0.9	11
36	50.65	100	42	11.9	0.675	90.0	0.40	1.2	23.0	0.9	11
37	50.66	100	42	12.0	0.690	91.9	0.42	1.2	23.0	0.9	11
38	50.67	100	43	11.8	0.708	94.4	0.45	1.2	23.0	0.9	13
39	50.68	100	42	11.9	0.701	93.4	0.44	1.2	23.1	0.9	12
40	50.69	100	42	11.8	0.681	90.8	0.41	1.2	23.1	0.9	12
41	50.70	100	42	12.0	0.683	91.1	0.41	2.0	23.0	1.3	11
42	50.71	100	42	12.0	0.679	90.5	0.41	2.0	23.1	1.3	12
43	50.72	100	42	12.0	0.692	92.3	0.42	1.9	23.1	1.3	11
44	50.73	100	41	12.1	0.702	93.6	0.43	1.9	23.0	1.4	10
45	50.74	100	42	12.0	0.722	96.2	0.45	1.9	23.0	1.4	11
46	50.75	100	42	12.1	0.715	95.3	0.44	1.9	23.0	1.4	11
47	50.76	100	42	12.0	0.716	95.5	0.44	1.9	23.0	1.4	12
48	50.77	100	42	12.0	0.684	91.3	0.41	1.9	23.0	1.4	11
49	50.78	100	42	12.0	0.715	95.3	0.44	1.9	23.0	1.4	11
50	50.79	100	41	12.1	0.685	91.4	0.41	1.9	23.1	1.4	11
51	50.80	100	41	12.1	0.736	98.1	0.46	1.9	23.0	1.5	10
52	50.81	100	41	12.0	0.704	93.9	0.43	1.9	23.0	1.5	11
53	50.82	100	41	12.0	0.701	93.5	0.43	1.9	23.0	1.5	11
54	50.83	100	41	12.1	0.710	94.7	0.44	1.9	23.0	1.5	11
55	50.84	100	41	12.2	0.721	96.1	0.45	1.9	23.0	1.5	11
56	50.85	100	41	12.0	0.675	90.0	0.40	1.9	23.0	1.4	11
57	50.86	100	42	12.0	0.710	94.6	0.44	1.9	23.0	1.5	12
58	50.87	100	42	11.9	0.682	90.9	0.41	1.9	23.0	1.4	13
59	50.88	100	42	12.0	0.719	95.8	0.45	1.9	23.0	1.5	12
60	50.89	100	42	12.0	0.715	95.4	0.45	1.9	23.0	1.4	12
61	50.90	100	42	11.8	0.694	92.5	0.43	1.9	23.0	1.4	12
62	50.91	100	42	11.9	0.689	91.8	0.41	1.9	23.0	1.5	13
63	50.92	100	42	11.9	0.682	90.9	0.41	1.9	23.0	1.5	13
64	50.93	100	43	11.9	0.704	93.9	0.44	1.9	23.0	1.5	13
65	50.94	100	42	11.9	0.693	92.4	0.42	1.9	23.0	1.4	12
66	50.95	100	42	11.9	0.702	93.6	0.43	1.9	23.0	1.5	13
67	50.96	100	43	12.1	0.710	94.6	0.44	1.9	23.0	1.5	12
68	50.97	100	42	12.0	0.701	93.5	0.43	1.9	23.0	1.5	13
69	50.98	100	42	12.1	0.699	93.3	0.42	1.9	23.1	1.5	12
70	50.99	100	41	12.1	0.700	93.3	0.43	1.9	23.0	1.4	12
71	51.00	100	42	12.2	0.712	95.0	0.44	1.9	23.0	1.4	11
		Average	42	12.0	0.698	93.1	0.43	1.7	23.0	1.2	12
		Std. Dev.	0	0.1	0.014	1.9	0.02	0.4	0.0	0.3	1
		Maximum	43	12.2	0.736	98.1	0.47	2.0	23.1	1.5	13
		@ Blow#	64	71	51	51	30	41	39	67	58

Total number of blows analyzed: 50

Time Summary

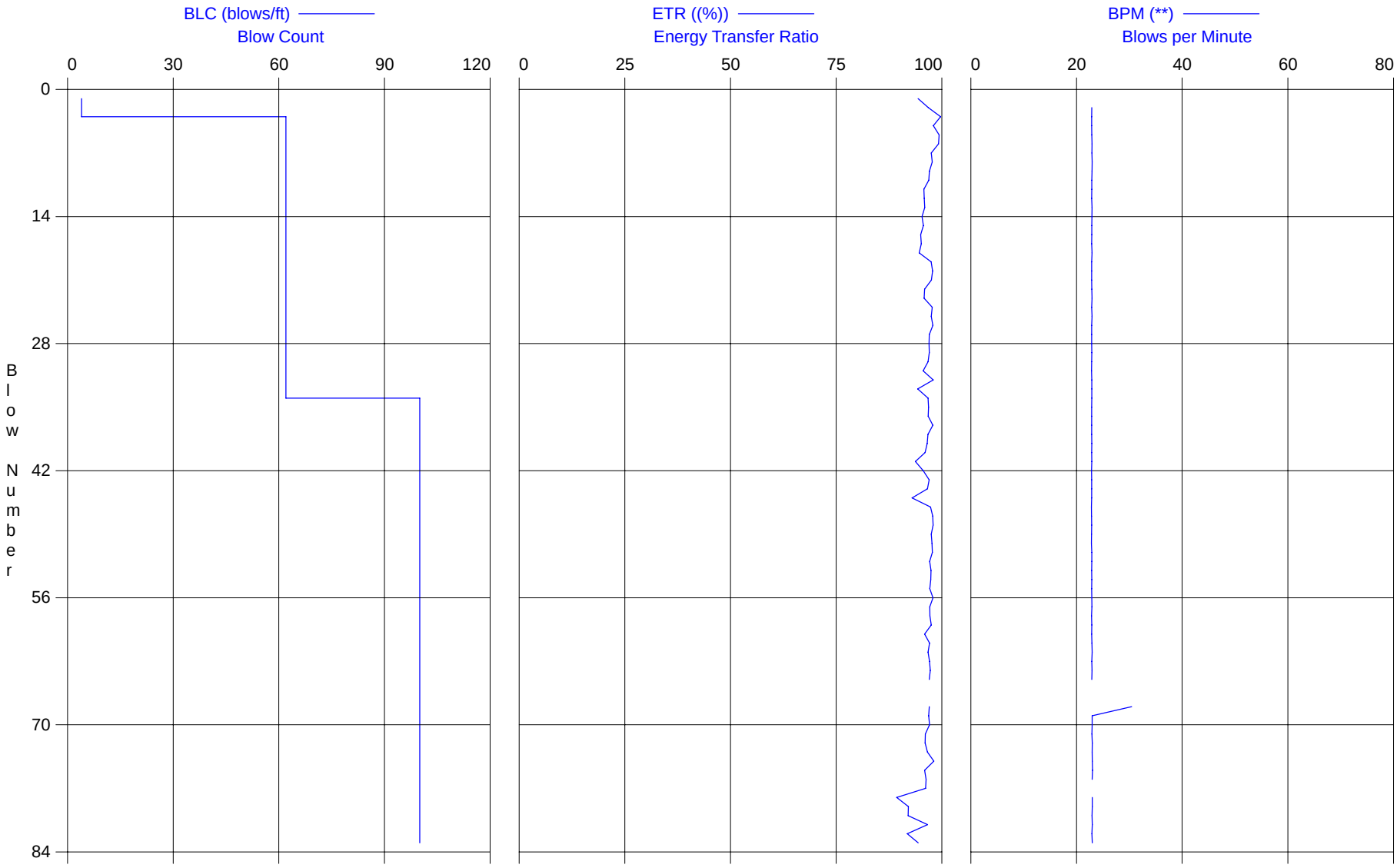
Drive 3 minutes 3 seconds 11:57:55 AM - 12:00:58 PM (1/24/2011) BN 1 - 71

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

Test date: 24-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-12 @55FT, CALF.MOD W/300LB



MAJOR DRILLING, WM SPT - SAMPLE 02-12 @55FT, CALF.MOD W/300LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

AR: 1.42 in^2
LE: 58.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.40

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio
DMX: Maximum Displacement

RAT: SPT Length Ratio
BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
3	55.52	62	42	13.5	0.748	99.7	1.34	1.1	22.9	0.9	15
4	55.53	62	42	13.5	0.735	98.0	1.29	1.1	22.9	0.9	15
5	55.55	62	42	13.3	0.745	99.3	0.88	1.1	22.9	0.9	16
6	55.57	62	42	12.8	0.744	99.2	0.75	1.1	22.9	0.9	14
7	55.58	62	42	12.1	0.731	97.5	0.74	1.1	22.9	0.9	14
8	55.60	62	42	11.6	0.733	97.7	0.66	1.1	22.9	0.9	16
9	55.61	62	43	11.6	0.728	97.1	0.62	1.1	22.9	0.9	14
10	55.63	62	43	11.6	0.727	96.9	0.58	1.1	22.9	0.9	14
11	55.65	62	43	11.6	0.718	95.8	0.56	1.1	22.9	0.9	15
12	55.66	62	43	11.7	0.719	95.8	0.56	1.2	22.9	0.9	15
13	55.68	62	43	11.7	0.720	95.9	0.55	1.2	22.9	0.9	15
14	55.69	62	43	11.7	0.715	95.3	0.54	1.2	22.9	0.9	16
15	55.71	62	43	11.7	0.717	95.6	0.55	1.2	22.9	0.9	16
16	55.73	62	42	11.7	0.712	95.0	0.55	1.2	22.9	0.9	16
17	55.74	62	42	11.7	0.713	95.1	0.54	1.2	22.9	0.9	17
18	55.76	62	42	11.6	0.710	94.6	0.55	1.2	22.9	0.9	15
19	55.77	62	41	12.0	0.731	97.5	0.56	1.2	22.9	0.9	12
20	55.79	62	41	11.9	0.734	97.8	0.56	1.2	22.9	0.9	11
21	55.81	62	41	12.0	0.731	97.5	0.56	1.2	22.9	0.9	11
22	55.82	62	41	11.9	0.719	95.9	0.55	1.2	22.9	0.9	12
23	55.84	62	41	12.0	0.719	95.8	0.55	1.2	22.9	0.9	13
24	55.86	62	41	12.1	0.733	97.7	0.56	1.2	22.9	0.9	12
25	55.87	62	41	12.2	0.731	97.5	0.56	1.2	22.9	0.9	10
26	55.89	62	41	12.3	0.734	97.9	0.56	1.2	22.9	0.9	11
27	55.90	62	41	12.1	0.728	97.0	0.56	1.2	22.9	0.9	10
28	55.92	62	41	12.2	0.727	97.0	0.56	1.2	22.9	0.9	11
29	55.94	62	41	12.2	0.728	97.0	0.55	1.2	22.9	0.9	11
30	55.95	62	41	12.1	0.726	96.8	0.55	1.2	22.9	0.9	11
31	55.97	62	41	11.9	0.717	95.6	0.54	1.2	22.8	0.9	12
32	55.98	62	41	12.2	0.735	98.0	0.54	1.2	22.9	0.9	11
33	56.00	62	40	11.9	0.707	94.3	0.50	1.2	22.9	0.8	11
34	56.01	100	42	11.6	0.726	96.7	0.51	1.2	22.9	0.9	14
35	56.02	100	42	11.7	0.726	96.8	0.51	1.2	22.9	0.9	14
36	56.03	100	42	11.7	0.726	96.8	0.51	1.2	22.9	0.9	13
37	56.04	100	43	11.8	0.734	97.9	0.52	1.2	22.8	0.9	16
38	56.05	100	42	11.7	0.725	96.7	0.51	1.2	22.9	0.9	15
39	56.06	100	43	11.7	0.724	96.5	0.51	1.2	22.9	0.9	17
40	56.07	100	43	11.6	0.720	96.1	0.51	1.2	22.9	0.9	15
41	56.08	100	43	11.7	0.703	93.8	0.47	1.2	22.9	0.9	9
42	56.09	100	44	11.5	0.717	95.6	0.50	1.2	22.8	0.9	17
43	56.10	100	43	11.6	0.727	97.0	0.68	1.3	22.9	0.9	15
44	56.11	100	43	11.6	0.725	96.6	0.63	1.3	22.9	0.9	8
45	56.12	100	43	11.6	0.697	93.0	0.45	1.3	22.9	0.9	9
46	56.13	100	43	11.7	0.730	97.3	0.49	1.3	22.8	0.9	17
47	56.14	100	43	11.9	0.734	97.8	0.49	1.3	22.8	0.9	17
48	56.15	100	44	11.8	0.735	97.9	0.50	1.2	22.9	0.9	15
49	56.16	100	43	11.9	0.731	97.5	0.48	2.0	22.8	1.2	17
50	56.17	100	44	11.8	0.733	97.7	0.48	2.0	22.8	1.3	16
51	56.18	100	44	11.9	0.733	97.8	0.47	1.9	22.9	1.4	18
52	56.19	100	44	11.8	0.728	97.1	0.46	2.0	22.9	1.3	18
53	56.20	100	43	11.7	0.731	97.4	0.46	1.9	22.9	1.3	18
54	56.21	100	45	11.8	0.730	97.4	0.46	1.9	22.9	1.3	18
55	56.22	100	44	11.7	0.729	97.1	0.47	1.9	22.9	1.4	18
56	56.23	100	44	11.8	0.734	97.9	0.54	1.9	22.9	1.4	18
57	56.24	100	44	11.8	0.728	97.1	0.46	1.9	22.9	1.4	18
58	56.25	100	43	11.7	0.729	97.2	0.46	1.9	22.8	1.4	17
59	56.26	100	44	11.8	0.731	97.5	0.46	1.9	22.9	1.4	18
60	56.27	100	43	11.7	0.719	95.9	0.45	1.9	22.9	1.4	17
61	56.28	100	43	11.8	0.728	97.1	0.46	1.9	22.9	1.4	17
62	56.29	100	43	11.9	0.725	96.7	0.46	1.9	22.9	1.4	17

MAJOR DRILLING, WM SPT - SAMPLE 02-12 @55FT, CALF.MOD W/300LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
63	56.30	100	43	12.0	0.728	97.1	0.46	1.9	22.9	1.4	16
64	56.31	100	44	11.9	0.729	97.3	0.46	1.9	22.9	1.4	17
65	56.32	100	44	11.9	0.728	97.0	0.45	1.9	22.9	1.5	18
68	56.35	100	43	11.7	0.728	97.0	0.54	1.9	30.4	1.5	16
69	56.36	100	43	11.8	0.727	96.9	0.46	1.9	23.0	1.5	17
70	56.37	100	43	11.6	0.728	97.1	0.60	1.9	23.0	1.6	8
71	56.38	100	44	11.7	0.721	96.1	0.45	1.9	22.9	1.6	17
72	56.39	100	43	11.7	0.720	96.1	0.45	1.9	23.0	1.6	18
73	56.40	100	44	11.7	0.725	96.6	0.45	1.9	23.0	1.7	18
74	56.41	100	44	11.7	0.736	98.1	0.47	1.9	23.0	1.7	8
75	56.42	100	44	11.7	0.719	95.9	0.44	1.8	23.0	1.7	9
76	56.43	100	44	11.6	0.722	96.3	0.45	1.9	22.9	1.7	19
77	56.44	100	44	11.7	0.721	96.2	0.45	1.9	0.0	1.7	18
78	56.45	100	44	11.8	0.670	89.3	0.38	1.8	23.0	1.7	10
79	56.46	100	44	11.6	0.691	92.1	0.41	1.9	23.0	1.7	9
80	56.47	100	44	11.6	0.690	92.0	0.42	1.8	22.9	1.7	9
81	56.48	100	44	11.6	0.725	96.6	0.45	1.8	23.0	1.7	19
82	56.49	100	43	11.7	0.689	91.8	0.41	1.8	22.9	1.7	9
83	56.50	100	44	11.7	0.708	94.4	0.44	1.8	23.0	1.7	8
		Average	43	11.9	0.724	96.5	0.54	1.5	23.0	1.1	14
		Std. Dev.	1	0.4	0.013	1.7	0.15	0.3	0.8	0.3	3
		Maximum	45	13.5	0.748	99.7	1.34	2.0	30.4	1.7	19
		@ Blow#	54	3	3	3	3	49	68	81	76

Total number of blows analyzed: 79

Time Summary

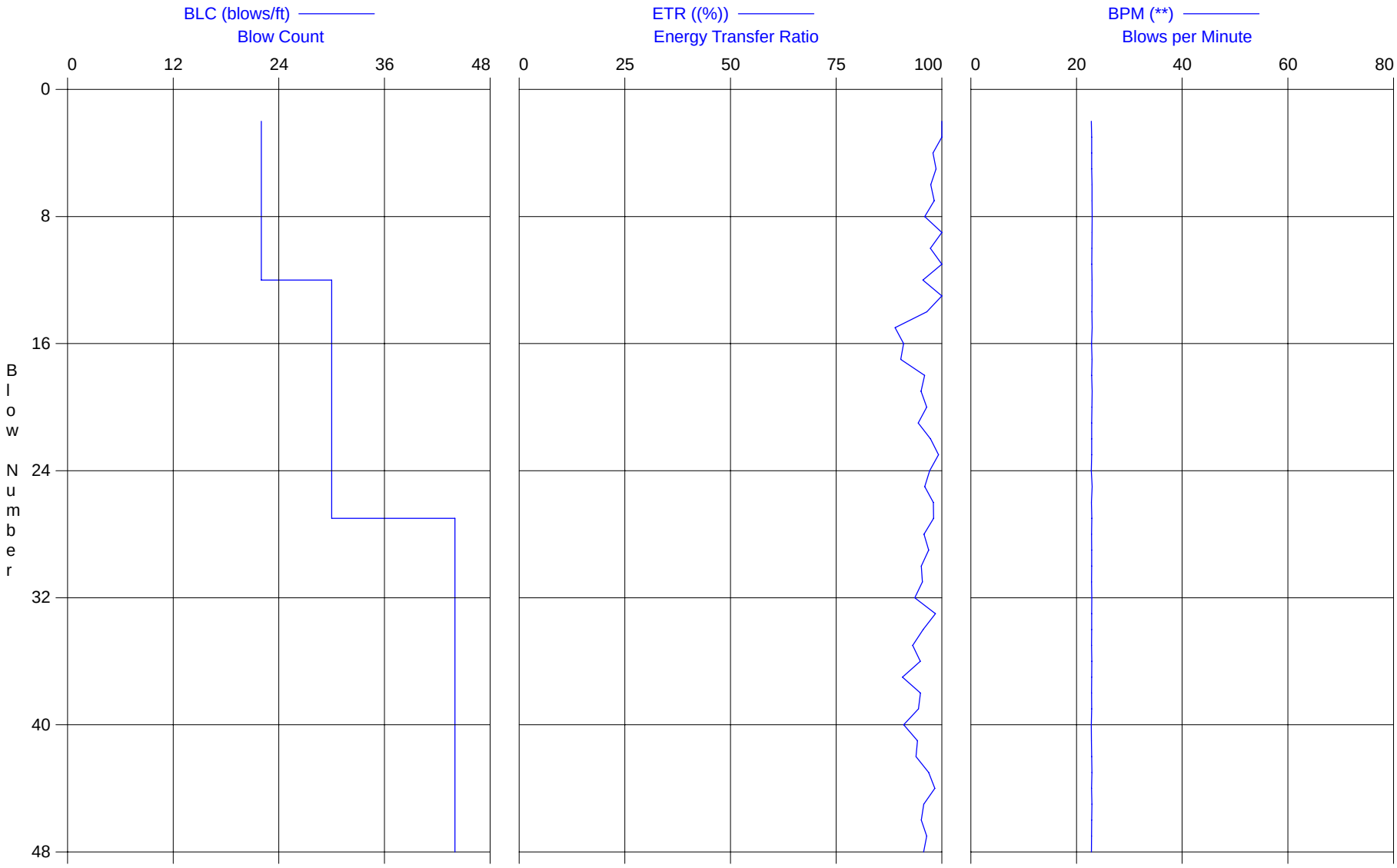
Drive 3 minutes 54 seconds 12:28:06 PM - 12:32:00 PM (1/24/2011) BN 1 - 83

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 31-Jan-2011

Test date: 24-Jan-2011

MAJOR DRILLING, WM SPT - SAMPLE 02-13 @60FT, CALF.MOD W/300LB



MAJOR DRILLING, WM SPT - SAMPLE 02-13 @60FT, CALF.MOD W/300LB
OP: RMDT-A,BANAS

BOREHOLE GT11-02
Test date: 24-Jan-2011

AR: 1.42 in^2
LE: 63.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.40

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
ETR: Energy Transfer Ratio
DMX: Maximum Displacement

RAT: SPT Length Ratio
BPM: Blows per Minute
EF2: Energy of F^2
SFT: Skin friction total

BL#	depth	BLC	FMX	VMX	EFV	ETR	DMX	RAT	BPM	EF2	SFT
	ft	bl/ft	kips	f/s	k-ft	(%)	in	[]	**	k-ft	kips
12	60.53	30	42	12.3	0.716	95.5	0.64	1.2	22.9	0.9	11
13	60.57	30	41	12.1	0.753	100.4	0.71	1.2	22.9	0.9	11
14	60.60	30	41	12.0	0.723	96.4	0.68	1.2	22.9	0.9	11
15	60.63	30	42	11.5	0.667	88.9	0.55	1.2	22.9	0.9	13
16	60.67	30	43	11.9	0.682	90.9	0.55	1.2	22.8	0.9	12
17	60.70	30	42	11.8	0.677	90.3	0.52	1.2	22.9	0.9	12
18	60.73	30	42	12.0	0.719	95.9	0.59	1.2	22.8	0.9	12
19	60.77	30	41	12.1	0.713	95.1	0.55	1.2	23.0	0.9	11
20	60.80	30	41	12.0	0.723	96.4	0.57	1.2	22.9	0.9	11
21	60.83	30	41	12.1	0.708	94.4	0.54	1.2	22.8	0.9	11
22	60.87	30	41	12.0	0.730	97.3	0.57	1.2	22.9	0.9	11
23	60.90	30	41	11.8	0.744	99.2	0.63	1.2	22.9	0.9	10
24	60.93	30	41	12.3	0.728	97.1	0.55	1.2	22.8	0.9	10
25	60.97	30	41	12.3	0.720	95.9	0.53	1.2	23.0	0.9	10
26	61.00	30	41	12.4	0.735	98.0	0.55	1.2	22.8	0.9	10
27	61.02	44	41	12.2	0.736	98.1	0.55	1.2	22.9	0.9	11
28	61.05	44	41	12.1	0.718	95.8	0.52	1.2	22.8	0.9	11
29	61.07	44	41	12.1	0.727	96.9	0.53	1.2	22.9	0.9	11
30	61.09	44	42	12.1	0.714	95.2	0.50	1.2	22.9	0.9	11
31	61.11	44	41	12.0	0.715	95.4	0.51	1.2	22.8	0.9	13
32	61.14	44	41	11.8	0.702	93.6	0.48	1.2	22.9	0.9	13
33	61.16	44	41	12.0	0.739	98.5	0.53	1.2	22.9	0.9	11
34	61.18	44	41	11.8	0.717	95.6	0.50	1.2	22.9	0.9	13
35	61.21	44	41	12.0	0.698	93.1	0.47	1.2	22.8	0.9	12
36	61.23	44	43	12.3	0.712	94.9	0.48	1.2	22.9	0.9	12
37	61.25	44	42	12.1	0.680	90.7	0.44	1.2	22.8	0.9	11
38	61.27	44	43	12.0	0.712	94.9	0.48	1.2	22.8	0.9	12
39	61.30	44	43	12.0	0.709	94.5	0.48	1.2	22.9	0.9	13
40	61.32	44	43	11.9	0.682	91.0	0.44	1.2	22.8	0.9	13
41	61.34	44	43	12.0	0.707	94.2	0.46	1.2	22.8	0.9	13
42	61.36	44	42	12.0	0.704	93.9	0.45	1.2	22.9	0.9	13
43	61.39	44	43	11.9	0.727	96.9	0.49	1.2	22.9	0.9	14
44	61.41	44	42	12.0	0.738	98.4	0.50	1.2	22.8	0.9	13
45	61.43	44	43	11.9	0.718	95.7	0.47	1.2	22.9	0.9	13
46	61.46	44	42	11.9	0.714	95.2	0.47	1.2	22.9	0.9	14
47	61.48	44	42	12.0	0.723	96.4	0.48	1.2	22.8	0.9	13
48	61.50	44	42	12.0	0.718	95.7	0.47	1.2	22.8	0.9	13
		Average	42	12.0	0.715	95.3	0.53	1.2	22.9	0.9	12
		Std. Dev.	1	0.2	0.019	2.5	0.06	0.0	0.0	0.0	1
		Maximum	43	12.4	0.753	100.4	0.71	1.2	23.0	0.9	14
		@ Blow#	41	26	13	13	13	35	19	48	43

Total number of blows analyzed: 37

Time Summary

Drive 2 minutes 4 seconds 1:07:01 PM - 1:09:05 PM (1/24/2011) BN 1 - 48

APPENDIX E

2012 Boring Logs

LEGEND FOR BORING LOGS

SAMPLE LOCATION / TYPE

Sampled Interval

Sample Recovery

Standard Penetration Test (SPT) sample (1.4-inch I.D.)

Shelby tube sample (thin wall, 3-inch I.D.)

Bulk drill cuttings sample (> 3 ft. interval)

California Modified split spoon sample (2.5-inch I.D.)

Continuous core barrel sample (3-inch I.D., 5 feet long)

Grab drill cuttings sample (< 3 ft. interval)

BLOW COUNTS

Refers to number of blows by standard 140 pound hammer (unless otherwise indicated on log) per 6 inches of driven depth.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) DESCRIPTION (common terms used)

MOISTURE CONDITION

Dry - apparent absence of moisture, dry to the touch
Damp - slight moisture but does not adhere to hand
Moist - optimum water content but no visible water
Wet - visible free water

CONSISTENCY

Very Soft - thumb will penetrate more than 1 inch
Soft - thumb will penetrate about 1 inch
Firm or Stiff - thumb will indent soil about 1/4 inch
Hard or Very Stiff - thumb will not indent soil but readily indented by thumbnail
Very Hard - thumbnail will not indent soil

PLASTICITY

Non-plastic - an 1/8-inch thread cannot be rolled at any water content
Low - a thread can barely be rolled
Medium - a thread is easy to roll but can't be rerolled below the plastic limit
High - considerable rolling effort to reach the plastic limit; thread can be rerolled below the plastic limit

DENSITY (SANDY SOIL)

Sand consistency described using terms ranging from Very Loose to Very Dense

OTHER TERMS

Standard terms (as per ASTM D2488) are used to describe the size range, sorting, angularity, and shape of particles making up the soil
Standard terms may be used to described such soil properties as dilatancy and toughness if called for by the project

OTHER SYMBOLS

WATER - First depth at which free water (wet soil conditions) encountered (▽), static water level (▼).

CONTACTS:

———— Contact between different lithologies directly observed.
Horizontal line indicates sharp contact; slant line indicates gradational contact.

– – – – Inferred contact (contact between different lithologies not observed).

UNIFIED SOIL CLASSIFICATION SYSTEM CHART

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW		Well-graded gravels, gravels, gravel/sand mixtures, little or no fines.
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GM		Silty gravels, gravel-sand-silt mixtures
			GC		Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL		Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH		Inorganic clays of medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH		Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTES: No. 4 size = 5mm (0.25 in); No. 200 size = 0.0075 mm (0.0003 in)

Dual symbols are used to indicate borderline soil classifications

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-01A

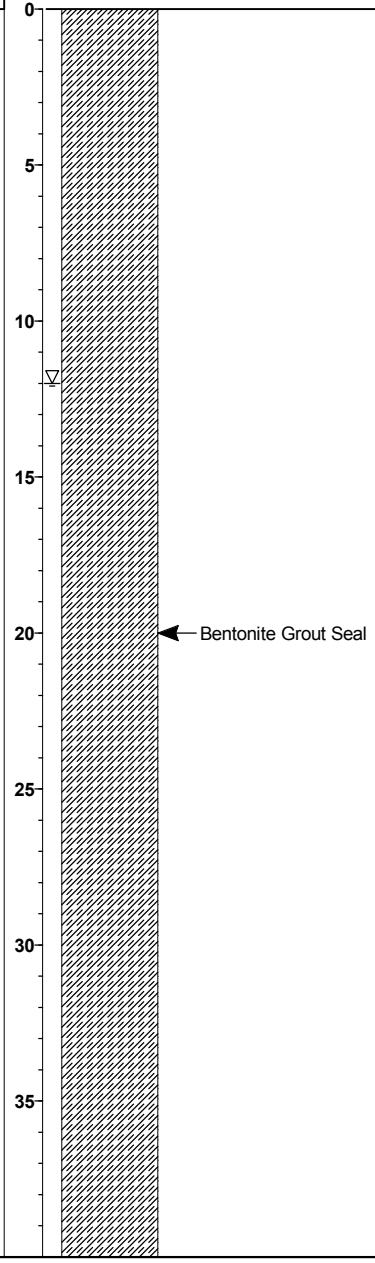
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0	0					FILL	Surface: gravel fill Note: Initially use 140 lb. hammer and switched to 300 lb. hammer as noted below. **ALLUVIUM**
			1A-1	---			
1						CL	At 4.5 feet (bottom of Shelby tube sample 1A-1), CLAYEY SILT (ML), brown (10YR 5/3), very moist, slight orange brown (oxide) mottling, medium plasticity
	5		1A-2	---			
2							Sample 1A-2 disturbed and poor recovery, did not retain sample
			1A-3	---			Sample 1A-3 no recovery
3	10		1A-4	---			
			1A-5	---		ML	At 12.0 feet (bottom of Shelby tube sample 1A-4), CLAYEY SILT (ML), brown (10YR 5/3), wet, low to medium plasticity
4						ML	At 14.5 feet (bottom of Shelby tube sample 1A-5), SILT (ML), yellowish borwn (10YR 5/4), wet, some orange brown (oxide) mottling, slightly micaceous, low to medium plasticity
5	15						
6	20		1A-6	---			
7			1A-7	3 4 5		ML	At 22.5 feet (bottom of Shelby tube sample 1A-6), same SILT (ML) as above in sample 1A-5 Sample 1A-7 disturbed, apparent slough only, did not retain. Firm to stiff based on blow counts.
	25		1A-8	---			
8						CL	At 27.5 feet (bottom of Shelby tube sample 1A-8), SILTY CLAY (CL), dark gray (5Y 4/1), very moist, scattered small (< 1.8-inch) hard nodules, low to medium plasticity
9	30		1A-9	---		CL/ML	At 32.5 feet (bottom of Shelby tube sample 1A-9), SILTY CLAY / CLAYEY SILT (CL/ML), dark gray (5Y 4/1), very moist, scattered small (<1.8-inch) hard nodules, medium plasticity
10	35		1A-10	---		CH	At 37.5 feet (bottom of Shelby tube sample 1A-10), SILTY CLAY (CH), dark gray (5Y 4/1) with greenish tint, moist to very moist, more apparent firmness than all soils above but high plasticity, slight orange-brown mottling
11			1A-11	---			Sample 1A-11 disturbed and poor recovery, did not retain sample. Sample tube was bent/damaged at the bottom.
12	40						

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/26/12**
Date Ended: **1/27/11**
Boring Diameter: **5.0"**

Elevation: **151.7 ft.**
Total Depth: **66.5 ft.**

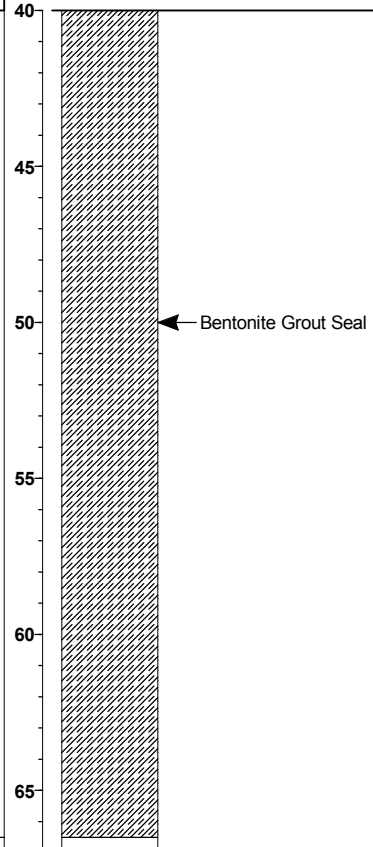
STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
	40		1A-12	5 7 11		ML-SM		**ALLUVIUM (Continued)** At 40.0 feet, crudely layered SILT (ML), SANDY SILT (ML), and SILTY SAND (SM), some clay, mottled dark yellowish brown (10YR 4/4), pale brown (2.5Y 7.4), and pale olive (5Y 6/3), moist, very stiff, 1/2-inch gravel at bottom of sample
13								
	45		1A-13	7 7 11		ML CL		At 45.0 feet, CLAYEY SILT (ML), light brownish gray (2.5Y 6/2) with orange-brown (oxide) mottling (abundant mottling at top of sample), damp to moist Quickly grades to SILTY CLAY (CL), same color as above, damp to moist, very stiff
14								
15								Drilled reported gravel encountered at 49.8 feet
	50		1A-14	17 27 38		GW		SANDY GRAVEL (GW) with clay, dark yellowish brown (10YR 4/4), wet, dense, fine to coarse sand (f,m,c -= 20,20,60), fine to coarse subangular gravel to 1-inch diameter
16								Switch to 300 lb. hammer before collecting sample 1A-15 and for remainder of samples
	55		1A-15	18 28 47		GM/GW		SILTY GRAVEL / SANDY GRAVEL (GM/GW), dark yellowish brown (10YR 4/4), very moist, dense, sand-silt approximately 50 percent, fine to coarse sand (f,m,c = 20,40,20), fine to coarse subangular gravel to 1-inch diameter
17								
18								
	60		1A-16	7 37 50/5"		SM		SILTY SAND (SM) with some fine gravels, very dark gray (5Y 3/1) with greenish tint, damp, silt 10 - 20 percent, fine to medium sand, predominantly fine sand
19								
	65		1A-17	15 40 50/2"		SM		Same SILTY SAND (SM) as above but with 20 - 30 percent fine to coarse gravel to 3/4-inch diameter
20								
21								Total Depth = 66.5 feet (Northing 4140.530, Easting 3989.042)
	70							NOTES: 1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample 1A-18 from 0 to 10.0 feet.
22								
	75							2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 1A-15 at 55 feet and for remainder of borehole. Hammers not used for Shelby tube samples.
23								
								3. 36-inch long Shelby tube samples were pushed 30 inches only.
24								
	80							4. Shallow (Silt-Clay unit) groundwater encountered at 12.0 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 50.0 feet during drilling.
25								
								5. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
26	85							

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-01B

Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. hammer; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0						Surface: Grass **ALLUVIUM**
		1B-1	---			
5		1B-2	1 2 2		MH	CLAYEY SILT (ML), very moist, brown (10YR 4/3), soft, slightly micaceous, high plasticity
		1B-3	---			
10					ML	At 10.0 feet (bottom of Shelby tube sample 1B-3), same as above in sample 01B-2, but trace to some clay, wet, medium to high plasticity
		1B-4	---			
15		1B-5	1 3 2		ML	VERY CLAYEY SILT (ML), mottled brown (10YR 4/3) and yellowish brown (10YR 5/4), wet, firm, medium plasticity
		1B-6	---			
20					ML	At 20.0 feet (bottom of Shelby tube sample 1B-6), CLAYEY SILT (ML), brown (10YR 5/3), wet, less clay than in sample 01B-5
		1B-7	---			
25		1B-8	---		ML	At 25.0 feet (bottom of Shelby tube sample 1B-7), SILT (ML), brown (10YR 5/3), wet, faintly micaceous, trace to some clay, low to medium plasticity
		1B-9	---		ML	At 27.5 feet (bottom of Shelby tube sample 1B-8), same SILT (ML) as above in sample 1B-7, but dark gray (5Y 4/1), very moist
30					CL/ML	At 30.0 feet (bottom of Shelby tube sample 1B-9), SILTY CLAY / CLAYEY SILT (CL/ML), dark gray (5Y 4/1), very moist, medium plasticity

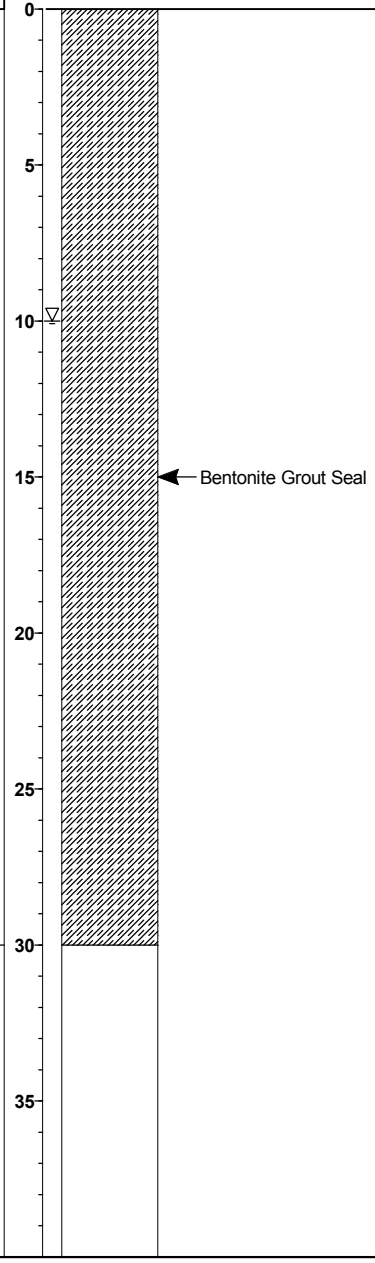
Total Depth = 30.0 feet

(Northing 4034.671, Easting 3930.587)

NOTES:

1. 36-inch long Shelby tube samples were pushed 30 inches only.
2. Used 140 lb. hammer throughout entire borehole for SPT sample collection.
3. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



Drilling Company:	**Major Drilling Environmental, LLC**
Drilling Method:	**Mud Rotary**
Logged By:	**David Lamadrid**
Sampling Method:	**See legend for explanation of sample types**

Date Started:	**1/27/12**	Elevation:	**150.8 ft.**
Date Ended:	**1/27/12**	Total Depth:	**30.0 ft.**
Boring Diameter:	**5.0"**		

STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-02A

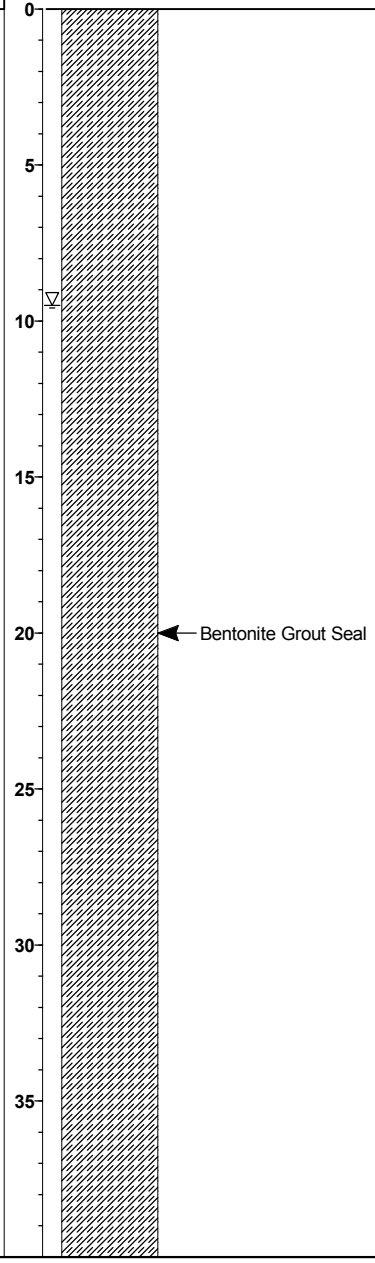
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0	0					FILL	Surface: gravel road base Initially used 140 lb. hammer and switched to 300 lb. hammer as noted below. **ALLUVIUM**
1			2A-1	---			
	5		2A-2	---		CL	At 4.5 feet (bottom of Shelby tube sample 2A-1), SILTY CLAY (CL), brown (10YR 5/3), very moist, low to medium plasticity
2			2A-3	---		CL	At 7.0 feet (bottom of Shelby tube sample 2A-2), SILTY CLAY (CL), brown (10YR 4/3) with slight orange brown (oxide) mottling, very moist, faintly micaceous, low to medium plasticity
3	10		2A-4	---		CL	At 9.5 feet (bottom of Shelby tube sample 2A-3), same SILTY CLAY (CL) as above in sample 2A-3, but wet
4			2A-5	---		CL	
5	15		2A-6	1 1 1		CL-ML	Bedded SILTY CLAY (CL) and CLAYEY SILT (ML), brown (10YR 5/3) with slight orange-brown (oxide) mottling, wet, soft, beds up to 4 inches thick
6	20		2A-7	---			
7						CL/ML	At 22.5 feet (bottom of Shelby tube sample 2A-7), SILTY CLAY / CLAYEY SILT (CL/ML), dark gray (5Y 4/1), wet, scattered, small (<1/16 inch) granules)
8	25		2A-8	---			Driller reported more firm drilling than above
			2A-9	1 3 5		CL	SILTY CLAY (CL), dark gray (5Y 4/1), very moist, firm, low to medium plasticity
9	30		2A-10	---		CL	Grades to SILTY CLAY (CL), same color and characteristics as above but with slight orange-brown (oxide) mottling
10						CL	At 32.5 feet (bottom of Shelby tube sample 2A-10), slightly SILTY CLAY (CL), dark gray (5Y 4/1), very moist, medium plasticity, small (<1/16 inch) granules
11	35		2A-11	---			
12	40		2A-12	---		CH	At 37.5 feet (bottom of Shelbe tube sample 2A-11), same SILTY CLAY (CL) as above in sample 2A-10, with trace fine sand, high plasticity

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/30/12**
Date Ended: **1/31/12**
Boring Diameter: **5.0"**
Elevation: **149.3 ft.**
Total Depth: **68.0 ft.**

STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

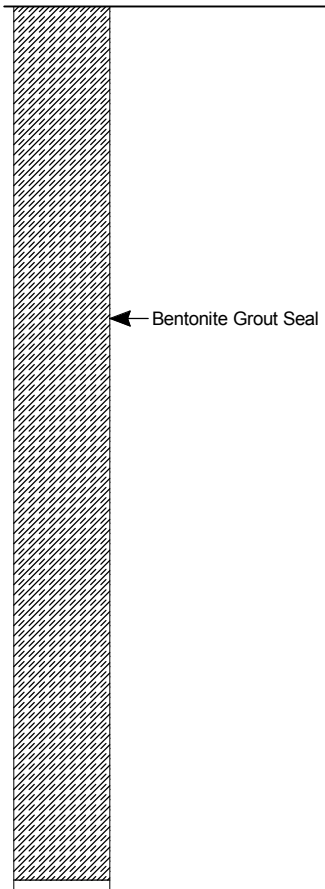
Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
	40					CL/ML	**ALLUVIUM (Continued)** At 40 feet (bottom of Shelby tube sample 2A-12), SILTY CLAY / CLAYEY SILT (CL/ML), dark greenish gray (5GY 4/2) with slight orange brown (oxide) mottling, moist, faintly micaceous, low to medium plasticity
13							At 42 feet, driller reported harder drilling and gravel
	45		2A-13	17 36 32		SC	CLAYEY SAND (SC) with gravel, mottled srong brown (7.5Y 4/6) and brownish yellow (10YR 6/6), very moist, clay 30 - 40 percent, fine to coarse sand (f,m,c = 40,40,20), fine to coarse gravel to 1-inch diameter, weathered appearance
14							
15							Switch to 300 lb. hammer before collecting sample 2A-14 and for remainder of samples
	50		2A-14	6 6 8		SC SM	At 50 feet, same as above in sample 2A-13
16							Contact in sample 2A-14 with SILTY FINE SAND (SM), light olive brown (2.5Y 5/4) with some orange brown (oxide) mottling), moist, loose, silt 10 - 20 percent increasing with depth
							Color change in sample shoe to dark gray (5Y 4/1) but same SILTY FINE SAND (SM)
	55		2A-15	8 13 20		SW	At 55.0 feet, GRAVELLY SAND (SW) with trace silt, black (5Y 2.5/1) moist, medium dense, fine subround gravel to 1/2-inch diameter, fine to coarse sand (f,m,c = 40,30,10)
17							
18							
	60		2A-16	9 15 18		SW	Same GRAVELLY SAND (SW) as above in sample 2A-15, but dark gray (5Y 4/1) and medium dense
19							
	65		2A-17	9 18 22			No recovery in sample 2A-17
20			2A-18	9 19 31		SW	Same GRAVELLY SAND (SW) as above in sample 2A-15, but very dark greenish gray (GLEY 1 3/1) and medium dense
21							
	70						Total Depth = 68.0 feet
							(Northing 3553.346, Easting 3963.072)
22							NOTES:
							1. Drilled adjacent borehole hollow stem augers to collect bulk soil cuttings sample 2A-19 from 0 to 10.0 feet.
23	75						2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 2A-14 at 50 feet and for remainder of borehole. Hammers not used for Shelby tube samples.
24							3. 36-inch long Shelby tube samples were pushed 30 inches only.
	80						4. Shallow (Silt-Clay unit) groundwater encountered at 9.5 feet during drilling. Deep (Sand-Gravel unit) groundwater not encountered during drilling (no visible signs of saturated soils).
25							5. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
26	85						

Graphic Log

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-02B

Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. hammer; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
							Surface: Grass **ALLUVIUM**
			2B-1	---		CL	At 5.0 feet (bottom of Shelby tube sample 2B-1), SILTY CLAY (CL), brown (10YR 5/3), moist, faintly micaceous, low to medium plasticity
			2B-2	---			
			2B-3	1 2 2		ML	CLAYEY SILT (ML), brown (10YR 5/3), moist, faintly micaceous, low to medium plasticity
						CL/ML	Grades to SILTY CLAY / CLAYEY SILT (CL/ML), same color as above, wet, soft, low to medium plasticity
			2B-4	---		ML	At 15.0 feet (bottom of Shelby tube sample 2B-4, CLAYEY SILT (ML), brown (10YR 4/3), wet, faintly micaceous, trace sand, low to medium plasticity
			2B-5	---			
			2B-6	1 1 2		CL	SILTY CLAY (CL), grayish brown (2.5Y 5/2), wet, soft, medium plasticity
			2B-7	---		CL/ML	At 25.0 feet (bottom of Shelby tube sample 2B-7), SILTY CLAY / CLAYEY SILT (CL/ML), dark gray (5Y 4/1), wet, low to medium plasticity At approximately 27.0 feet, driller reported relatively more firm drilling than above
			2B-8	---		ML	At 30 feet (bottom of Shelby tube sample 2B-8), SILT (ML), dark gray (5Y 4/1), very moist, slightly micaceous, low to medium plasticity

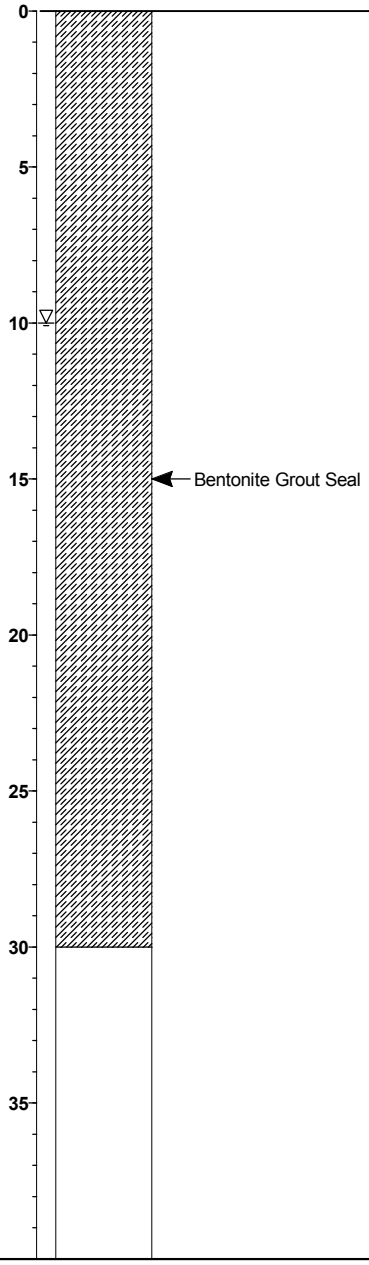
Total Depth = 30.0 feet

(Northing 3503.039, Easting 3901.078)

NOTES:

1. 36-inch long Shelby tube samples were pushed 30 inches only.
2. Used 140 lb. hammer throughout entire borehole for SPT sample collection.
3. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



Drilling Company:	**Major Drilling Environmental, LLC**
Drilling Method:	**Mud Rotary**
Logged By:	**David Lamadrid**
Sampling Method:	**See legend for explanation of sample types**

Date Started:	**2/1/12**	Elevation:	**148.9 ft.**
Date Ended:	**2/1/12**	Total Depth:	**30.0 ft.**
Boring Diameter:	**5.0"**		

STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-03A

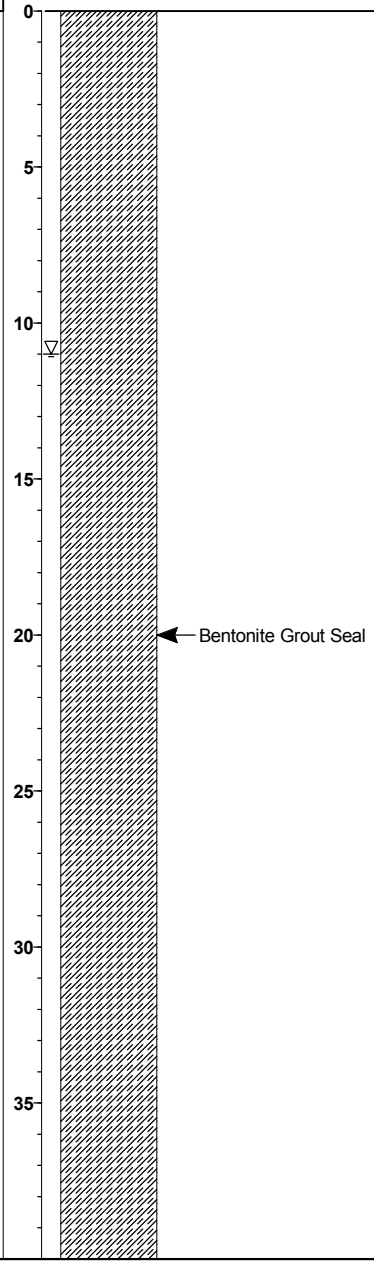
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0					FILL	Surface: gravel road base Initially used 140 lb. hammer and switched to 300 lb. hammer as noted below.
1		3A-1	---		ML	**ALLUVIUM** Shelby tube sample 3A-1 could only be pushed 12 inches. At bottom of sample CLAYEY SILT (ML), brown (10YR 4/3), moist, slightly micaceous, low to medium plasticity
		3A-2	---			
5					CL/ML	At 6.0 feet (bottom of Shelby tube sample 3A-2), SILTY CLAY / CLAYEY SILT (ML), brown (10YR 4/3), very moist, slightly micaceous, low to medium plasticity
2		3A-3	---			
		3A-4	---		ML	At 8.5 feet (bottom of Shelby tube sample 3A-3), slightly CLAYEY SILT (ML), brown (10YR 4/3), very moist, slightly micaceous, low to medium plasticity
3 / 10		3A-5	---		ML	At 11.0 feet (bottom of Shelby tube sample 3A-4), same CLAYEY SILT (ML) as above in sample 3A-3 but wet
4		3A-6	---		ML	At 13.5 feet (bottom of Shelby tube sample 3A-5), CLAYEY SILT (ML), brown (10YR 4/3), wet, medium plasticity
15 / 5					ML	At 16.0 feet (bottom of Shelby tube sample 3A-6), same CLAYEY SILT (ML) as above in sample 3A-5, with slight pale brown (10YR 6/3) mottling, few small (<1/8 inch) black flecks
6 / 20		3A-7	---			
7		3A-8	0 2 3		CL	SILTY CLAY (CL), dark gray (5Y 4/1), moist to wet, firm, bedded layers with varying silt content, beds up to 4 inches thick
25		3A-9	---			Shelby tube sample 3A-9 could only be pushed 7 inches
8		3A-10	3 4 5		ML	CLAYEY SILT (ML), dark gray (5Y 4/1), moist, stiff, grades quickly to trace clay at bottom of sample, faintly micaceous, low to medium plasticity
9 / 30		3A-11	---			
10					CL	At 32.5 feet (bottom of Shelby tube sample 3A-11), SILTY CLAY (CL), dark gray (5Y 4/1), moist, low to medium plasticity (driller reported firm push)
35 / 11		3A-12	---			
12 / 40		3A-13			CL	At 37.5 feet (bottom of Shelby tube sample 3A-12), same SILTY CLAY (CL) as above in sample 3A-11 (driller reported firm push)

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **1/30/12**
Date Ended: **1/30/12**
Boring Diameter: **5.0"**

Elevation: **147.8 ft.**
Total Depth: **71.5 ft.**

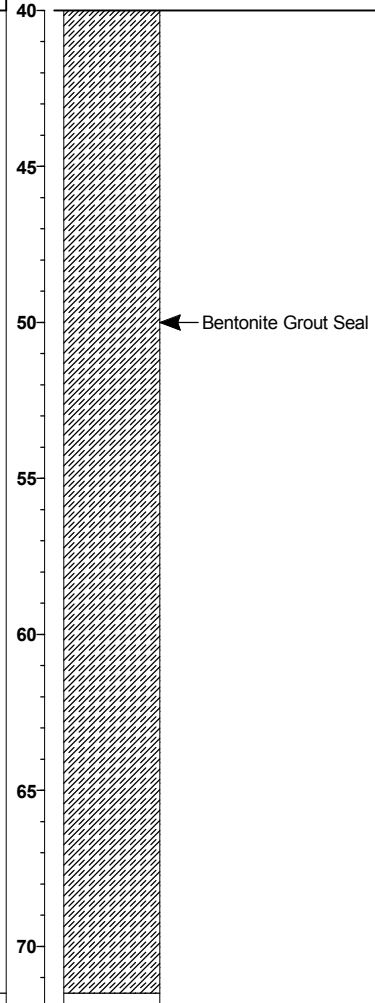
STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
	40					CL		**ALLUVIUM (Continued)** At 40 feet (bottom of Shelby tube sample 3A-13), CLAY (CL), dark gray (5Y 4/1), very moist, medium to high plasticity
13								Shelby tube sample 3A-14 could only be pushed 15 inches. Sample was disturbed and tube severly bent at bottom. Sample not retained. At bottom of sample
	45		3A-14			ML/SM		FINE SANDY SILT / SILTY FINE SAND (ML/SM), dark gray (5Y 4/1) with greenish tint, very moist.
14			3A-15	15 19 26		GC		At 46.5 feet, SANDY, CLAYEY GRAVEL (GC), yellowish brown (10YR 4/6), wet, dense, abundant mottling with gray and brown, fine to coarse sand (f,m,c = 10,30,60), fine to coarse subrounded gravel to 1-inch diameter
15								
	50		3A-16	14 25 34		GC		Switched to 300 lb. hammer for sample 3A-16 and for remainder of samples
16								At 50 feet, same SANDY, CLAYEY GRAVEL (GC) as above in sample 3A-15, but gravel up to 2.5 inch diameter
	55		3A-17	7 9 16		SW/GW		GRAVELLY SAND / SANDY GRAVEL (SW/GW), very dark gray (5Y 3/1), wet, medium dense, trace fines, fine to coarse sand (f,m,c = 20,40,40), fine to coarse subrounded gravel to 1 inch diameter
17								
18								
	60		3A-18	8 21 48		SW/GW		Same GRAVELLY SAND / SANDY GRAVEL (SW/GW) as above in sample 3A-17, but very moist, dense, gravels up to 2.5 inch diametr
19								
						SW		FINE TO MEDIUM SAND (SW), very dark gray (5Y 3/1), very moist, medium dense, predominantly fine sand, trace silt, few pebbles
	65		3A-19	7 14 18				
20						ML		Contact in sample with slightly SANDY SILT (ML), dark gray (5Y 4/1), moist, very stiff, some pebbles
21						SM		At 70.0 feet, SILTY SAND (SM), dark gray (5Y 4/1), moist, medium dense, silt 30 - 40 percent, fine to coarse sand, some pebbles
	70		3A-20	8 10 14		ML/SM		Grades with increasing silt content to SANDY SILT / SILTY SAND (ML/SM)
22								Total Depth = 71.5 feet (Northing 3082.638, Easting 3955.140) NOTES: 1. Drilled adjacent borehole with hollow stem augers to collect bulk soil cuttings sample from 0 to 10.0 feet. 2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collected sample 3A-16 and for remainder of borehole. Hammer not used for Shelby tube samples. 3. 36-inch long Shelby tube samples were pushed 30 inches only. 4. Shallow (Silt-Clay unit) groundwater encountered at 11.0 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 46.0 feet during drilling. 5. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
23	75							
24								
	80							
25								
26	85							

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-03B

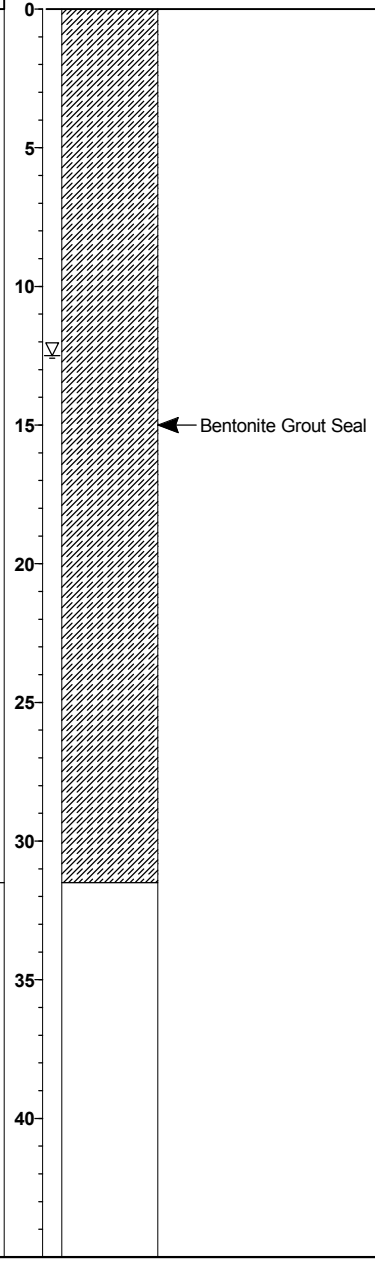
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. hammer; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0					FILL		Surface: gravel fill
1			3B-1	---				**ALLUVIUM** Shelby tube sample 3B-1 poor recovery and slightly disturbed; did not retain sample. At bottom of sample, SILTY CLAY (CL), dark yellowish brown (10YR 3/4), very moist to wet, medium plasticity
	5		3B-2	---		CL		
2			3B-3	1 2 3		ML		At 7.0 feet, slightly CLAYEY SILT (ML), yellowish brown (10YR 5/4), very moist, firm, irregular partings with some oxide filled, medium plasticity
3	10		3B-4	---				
4						CL/ML		At 12.5 feet (bottom of Shelby tube sample 3B-4), SILTY CLAY / CLAYEY SILT (CL/ML), brown (10YR 4/3), very moist to wet, low to medium plasticity
5	15		3B-5	---				
6			3B-6	1 2 2		CL		SILTY CLAY (CL), mottled yellowish brown (2.5Y 6/3) and brown (10YR 5/3), wet, soft
	20		3B-7	---				
7						CL		At 22.5 feet (bottom of Shelby tube sample 3B-7), SILTY CLAY (CL), light olive brown (2.5Y 5/3), wet, scattered small (<1/16 inch) hard granules
								At approximately 23 to 24 feet, driller reported relatively harder drilling
8	25		3B-10	2 4 5		ML		SILT (ML) with trace clay, dark grayish green (GLEY1 4/1), moist, firm, faintly micaceous, low to medium plasticity
9	30		3B-11	2 5 4		ML		Same SILT (ML) as above but slightly clayey
10								Total Depth = 31.5 feet
								(Northing 3126.117, Easting 3904.878)
11	35							NOTES: 1. 36-inch long Shelby tube samples were pushed 30 inches only.
								2. Used 140 lb. hammer throughout entire borehole for SPT and California modified sample collection.
12	40							3. Shelby tube sample collection was attempted at 25.0 feet (sample 3B-8) and 27.5 feet (sample 3B-9), but little or no recovery was obtained and the tube at 27.5 feet sheared off and remained in the borehole. Another adjacent borehole was drilled to collect California modified samples at 25.0 feet (sample 3B-10) and 30.0 feet (sample 3B-11).
13								4. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
	45							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **2/1/12**
Date Ended: **2/1/12**
Boring Diameter: **5.0"**

Elevation: **148.7 ft.**
Total Depth: **31.5 ft.**

STANDARD_LOG RLF_PHASE 1A MSE BERM GEOTECHNICAL BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-04A

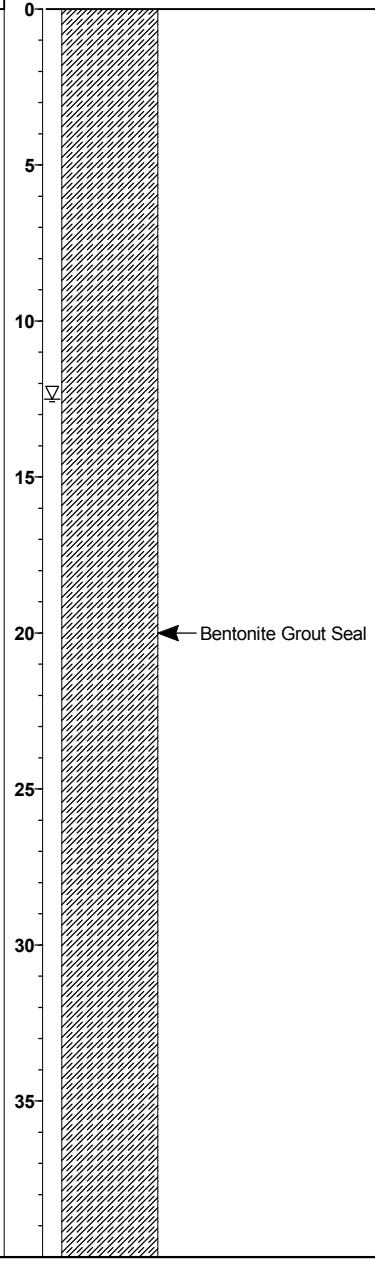
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0					FILL	Surface: gravel fill Note: Initially use 140 lb. hammer and switched to 300 lb. hammer as noted below. **ALLUVIUM**
1		4A-1	---			
5		4A-2	---		CL/ML	At 5.0 feet (bottom of Shelby tube sample 4A-1), SILTY CLAY / CLAYEY SILT (CL/ML), olive gray (5Y 4/2) with slight orange brown (oxide) mottling, moist, low to medium plasticity
2					CL/ML	At 7.5 feet (bottom of Shelby tube sample 4A-2), same SILTY CLAY / CLAYEY SILT (CL/ML) as above
3 / 10		4A-3	---			
4		4A-4	1 2 2		CL	Slightly SILTY CLAY (CL), yellowish brown (10YR 5/4), wet, soft, slightly micaceous, medium plasticity
15		4A-5	---			
5					CL	At 17.5 feet (bottom of Shelby tube sample 4A-5), same SILTY CLAY (CL) as above in sample 4A-4
6 / 20		4A-6	---			
7					CL	At 22.5 feet (bottom of Shelby tube sample 4A-6), SILTY CLAY (CL), light olive brown (2.5Y 5/3), moist to wet, rare fine gravels, medium plasticity
25		4A-7	---			
8		4A-8	---		ML	At 27.5 feet (bottom of Shelby tube sample 4A-7), SILT (ML), dark grayish olive (10YR 4/2), moist, slightly micaceous, low to medium plasticity
9 / 30		4A-9	3 4 5		CL	SILTY CLAY (CL), dark gray (5Y 4/1), moist, stiff, grades to more silt with depth
10						
35		4A-10	---			
11					CL	At 37.5 feet (bottom of Shelby tube sample 4A-10), CLAY (CL), dark greenish gray (GLEY1 4/1), moist, medium to high plasticity
12 / 40						

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/1/12**
Date Ended: **3/1/12**
Boring Diameter: **5.0"**

Elevation: **147.4 ft.**
Total Depth: **61.5 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
40 / 13		4A-12	3 5 6				**ALLUVIUM (Continued)** CLAY (CL), greenish gray (GLEY1 5/1), very moist, medium to high plasticity Sharp contact in sample 4A-12 with CLAY (CL), dark greenish gray (GLEY1 4/1) with minor orange brown (oxide) mottling, moist, stiff, medium to high plasticity (more relative firmness at bottom of sample)
45 / 14		4A-13	7 7 13		SW		Driller reported harder drilling at 43 feet At 45.0 feet, FINE TO MEDIUM SAND (SW), strong brown (7.5YR 4/6) with yellowish brown (10YR 5/6) motting, wet, medium dense, fine to medium sand, trace to some scattered fine gravels, with two 1-inch lenses with fines
50 / 15		4A-14	12 26 50		SW		- Switched to 300 lb. hammer for sample 4A-14 and for remainder of samples - At 50 feet, GRAVELLY SAND (SW) with fines, strong brown (7.5YR 4/6) with yellowish brown (10YR 5/6) mottling, very moist, dense, fine to coarse subrounded gravel to 2-inch diameter, fine to coarse sand (f:m:c = 40:40:20)
55 / 16		4A-15	18 32 50/3"		GW		- At 55.0 feet, CLAYEY, SANDY GRAVEL (GW), yellowish brown (10YR 5/6) with slight orange brown (oxide) mottling, moist, very dense, clay 10-20 percent, fine to coarse sand (f:m:c = 40:40:20), fine to coarse subrounded gravel to 2-inch diameter - At 60 feet, SANDY GRAVEL (GW), very dark gray (5Y 3/1), medium dense, fine to coarse sand, fine to coarse subrounded gravel to 1.5-inch diameter
60 / 17		4A-16	10 25 42		GW GC		- Contact in bottom ring with SANDY, CLAYEY GRAVEL (GC), dark gray (5Y 4/1), moist, predominantly medium and coarse sand, fine to coarse subrounded gravel to 2-inch diameter

Total Depth = 61.5 feet

(Northing 2888.126, Easting 4026.358)

NOTES:

1. Drilled adjacent borehole on 3/6/12 with hollow stem augers to collect bulk soil cuttings samples 4A-17 (from 2.0 to 5.0 feet) and 4A-18 (from 5.0 to 10.0 feet).

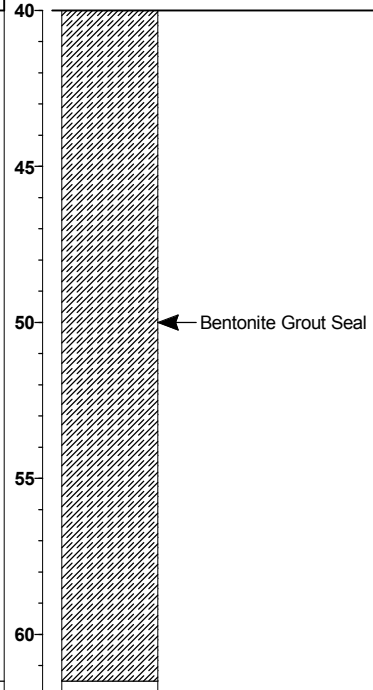
2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 4A-14 at 50 feet and for remainder of borehole. Hammers not used for Shelby tube samples.

3. 36-inch long Shelby tube samples were pushed 30 inches only.

4. Shallow (Silt-Clay unit) groundwater encountered at 12.5 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 45.0 feet during drilling.

5. Refer to compilation of labortaory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-04B

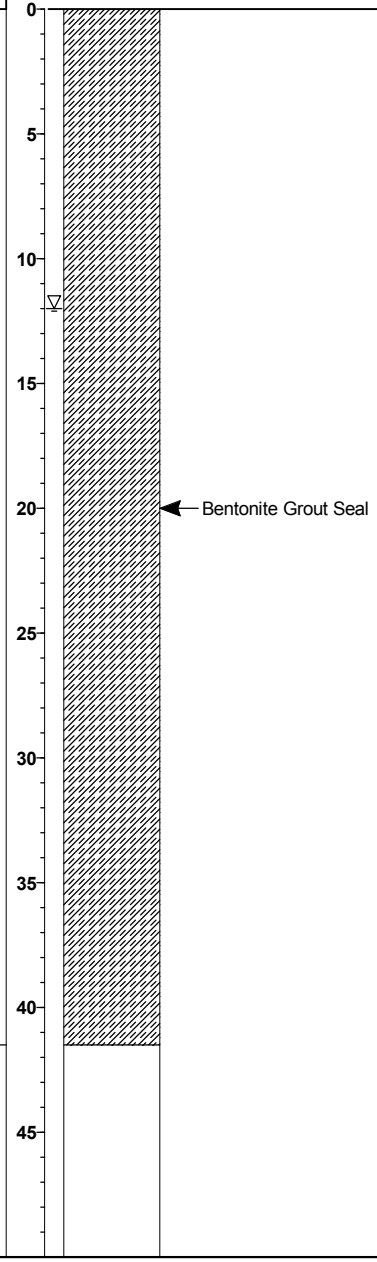
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. hammer; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
							Surface: gravel fill
							ALLUVIUM
			4B-1	---			
	5		4B-2	---		ML	5.0 feet (bottom of Shelby tube sample 4B-1), slightly CLAYEY SILT (ML), dark olive gray (5Y 3/2) with minor orange brown (oxide) mottling, moist, low to medium plasticity
						ML	At 7.5 feet (bottom of Shelby tube sample 4B-2), SILTY CLAY (CL), light olive brown (2.5Y 5/3) with orange brown (oxide) mottling, very moist, medium plasticity
	10		4B-3	---			
			4B-4	1 2 2		CL/ML	SILTY CLAY / CLAYEY SILT (ML/CL), dark yellowish brown (10YR 4/4), wet, soft, medium plasticity Grades to SILTY CLAY (CL) at bottom of sample
	15		4B-5	---			
						ML	At 17.5 feet (bottom of Shelby tube sample 4B-5), CLAYEY SILT (ML), dark yellowish brown (10YR 4/4), wet, faintly micaceous, low to medium plasticity
	20		4B-6	---			
						ML	At 22.5 feet (bottom of Shelby tube sample 4B-6), slightly CLAYEY SILT (ML), light olive brown (2.5Y 5/4), wet, slightly crumbly texture, low to medium plasticity
	25		4B-7	---			
			4B-8	3 4 8		ML	SILT (ML), dark greenish gray (GLEY1 4/1), wet at top of sample 4B-8 grading to very moist, stiff, low to medium plasticity
	30		4B-9	---			Could only push Shelby tube sample 4B-9 24 inches
			4B-10	---		ML	At 32.0 feet (bottom of Shelby tube sample 4B-9), CLAYEY SILT (ML), dark greenish gray (GLEY1 4/1), wet, very moist, low to medium plasticity
	35					ML	At 34.5 feet (bottom of Shelby tube sample 4B-10), same CLAYEY SILT (ML) as above in sample 4B-9
			4B-11	---			Only 4 inch recovery in Shelby tube sample 4B-11; did not retain sample
	40		4B-12	2 5 9		CL	CLAY (CL), very dark greenish gray (GLEY1 3/1) with slight orange brown (oxide) mottling), moist, stiff, medium to high plasticity
							Total Depth = 41.5 feet
							(Northing 2858.555, Easting 3904.450)
	45						NOTES: 1. 36-inch long Shelby tube samples were pushed 30 inches only. 2. Used 140 lb. hammer throughout entire borehole for SPT sample collection. 3. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
0	0						
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15	50						

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/2/12**
Date Ended: **3/2/12**
Boring Diameter: **5.0"**

Elevation: **146.3 ft.**
Total Depth: **41.5 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-05A

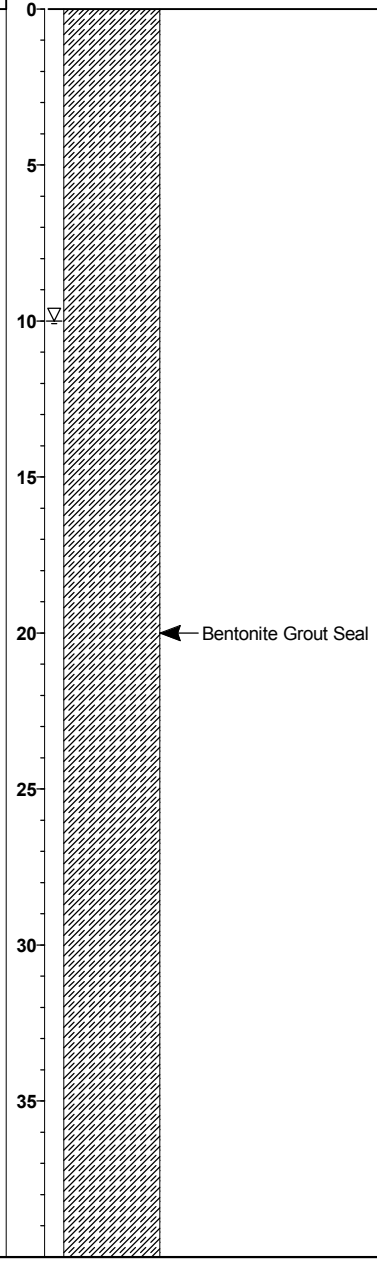
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
0	0					FILL	Surface: gravel fill Initially used 140 lb. hammer and switched to 300 lb. hammer as noted below. **ALLUVIUM**
1			5A-1	---			
	5		5A-2	0 (push)		CL	SILTY CLAY (CL), mottled very dark grayish brown (10YR 3/2) and dark yellowish brown (10YR 4/6), very moist, soft, some black soft carbonaceous nodules, medium plasticity
2			5A-3	---			
3	10					CL	At 10.0 feet (bottom of Shelby tube sample 5A-3), same SILTY CLAY (CL) as above but only slight dark grayish brown mottling, wet
4			5A-4	---			
	15					ML	At 15.0 feet (bottom of Shelby tube sample 5A-4), CLAYEY SILT (ML), yellowish brown (10YR 5/4), wet, medium plasticity
5			5A-5	---			
6	20		5A-6	1 3 3		CL	Same SILTY CLAY (CL) as above in sample 5A-4, with 1.5-inch lens of clayey silt, firm
7			5A-7	---			
	25					ML	At 25 feet (bottom of Shelby tube sample 5A-7), CLAYEY SILT (ML), dark gray (5Y 4/1) with slight greenish tint, moist, low to medium plasticity
8			5A-8	---			
9	30					CL/ML	At 30 feet (bottom of Shelby tube sample 5A-8), SILTY CLAY / CLAYEY SILT (CL/ML), dark gray (5Y 4/1), moist, low to medium plasticity, crumbly texture
10			5A-9	---			
	35					CH	At 35.0 feet (bottom of Shelby tube sample 5A-9), CLAY (CL), dark greenish gray (GLEY1 4/1) with minor orange brown (oxide) mottling, moist, high plasticity
11			5A-10	---			Could only push Shelby tube sample 5A-10 22 inches.
12	40					SM	At bottom of sample, SILTY FINE SAND (SM), yellowish brown (10YR 5/4) with moderate orange brown (oxide) mottling, moist, silt 20 - 30 percent

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **2/29/12**
Date Ended: **3/1/12**
Boring Diameter: **5.0"**

Elevation: **139.1 ft.**
Total Depth: **70.3 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
12.8	40		5A-11	6 9 23		SM SW		**ALLUVIUM (Continued)** At 40 feet, same SILTY FINE SAND (SM) as above - Sharp contact with GRAVELLY SAND (SW) with fines, strong brown (7.5 YR 4/6) with abundant orange brown (oxide) mottling, very moist, dense, fine subrounded gravel 10 - 20 percent, fine to coarse sand, very weathered appearance
13.7	45		5A-12	26 50/4"		SC		- At 44 feet, driller reported abundant gravel encountered - At 45 feet, GRAVELLY, CLAYEY SAND (SC), mottled light olive brown (2.5Y 5/3) and yellowish brown (10YR 5/4) with abundant orange brown (oxide) mottling, moist, dense, fine to coarse subrounded gravel to 1-inch diameter 10 - 20 percent, fine to coarse sand (f:m:c = 60:30:10)
15.2	50		5A-13	14 21 36		GW		- Switched to 300 lb. hammer for sample 5A-13 and remaining samples - At 50 feet, SANDY GRAVEL (GW), brown (7.5Y 4/4) with abundant orange brown (oxide) mottling, wet, dense, fine to coarse sand (f:m:c = 60:30:10), fine to coarse subrounded gravel to 2-inch diameter, weathered appearance
16.8	55		5A-14	5 7 17		SM SW/GW		At 55 feet, SILTY FINE SAND (SM), dark gray (2.5Y 4/1), wet, medium dense, silty 20 - 30 percent, grades to fine to coarse sand Quickly grades to GRAVELLY SAND / SANDY GRAVEL (SW/GW), same color as above, fine to coarse sand (f:m:c = 20:40:40), fine to coarse subrounded gravel to 1-inch diameter
18.3	60		5A-15	9 9 12		SW/GW		At 60 feet, same GRAVELLY SAND / SANDY GRAVEL (SW/GW) as above Contact in sample with same SW/GW, but dark gray (2.5Y 4/1), fine to coarse sand (f:m:c = 40:40:20), gravels to 1/2-inch diameter, medium dense
19.8	65		5A-16	7 8 6		SW/GW		Same as above but loose. Primarily large piece of wood in sample shoe At 68 feet, driller reported much harder drilling
21.3	70		5A-17	50/3"		SLST		At 70 feet, SILTSTONE (SLST) with some fine sand, dark gray (2.5Y N4), moist, hard (moderately indurated), scattered white small nodules (1/16 to 1/8 inch)
22.8	75							
24.4	80							
25.9	85							

Total Depth = 70.3 feet
(Northing 2586.445, Easting 3967.732)

NOTES:
1. Drilled adjacent borehole on 3/2/12 with hollow stem augers to collect bulk soil cuttings samples 5A-18 (from 2.0 to 5.0 feet) and 5A-19 (from 5.0 to 10.0 feet).

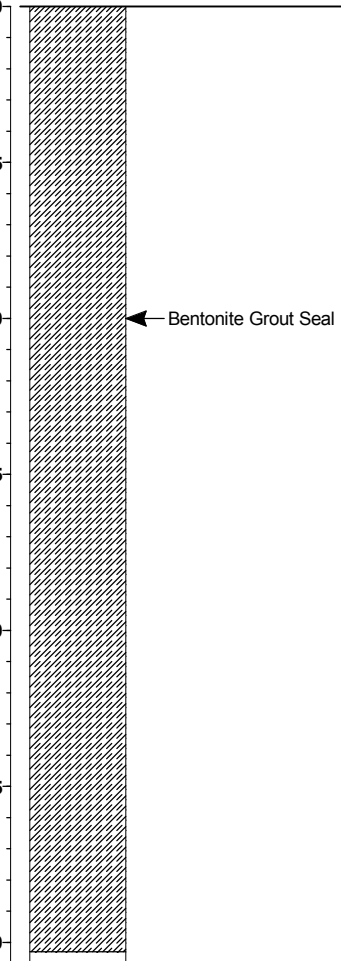
2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 5A-13 at 50 feet and for remainder of borehole. Hammers not used for Shelby tube samples.

3. 36-inch long Shelby tube samples were pushed 30 inches only.

4. Shallow (Silt-Clay unit) groundwater encountered at 12.5 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 50.0 feet during drilling.

5. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-05B

Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

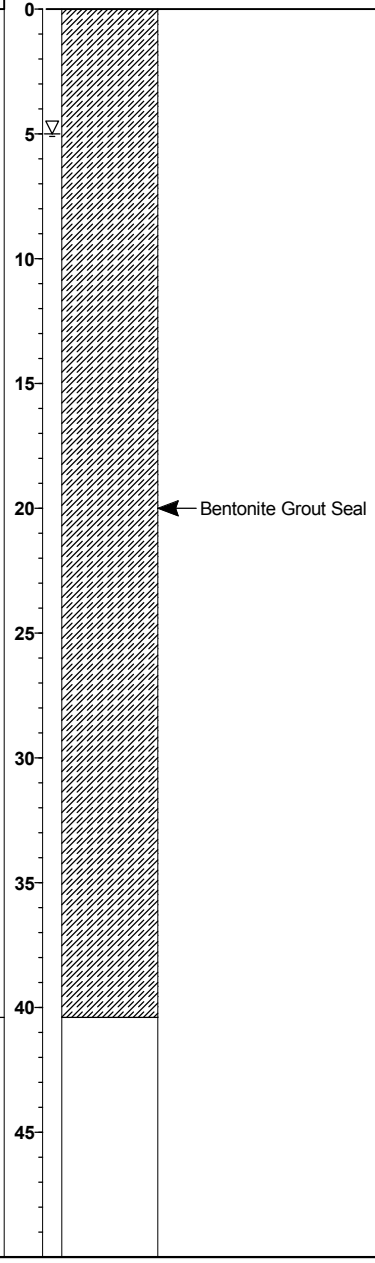
REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
							Surface: Grass **ALLUVIUM**
			5B-1	---			
			5B-2	0 2 3		CH	CLAY (CH) with sand, mottled dark yellowish brown (10YR 3/6) and dark grayish brown (2.5Y 4/2), wet, firm, high plasticity
			5B-3	---			
						CH	At 10.0 feet (bottom of Shelby tube sample 5B-3), CLAY (CH), grayish brown (2.5Y 5/2) with some orange brown (oxide) mottling, wet, high plasticity
			5B-4	---			
			5B-5	---		CH	At 15.0 feet (bottom of Shelby tube sample 5B-4), SILTY CLAY (CH), very dark greenish gray (GLEY1 3/1), very moist, high plasticity Drilled/sampled to 17.5 feet on 3/5/12, and completed remainder of borehole on 3/6/12
			5B-6	2 3 4		CH	At 17.5 feet, same SILTY CLAY (CH) as above but with few scattered rootlets, firm
			5B-7	---			
						CH	At 22.5 feet (bottom of Shelby tube sample 5B-7), SILTY CLAY (CH), dark greenish gray (GLEY1 4/1), very moist to wet, few scattered rootlets, high plasticity
			5B-8	---			- Driller reported last 3 inches of push for Shelby tube sample 5B-8 was hard, and tube was bent at the bottom
						GW	- At 27.5 feet (bottom of Shelby tube sample 5B-8), SANDY GRAVEL (GW), mottled dark yellowish brown (10YR 4/6) and olive gray (5Y 4/2), moist, fine to coarse sand (f:m:c = 20:40:40), fine to coarse subrounded gravel to 2-inch diameter - Switched to 300 lb. hammer for sample 5B-9 and for remainder of samples
			5B-9	13 26 50/4"			- At 32.0 feet, GRAVELLY SAND / SANDY GRAVEL (SW/GW) with clay, yellowish brown (10YR 5/6) with orange brown (oxide) mottling, very moist, very dense, fine to coarse sand (f:m:c = 40:40:20), fine to coarse subrounded gravel to 2-inch diameter
			5B-10	34 50/4"		SW/GW	- At 36.0 feet, same GRAVELLY SAND / SANDY GRAVEL (SW/GW) as above in sample 5B-9 - At 40 feet, SANDY GRAVEL (GW), dark greenish gray (GLEY1 3/1), wet, very dense, fine to coarse sand (f:m:c = 40:40:20), fine to coarse subrounded gravel to 1-inch diameter
			5B-11	50/5"		GW	

Total Depth = 40.4 feet (N. 2394.709, E. 3957.493)

NOTES:
1. 36-inch long Shelby tube samples were pushed 30 inches only.
2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer for sample 5B-9 and remaining samples.
3. Shallow (Silt-Clay unit) and deep (Sand-Gravel unit) groundwater encountered at 5.0 and 40 feet, respectively, during drilling.
4. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



Drilling Company:	**Major Drilling Environmental, LLC**
Drilling Method:	**Mud Rotary**
Logged By:	**David Lamadrid**
Sampling Method:	**See legend for explanation of sample types**

Date Started:	**3/5/12**	Elevation:	**125.9 ft.**
Date Ended:	**3/6/12**	Total Depth:	**40.4 ft.**
Boring Diameter:	**5.0"**		

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-06A

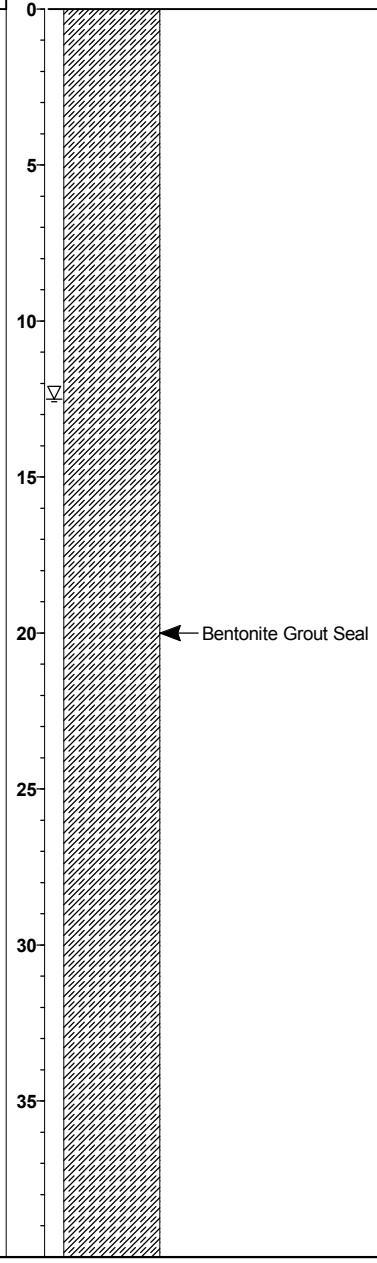
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Description
							Surface: Grass Note: Initially used 140 lb. hammer and switched to 300 lb. hammer as noted below.
1			6A-1	---			**ALLUVIUM**
	5		6A-2	---		CL	At 5.0 feet (bottom of Shelby tube sample 6A-1), SILTY CLAY (CL), brown (10YR 4/3) with pale brown (2.5Y 7/3) mottling, very moist, medium plasticity
2						CL	Can only push Shelby tube sample 6A-2 24.0 inches.
			6A-3	---			At bottom of sample, SILTY CLAY (CL), dark gray (2.5Y 4/1), very moist, medium plasticity
3	10		6A-4	---		CL	At 10.0 feet (bottom of Shelby tube sample 6A-3), SILTY CLAY (CL), dark gray (2.5Y 4/1) with slight orange brown (oxide) mottling, moist, noticeably more firm than above
4						CL	At 12.5 feet (bottom of Shelby tube ample 6A-4), SILTY CLAY (CL), very dark grayish brown (10YR 3/2), wet, low to medium plasticity
	15		6A-5	---			
5							
			6A-6	3 3 7		CL	SILTY CLAY (CL), light yellowish brown (2.5Y 6/3) with moderate orange brown (oxide) mottling, moist, stiff, low to medium plasticity
6	20		6A-7	---			
7						CL	At 22.5 feet (bottom of Shelby tube sample 6A-7), same SILTY CLAY (CL) as above in sample 6A-6
	25		6A-8	---			
8						CL	At 27.5 feet (bottom of Shelby tube sample 6A-8), SILTY CLAY (CL), dark grayish green (5GY 4/2), moist, low to medium plasticity, crumbly texture
9	30		6A-9	---			
10			6A-10	2 5 7		CL/CH	CLAY (CL/CH), dark greenish gray (GLEY 4/1), moist, stiff, medium to high plasticity
11	35		6A-11	---		CH	34-inch recovery in Shelby tube sample 6A-11 likely due to swelling. At top of sample, CLAY as above in sample 6A-10 but high plasticity
						ML	At bottom of sample 6A-11, SILT (ML) with clay, dark greenish gray (GLEY1 4/1) with some orange brown (oxide) mottling, slightly micaceous, low to medium plasticity
12	40						

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Mud Rotary**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **2/28/12**
Date Ended: **2/29/12**
Boring Diameter: **5.0"**

Elevation: **140.0 ft.**
Total Depth: **67.3 ft.**

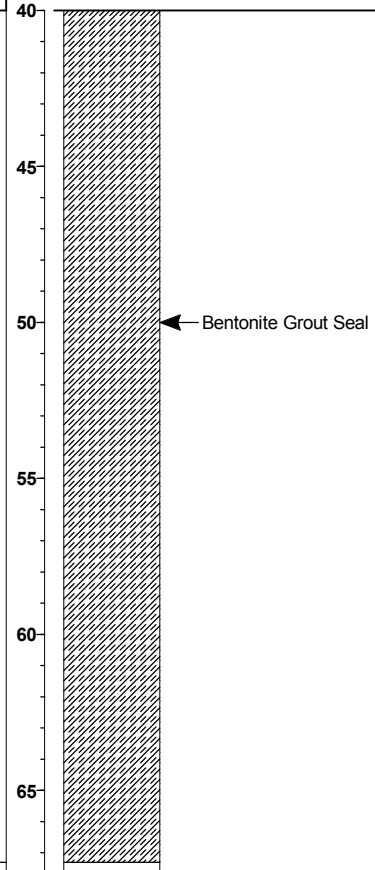
STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

Riverbend Landfill Company

JOB NUMBER: 04211001.01

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
	40		6A-12	---				**ALLUVIUM (Continued)**
13			6A-13	9 32 33		SM SM		SILTY FINE SAND (SM), yellowish brown (10YR 5/6), moist, silt 10 - 20 percent At 43.0 feet, sharp contact with SILTY SAND (SM) with fine gravel, strong brown (7.5YR 4/6) with orange brown (oxide) mottling, moist, hard, silt 10 - 20 percent, fine to coarse sand (f:m:c = 50:30:20), weathered appearance
14	45							At 46 feet, driller reported gravel encountered. Switched to 300 lb. hammer before collecting sample 6A-14 and for remainder of samples
15								
16	50		6A-14	20 40 50/2"		GC		SANDY, CLAYEY GRAVEL (GC), mottled dark grayish brown (10YR 4/2) and light yellowish brown (2.5Y 6/4), moist, hard, fine to medium sand 10 - 20 percent, fine to coarse subrounded gravel to 1.5-inch diameter
17	55		6A-15	23 16 16		GW SW		SANDY GRAVEL (GW), black (5Y 2.5/1), wet, medium dense, fine to coarse sand (f:m:c: = 20:40:40) 20 - 30 percent, fine to coarse subrounded gravel to 2.5-inch diameter Contact with GRAVELLY SAND (SW), dark yellowish brown (10YR 3/6), wet, medium dense, fine gravel to 1/2-inch diameter 10 - 20 percent, fine to medium sand (approximately 50/50)
18								
19	60		6A-16 6A-17	5 8 9 12 22 30		SM SM		Sample 6A-16, no recovery. In sample shoe is SILTY FINE SAND (SM), very dark gray (2.5Y 3/1), wet, silt 5 - 10 percent Sample 6A-17, same SILTY SAND (SM) as above but with 10 - 20 percent predominantly fine gravel to 1-inch diameter, increasing silt and gravel content with depth, medium dense to dense
20	65							At 67.0 feet, SILTSTONE (SLST) with some fine sand, dark gray (2.5Y N4), moist, hard (moderately indurated), scattered while small nodules (1/16 to 1/8 inch)
			6A-18	50/3"		SLST		
21								Total Depth = 67.3 feet (Northing 2550.768, Easting 4122.694)
22	70							NOTES: 1. Drilled adjacent borehole on 3/2/12 with hollow stem augers to collect bulk soil cuttings samples 6A-19 (0 to 5.0 feet) and 6A-20 (from 5.0 to 10.0 feet).
23	75							2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collected sample 6A-14 at 50 feet and for remainder of borehole. Hammer not used for Shelby tube samples. 3. 36-inch long Shelby tube samples were pushed 30 inches only.
24	80							4. Shallow (Silt-Clay unit) groundwater encountered at 12.5 feet during drilling. Deep (Sand-Gravel unit) groundwater encountered at 55.0 feet during drilling.
25								5. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
26	85							

Completion Detail



SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-06B

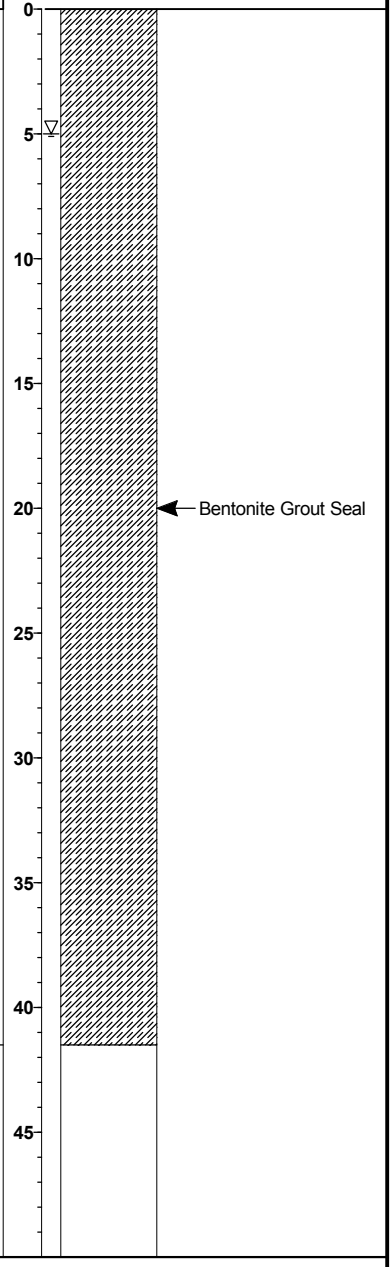
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig with automatic hammer (140 lb. and 300 lb. hammers used, see notes at end of log; 30-inch drop). NWJ rods used.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0							Surface: grass Note: Initially used 140 lb. hammer and switched to 300 lb. hammer as noted below
1		6B-1	---				**ALLUVIUM**
5		6B-2	---		CL/CH		At 5.0 feet (bottom of Shelby tube sample 6B-1), CLAY (CL/CH), dark grayish brown (2.5Y 4/2) with minor minor orange brown (oxide) mottling, wet, medium to high plasticity
2					CL		At 7.5 feet (bottom of Shelby tube sample 6B-2), SILTY CLAY (CL), light olive brown (2.5Y 5/3) with moderate orange brown (oxide) mottling, wet, medium plasticity
3 / 10		6B-3	---				
4		6B-4	0 0 4		CH		At top of sample 6B-4, CLAY (CH), yellowish brown (10YR 5/4), wet, high plasticity
15		6B-5	---		CL		Sharp contact with CLAY (CL), dark gray (5Y 4/1), moist, noticeably more firm than above, medium plasticity
5		6B-6	---		CL		At 17.5 feet (bottom of Shelby tube sample 6B-5), SILTY CLAY (CL), dark greenish gray (GLEY1 4/1), moist, medium plasticity
6 / 20							At 20 feet (bottom of Shelby tube sample 6B-6), same SILTY CLAY (CL) but slightly crumbly texture
7							- Could only push Shelby tube sample 6B-7 20 inches. Disturbed gravels observed at bottom of sample. Switched to 300 lb. hammer for sample 6B-8 and remaining samples
25		6B-7	---		ML		- At 26.5 feet, CLAYEY GRAVELLY SAND / SANDY GRAVEL (SC/GC), strong brown (7.5YR 4/6) with abundant orange brown (oxide) mottling, moist, medium dense, clay 10 - 20 percent, fine to coarse sand (f:m:c = 40:30:30), fine to coarse subrounded gravel to 1.5-inch diameter, weathered appearance
8		6B-8	15 18 32		SC/GC		
9 / 30		6B-9	30 20 37		SC/GC		- At 30 feet, Same SC/GC as above - At 35.0 feet, SANDY CLAYEY GRAVEL (GC), mottled pale brown (2.5Y 8/4) and dark yellowish brown (10YR 4/4), very moist, dense, fine to coarse sand (f:m:c = 20:40:40) 10 - 20 percent, clay 10 - 20 percent, fine subrounded gravel to 3/4-inch diameter
10							- Sharp contact in sample 6B-10 with SANDY GRAVEL (GW) with fines, mottled strong brown (7.5YR 4/6) and light yellowish brown (2.5Y 6/4), very moist, dense, fine to coarse sand (f:m:c = 40:30:30), fine to coarse subrounded gravel to 2-inch diameter
35 / 11		6B-10	15 30 50/5"		GC GW		
12 / 40		6B-11	6 11 20		GW SW		- At 40 feet, same SANDY GRAVEL (GW) as above but with trace fines, wet. Sharp contact with GRAVELLY SAND (SW), dark greenish gray (GLEY1 3/1), wet, medium dense, trace fines, predominantly fine gravel, fine to coarse sand (f:m:c = 40:40:20)
13							Total Depth = 31.5 feet (N. 2413.173, E. 4135.229)
45 / 14							NOTES: 1. 36-in. long Shelby tubes were pushed 30 in. only. 2. Initially used 140 lb. hammer for sample collection; switched to 300 lb. hammer before collecting sample 6B-8 and remaining samples. 3. Shallow and deep groundwater encountered at 5.0 and 40.0 feet, respectively, during drilling. 4. Refer to compilation of laboratory test data by Geosyntec consultants, Inc., for soil test information.
15 / 50							

Completion Detail



Drilling Company:	**Major Drilling Environmental, LLC**	Date Started:	**3/5/12**
Drilling Method:	**Mud Rotary**	Date Ended:	**3/5/12**
Logged By:	**David Lamadrid**	Boring Diameter:	**5.0"**
Sampling Method:	**See legend for explanation of sample types**	Elevation:	**124.5 ft.**
		Total Depth:	**41.5 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-07

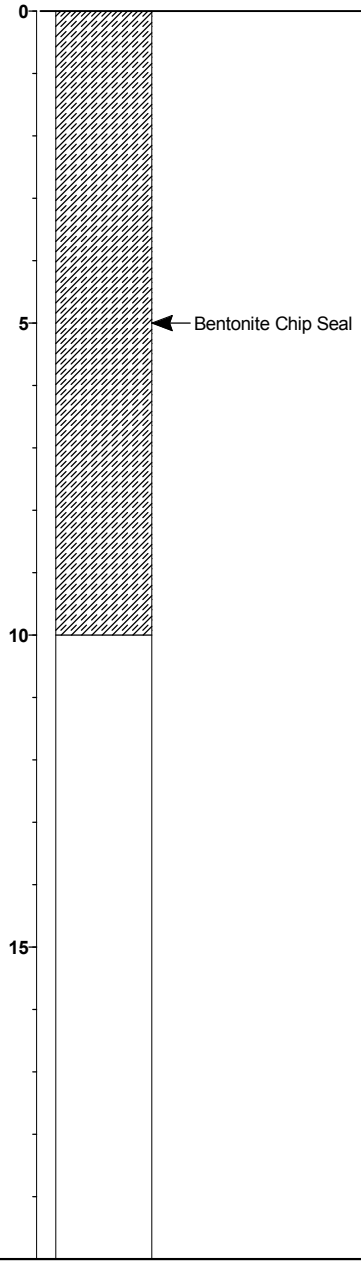
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0					FILL		Surface: gravel fill
1		7-1	---		CL		**ALLUVIUM** SILTY CLAY (CL), yellowish brown, very moist
5		7-2	---		CL		Grades to very moist to wet
10							Total Depth = 10.0 feet (Northing 3700.361, Easting 3967.166) NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc. for soil test information.

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/6/12**
Date Ended: **3/6/12**
Boring Diameter: **8.0"**

Elevation: **149.9 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-08

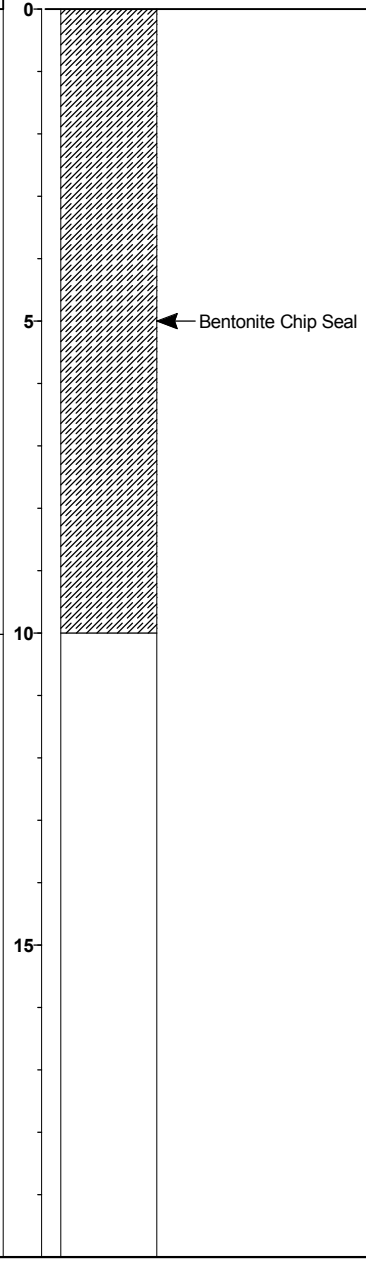
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0					FILL		Surface: gravel fill
	1		8-1	---		CL		**ALLUVIUM** SILTY CLAY (CL), grayish brown, very moist
	2							
	3							
1								
	4							Becomes very moist to wet
	5		8-2	---		CL		
	6							
2								
	7							
	8							
	9							
3	10							Total Depth = 10.0 feet (Northing 3300.262, Easting 3956.582)
	11							
	12							NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
4	13							
	14							
	15							
5	16							
	17							
	18							
	19							
6	20							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/6/12**
Date Ended: **3/6/12**
Boring Diameter: **8.0"**

Elevation: **149.2 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-09

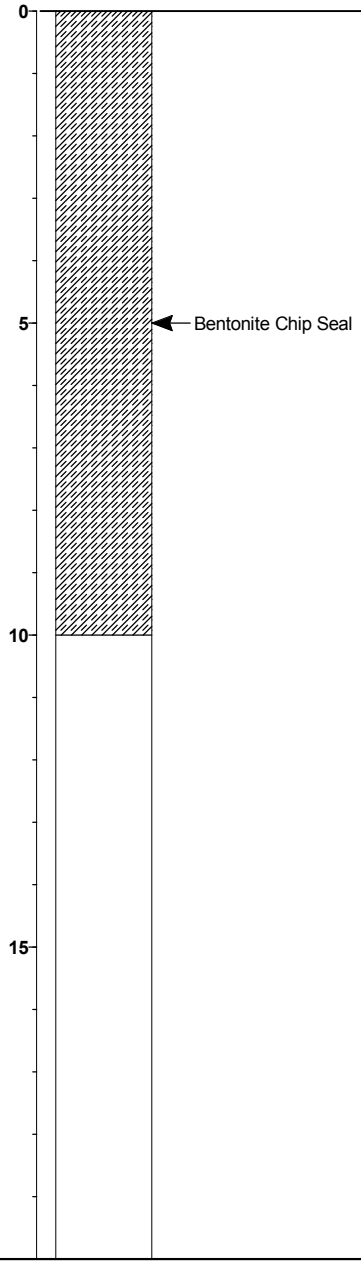
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters / feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0					FILL		Surface: gravel fill
2		9-1	---		ML		**ALLUVIUM** CLAYEY SILT (ML), yellowish brown, moist
5		9-2	---		ML		
							Grades to very moist to wet
10							Total Depth = 10.0 feet (Northing 3049.643, Easting 3999.323) NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/6/12**
Date Ended: **3/6/12**
Boring Diameter: **8.0"**

Elevation: **148.8 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-10

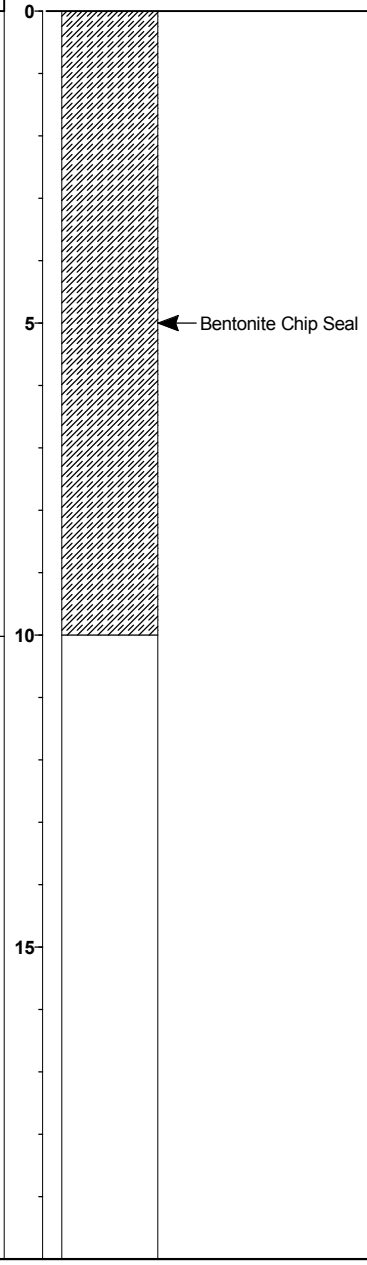
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0					FILL		Surface: gravel fill
	1		10-1	---		CL		**FILL** SILTY CLAY (CL), greenish gray, moist, apparent fill soil
	2							
	3							
1	4							
	5		10-2	---		CL		
	6							
2	7							At approximately 7.0 feet, minor plastics and organics in fill soil
	8							
	9							
3	10							Total Depth = 10.0 feet (Northing 2964.379, Easting 4106.519)
	11							
	12							NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
4	13							
	14							
	15							
5	16							
	17							
	18							
	19							
6	20							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/6/12**
Date Ended: **3/6/12**
Boring Diameter: **8.0"**

Elevation: **148.3 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-11

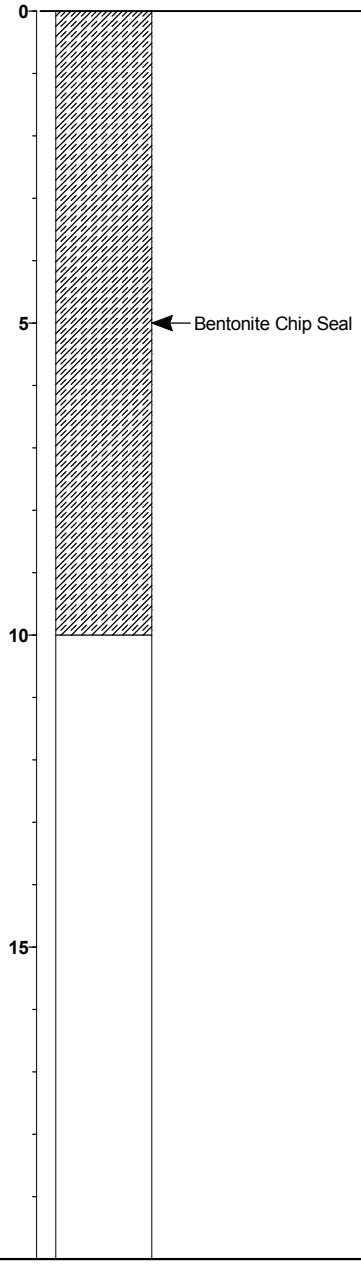
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0		11-1	---				Surface: Grass
	1					CL		**FILL** SILTY CLAY (CL), gray-brown, moist
	2					CL/ML		SILTY CLAY / CLAYEY SILT (CL/ML), greenish gray, moist, apparent fill soil
1	3							
	4							
	5		11-2	---		CL/ML		Grades to very moist
2	6							
	7							
	8							
	9							Plastic debris encountered in fill soil near bottom of borehole
3	10							Total Depth = 10.0 feet (Northing 2846.369, Easting 4129.031)
	11							
	12							NOTES: 1. Groundwater not encountered during drilling.
4	13							2. Refer to compilation of laboratory test data by Geosyntec, Inc., for soil test information.
	14							
	15							
5	16							
	17							
	18							
	19							
6	20							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/6/12**
Date Ended: **3/6/12**
Boring Diameter: **8.0"**

Elevation: **148.0 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-12

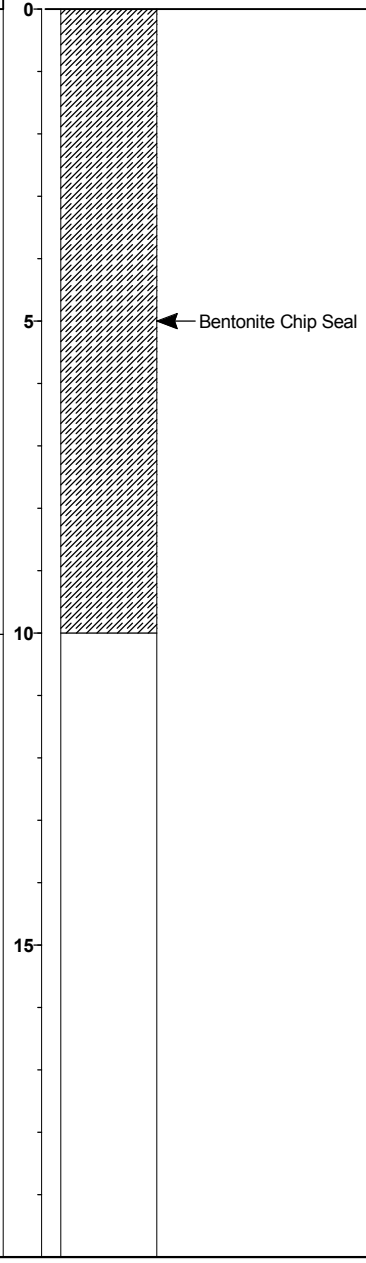
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0					FILL		Surface: gravel fill
	2		12-1	---		CL		**ALLUVIUM** SILTY CLAY (CL), light bronw, very moist
1	5		12-2	---		CL		
2	6							Grades to very moist to wet
3	10							Total Depth = 10.0 feet (Northing 2710.683, Easting 3994.257) NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
4	13							
5	15							
6	20							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/2/12**
Date Ended: **3/2/12**
Boring Diameter: **8.0"**

Elevation: **143.1 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

SCS ENGINEERS

BORING LOG

14945 SW Sequoia Parkway, Suite 180
Portland, OR 97224

BORING NUMBER: GT12-13

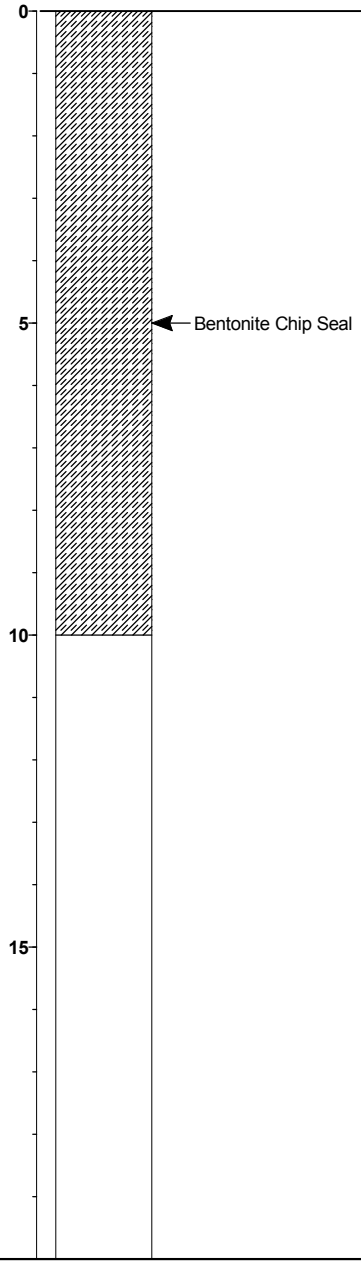
Riverbend Landfill Company
Riverbend Landfill
McMinnville, Oregon

JOB NUMBER: 04211001.01

REMARKS:
Mobile B-54 drill rig.

Depth (meters)	Depth (feet)	Sample Location	Sample Number	Blow Counts	OVM (ppm)	USCS Soil Class.	Graphic Log	Description
0	0					FILL		Surface: gravel fill
	1		13-1	---		CH		**ALLUVIUM** SILTY CLAY (CL), brown, moist, high plasticity
1	2							
	3							
	4							
	5		13-2	---		CL		Grades to very moist, medium to high plasticity
2	6							
	7							
	8							
	9							
3	10							Total Depth = 10.0 feet (Northing 2624.516, Easting 4128.381)
	11							
	12							NOTES: 1. Groundwater not encountered during drilling. 2. Refer to compilation of laboratory test data by Geosyntec Consultants, Inc., for soil test information.
4	13							
	14							
	15							
5	16							
	17							
	18							
	19							
6	20							

Completion Detail



Drilling Company: **Major Drilling Environmental, LLC**
Drilling Method: **Hollow Stem Auger**
Logged By: **David Lamadrid**
Sampling Method: **See legend for explanation of sample types**

Date Started: **3/2/12**
Date Ended: **3/2/12**
Boring Diameter: **8.0"**

Elevation: **141.6 ft.**
Total Depth: **10.0 ft.**

STANDARD_LOG RLF_PHASE 1B MSE BERM GEOTECH SHALLOW BOREHOLE LOGS_V1.0.GPJ STD_LOG.GDT 7/17/12

APPENDIX F

2012 Energy Measurement

Robert Miner Dynamic Testing, Inc.

Dynamic Measurements and Analyses for Deep Foundations

March 15, 2012

Mr. Terry Jacques
Major Drilling Environmental, LLC
13565 SW Tualitin Sherwood Rd, STE 700
Sherwood, OR 77140

Re: Penetration Test Energy Measurements
Major Drilling B-54 Rig, Mobile Automatic Hammer
Borehole 01A, January 26 and 27, 2012
River Bend Landfill, McMinnville, OR

RMDT Job No. 12F09

Dear Mr. Jacques,

This letter presents energy transfer measurements made during Standard Penetration Tests and California Modified Samples for the drill hole and drill rig referenced above. Robert Miner Dynamic Testing, Inc. (RMDT) made dynamic measurements with a Pile Driving Analyzer® as a hammer advanced the NW rod during sampling with a split spoon sampler and a California Modified sampler.

The purpose of RMDT's testing was the measurement of energy transferred to the drill rods. Measurements were made on a section of NW gauge rod at the top of the drill rod. Strain gages and accelerometers on the rod were connected to a Pile Driving Analyzer® (PDA) which generally processed acceleration and strain measurements from each hammer blow and stored both the measurements and computed results. Measurements and data processing generally followed the ASTM D 4633-10 standard. Energy transfer past the gage location, EFV, was computed by the PDA using force and velocity records as follows:

$$EFV = \int_a^b F(t)\ v(t)\ dt$$

The value "a" corresponds to the start of the record which is when the energy transfer begins and *"b"* is the time at which energy transferred to the rod reaches a maximum value. Appendix A contains more information on our measurement equipment and methods of analysis. The EFV energy calculation is identical to the EMX energy result discussed in Appendix A. The EFV and EMX values apply to the sensor location near the top of the rod.

TEST DETAILS

Testing occurred on January 26 and 27, 2012. Boring 0A1 was advanced near the weigh station of the River Bend Landfill facility located in McMinnville, OR. NW size rod was used to advance both samplers. The automatic hammer in use during our testing was manufactured

Mailing Address: P.O. Box 340, Manchester, WA, 98353, USA **Phone:** 360-871-5480
Location: 2288 Colchester Dr. E., Ste A, Manchester, WA, 98353 **Fax:** 360-871-5483

by Foremost Mobile (Mobile) and was reported to use either a 140 lb or a 300 lb ram. The drill rig was a track-mounted Mobile B-54.

RESULTS

A summary of the results for tests conducted with the 140 lb and 300 lb ram are given in Tables 1 and 2, respectively. The tabulated results include the starting sample depth, the penetration resistance, the number of hammers blows in our data set, measured energy transfer, EFV, the computed transfer efficiency, ETR, and the hammer blow rate, BPM. Appendix B contains detailed numeric results for each individual test.

Energy measurements must be divided by the theoretical free fall energy of the hammer to obtain an efficiency. In anticipation of future site demands measurements were made with 140 lb and 300 lb rams in the Mobile Automatic Hammer. A 140 lb ram raised 30 inches above an impact surface has 350 lb-ft of potential energy. A 300 lb ram raised 30 inches above an impact surface has 750 lb-ft of potential energy. Thus, the transfer energy results for sampling with the 140 and 300 lb rams may be divided by 350 or 750 lb-ft to yield the ratio of the delivered energy to the nominal potential energy. This efficiency ratio, ETR, is given for each sample interval as a percent efficiency.

Three sample returns were monitored while the 140 lb ram and standard split spoon sampler were in use. The overall average ETR was 85 percent and the average hammer blow rate was 39 blows per minute.

Table 1. Summary of Test Details and Results for the 140-lb ram and Split Spoon Sampler

Sample Name and Sample Start Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
01A-7 @22.5ft	9/1ft	9	299	85	42
01A-12 @40ft	18/1ft	18	290	83	36
01A-13 @45ft	18/1ft	18	301	86	40
Average for Split Spoon samples:			**297**	**85**	**39**

Three additional sample returns were monitored while the 300 lb ram and California Modified Sampler were in use. For the 300 lb ram the average ETR values within the sample intervals

ranged from 96 to 102 percent, and the overall average ETR value was 98 percent. The blow rate was reduced after sample 01A-15 was recorded to matched those of previously recorded tests performed with the 300 lb ram. When considering consistency between past and present tests with the 300 lb hammer we suggest that the present 55 ft sample be removed from the overall average. Considering the present 60 and 65 ft samples, the average is relatively similar to prior tests.

Table 2. Summary of Test Details and Results for the 300-lb ram and California Modified Sampler

Sample Name and Sample Start Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
01A-15 @55 ft	75/1 ft	75	767	102	39
01A-16 @60 ft	50/5 in	88	716	96	26
01A-17 @65 ft	50/2 in	90	729	97	26
		Average:	**737**	**98**	**30**

It was a pleasure to assist you and to participate on this project with the staff of Major Drilling Environmental, LLC. Please do not hesitate to contact us if you or your client have any questions about this report.

Sincerely,

Robert Miner Dynamic Testing, Inc.

Andrew Banas
Staff Engineer

APPENDIX A
AN INTRODUCTION INTO DYNAMIC PILE TESTING METHODS

The following has been written by Goble Rausche Likins and Associates, Inc. and may only be copied with its written permission.

BACKGROUND

Modern procedures of design and construction control require verification of bearing capacity and integrity of deep foundations during preconstruction test programs and also production installation. Dynamic pile testing methods meet this need economically and reliably, and therefore, form an important part of a quality assurance program when deep foundations are executed. Several dynamic pile testing methods exist; they have different benefits and limitations and different requirements for proper execution.

The Case Method of dynamic pile testing, named after the Case Institute of Technology where it was developed between 1964 and 1975, requires that a substantial ram mass (such as that of a pile driving hammer) impacts the pile top such that the pile undergoes at least a small permanent set. The method is therefore also referred to as a "High Strain Method". The Case Method requires dynamic measurements on the pile or shaft under the ram impact and then an evaluation of various quantities based on closed form solutions of the wave equation, a partial differential equation describing the motion of a rod under the effect of an impact. Conveniently, measurements and analyses are done by a single piece of equipment: the Pile Driving Analyzer® (PDA). However, for bearing capacity evaluations an important additional method is CAPWAP® which performs a much more rigorous analysis of the dynamic records than the simpler Case Method.

A related analysis method is the "Wave Equation Analysis" which calculates a relationship between bearing capacity and pile stress and field blow count. The GRLWEAP™ program performs this analysis and provides a complete set of helpful information and input data.

The following description deals primarily with the Case Method or "High Strain Test" Method of pile testing, however, for the sake of completeness, the "Low Strain Test" performed with the Pile Integrity Test™ (PIT), mainly for pile integrity evaluation, will also be described.

RESULTS FROM DYNAMIC TESTING

There are two main objectives of high strain dynamic pile testing:

- *Dynamic Pile Monitoring* and
- *Dynamic Load Testing*.

Dynamic pile monitoring is conducted during the installation of impact driven piles to achieve a safe and economical pile installation. Dynamic load testing, on the other hand, has as its primary goal the assessment of pile bearing capacity. It is applicable to both cast *insitu* piles or drilled shafts and impact driven piles during restrike.

Dynamic Pile Monitoring

During pile installation, the sensors attached to the pile measure pile top force and velocity. A PDA conditions and processes these signals and calculates or evaluates:

- Bearing capacity at the time of testing, including an assessment of shaft resistance development and driving resistance. This information supports formulation of a driving criterion.

- Dynamic pile stresses, axial and averaged over the pile cross section, both tensile and compressive, during pile driving to limit the potential of damage either near the pile top or along its length. Bending stresses can be evaluated at the point of sensor attachment.

- Pile integrity assessment by the PDA is based on the recognition of certain wave reflections from along the pile. If detected early enough, a pile may be saved from complete destruction. On the other hand, once damage is recognized measures can be taken to prevent reoccurrence.

- Hammer performance parameters including the energy transferred to the pile, the hammer speed in blows per minute and the stroke of open ended diesel hammers.

© 1999, Goble Rausche Likins and Associates, Inc.

Dynamic Pile Load Testing

Bearing capacity testing of either driven piles or drilled shafts applies the same basic measurement approach of dynamic pile monitoring. However, the test is done independent of the pile installation process and therefore a pile driving hammer or other dynamic loading device may not be available. If a special ram has to be mobilized then its weight should be between 0.8 and 2% of the test load (e.g. between 4 and 10 tons for a 500 ton test load) to assure sufficient soil resistance activation.

For a successful test, it most important that the test is conducted after a sufficient waiting time following pile installation for soil properties approaching their long term condition or concrete to properly set. During testing, PDA results of pile/shaft stresses and transferred energy are used to maintain safe stresses and assure sufficient resistance activation. For safe and sufficient testing of drilled shafts, ram energies are often increased from blow to blow until the test capacity has been activated. On the other hand, restrike tests on driven piles may require a warm hammer so that the very first blow produces a complete resistance activation. Data must be evaluated by CAPWAP for bearing capacity.

After the dynamic load test has been conducted with sufficient energy and safe stresses, the CAPWAP analysis provides the following results:

- Bearing capacity i.e. the mobilized capacity present at the time of testing
- Resistance distribution including shaft resistance and end bearing components
- Stresses in pile or shaft calculated for both the static load application and the dynamic test. These stresses are averages over the cross section and do not include bending effects or nonuniform contact stresses, e.g. when the pile toe is on uneven rock.
- Shaft impedance vs depth; this is an estimate of the shaft shape if it differs substantially from the planned profile
- Dynamic soil parameters for shaft and toe, i.e. damping factors and quakes (related to the dynamic stiffness of the resistance at the pile/soil interface.)

MEASUREMENTS

PDA

The basis for the results calculated by the PDA are pile top strain and acceleration measurements which are converted to force and velocity records, respectively. The PDA conditions, calibrates and displays these signals and immediately computes average pile force and velocity thereby eliminating bending effects. Using closed form Case Method solutions, based on the one-dimensional linear wave equation, the PDA calculates the results described in the analytical solutions section below.

HPA

The ram velocity may be directly obtained using radar technology in the Hammer Performance Analyzer™. For this unit to be applicable, the ram must be visible. The impact velocity results can be automatically processed with a PC or recorded on a strip chart.

Saximeter™

For open end diesel hammers, the time between two impacts indicates the magnitude of the ram fall height or stroke. This information is not only measured and calculated by the PDA but also by the convenient, hand-held Saximeter.

PIT

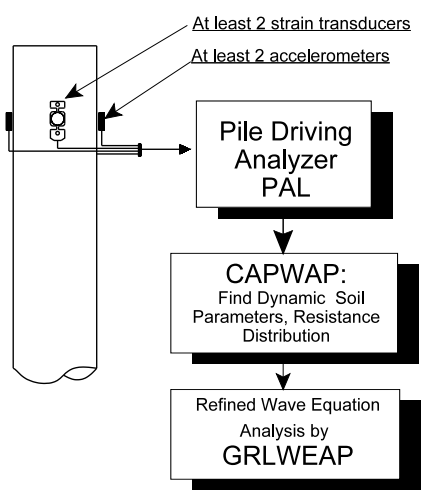
The Pile Integrity Tester™ (PIT) can be used to evaluate defects in concrete piles or shafts which may have occurred during driving or casting. Also timber piles of limited length can be tested in that manner. This so-called "Low Strain Method" or “Pulse-Echo Method” of integrity testing requires only the measurement of acceleration at the pile top. The stress wave producing impact is then generated by a small hand-held hammer and the records interpreted in the time domain. PIT also supports the so-called “Transient Response Method” which requires the additional measurement of the hammer force and an analysis in the frequency domain. This method may also be used to evaluate the unknown length of deep foundations under existing structures.

ANALYTICAL SOLUTIONS
BEARING CAPACITY

Wave Equation

GRL has written the GRLWEAP™ program which calculates a relationship between bearing capacity, pile stress and blow count. This relationship is often called the "bearing graph." Once the blow count is known from pile installation logs, the bearing graph yields the bearing capacity. This approach requires no measurements and therefore can be performed during the design stage of a project, for example for the selection of hammer, cushion and pile size.

After dynamic pile monitoring and/or dynamic load testing has been performed, the "Refined Wave Equation Analysis" or RWEA (see schematic below) is often performed by inputting the PDA and CAPWAP calculated parameters. Then the bearing graph from the RWEA is the basis for a safe and sufficient driving criteria.



Case Method

The Case Method is a closed form solution based on a few simplifying assumptions such as ideal plastic soil behavior and an ideally elastic and uniform pile. Given the measured pile top force F(t) and pile top velocity v(t), the total soil resistance is

$$R(t) = \tfrac{1}{2}\{[F(t) + F(t_2)] + Z[v(t) - v(t_2)]\} \qquad (1)$$

where

- t = a point in time after impact
- t_2 = time $t + 2L/c$
- L = pile length below gages
- c = $(E/\rho)^{1/2}$ is the speed of the stress wave
- ρ = pile mass density
- Z = EA/c is the pile impedance
- E = elastic modulus of the pile (ρc^2)
- A = pile cross sectional area

The total soil resistance consists of a dynamic (R_d) and a static (R_s) component. The static component is therefore

$$R_s(t) = R(t) - R_d(t) \qquad (2)$$

The dynamic component may be computed from a soil damping factor, J, and a pile toe velocity, $v_t(t)$ which is conveniently calculated for the pile toe. Using wave considerations, this approach leads immediately to the dynamic resistance

$$R_d(t) = J[F(t) + Zv(t) - R(t)] \qquad (3)$$

and finally to the static resistance by means of Equation 2.

There are a number of ways in which Eq. 1 through 3 can be evaluated. Most commonly, t_2 is set to that time at which the static resistance becomes maximum. The result is the so-called **RMX** capacity. Damping factors for RMX typically range between 0.5 for coarse grained materials to 1.0 for clays. The **RSP** capacity (this method is most commonly referred to in the literature, yet it is not very frequently used) requires damping factors between 0.1 for sand and 1.0 for clay. Another capacity, **RA2**, determines the capacity at a time when the pile is essentially at rest and thus damping is small; RA2

therefore requires no damping parameter. In any event, the proper Case Method and its associated damping parameter is most conveniently found after a CAPWAP analysis has been performed.

The static resistance calculated by Case Method or CAPWAP is the mobilized resistance at the time of testing. Consideration therefore has to be given to soil setup or relaxation effects and whether or not a sufficient set has been achieved under the test loading that would correspond to a full activation of the ultimate soil resistance.

The PDA also calculates an estimate of shaft resistance as the difference between force and velocity times impedance at the time immediately prior to the return of the stress wave from the pile toe. This shaft resistance is not reduced by damping effects and is therefore called the total shaft resistance **SFT**. A correction for damping effects produces the static shaft resistance estimate, **SFR**.

The Case Method solution is simple enough to be evaluated "in real time," i.e. between hammer blows, using the PDA. It is therefore possible to calculate all relevant results for all hammer blows and plot these results as a function of depth or blow number. This is done in the PDAPLOT program.

CAPWAP

The CAse Pile Wave Analysis Program combines the wave equation pile and soil model with the Case Method measurements. Thus, the solution includes not only the total and static bearing capacity values but also the shaft resistance, end bearing, damping factors and soil stiffnesses. The method iteratively calculates a number of unknowns by signal matching. While it is necessary to make hammer performance assumptions for a GRLWEAP analysis, the CAPWAP program works with the pile top measurements. Furthermore, while GRLWEAP and Case Method require certain assumptions regarding the soil behavior, CAPWAP calculates these soil parameters.

STRESSES

During pile monitoring, it is important that compressive stress maxima at pile top and toe and tensile stress maxima somewhere along the pile be calculated for each hammer blow.

At the pile top (location of sensors) both the maximum compression stress, **CSX**, and the maximum stress from individual strain transducers, **CSI**, are directly obtained from the measurements. Note that CSI is greater than or equal to CSX and the difference between CSI and CSX is a measure of bending in the plane of the strain transducers. Note also that all stresses calculated for locations below the sensors are averaged over the pile cross section and therefore do not include components from either bending or eccentric soil resistance effects.

The PDA calculates the compressive stress at the pile bottom, **CSB**, assuming (a) a uniform pile and (b) that the pile toe force is the maximum value of the total resistance R(t) minus the total shaft resistance, SFT. Again, for this stress estimation uniform resistance force are assumed (e.g. not a sloping rock.)

For concrete piles, the maximum tension stress, **TSX**, is also of great importance. It occurs at some point below the pile top. The maximum tension stress can be computed from the pile top measurements by finding the maximum tension wave (either traveling upward, W_U, or downward, W_d) and reducing it by the minimum compressive wave traveling in opposite direction.

$$W_u = ½[F(t) - Zv(t)] \quad (4)$$

$$W_d = ½[F(t) + Zv(t)] \quad (5)$$

CAPWAP also calculates tensile and compressive stresses along the pile and, in general, more accurately than the PDA. In fact, for non-uniform piles or piles with joints, cracks or other discontinuities, the closed form solutions from the PDA may be in error.

PILE INTEGRITY

High Strain Tests (PDA)

Stress waves in a pile are reflected wherever the pile impedance, $Z = EA/c = \rho cA = A \sqrt{(E \rho)}$, changes. Therefore, the pile impedance is a measure of the quality of the pile material (E, ρ, c) and the size of its cross section (A). The reflected waves arrive at the pile top at a time which is greater the farther away from the pile top the reflection occurs. The

magnitude of the change of the upward traveling wave (calculated from the measured force and velocity, Eq. 4) indicates the extent of the cross sectional change. Thus, with β_i (**BTA**) being a relative integrity factor which is unity for no impedance change and zero for the pile end, the following is calculated by the PDA.

$$\beta_i = (1 - \alpha_i)/(1 + \alpha_i) \tag{6}$$

with

$$\alpha_i = ½(W_{UR} - W_{UD})/(W_{Di} - W_{UR}) \tag{7}$$

where

W_{UR} is the upward traveling wave at the onset of the reflected wave. It is caused by resistance.

W_{UD} is the upwards traveling wave due to the damage reflection.

W_{Di} is the maximum downward traveling wave due to impact.

It can be shown that this formulation is quite accurate as long as individual reflections from different pile impedance changes have no overlapping effects on the stress wave reflections.

Without rigorous derivation, it has been proposed to consider as slight damage when β is above 0.8 and a serious damage when β is less than 0.6.

Low Strain Tests (PIT)

The pile top is struck with a held hand hammer and the resulting pile top velocity is measured, displayed and interpreted for signs of wave reflections. In general, a comparison of the reflected acceleration leads to a relative measure of extent of damage, again the location of the problem is indicated by the arrival time of the reflection. PIT records can also be interpreted by the β-Method. However, low strain tests do not activate much resistance which simplifies Eq. 7 since W_{UR} is then equal to zero.

For drilled shafts and PIT records that clearly show a toe reflection, an approximate shaft profile can be calculated from low strain records using the PITSTOP program's PROFILE routine.

HAMMER PERFORMANCE

The PDA calculates the energy transferred to the pile top from:

$$E(t) = \int_0^t F(t)v(t)\,dt \tag{8a}$$

The maximum of the E(t) curve is the most important information for an overall evaluation of the performance of a hammer and driving system. This **EMX** value allows for a classification of the hammer's performance when presented as the rated transfer efficiency, also called energy transfer ratio (**ETR**) or global efficiency

$$e_T = EMX/E_R \tag{8b}$$

where

E_R is the manufacturer's rated energy value.

Both Saximeter and PDA calculate the stroke (**STK**) of an open end diesel hammer using

$$STK = (g/8)\,T_B^2 - h_L \tag{9}$$

where

g is the earth's gravitational acceleration,
T_B is the time between two hammer blows,
h_L is a stroke loss value due to gas compression and time losses during impact (usually 0.3 ft or 0.1 m).

DETERMINATION OF WAVE SPEED

An important facet of dynamic pile testing is an assessment of pile material properties. Since in general force is determined from strain by multiplication with elastic modulus, E, and cross sectional area, A, the dynamic elastic modulus has to be determined for pile materials other than steel. In general, the records measured by the PDA clearly indicate a pile toe reflection as long as pile penetration per blow is greater than 1 mm or .04 inches. The time between the onset of the force and velocity records at impact and the onset of the reflection from the toe (usually apparent by a local maximum of the wave up curve) is the so-called wave travel time, T. Dividing 2L (L is here the length of the pile below sensors) by T leads to the stress wave speed in the pile:

$$c = 2L/T \tag{10}$$

The elastic modulus of the pile material is related to the wave speed according to the linear elastic wave equation theory by

$$E = c^2\rho \tag{11}$$

Since the mass density of the pile material, ρ, is usually well known (an exception is timber for which samples should be weighed), the elastic modulus is easily found from the wave speed. Note, however, that this is a dynamic modulus which is generally higher than the static one and that the wave speed depends to some degree on the strain level of the stress wave. For example, experience shows that the wave speed from PIT is roughly 5% higher than the wave speed observed during a high strain test.

Other Notes:

- If the pile material is nonuniform then the wave speed c, according to Eq. 10, is an average wave speed and does not necessarily reflect the pile material properties of the location where the strain sensors are attached to the pile top. For example, pile driving often causes fine tension cracks some distance below the top of concrete piles. Then the average c is slower than that at the pile top. It is therefore recommended to determine E in the beginning of pile driving and not adjust it when the average c changes.

- If the pile has such a high resistance that there is no clear indication of a toe reflection then the wave speed of the pile material must be determined either by assumption or by taking a sample of the concrete and measuring its wave speed in a simple free column test. Another possibility is to use the proportionality relationship, discussed under "DATA QUALITY CHECKS" to find c as the ratio between the measured velocity and measured strain.

DATA QUALITY CHECKS

Quality data is the first and foremost requirement for accurate dynamic testing results. It is therefore important that the measurement engineer performing PDA or PIT tests has the experience necessary to recognize measurement problems and take appropriate corrective action should problems develop. Fortunately, dynamic pile testing allows for certain data quality checks because two independent measurements are taken that have to conform to certain relationships.

Proportionality

As long as there is only a wave traveling in one direction, as is the case during impact when only a downward traveling wave exists in the pile, force and velocity measured at the pile top are proportional

$$F = v\,Z = v\,(EA/c) \tag{12a}$$

This relationship can also be expressed in terms of stress

$$\sigma = v\,(E/c) \tag{12b}$$

or strain

$$\epsilon = v / c \tag{12c}$$

This means that the early portion of strain times wave speed must be equal to the velocity unless the proportionality is affected by high friction near the pile top or by a pile cross sectional change not far below the sensors. Checking the proportionality is an excellent means of assuring meaningful measurements.

Measurements are always taken at opposite sides of the pile as a means of calculating the average force and velocity in the pile. The velocity on the two sides of the pile is very similar even when high bending exists. Thus, an independent check of the velocity measurements is easy and simple.

Strain measurements may differ greatly between the two sides of the pile when bending exists. It is even possible that tension is measured on one side while very high compression exists on the other side of the pile. In extreme cases, bending might be so high that it leads to a nonlinear stress distribution. The averaging of the two strain signals does then not lead to the average pile force and proportionality will not be achieved.

When testing drilled shafts, measurements of strain may also be affected by local concrete quality variations. It is then often necessary to use four strain transducers spaced at 90 degrees around the pile for an improved strain data quality. The use of four transducers is also recommended for large pile

diameters, particularly when it is difficult to mount the sensors at least two pile widths or diameters below the pile top.

LIMITATIONS, ADDITIONAL CONSIDERATIONS

Mobilization of capacity

Estimates of pile capacity from dynamic testing indicate the **mobilized pile capacity at the time of testing**. At very high blow counts (low set per blow), dynamic test methods tend to produce lower bound capacity estimates as not all resistance (particularly at and near the toe) is fully activated.

Time dependent soil resistance effects

Static pile capacity from dynamic method calculations provide an estimate of the axial pile capacity. Increases and decreases in the pile capacity with time typically occur (soil setup/relaxation). Therefore, **restrike testing usually yields a better indication of long term pile capacity than a test at the end of pile driving**. Often a wait period of one or two days between end of driving and restrike is satisfactory for a realistic prediction of pile capacity but this waiting time depends, among other factors, on the permeability of the soil.

(A) Soil setup

Because excess positive pore pressures often develop during pile driving in fine grained soil (clays, silts or even fine sands), the capacity of a pile at the time of driving may often be less than the long term pile capacity. These pore pressures reduce the effective stress acting on the pile thereby reducing the soil resistance to pile penetration, and thus the pile capacity at the time of driving. As these pore pressures dissipate, the soil resistance acting on the pile increases as does the axial pile capacity. This phenomena is routinely called soil setup or soil freeze.

(*B) Relaxation*

Relaxation (capacity reduction with time) has been observed for piles driven into weathered shale, and may take several days to fully develop. Pile capacity estimates based upon initial driving or short term restrike tests can significantly overpredict long term pile capacity. Therefore, piles driven into shale should be tested after a minimum one week wait either statically or dynamically (with particular emphasis than on the first few blows). Relaxation has also been observed for displacement piles driven into dense saturated silts or fine sands due to a negative pore pressure effect at the pile toe. Again, restrike tests should be used, with great emphasis on early blows.

Capacity results for open pile profiles

Larger diameter open ended pipe piles (or H-piles which do not bear on rock) may behave differently under dynamic and static loading conditions. Under dynamic loads the soil inside the pile or between its flanges may slip and produce internal friction while under static loads the plug may move with the pile, thereby creating end bearing over the full pile cross section. As a result both friction and end bearing components may be different under static and dynamic conditions.

CAPWAP Analysis Results

A portion of the soil resistance calculated on an individual soil segment in a CAPWAP analysis can usually be shifted up or down the shaft one soil segment without significantly altering the match quality. Therefore, use of the CAPWAP resistance distribution for uplift, downdrag, scour, or other geotechnical considerations should be made with an understanding of these analysis limitations.

Stresses

PDA and CAPWAP calculated stresses are average values over the cross section. Additional allowance has to be made for bending or non-uniform contact stresses. To prevent damage it is therefore important to maintain good hammer-pile alignment and to protect the pile toes using appropriate devices or an increased cross sectional area.

In the United States is has become generally acceptable to limit the dynamic installation stresses of driven piles to the following levels:

- 90% of yield strength for steel piles
- 85% of the concrete compressive strength - after subtraction of the effective prestress - for concrete piles in compression

100% of effective prestress plus ½ of the concrete's tension strength for prestressed piles in tension

70% of the reinforcement strength for regularly reinforced concrete piles in tension

300% of the static design allowable stress for timber

Note that the dynamic stresses may either be directly measured at the pile top by the PDA or calculated by the PDA for other locations along the pile based on the pile top measurements.

Additional design considerations

Numerous factors have to be considered in pile foundation design. Some of these considerations include

- additional pile loading from downdrag or negative skin friction,
- lateral and uplift loading requirements
- effective stress changes (due to changes in water table, excavations, fills or other changes in overburden),
- long term settlements in general and settlement from underlying weaker layers and/or pile group effects,

These factors have not been evaluated by GRL and have not been considered in the interpretation of the dynamic testing results. The foundation designer should determine if these or any other considerations are applicable to this project and the foundation design.

Wave equation analysis results

The results calculated by the wave equation analysis program depend on a variety of hammer, pile and soil input parameters. Although attempts have been made to base the analysis on the best available information, actual field conditions may vary and therefore stresses and blow counts may differ from the predictions reported. Capacity predictions derived from wave equation analyses should use restrike information. However, because of the uncertainties associated with restrike blow counts and restrike hammer energies, correlations of such results with static test capacities with have often displayed considerable scatter.

As for PDA and CAPWAP, the theory on which GRLWEAP is based is the one-dimensional wave equation. For that reason, stress predictions by the wave equation analysis can only be averages over the pile cross section. Thus, bending stresses or stress concentrations due to non-uniform impact or uneven soil or rock resistance are not considered in these results. Stress maxima calculated by the wave equation are usually subjected to the same limits as those measured directly or calculated from measurements by the PDA.

Appendix B

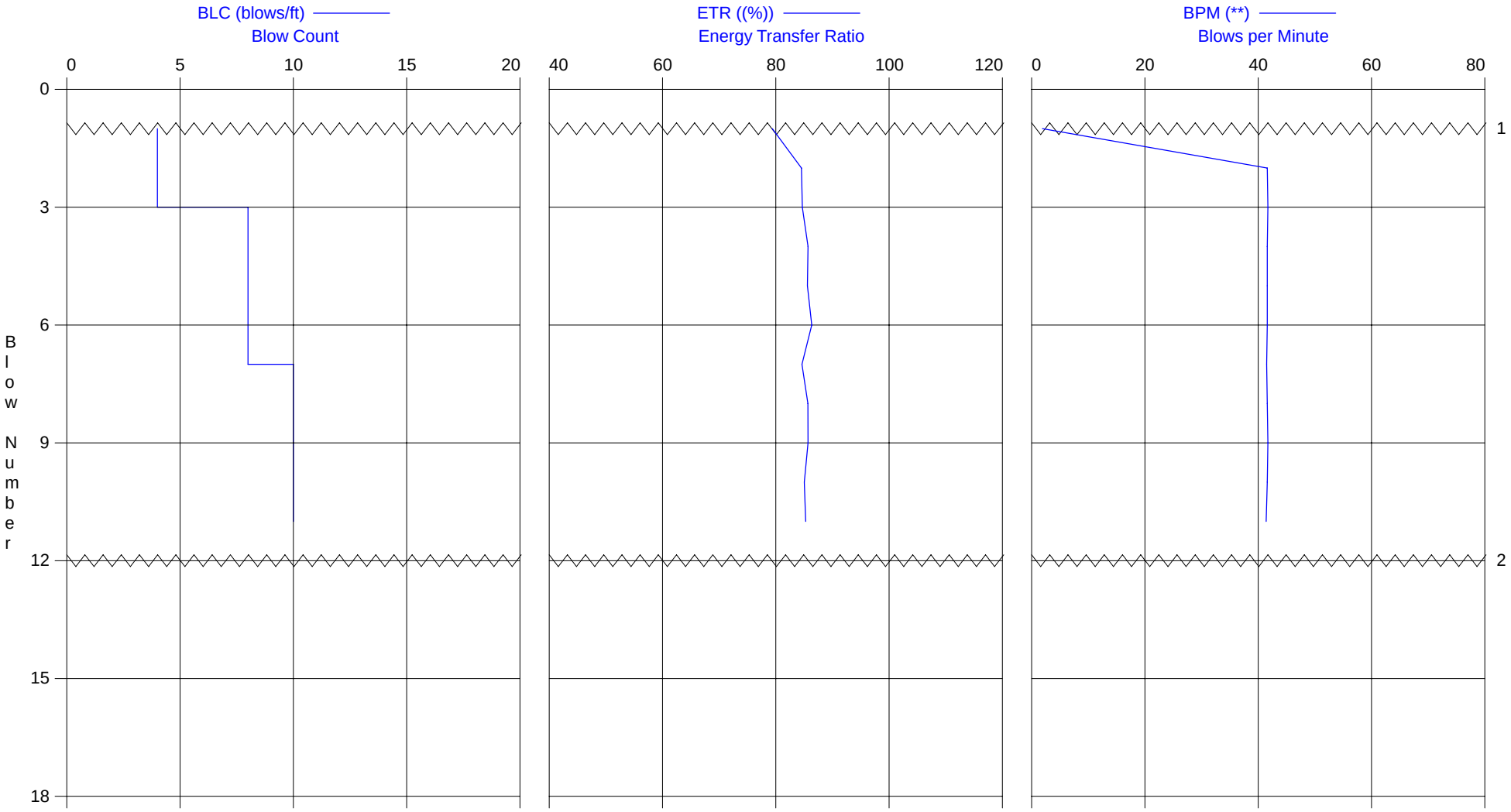
Summary of Case Method Field Results

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 29-Feb-2012

Test date: 26-Jan-2012

MAJOR DRILLING, RIVEREND LANDFILL - 01A-7, SPT 22.5FTNW-J, MOBILE HAMMER



1 - Start of test on 1/26/2012 at 1:14:50 PM

2 - End of test on 1/26/2012 at 1:15:06 PM

Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 29-Feb-2012

MAJOR DRILLING, RIVEREND LANDFILL - 01A-7, SPT 22.5FT

NW-J, MOBILE HAMMER

OP: RMDT

Test date: 26-Jan-2012

AR: 1.42 in^2
LE: 27.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSX: Max Measured Compr. Stress
CSI: Max F1 or F2 Compr. Stress
ETR: Energy Transfer Ratio
EFV: Energy of FV
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
CSB: Compression Stress at Bottom

BL#	depth	BLC	CSX	CSI	ETR	EFV	BPM	FMX	VMX	RAT	CSB
	ft	bl/ft	ksi	ksi	(%)	k-ft	**	kips	f/s	[]	ksi
3	22.63	8	28.1	29.0	84.7	0.296	41.7	40	16.2	0.9	2.9
4	22.75	8	27.3	27.6	85.7	0.300	41.6	39	16.3	0.9	3.3
5	22.88	8	27.9	28.3	85.6	0.300	41.6	40	16.2	0.9	3.9
6	23.00	8	27.6	28.5	86.4	0.302	41.6	39	16.2	0.9	2.9
7	23.10	10	26.7	27.0	84.6	0.296	41.5	38	16.0	0.9	2.4
8	23.20	10	26.5	26.7	85.7	0.300	41.6	38	16.2	0.9	2.7
9	23.30	10	26.1	26.5	85.7	0.300	41.7	37	16.0	0.9	2.0
10	23.40	10	26.0	26.1	85.0	0.298	41.6	37	15.9	0.9	2.3
11	23.50	10	26.9	27.3	85.3	0.298	41.4	38	16.0	0.9	2.4
		Average	27.0	27.4	85.4	0.299	41.6	38	16.1	0.9	2.8
		Std. Dev.	0.7	0.9	0.5	0.002	0.1	1	0.1	0.0	0.6
		Maximum	28.1	29.0	86.4	0.302	41.7	40	16.3	0.9	3.9
		@ Blow#	3	3	6	6	3	3	4	4	5

Total number of blows analyzed: 9

BL#	depth (ft)	Comments
1	22.25	Start of test on 1/26/2012 at 1:14:50 PM
12	23.60	End of test on 1/26/2012 at 1:15:06 PM

Time Summary

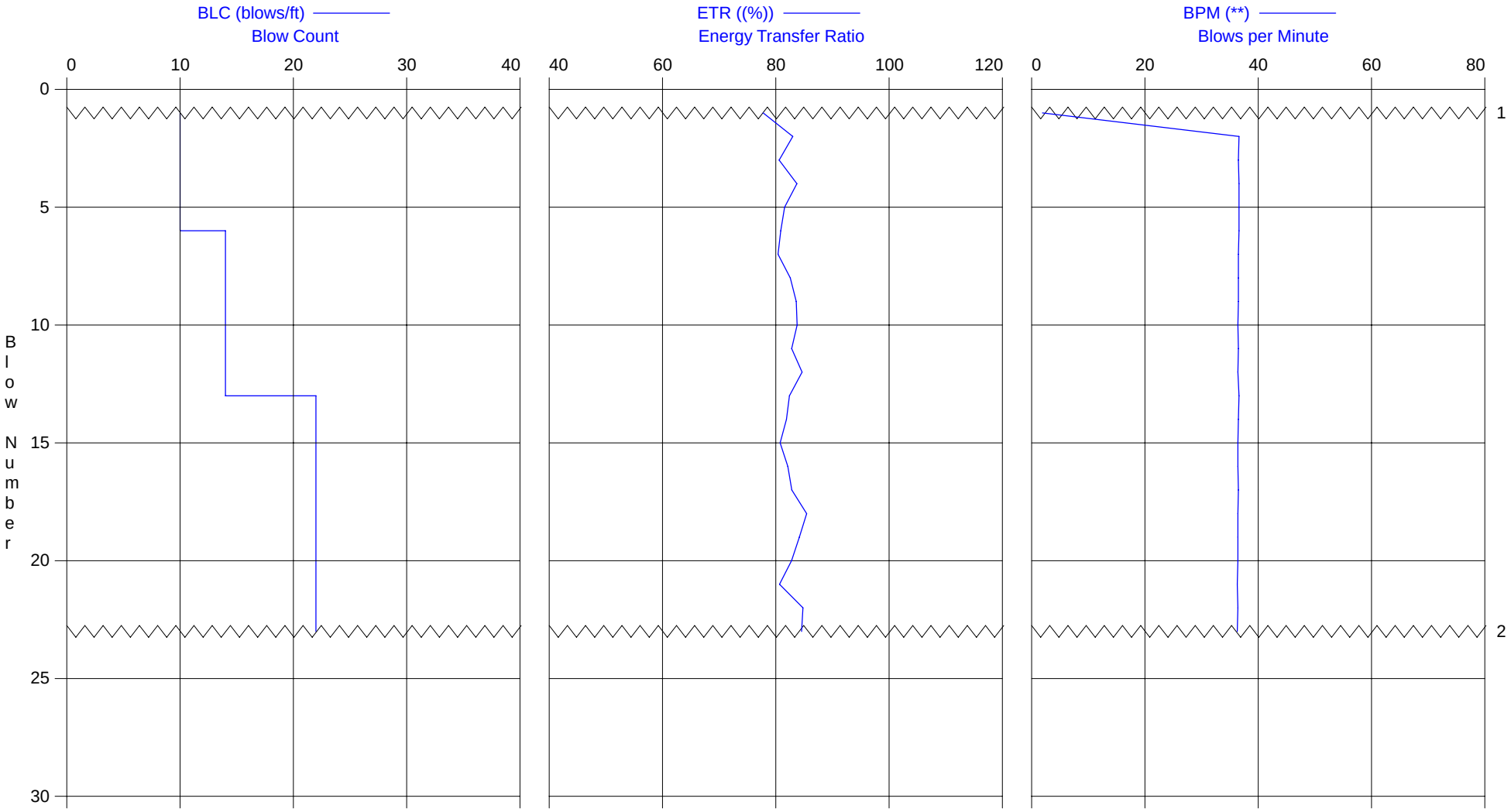
Drive 16 seconds 1:14:50 PM - 1:15:06 PM (1/26/2012) BN 1 - 12

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 30-Jan-2012

Test date: 26-Jan-2012

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-12, SPT 40FTNW-J, MOBILE HAMMER



1 - Start of test on 1/26/2012 at 3:09:49 PM

2 - End of test on 1/26/2012 at 3:10:25 PM

Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 30-Jan-2012

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-12, SPT 40FT

NW-J, MOBILE HAMMER

OP: RMDT

Test date: 26-Jan-2012

AR: 1.42 in^2
LE: 47.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSX: Max Measured Compr. Stress
CSI: Max F1 or F2 Compr. Stress
ETR: Energy Transfer Ratio
EFV: Energy of FV
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
CSB: Compression Stress at Bottom

BL#	depth	BLC	CSX	CSI	ETR	EFV	BPM	FMX	VMX	RAT	CSB
	ft	bl/ft	ksi	ksi	(%)	k-ft	**	kips	f/s	[]	ksi
6	40.57	14	27.6	28.5	80.9	0.283	36.6	39	14.7	1.0	9.0
7	40.64	14	27.1	27.8	80.4	0.281	36.5	39	14.5	1.0	7.2
8	40.71	14	27.7	28.6	82.6	0.289	36.5	39	15.2	1.0	10.2
9	40.79	14	28.2	28.8	83.6	0.293	36.5	40	15.6	1.0	8.7
10	40.86	14	27.5	28.4	83.8	0.293	36.4	39	15.5	1.0	9.4
11	40.93	14	27.6	28.3	82.8	0.290	36.5	39	15.3	1.0	8.0
12	41.00	14	27.6	28.3	84.6	0.296	36.4	39	15.7	1.0	8.8
13	41.05	22	27.7	28.3	82.4	0.288	36.6	39	14.7	1.0	9.2
14	41.09	22	27.8	28.5	81.9	0.287	36.5	40	14.2	0.9	9.7
15	41.14	22	27.5	28.1	80.8	0.283	36.4	39	13.7	1.0	8.1
16	41.18	22	27.8	28.3	82.1	0.287	36.4	39	13.6	1.0	9.3
17	41.23	22	27.7	28.4	82.8	0.290	36.5	39	13.9	1.0	9.3
18	41.27	22	28.3	29.1	85.4	0.299	36.4	40	13.9	1.0	8.4
19	41.32	22	27.9	28.6	84.2	0.295	36.4	40	13.3	1.0	10.3
20	41.36	22	27.8	28.4	82.8	0.290	36.4	39	13.0	1.0	8.9
21	41.41	22	26.5	27.1	80.6	0.282	36.3	38	12.2	1.0	8.2
22	41.46	22	28.0	28.7	84.8	0.297	36.4	40	13.8	1.0	10.4
23	41.50	22	28.2	28.9	84.6	0.296	36.3	40	13.6	0.7	11.2
		Average	27.7	28.4	82.8	0.290	36.4	39	14.3	1.0	9.1
		Std. Dev.	0.4	0.4	1.5	0.005	0.1	1	0.9	0.1	1.0
		Maximum	28.3	29.1	85.4	0.299	36.6	40	15.7	1.0	11.2
		@ Blow#	18	18	18	18	6	18	12	7	23

Total number of blows analyzed: 18

BL#	depth (ft)	Comments
1	40.10	Start of test on 1/26/2012 at 3:09:49 PM
23	41.50	End of test on 1/26/2012 at 3:10:25 PM

Time Summary

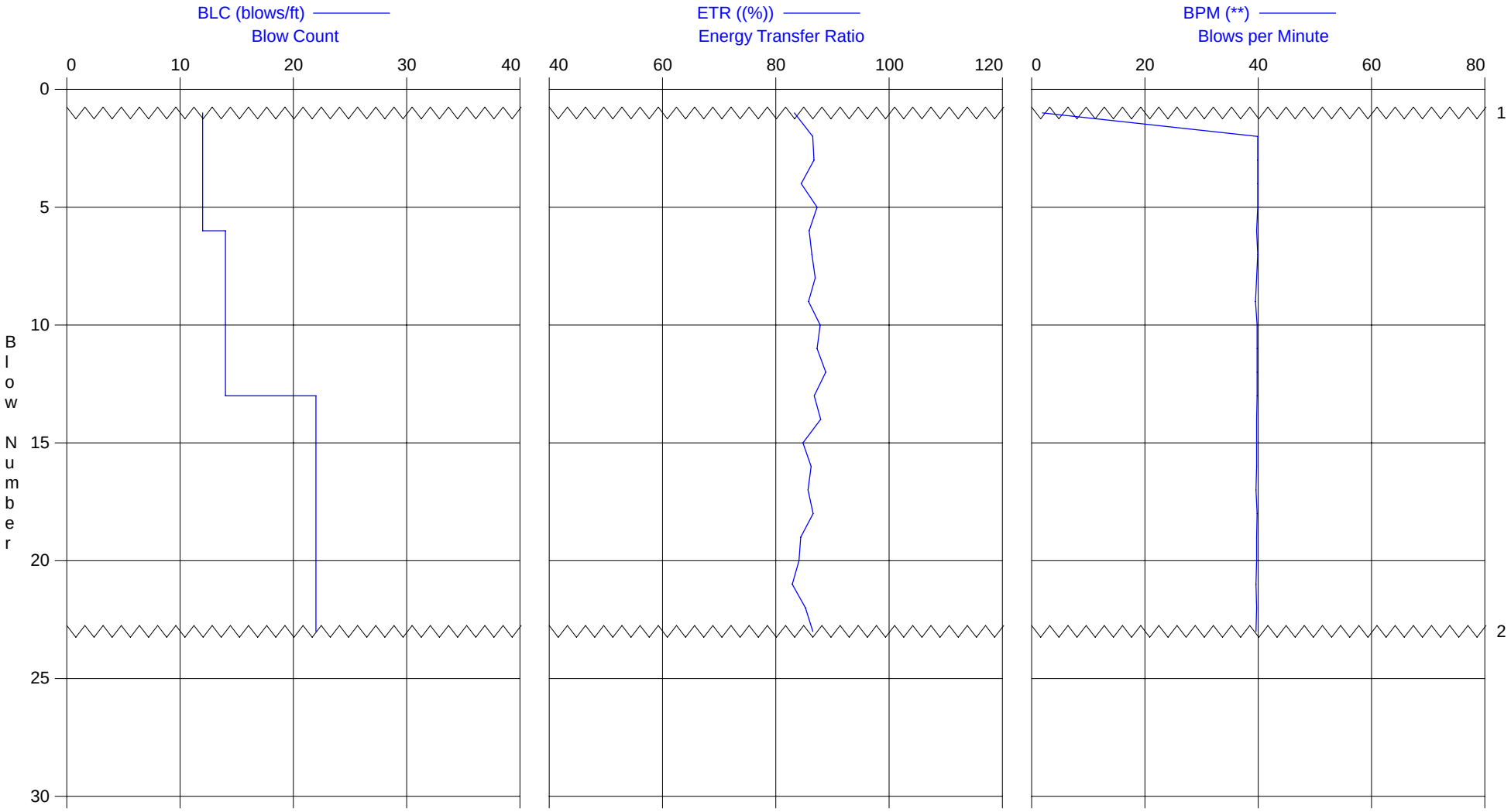
Drive 36 seconds 3:09:49 PM - 3:10:25 PM (1/26/2012) BN 1 - 23

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 30-Jan-2012

Test date: 26-Jan-2012

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-13, SPT 45FTNW-J, MOBILE HAMMER



1 - Start of test on 1/26/2012 at 3:23:15 PM

2 - End of test on 1/26/2012 at 3:23:48 PM

Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 30-Jan-2012

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-13, SPT 45FT

NW-J, MOBILE HAMMER

OP: RMDT

Test date: 26-Jan-2012

AR: 1.42 in^2
LE: 52.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSX: Max Measured Compr. Stress
CSI: Max F1 or F2 Compr. Stress
ETR: Energy Transfer Ratio
EFV: Energy of FV
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
CSB: Compression Stress at Bottom

BL#	depth	BLC	CSX	CSI	ETR	EFV	BPM	FMX	VMX	RAT	CSB
	ft	bl/ft	ksi	ksi	(%)	k-ft	**	kips	f/s	[]	ksi
6	45.57	14	28.3	29.2	85.9	0.301	39.7	40	13.8	1.0	5.6
7	45.64	14	28.3	29.2	86.4	0.302	39.9	40	13.8	0.7	4.6
8	45.71	14	27.7	28.3	86.9	0.304	39.7	39	13.7	0.9	5.4
9	45.79	14	27.5	28.0	85.8	0.300	39.5	39	13.4	1.0	4.3
10	45.86	14	28.3	29.1	87.8	0.307	39.8	40	13.7	0.7	5.8
11	45.93	14	28.5	29.5	87.3	0.305	39.8	41	13.6	1.0	6.1
12	46.00	14	28.3	29.5	88.8	0.311	39.8	40	13.6	0.9	7.6
13	46.05	22	28.4	29.2	86.8	0.304	39.8	40	13.3	1.0	6.7
14	46.09	22	27.7	28.1	87.9	0.308	39.7	39	13.8	1.0	7.9
15	46.14	22	28.2	29.0	84.8	0.297	39.7	40	12.9	0.7	7.9
16	46.18	22	27.8	28.3	86.2	0.302	39.7	39	12.9	0.7	7.3
17	46.23	22	28.0	28.6	85.7	0.300	39.6	40	12.8	0.7	7.9
18	46.27	22	28.5	29.6	86.6	0.303	39.8	41	13.3	0.7	7.5
19	46.32	22	27.8	28.3	84.4	0.295	39.7	40	12.9	0.7	9.2
20	46.36	22	28.1	28.9	84.1	0.294	39.7	40	13.0	0.7	9.9
21	46.41	22	27.1	27.6	82.9	0.290	39.6	38	12.7	1.0	8.9
22	46.46	22	28.0	28.8	85.2	0.298	39.7	40	12.9	1.0	9.4
23	46.50	22	27.8	28.5	86.5	0.303	39.6	39	13.4	1.0	9.9
		Average	28.0	28.8	86.1	0.301	39.7	40	13.3	0.9	7.3
		Std. Dev.	0.4	0.6	1.4	0.005	0.1	1	0.4	0.1	1.7
		Maximum	28.5	29.6	88.8	0.311	39.9	41	13.8	1.0	9.9
		@ Blow#	11	18	12	12	7	11	7	23	20

Total number of blows analyzed: 18

BL#	depth (ft)	Comments
1	45.17	Start of test on 1/26/2012 at 3:23:15 PM
23	46.50	End of test on 1/26/2012 at 3:23:48 PM

Time Summary

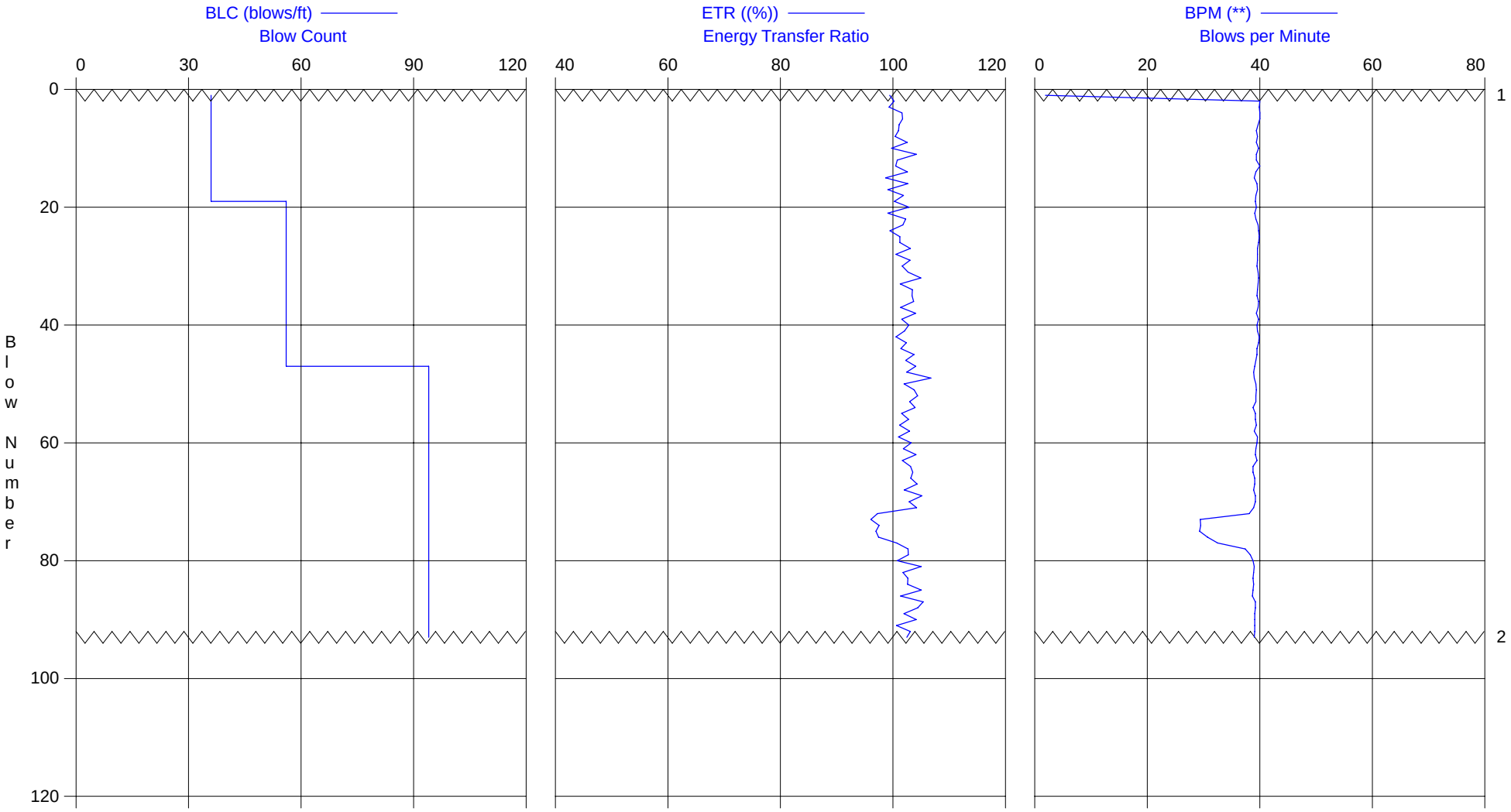
Drive 33 seconds 3:23:15 PM - 3:23:48 PM (1/26/2012) BN 1 - 23

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 30-Jan-2012

Test date: 26-Jan-2012

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-15, CALI SAMPLER 55FTNW-J, MOBILE HAMMER



1 - Start of test on 1/26/2012 at 4:20:10 PM

2 - End of test on 1/26/2012 at 4:22:32 PM

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-15, CALI SAMPLER 55FT
OP: RMDT

NW-J, MOBILE HAMMER
Test date: 26-Jan-2012

AR: 1.42 in^2
LE: 58.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSX: Max Measured Compr. Stress
CSI: Max F1 or F2 Compr. Stress
ETR: Energy Transfer Ratio
EFV: Energy of FV
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
CSB: Compression Stress at Bottom

BL#	depth	BLC	CSX	CSI	ETR	EFV	BPM	FMX	VMX	RAT	CSB
	ft	bl/ft	ksi	ksi	(%)	k-ft	**	kips	f/s	[]	ksi
19	55.52	56	32.3	33.5	100.3	0.752	39.2	46	14.2	1.0	15.0
20	55.54	56	31.9	33.4	102.9	0.771	39.4	45	14.4	1.0	15.1
21	55.55	56	32.1	32.9	99.1	0.743	39.1	46	14.0	1.0	14.5
22	55.57	56	31.9	32.9	102.3	0.767	39.3	45	14.4	1.0	15.6
23	55.59	56	31.9	32.9	101.8	0.763	39.7	45	14.5	1.0	15.3
24	55.61	56	32.1	33.1	99.5	0.746	39.8	46	14.3	1.0	15.2
25	55.63	56	31.7	33.1	101.2	0.759	39.9	45	14.6	1.0	15.7
26	55.64	56	31.6	32.6	101.2	0.759	39.8	45	14.5	1.0	15.8
27	55.66	56	31.6	32.8	103.1	0.773	39.6	45	14.7	0.8	16.1
28	55.68	56	32.1	33.4	100.5	0.754	39.6	46	14.4	0.8	15.4
29	55.70	56	31.7	32.9	103.0	0.773	39.6	45	14.9	0.8	15.7
30	55.71	56	31.9	33.0	101.6	0.762	39.5	45	14.8	0.8	15.8
31	55.73	56	32.0	33.2	102.7	0.770	39.7	45	14.8	0.8	15.5
32	55.75	56	31.7	32.7	104.9	0.787	39.8	45	15.2	0.8	15.8
33	55.77	56	32.2	33.2	101.3	0.760	39.7	46	14.9	0.8	15.6
34	55.79	56	32.1	33.2	103.4	0.776	39.6	46	15.1	1.0	15.4
35	55.80	56	31.8	32.9	103.4	0.775	39.5	45	15.0	0.8	15.7
36	55.82	56	32.2	32.9	103.7	0.778	39.8	46	15.0	0.8	16.2
37	55.84	56	32.2	33.0	101.4	0.760	39.7	46	14.9	0.8	15.0
38	55.86	56	32.2	33.2	104.0	0.780	39.4	46	15.1	0.8	15.3
39	55.88	56	32.3	33.1	101.6	0.762	39.8	46	14.7	0.8	15.2
40	55.89	56	32.2	32.9	102.8	0.771	39.5	46	14.8	1.0	15.5
41	55.91	56	32.2	33.3	102.0	0.765	39.6	46	14.9	0.8	15.5
42	55.93	56	32.1	33.0	100.6	0.754	39.9	46	14.7	0.8	15.0
43	55.95	56	31.8	32.8	102.4	0.768	39.8	45	14.7	0.8	15.5
44	55.96	56	32.1	33.2	101.4	0.760	39.5	46	14.7	1.0	15.4
45	55.98	56	32.0	33.2	103.7	0.778	39.5	45	14.9	0.8	16.1
46	56.00	56	32.0	32.9	102.3	0.767	39.3	46	14.8	0.8	15.4
47	56.01	94	31.8	33.0	104.0	0.780	39.1	45	14.8	1.0	16.2
48	56.02	94	32.2	32.9	102.4	0.768	38.9	46	14.6	1.0	15.8
49	56.03	94	32.2	33.2	106.7	0.801	39.0	46	15.1	0.8	16.6
50	56.04	94	32.3	33.5	102.0	0.765	39.3	46	14.7	1.0	15.6
51	56.05	94	32.3	33.5	103.8	0.778	39.4	46	14.7	0.8	16.1
52	56.06	94	32.5	33.5	104.4	0.783	39.3	46	14.9	0.8	16.5
53	56.07	94	32.5	33.6	103.0	0.772	39.3	46	15.0	0.8	16.4
54	56.09	94	32.5	33.3	103.9	0.780	38.8	46	14.9	0.8	16.4
55	56.10	94	32.1	33.2	101.5	0.761	39.2	46	14.5	0.8	15.9
56	56.11	94	31.8	32.5	102.8	0.771	39.2	45	14.7	0.8	16.2
57	56.12	94	32.4	33.1	101.2	0.759	39.4	46	14.6	0.8	16.3
58	56.13	94	31.9	32.2	102.9	0.772	39.0	45	14.8	1.0	16.6
59	56.14	94	32.4	33.3	101.0	0.757	39.6	46	14.5	1.0	15.9
60	56.15	94	32.2	33.3	103.2	0.774	39.5	46	14.7	0.8	16.6
61	56.16	94	32.4	33.3	101.8	0.764	39.3	46	14.5	1.0	16.2
62	56.17	94	31.9	32.8	104.1	0.781	39.2	45	14.7	0.8	16.5
63	56.18	94	32.3	33.2	101.7	0.763	39.5	46	14.7	1.0	16.2
64	56.19	94	32.4	33.8	103.1	0.773	38.8	46	14.8	0.8	17.0
65	56.20	94	32.3	33.6	103.5	0.776	38.8	46	14.7	0.8	16.6
66	56.21	94	32.4	33.4	103.2	0.774	39.1	46	14.8	1.0	16.5
67	56.22	94	32.4	33.6	104.3	0.782	39.1	46	14.8	0.8	17.2
68	56.23	94	32.8	33.4	102.0	0.765	38.9	47	14.8	0.8	16.9
69	56.25	94	33.5	34.2	105.1	0.789	39.2	48	14.8	0.8	16.4
70	56.26	94	33.1	33.9	102.9	0.772	39.2	47	14.9	0.8	15.9
71	56.27	94	32.9	33.5	104.2	0.782	38.9	47	14.9	0.8	16.8
72	56.28	94	31.9	32.8	97.2	0.729	38.1	45	14.3	1.0	16.3
73	56.29	94	31.7	32.3	96.1	0.721	29.4	45	14.4	1.0	16.4
74	56.30	94	31.9	32.4	97.5	0.731	29.5	45	14.4	1.0	16.3
75	56.31	94	31.4	32.0	97.0	0.727	29.3	45	14.4	0.8	16.4
76	56.32	94	31.6	32.2	97.4	0.731	30.7	45	14.5	1.0	17.1
77	56.33	94	32.1	32.9	100.6	0.755	32.5	46	14.8	1.0	17.3
78	56.34	94	32.8	33.1	102.7	0.770	37.4	47	14.8	1.0	16.4
79	56.35	94	32.7	33.1	102.7	0.770	38.3	46	14.7	1.0	16.7
80	56.36	94	32.5	33.1	100.8	0.756	38.8	46	14.6	1.0	16.4
81	56.37	94	32.9	33.4	105.0	0.787	39.0	47	15.1	0.8	16.8
82	56.38	94	32.7	33.1	101.8	0.763	38.9	46	14.8	1.0	16.7
83	56.39	94	32.4	33.3	102.7	0.770	38.8	46	14.7	0.8	17.1

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-15, CALI SAMPLER 55FT
OP: RMDT

NW-J, MOBILE HAMMER
Test date: 26-Jan-2012

BL#	depth	BLC	CSX	CSI	ETR	EFV	BPM	FMX	VMX	RAT	CSB
	ft	bl/ft	ksi	ksi	(%)	k-ft	**	kips	f/s	[]	ksi
84	56.40	94	32.4	33.4	102.6	0.769	38.9	46	14.8	1.0	17.0
85	56.42	94	32.7	33.1	105.0	0.788	38.8	46	14.8	0.8	17.1
86	56.43	94	32.9	33.6	101.4	0.760	38.7	47	14.5	1.0	16.5
87	56.44	94	32.7	33.1	105.4	0.790	39.2	46	15.0	1.0	16.8
88	56.45	94	32.6	33.1	104.4	0.783	39.2	46	14.9	1.0	17.4
89	56.46	94	32.6	33.0	101.9	0.765	39.1	46	14.6	1.0	16.5
90	56.47	94	32.5	33.1	104.1	0.781	39.1	46	14.9	0.8	17.2
91	56.48	94	32.3	33.0	100.6	0.755	39.1	46	14.7	1.0	16.7
92	56.49	94	32.0	32.6	103.1	0.773	39.1	45	14.9	0.8	17.3
93	56.50	94	32.4	33.1	102.5	0.769	39.0	46	14.8	1.0	17.5
		Average	32.2	33.1	102.3	0.767	38.6	46	14.7	0.9	16.2
		Std. Dev.	0.4	0.4	2.0	0.015	2.3	1	0.2	0.1	0.7
		Maximum	33.5	34.2	106.7	0.801	39.9	48	15.2	1.0	17.5
		@ Blow#	69	69	49	49	25	69	32	21	93

Total number of blows analyzed: 75

BL#	depth (ft)	Comments
1	55.03	Start of test on 1/26/2012 at 4:20:10 PM
93	56.50	End of test on 1/26/2012 at 4:22:32 PM

Time Summary

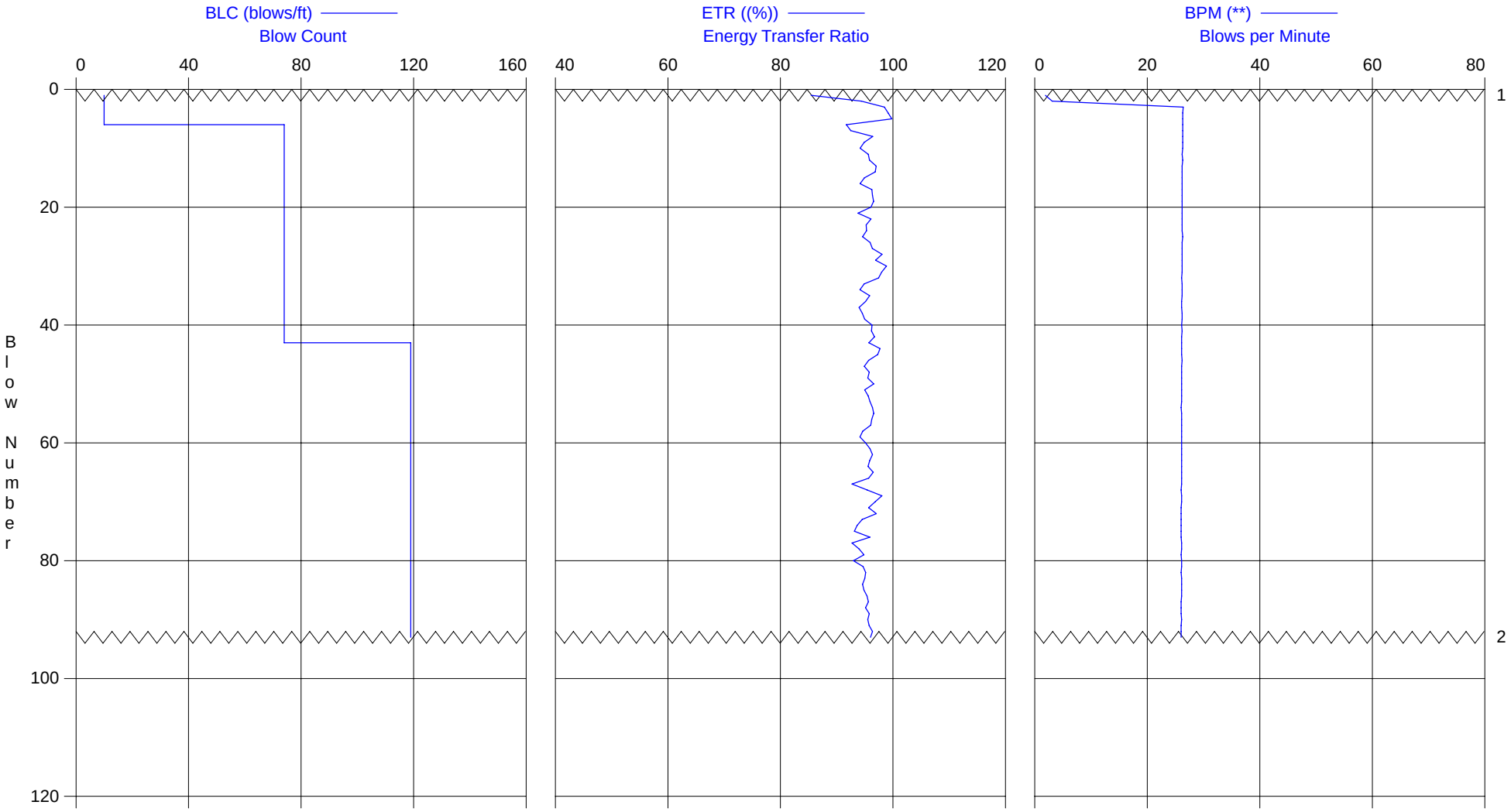
Drive	2 minutes 22 seconds	4:20:10 PM - 4:22:32 PM (1/26/2012) BN 1 - 93

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 30-Jan-2012

Test date: 27-Jan-2012

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-16, CALI SAMPLER 60FTNW-J, MOBILE HAMMER



1 - Start of test on 1/27/2012 at 8:14:21 AM

2 - End of test on 1/27/2012 at 8:18:08 AM

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-16, CALI SAMPLER 60FT
OP: RMDT

NW-J, MOBILE HAMMER
Test date: 27-Jan-2012

AR: 1.42 in^2
LE: 65.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSX: Max Measured Compr. Stress
CSI: Max F1 or F2 Compr. Stress
ETR: Energy Transfer Ratio
EFV: Energy of FV
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
CSB: Compression Stress at Bottom

BL#	depth	BLC	CSX	CSI	ETR	EFV	BPM	FMX	VMX	RAT	CSB
	ft	bl/ft	ksi	ksi	(%)	k-ft	**	kips	f/s	[]	ksi
6	60.51	74	31.1	32.3	91.7	0.688	26.3	44	14.6	1.0	14.4
7	60.53	74	30.7	31.2	92.5	0.694	26.3	44	14.7	1.0	14.7
8	60.54	74	30.8	31.6	96.4	0.723	26.3	44	14.5	1.0	13.9
9	60.55	74	30.6	31.5	94.9	0.712	26.3	43	14.8	1.0	14.9
10	60.57	74	30.6	31.4	94.2	0.706	26.3	44	14.4	1.0	14.1
11	60.58	74	30.8	31.7	95.6	0.717	26.2	44	14.5	1.0	14.2
12	60.60	74	30.9	31.8	95.8	0.719	26.3	44	14.9	1.0	14.5
13	60.61	74	31.0	32.0	97.0	0.728	26.2	44	14.8	1.0	14.6
14	60.62	74	31.1	32.4	96.8	0.726	26.2	44	14.6	1.0	14.6
15	60.64	74	31.2	32.3	94.9	0.712	26.2	44	14.7	1.1	13.7
16	60.65	74	31.2	32.5	94.1	0.706	26.2	44	14.3	1.0	14.0
17	60.66	74	31.4	32.8	96.2	0.722	26.2	45	14.2	1.1	13.7
18	60.68	74	31.4	32.6	96.3	0.723	26.2	45	14.2	1.1	13.9
19	60.69	74	31.4	32.6	96.6	0.724	26.2	45	14.2	1.1	13.4
20	60.70	74	31.4	32.5	96.1	0.721	26.2	45	14.3	1.1	13.5
21	60.72	74	31.6	32.8	93.8	0.703	26.2	45	14.3	1.1	14.0
22	60.73	74	31.7	33.2	96.1	0.721	26.2	45	14.2	1.1	13.7
23	60.74	74	31.8	33.4	95.2	0.714	26.2	45	14.4	1.1	14.1
24	60.76	74	31.5	32.9	95.3	0.715	26.2	45	14.2	1.1	14.3
25	60.77	74	31.7	33.4	94.6	0.709	26.3	45	14.4	1.1	14.1
26	60.78	74	31.4	32.9	95.9	0.720	26.2	45	14.4	1.1	15.0
27	60.80	74	31.3	33.0	96.3	0.722	26.2	44	14.4	1.1	14.3
28	60.81	74	31.2	32.7	98.0	0.735	26.2	44	14.4	1.1	15.2
29	60.82	74	31.3	32.9	96.9	0.727	26.2	44	14.4	1.1	14.2
30	60.84	74	31.3	32.9	98.8	0.741	26.2	45	14.3	1.1	14.2
31	60.85	74	30.9	32.1	98.0	0.735	26.2	44	14.3	1.1	14.3
32	60.87	74	31.3	32.8	97.4	0.731	26.1	44	14.3	1.1	15.0
33	60.88	74	31.5	32.9	94.9	0.712	26.2	45	14.4	1.1	14.9
34	60.89	74	31.5	32.9	94.1	0.706	26.2	45	14.2	1.1	14.6
35	60.91	74	31.8	33.3	95.9	0.719	26.2	45	14.2	1.1	14.7
36	60.92	74	31.6	33.1	95.1	0.713	26.1	45	14.0	1.1	14.8
37	60.93	74	31.7	33.0	94.0	0.705	26.1	45	14.3	1.1	14.8
38	60.95	74	31.6	32.9	94.6	0.709	26.2	45	14.2	1.1	14.2
39	60.96	74	31.7	32.8	95.0	0.712	26.2	45	14.3	1.1	14.8
40	60.97	74	31.7	33.0	96.3	0.722	26.1	45	14.3	1.1	14.1
41	60.99	74	31.4	32.8	96.2	0.721	26.2	45	14.4	1.1	14.2
42	61.00	74	31.1	32.4	96.7	0.725	26.1	44	14.4	1.1	14.6
43	61.01	119	31.5	32.7	95.7	0.718	26.1	45	14.6	1.1	14.4
44	61.02	119	31.4	33.1	97.7	0.733	26.1	45	14.6	1.1	14.1
45	61.03	119	31.5	33.0	97.3	0.730	26.1	45	14.4	1.1	14.1
46	61.03	119	31.5	32.7	95.7	0.718	26.2	45	14.3	1.1	13.7
47	61.04	119	31.5	33.0	94.9	0.712	26.1	45	14.3	1.1	13.6
48	61.05	119	31.4	32.9	95.8	0.718	26.1	45	14.3	1.1	14.1
49	61.06	119	31.2	32.7	95.5	0.716	26.1	44	14.5	1.1	14.2
50	61.07	119	30.9	32.5	96.6	0.724	26.1	44	14.7	1.1	13.0
51	61.08	119	31.3	32.8	95.0	0.712	26.1	44	14.4	1.0	12.5
52	61.08	119	31.3	32.7	95.6	0.717	26.1	45	14.6	1.0	12.2
53	61.09	119	31.4	33.0	95.9	0.719	26.1	45	14.6	1.0	12.6
54	61.10	119	31.5	33.0	96.4	0.723	26.0	45	14.5	1.0	12.5
55	61.11	119	31.8	33.3	96.6	0.724	26.1	45	14.3	1.0	12.2
56	61.12	119	31.3	32.8	96.2	0.722	26.1	44	14.5	1.0	12.8
57	61.13	119	31.4	33.1	96.1	0.720	26.1	45	14.5	1.0	12.5
58	61.13	119	31.4	32.6	94.6	0.710	26.1	45	14.2	1.0	13.8
59	61.14	119	31.4	32.6	94.1	0.706	26.1	45	14.4	1.0	13.7
60	61.15	119	31.3	32.9	95.1	0.713	26.1	44	14.4	1.0	13.0
61	61.16	119	31.1	32.7	95.9	0.719	26.1	44	14.7	1.0	12.8
62	61.17	119	31.4	32.8	96.4	0.723	26.1	45	14.8	1.0	12.8
63	61.18	119	31.1	32.7	95.9	0.719	26.1	44	14.6	1.0	12.4
64	61.19	119	31.6	33.3	95.6	0.717	26.1	45	14.6	1.0	12.9
65	61.19	119	31.5	33.1	96.5	0.724	26.1	45	14.7	1.0	13.0
66	61.20	119	31.3	32.8	95.7	0.717	26.1	44	14.5	1.0	12.2
67	61.21	119	31.3	32.9	92.7	0.695	26.1	44	14.8	1.0	12.7
68	61.22	119	31.1	32.7	95.4	0.716	26.0	44	14.8	1.0	12.3
69	61.23	119	30.9	32.3	98.0	0.735	26.1	44	14.6	1.0	12.4
70	61.24	119	31.2	32.8	96.8	0.726	26.1	44	14.8	1.0	12.2

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-16, CALI SAMPLER 60FT
OP: RMDT

NW-J, MOBILE HAMMER
Test date: 27-Jan-2012

BL#	depth	BLC	CSX	CSI	ETR	EFV	BPM	FMX	VMX	RAT	CSB
	ft	bl/ft	ksi	ksi	(%)	k-ft	**	kips	f/s	[]	ksi
71	61.24	119	31.4	32.6	95.7	0.717	26.0	45	14.6	1.0	11.6
72	61.25	119	31.1	32.8	97.1	0.728	26.0	44	14.6	1.0	11.6
73	61.26	119	31.2	32.9	94.5	0.709	26.0	44	14.5	1.0	12.3
74	61.27	119	31.2	32.5	93.6	0.702	26.0	44	14.9	1.0	13.0
75	61.28	119	30.9	32.3	93.1	0.699	26.0	44	14.8	1.0	12.5
76	61.29	119	31.2	32.7	95.9	0.719	26.0	44	14.9	1.0	11.9
77	61.29	119	31.3	33.0	92.7	0.695	26.1	44	14.6	1.0	12.4
78	61.30	119	31.1	32.5	94.0	0.705	26.1	44	14.8	1.0	12.1
79	61.31	119	31.4	32.8	94.8	0.711	26.0	45	14.6	1.0	12.5
80	61.32	119	31.3	32.8	93.0	0.697	26.1	44	14.6	1.0	12.4
81	61.33	119	31.2	32.7	94.7	0.710	26.1	44	14.7	1.0	12.0
82	61.34	119	31.3	32.8	95.1	0.714	26.0	44	14.4	1.0	12.4
83	61.34	119	31.4	33.0	95.0	0.712	26.1	45	14.7	1.0	12.5
84	61.35	119	31.2	32.8	94.6	0.709	26.1	44	14.9	1.0	13.0
85	61.36	119	31.4	33.0	94.8	0.711	26.1	45	14.6	1.0	12.8
86	61.37	119	31.4	32.9	95.4	0.715	26.1	45	14.6	1.0	12.4
87	61.38	119	31.3	33.0	95.6	0.717	26.0	44	14.7	1.0	12.8
88	61.39	119	31.0	32.4	95.1	0.713	26.0	44	14.6	1.0	12.3
89	61.40	119	30.8	31.8	95.8	0.718	26.0	44	14.8	1.0	13.2
90	61.40	119	31.2	32.7	95.5	0.716	26.1	44	14.7	1.0	12.2
91	61.41	119	31.0	32.1	95.8	0.718	26.0	44	14.6	1.0	12.5
92	61.42	119	31.1	32.5	96.4	0.723	26.0	44	14.8	1.0	12.3
93	61.43	119	30.9	32.6	96.0	0.720	26.0	44	14.8	1.0	12.2
		Average	31.3	32.7	95.5	0.716	26.1	44	14.5	1.1	13.4
		Std. Dev.	0.3	0.4	1.3	0.010	0.1	0	0.2	0.0	1.0
		Maximum	31.8	33.4	98.8	0.741	26.3	45	14.9	1.1	15.2
		@ Blow#	35	23	30	30	6	35	76	50	28

Total number of blows analyzed: 88

BL#	depth (ft)	Comments
1	60.10	Start of test on 1/27/2012 at 8:14:21 AM
93	61.43	End of test on 1/27/2012 at 8:18:08 AM

Time Summary

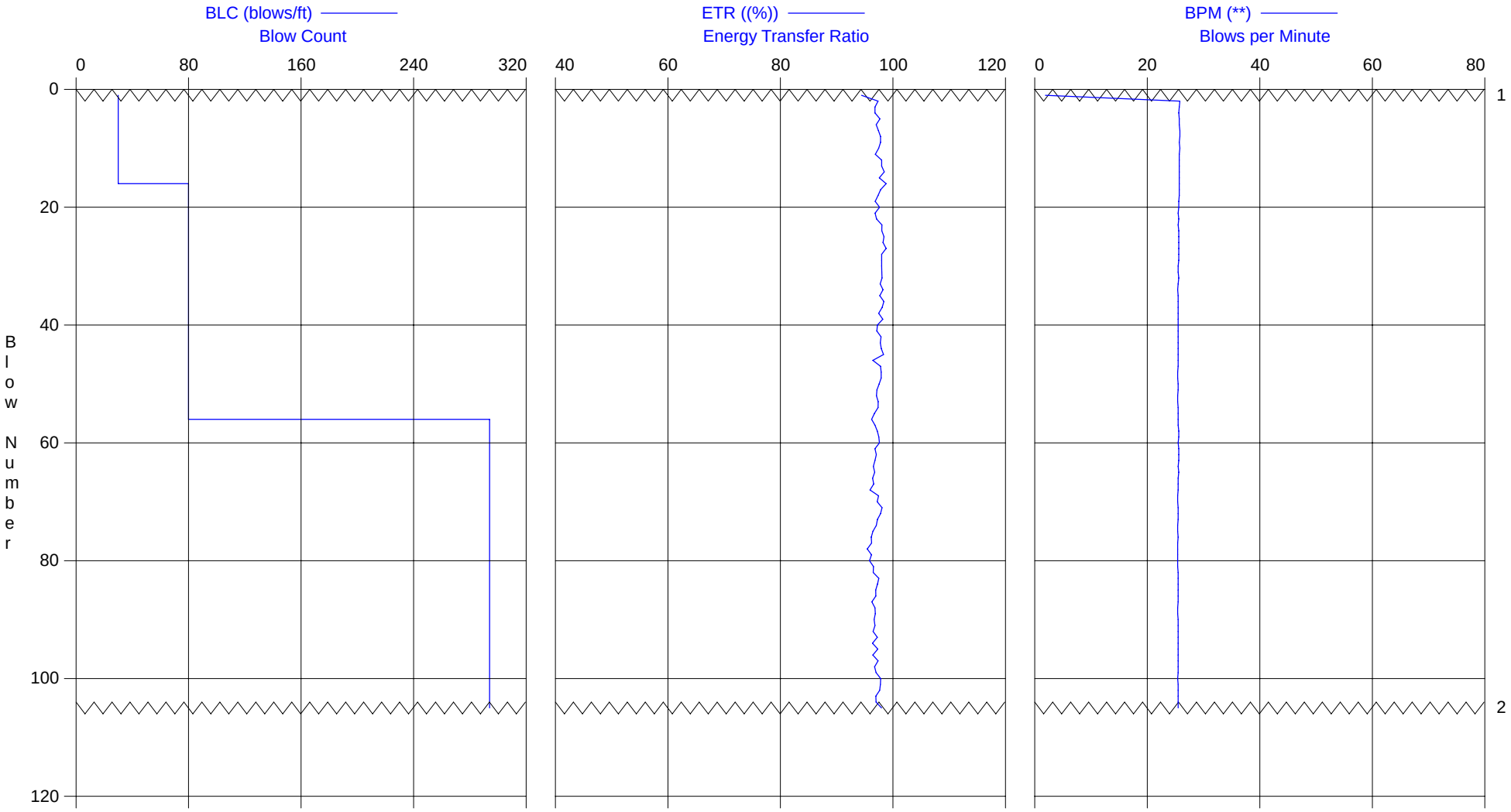
Drive	3 minutes 47 seconds	8:14:21 AM - 8:18:08 AM (1/27/2012) BN 1 - 93

Robert Miner Dynamic Testing, Inc. - Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 30-Jan-2012

Test date: 27-Jan-2012

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-17, CALI SAMPLER 65FTNW-J, MOBILE HAMMER



1 - Start of test on 1/27/2012 at 8:40:34 AM

2 - End of test on 1/27/2012 at 8:44:38 AM

Robert Miner Dynamic Testing, Inc.
Case Method Results

PDIPLOT Ver. 2010.2 - Printed: 30-Jan-2012

MAJOR DRILLING, RIVERBEND LANDFILL - 01A-17, CALI SAMPLER 65FT

NW-J, MOBILE HAMMER

OP: RMDT

Test date: 27-Jan-2012

AR: 1.42 in^2
LE: 69.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSX: Max Measured Compr. Stress
CSI: Max F1 or F2 Compr. Stress
ETR: Energy Transfer Ratio
EFV: Energy of FV
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
CSB: Compression Stress at Bottom

BL#	depth	BLC	CSX	CSI	ETR	EFV	BPM	FMX	VMX	RAT	CSB
	ft	bl/ft	ksi	ksi	(%)	k-ft	**	kips	f/s	[]	ksi
16	64.51	80	31.8	32.4	98.8	0.741	25.7	45	13.7	0.8	19.4
18	64.54	80	31.7	32.3	97.3	0.730	25.7	45	13.8	0.8	18.1
20	64.56	80	31.6	32.3	97.6	0.732	25.6	45	13.9	0.8	19.1
22	64.59	80	31.5	31.7	97.1	0.728	25.6	45	13.8	0.8	19.3
24	64.61	80	31.7	32.4	98.0	0.735	25.6	45	13.9	0.8	19.5
26	64.64	80	31.1	31.7	98.2	0.737	25.6	44	14.0	0.8	19.3
28	64.66	80	31.8	32.7	98.0	0.735	25.6	45	13.9	0.8	19.7
30	64.69	80	32.0	32.9	98.0	0.735	25.5	45	14.0	0.8	20.7
32	64.71	80	31.8	32.5	98.1	0.735	25.6	45	14.1	0.8	20.4
34	64.74	80	31.9	32.3	98.2	0.737	25.4	45	14.1	0.8	18.8
36	64.76	80	31.8	32.2	98.4	0.738	25.5	45	14.0	0.8	20.3
38	64.79	80	31.7	32.4	97.5	0.731	25.5	45	14.1	0.8	19.8
40	64.81	80	31.7	31.9	97.2	0.729	25.5	45	14.0	0.8	20.7
42	64.84	80	31.6	32.5	97.9	0.734	25.5	45	14.2	0.8	20.6
44	64.86	80	31.6	33.3	97.9	0.734	25.5	45	14.1	0.8	18.5
46	64.89	80	31.4	32.6	96.4	0.723	25.5	45	14.0	0.8	18.8
48	64.91	80	32.0	32.9	97.9	0.734	25.4	45	14.4	0.8	18.6
50	64.94	80	31.5	31.9	97.5	0.732	25.5	45	14.2	0.8	18.9
52	64.96	80	31.3	32.1	97.1	0.728	25.4	45	14.2	0.8	18.9
54	64.99	80	32.3	33.0	97.3	0.730	25.5	46	14.6	0.8	18.2
56	65.00	294	31.7	32.1	96.2	0.722	25.5	45	14.4	0.8	18.1
58	65.01	294	32.7	33.5	97.2	0.729	25.6	46	14.7	0.8	18.1
60	65.02	294	31.4	32.1	97.6	0.732	25.5	45	14.4	0.8	19.1
62	65.02	294	32.2	32.6	97.0	0.728	25.6	46	14.3	0.8	20.8
64	65.03	294	32.3	32.9	96.5	0.724	25.5	46	14.6	0.8	19.1
66	65.04	294	32.6	33.4	96.4	0.723	25.5	46	14.7	0.8	18.4
68	65.04	294	32.5	33.5	95.9	0.720	25.5	46	14.4	0.8	18.6
70	65.05	294	32.6	32.9	97.2	0.729	25.4	46	14.6	0.8	19.6
72	65.06	294	31.9	32.5	97.8	0.733	25.5	45	14.6	0.8	20.5
74	65.07	294	32.0	32.8	97.0	0.728	25.4	45	14.5	0.8	18.1
76	65.07	294	32.4	32.6	96.1	0.721	25.5	46	14.6	0.8	19.3
78	65.08	294	32.5	32.6	95.4	0.716	25.4	46	14.6	0.8	19.6
80	65.09	294	32.0	32.4	95.8	0.719	25.4	45	14.4	0.8	19.5
82	65.09	294	32.2	32.4	96.5	0.724	25.5	46	14.5	0.8	19.6
84	65.10	294	32.1	32.4	97.2	0.729	25.5	46	14.4	0.8	20.3
86	65.11	294	32.1	32.3	97.0	0.727	25.5	46	14.4	0.8	20.3
88	65.11	294	31.8	32.2	96.8	0.726	25.4	45	14.5	0.8	21.1
90	65.12	294	31.8	32.1	96.6	0.725	25.5	45	14.7	0.8	22.3
92	65.13	294	31.9	32.5	96.5	0.723	25.5	45	14.5	0.8	19.8
94	65.13	294	31.9	32.4	96.4	0.723	25.5	45	14.5	0.8	21.7
96	65.14	294	31.7	32.4	96.4	0.723	25.5	45	14.5	0.8	21.6
98	65.15	294	31.6	32.1	96.7	0.725	25.5	45	14.6	0.8	22.2
100	65.15	294	31.6	32.1	97.8	0.734	25.4	45	14.5	0.8	22.6
102	65.16	294	31.7	32.2	97.6	0.732	25.5	45	14.4	0.8	22.8
104	65.17	294	32.0	32.4	97.0	0.727	25.5	45	14.5	0.8	23.0
		Average	31.9	32.5	97.3	0.729	25.5	45	14.3	0.8	19.8
		Std. Dev.	0.3	0.4	0.7	0.005	0.1	0	0.3	0.0	1.3
		Maximum	32.7	33.5	98.8	0.741	25.7	46	14.8	0.8	23.0
		@ Blow#	58	58	16	16	16	58	71	46	104

Total number of blows analyzed: 90

BL#	depth (ft)	Comments
1	64.03	Start of test on 1/27/2012 at 8:40:34 AM
105	65.17	End of test on 1/27/2012 at 8:44:38 AM

Time Summary

Drive 4 minutes 4 seconds 8:40:34 AM - 8:44:38 AM (1/27/2012) BN 1 - 105

APPENDIX G

2013 Boring Logs

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

PROJECT 2013 Investigation
PROJECT LOCATION Riverbend Landfill
PROJECT NUMBER WG1772

KEY SHEET - CLASSIFICATIONS AND SYMBOLS

GS FORM: 01-KEY/SYMBOLS

EMPIRICAL CORRELATIONS WITH STANDARD PENETRATION RESISTANCE N VALUES *

	N VALUE * (BLOWS/FT)	CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS/SQ FT)
FINE GRAINED SOILS	0 - 2	VERY SOFT	<0.25
	3 - 4	SOFT	0.25 - 0.50
	5 - 8	FIRM	0.50 - 1.00
	9 - 15	STIFF	1.00 - 2.00
	16 - 30	VERY STIFF	2.00 - 4.00
	31 - 50	HARD	>4.00
	>50	VERY HARD	

	N VALUE * (BLOWS/FT)	RELATIVE DENSITY
COARSE GRAINED SOILS	0 - 4	VERY LOOSE
	5 - 10	LOOSE
	11 - 30	MEDIUM DENSE
	31 - 50	DENSE
	>50	VERY DENSE

* ASTM D 1586; NUMBER OF BLOWS OF 140 POUND HAMMER FALLING 30 INCHES TO DRIVE A 2 IN. O.D., 1.4 IN. I.D. SAMPLER ONE FOOT.

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

MAJOR DIVISIONS			SYMBOLS	DESCRIPTIONS
COARSE GRAINED SOILS (MORE THAN 50% OF MATERIAL COARSER THAN NO. 200 SIEVE SIZE)	GRAVEL AND GRAVELLY SOILS (MORE THAN 50% OF COARSE FRACTION RETAINED ON NO.4 SIEVE)	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS (MORE THAN 50% OF COARSE FRACTION PASSING NO.4 SIEVE)	CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS (MORE THAN 50% OF MATERIAL FINER THAN NO. 200 SIEVE SIZE)	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENT

NOTE: DUAL SYMBOLS USED FOR BORDERLINE CLASSIFICATIONS

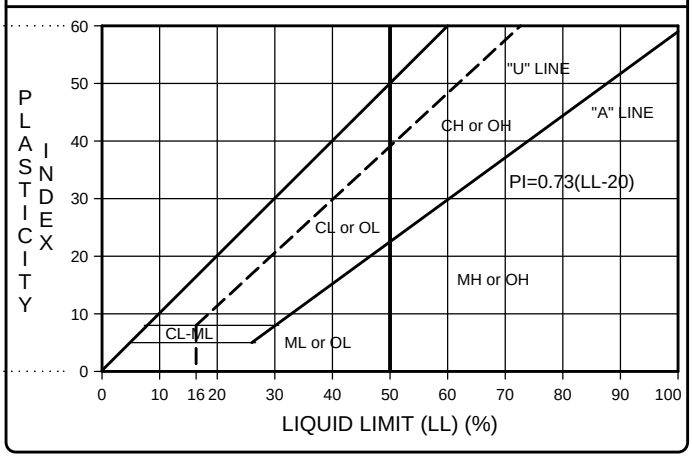
PARTICLE SIZE IDENTIFICATION

USCS (SOILS ONLY) *		SEDIMENTARY (ROCK ONLY)	
BOULDER	>300 mm	BOULDER	>256 mm
COBBLE	75 - 300 mm	COBBLE	64 - 256 mm
GRAVEL: COARSE	20 - 75 mm	PEBBLE	4 - 64 mm
GRAVEL: FINE	4.75 - 20 mm	GRANULE	2 - 4 mm
		SAND: V. COARSE	1 - 2 mm
SAND: COARSE	2 - 4.75 mm	SAND: COARSE	0.5 - 1 mm
SAND: MEDIUM	0.42 - 2 mm	SAND: MEDIUM	0.25 - 0.5 mm
SAND: FINE	0.074 - 0.42 mm	SAND: FINE	0.125 - 0.25 mm
		SAND: V. FINE	0.063 - 0.125 mm
SILT/CLAY	<0.074 mm	SILT	0.004 - 0.063 mm
		CLAY	<0.004 mm

* WELL GRADED - HAVING WIDE RANGE OF GRAIN SIZES AND APPRECIABLE AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES
* POORLY GRADED - PREDOMINANTLY ONE GRAIN SIZE, OR HAVING A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING

PERCENTAGE OF PARTICLE TYPE IN DECREASING ORDER OF PARTICLE SIZE (GRAVEL,SAND,FINES)

PLASTICITY CHART



OTHER MATERIAL SYMBOLS

- Conglomerate/ Agglomerate
- Sandstone
- Silty Sandstone
- Clayey Sandstone
- Sandy Siltstone
- Siltstone
- Claystone
- Clayey Siltstone/ Silty Claystone
- Sandy Claystone
- Granitic/Intrusive
- Volcanic/Extrusive
- Metamorphic
- Limestone
- Dolomite
- Glacial Till
- Landslide Debris
- Marker Bed
- Artificial Fill
- Refuse
- Concrete/Asphalt

WELL SYMBOLS

- CONCRETE
- GROUT
- BENTONITE SEAL
- TRANSITION SAND
- SAND/GRAVEL PACK
- NATIVE/SLUFF
- CENTRALIZER

SAMPLE TYPE AND OTHER SYMBOLS

- BULK SAMPLE
- STANDARD PENETRATION TEST
- MODIFIED CALIFORNIA SAMPLE
- CORE SAMPLE
- SHELBY TUBE
- DRIVE SAMPLE

- Water Level at Time Drilling, or as Shown
- Static Water Level
- Pump Inlet
- Loss of Drilling Fluid
- MSL: Mean Sea Level
- AGS: Above Ground Surface
- BGS: Below Ground Surface
- BTOC: Below Top of Casing
- HSA: Hollow Stem Auger

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-01 **SHEET** 1 **OF** 4
START DATE 8/9/2013
FINISH DATE 8/10/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 141.7 ft msl
DATUM Local
TOTAL DEPTH 99 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Surface: Brown grass and vegetation grubbed just off access road									13:30	
			140								
5	CLAY fill (CL), light brown, moist, 0-5%, fine sand, medium to high plasticity, medium stiff			1-1 C		2 3 4	7	50			
			135								Switch to 5" Wing Bit
10	Silty CLAY fill (CL), dark brown, moist, 5-10%, fine sand, medium to high plasticity, medium stiff			1-2				100			
			130								Pocket pen: 1.2 tsf
	Same but softer			1-3		0 2 2	4	100			
15	Same			1-4		1 3 2	5				
	Silty CLAY (CL), dark gray, moist, <5% fine sand, medium to high plasticity, firm		125								Cuttings: Clay, very dark gray to black
20	Silty CLAY (CL), dark brown to brown-gray with oxide mottling, moist, 5-10% fine sand, medium to high plasticity, stiff			1-5				100			
			120								Pocket pen: 2.3 tsf
				1-6		3 5 5	10	100			
25	Silty CLAY (CL), mottled dark brown and gray, moist, 5-10% fine sand, low to medium plasticity, stiff			1-7		3 5 6	11	70		14:45	
			115								Switch to 4 7/8" tricone
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2499.96
EASTING: 4488.65
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani

NOTES: Sunny and hot, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-01 **SHEET** 2 **OF** 4
START DATE 8/9/2013
FINISH DATE 8/10/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 141.7 ft msl
DATUM Local
TOTAL DEPTH 99 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Clayey SILT (ML), mottled dark brown and gray, moist to wet, 5-10% fine sand, low to medium plasticity, stiff		110	1-8							Pocket pen: 1.0 tsf
	Sandy SILT (ML), dark brown, wet, 10-15% fine sand, low plasticity, stiff			1-9		4 5 5	10	100			
35	Silty CLAY (CH), dark gray mottled with black and brown, wet, medium to high plasticity, firm		105	1-10		3 3 5	8	100		16:15	
40	Silty CLAY (CH), blue-gray, wet, 10-15% fine sand, low to medium plasticity, firm			1-11				100		16:30	Pocket pen overload. End 8/9/13
	Sandy GRAVEL with silt (GW), reddish brown with dark gray mottling, wet, 1/2-inch minus subrounded gravel, 20-30% fine to coarse sand (f:m:c 20:40:40), 10-15% silty fines, dense		100	1-12		12 21 24	45	100		7:40	Begin 8/10/13
45	Same, but with 1" minus gravel		95	1-13 B C		15 40 50/3.5"	50+	100			
50	Same, but with 1" minus gravel		90	1-14		27 47 50/4"	50+	100			Cobbles Softened up a little bit
55	Silty SAND (SM), dark gray-blue, wet, 60-70% fine to medium sand (f:m:c 90:10:0), trace 1/4" minus subrounded gravel, 30-40% silty fines, dense		85	1-15 B C		14 12 22	34	100			
60											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2499.96
EASTING: 4488.65
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani

NOTES: Sunny and hot, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-01 **SHEET** 3 **OF** 4
START DATE 8/9/2013
FINISH DATE 8/10/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 141.7 ft msl
DATUM Local
TOTAL DEPTH 99 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Sandy GRAVEL (GW), very dark gray with blue tint, wet, 3/4" minus subrounded gravel, 20-30% fine to coarse sand (f:m:c 10:40:50), 10-15% silty fines, dense to very dense		80	1-16		38 50/5.5"	50+	100			
65	Sandy GRAVEL with silt (GW), very dark gray to black, wet, 3/4" minus subrounded gravel, 20-30% fine to coarse sand (f:m:c 10:40:50), 20-25% silty fines, dense		75	1-17		16 22 21	43	100		09:30	
											Transition to silty sand
70	Silty SAND (SM), dark gray-blue, wet, fine to medium coarse sand (f:m:c 80:10:10), 15-25% silty fines, 20% gravel, medium dense to dense			1-18		17 14 16	30	100			
	Sandy GRAVEL with silt (GW), very dark gray to black, wet, 1" minus subrounded gravel, 20-30% sand (f:m:c 20:40:40), 20% silty fines, very dense		70	1-19 C		41 50/5.5"	50+	100			
75	Sandy GRAVEL (GW), very dark gray to olive, wet, 1" minus subrounded, 10-20% fine to medium coarse sand (f:m:c 30:30:40), 10% silty fines, very dense		65	1-20		38 50/4.5"	50+	100		10:30	
80	Sandy GRAVEL with silt (GW), very dark gray to black, wet, 1" minus subrounded gravel, 20-30% fine to coarse sand (f:m:c 20:30:50), 10% silty fines, dense		60	1-21		23 22 25	47	100			
85	Interbedded layers of silt and gravel		55	1-22 B C		8 18 24	42	100			
90											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2499.96
EASTING: 4488.65
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani

NOTES: Sunny and hot, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-01 **SHEET** 4 **OF** 4
START DATE 8/9/2013
FINISH DATE 8/10/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 141.7 ft msl
DATUM Local
TOTAL DEPTH 99 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	SILT (ML), olive with blue-green tint, moist, low plasticity, very stiff to hard		50	1-23		10 14 17	31				
95	SILTSTONE, olive with blue-green tint, moist, very fine grained, highly weathered (W4), extremely weak (R0), moderately soft (H4), brittle		45	1-24		48 50/2.5"	50+				
	End drilling at 99 ft bgs. 8/10 at 12:30. Boring backfilled by drilling contractor.										
100			40								
105			35								
110			30								
115			25								
120											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2499.96
EASTING: 4488.65
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani

NOTES: Sunny and hot, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-02 **SHEET** 1 **OF** 3
START DATE 8/10/2013
FINISH DATE 8/12/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 148.3 ft msl
DATUM Local
TOTAL DEPTH 73.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Surface: 0.5' of road base GRAVEL (GW), light gray, dry, 3" minus subrounded gravel, 10-20% nonplastic fines									14:30	8/10/13 - 2' with 4 1/4" HSA
										7:45	8/12/13
			145								
5	SILT fill (ML), very dark brown to black, moist, 0-5% fine sand, medium to high plasticity, stiff			2-1		4 4 4	8	100			
			140								
10	SILT fill (ML), very dark brown to gray, moist, 0-5% fine sand, medium to high plasticity, very stiff			2-2				87			
	Same as above		135	2-3		4 9 10	19	100			Pocket pen: 4.5 tsf
15	SILT fill (ML), dark brown, moist, 5-10% fine sand, low plasticity, very stiff			2-4 C		5 9 12	21	100			
			130								
20	Clayey SILT (ML), dark brown, moist, 5-10% fine sand, low plastcity, stiff to very stiff			2-5				85			
	Same as above		125	2-6		3 4 4	8	100		9:30	Pocket pen: 3.8 tsf
25	Clayey silt (ML), dark brown mottled with gray, moist, 5-10% fine sand, low to medium plasticity, stiff			2-7		4 5 7	12	90			
			120								
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2394.63
EASTING: 4788.02
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and hot, 60s in the morning, high temperature in the 80s, humid, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-02 **SHEET** 2 **OF** 3
START DATE 8/10/2013
FINISH DATE 8/12/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 148.3 ft msl
DATUM Local
TOTAL DEPTH 73.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Silty CLAY (CH), mottled dark brown and dark gray, moist, medium to high plasticity, stiff			2-8				67			
	Same as above		115	2-9		4 5 7	12	100			Pocket pen: 1.7 tsf
35	Same as above			2-10 C		3 5 8	13	67			
			110								
40	Silty CLAY (CH), dark gray with brown mottling, moist, 5-10% fine sand, medium to high plasticity, firm			2-11				100		10:55	
	Same as above		105	2-12		0 3 4	7	100			Pocket pen: 1.3 tsf
45	Silty CLAY (CH), dark gray with brown and black mottling, moist, 10-15% fine sand, medium to high plasticity, stiff			2-13 C		2 4 5	9	80			
			100								
50	Sandy SILT (ML), dark gray with oxide mottling, moist to wet, 30-40% fine sand, firm, very stiff			2-14				100			
	Same as above		95	2-15		2 2 3	5	100			Pocket pen: 2.1 tsf Switch to 4 7/8" tricone
55	Sandy GRAVEL with silt (GW), dark gray to reddish brown, moist to wet, 20-25% fine to coarse sand (f:m:c 30:40:30), 20-25% silty fines, very dense		90	2-16 B C		14 21 53	50+	70			
60											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2394.63
EASTING: 4788.02
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and hot, 60s in the morning, high temperature in the 80s, humid, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-02 **SHEET** 3 **OF** 3
START DATE 8/10/2013
FINISH DATE 8/12/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 148.3 ft msl
DATUM Local
TOTAL DEPTH 73.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Sandy GRAVEL (GW), reddish brown with black gravels, wet, 1/2" minus subrounded, 20-30% fine to coarse sand (f:m:c 20:40:40), 10-15% silty fines, very dense			2-17		42 50/4.7"	50+	100		13:40	
			85								
65	Same as above			2-18 B C		23 23 50	50+	100			
			80								
70	SILTSTONE, Olive w/blue-green tint and black speckling, highly weathered (W4), extremely weak (R0), moderately hard (H5), brittle			2-19		50/1"	50+	100		14:30	
			75								
	End drilling at 73.5 ft bgs. 8/12/13 at 14:30. Boring backfilled by drilling contractor.										
75											
			70								
80											
			65								
85											
			60								
90											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2394.63
EASTING: 4788.02
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and hot, 60s in the morning, high temperature in the 80s, humid, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-03 **SHEET** 1 **OF** 3
START DATE 8/6/2013
FINISH DATE 8/7/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 145.5 ft msl
DATUM Local
TOTAL DEPTH 72.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Road base GRAVEL (GW), light brown, dry to moist, 3" minus subrounded gravel, 20% nonplastic fines		145						0 0 0 20.9	15:30	8/6/13 - 2' with 4 1/4" HSA
										7:40	8/7/13
5	CLAY fill (CL), dark brown mottled with black, moist, medium to high plasticity, soft to firm		140	3-1		1 2 2	4	72			
10	CLAY fill (CL), dark gray with brown mottling, moist, medium to high plasticity, soft to firm		135	3-2		0 2 3	5	83			
15	Silty CLAY fill (CL), mottled dark gray and brown, moist, medium to high plasticity, soft to firm		130	3-3				70			
	Same as above			3-4		2 2 3	5	100			Pocket pen: 3.5 tsf
20	Clayey SILT (MH), dark gray mottled with brown, moist, medium to high plasticity, soft to firm		125	3-5		OST		100			
	Stiff			3-6		0 2 3	5	100	0 0 0 20.7	9:00	Pocket pen: 1.7 tsf
25	Silty CLAY (CL-ML), dark gray with brown mottling, moist, medium plasticity, soft to firm		120	3-7 C		2 2 3	5	50			
											Switch to 4 7/8" bit
30											Driller notes stiffening

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2198.3
EASTING: 4926.63
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-03 **SHEET** 2 **OF** 3
START DATE 8/6/2013
FINISH DATE 8/7/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 145.5 ft msl
DATUM Local
TOTAL DEPTH 72.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Silty CLAY (CH), dark brown with gray mottling, moist, medium to high plasticity, firm to stiff		115	3-8				100			Pocket pen: 3.0 tsf Switch to 5" bit
35	Same as above		110	3-9 B C		2 3 5	8	75	0 0 0 22.0	10:00	
40	Silty CLAY (CH), mottled dark brown and gray, moist, 5-10% fine sand, low to medium plasticity, firm to stiff		105	3-10				100			
	Same as above			3-11		2 3 5	8	100			Pocket pen: 1.7 tsf
45	Silty CLAY (CH), dark gray with brown mottling, moist to wet, 5-10% fine sand, medium to high plasticity, firm to stiff		100	3-12		0 3 5	8	100	0 0 0 22.7	10:30	
50	Same as above		95	3-13 B C		4 8 8	16	70			
	Sandy CLAY (CL), black with brown mottling, wet, 30% fine sand, trace gravel, loose to medium dense			3-14		4 5 6	11	100			
	Silty SAND (SM), bluish gray, 50-60% fine sand, 40-50% fines, medium dense			3-15		2 6 7	13	75			Switch to 4 7/8" bit
55	Sandy GRAVEL (GW), black with gray-blue tint, wet, 1/4"-2" subrounded gravel, 30-40% fine sand (f:m:c 70:20:10), 10-15% silty fines, very dense		90	3-16		3 26 48	50+	100			Driller notes 4-5" cobbles hit
60											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2198.3
EASTING: 4926.63
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-03 **SHEET** 3 **OF** 3
START DATE 8/6/2013
FINISH DATE 8/7/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 145.5 ft msl
DATUM Local
TOTAL DEPTH 72.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Sandy GRAVEL (GW), dark gray to reddish brown, wet, 1/4-1" subrounded gravel, 30-40% fine to medium coarse sand (f:m:c 60:30:10), 5-10% silty fines, dense to very dense		85	3-17		25 34 50/5.5"	50+	100			Driller notes rockier
65	Sandy GRAVEL (GW), dark gray to reddish yellow, wet, 1/8-3/4" subrounded gravel, 30-40% fine to medium coarse sand (f:m:c 50:40:10), 10% silty fines, dense		80	3-18		15 21 21	42	100		12:15	
	SILTSTONE, very fined grained, highly weathered (W4), extremely weak (R0), moderately hard (H5), platey, black with olive tint										
70			75	3-19		50/3"	50+	100			
	End drilling at 72.5 ft bgs. 8/7/2013 at 13:30. Boring backfilled by drilling contractor.										
75			70								
80			65								
85			60								
90											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2198.3
EASTING: 4926.63
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-04 **SHEET** 1 **OF** 3
START DATE 8/6/2013
FINISH DATE 8/6/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 144.1 ft msl
DATUM Local
TOTAL DEPTH 68.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Road base GRAVEL (GW), light brown and gray, dry to moist, 3" minus subrounded gravel, 20% fines, nonplastic								0 0 0 20.5	9:10	2' with 4 1/4" HSA
			140								
5	CLAY fill (CH), dark gray with brown mottling, moist, 5% fine sand, medium to high plasticity, soft			4-1				80			
	Same as above			4-2		0 0 3	3	67			Pocket pen: 1.0 tsf
			135								Driller notes stiffening: 9 to 10 ft bgs
10	CLAY fill (CH), dark brown with gray mottling, moist, medium to high plasticity, firm to stiff			4-3				100			Pocket pen: 2.1 tsf
			130						0 0 0 20.7	9:53	
15	CLAY fill (CH), dark brown with gray mottling, moist, medium to high plasticity, stiff			4-4 C		2 5 7	12	45			
			125								
20	CLAY fill (CH), dark gray with brown mottling, moist, medium to high plasticity, stiff			4-5 C		3 6 7	13	40			
			120								
25	Elastic SILT (MH), dark gray with brown mottling, moist, medium plasticity, very stiff			4-6				56			
	Same as above			4-7		2 3 3	6	100			Pocket pen: 2.4 tsf Switch to 4 7/8" bit
			115								
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2064.43
EASTING: 5172.41
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and hot, 60s in the morning, high temperature in the 90s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-04 **SHEET** 2 **OF** 3
START DATE 8/6/2013
FINISH DATE 8/6/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 144.1 ft msl
DATUM Local
TOTAL DEPTH 68.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Same as above			4-8				20			Sample not taken
			110						0 0 0 20.9	11:02	
35	Silty CLAY (CH), dark gray with brown mottling, moist, 5% fine sand, high plasticity, medium stiff			4-9				50			
	Same as above			4-10		0 0 3	3	100			Pocket pen: 0.8 tsf
			105								
40	Clayey SILT (MH), light to dark brown, moist to wet, 5-10% fine sand, high plasticity, medium stiff			4-11 C		1 2 3	5	60			
			100								
45	Clayey SILT (MH), dark gray, wet to moist, 5% fine sand, high plasticity, stiff			4-12		OST					
				4-13		0 0 1	1	100			Pocket pen: 1.5 tsf
			95								
50	Silty SAND (SM), black, wet, 10% silty nonplastic fines, fine to medium coarse sand, (f:m:c 20:60:20), medium dense			4-14 B C		4 5 6	11	75			
			90								
55	Silty SAND with gravel (SM), black, wet, 20% 1/8-1" subrounded gravel, 60% sand (f:m:c 40:50:10), 20-30% nonplastic fines, medium dense to dense			4-15 C		6 12 17	29	60	0 0 0 22.6	13:30	
			85								
60											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2064.43
EASTING: 5172.41
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani

NOTES: Sunny and hot, 60s in the morning, high temperature in the 90s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-04 **SHEET** 3 **OF** 3
START DATE 8/6/2013
FINISH DATE 8/6/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 144.1 ft msl
DATUM Local
TOTAL DEPTH 68.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Sandy SILT (ML), olive with blue tint, wet, 20% fine sand, low plasticity, stiff			4-16		3 4 5	9	100			
			80								Driller notes harder
65	SILTSTONE, olive with blue-green tint, moist, very fine grained, highly weathered (W4), extremely weak (R0), moderately hard (H9), platey, brittle			4-17		50/3.5"	50+	100			
	End drilling at 68 ft bgs. 8/6/13 at 14:20. Boring backfilled by drilling contractor.		75								
70											
			70								
75											
			65								
80											
			60								
85											
			55								
90											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2064.43
EASTING: 5172.41
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani

NOTES: Sunny and hot, 60s in the morning, high temperature in the 90s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-05 **SHEET** 1 **OF** 3
START DATE 8/5/2013
FINISH DATE 8/6/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 144.8 ft msl
DATUM Local
TOTAL DEPTH 66.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Road base GRAVEL (GW), light brown and gray, dry to moist, 1/4-3" subrounded gravel, 20-30% plastic fines									7:30	3' with 4 1/4" HSA
									0 0 0 20.5	7:55	
5	SILT fill (MH), dark brown, moist, medium to high plasticity, stiff		140	5-1 C		2 4 6	10	30			
10	SILT fill (MH), mottled dark brown and gray, moist, medium to high plasticity, very stiff		135	5-2				47			Pocket pen: 3.0 tsf
15			130	5-3		2 5 5	10	61			
									0 0 0 20.8	8:52	
20			125	5-4				65			Pocket pen: 3.4 tsf
25	Silty CLAY (CL/CH), mottled dark brown and gray, moist, 5-10% fine sand, medium to low plasticity, very stiff		120	5-5				60		9:45	Track breakdown at 9:45.
										15:15	Pocket pen: 2.5 tsf Back up
30			115								

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2148.54
EASTING: 5550.41
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s in the morning, high temperature in the 80s to 90s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-05 **SHEET** 2 **OF** 3
START DATE 8/5/2013
FINISH DATE 8/6/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 144.8 ft msl
DATUM Local
TOTAL DEPTH 66.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Silty CLAY (CL/CH), dark brown with gray mottling, moist, 5-10% fine sand, low to medium plasticity, stiff			5-6		4 4 4	8	100	0 0 0 20.9	16:00	
35	Clayey SILT (MH), dark brown with gray speckling, moist, 5-10% fine sand, low plasticity, medium stiff		110	5-7				100			Pocket pen: 1.2 tsf
40	Clayey SILT (MH), dark brown with gray speckling, moist to wet, 5-10% fine sand, medium to high plasticity, very soft		105	5-8		0 0 0	0	100			Switch to 4 7/8" bit
45	Silty CLAY (CH), dark gray with brown speckling, moist to wet, 5-10% fine sand, low plasticity, medium stiff		100	5-9				80			Pocket pen: 0.8 tsf
50	SILT to silty SAND (ML/SM), dark gray, wet, 50% fine to medium coarse sand, 50% low plasticity silt, soft, loose		95	5-10 B C		2 2 3	5	70		17:00 7:15	End drilling 8/5/13 Begin drilling 8/6/13
55	Sandy GRAVEL with silt (GW), dark gray to reddish brown, 1/16 - 1" subrounded gravel, wet, 30-40% sand (f:m:c 20:40:40), 15-20% silty fines, low plasticity, medium dense		90	5-11 C		8 15 17	32	65			
60			85								

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2148.54
EASTING: 5550.41
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s in the morning, high temperature in the 80s to 90s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-05 **SHEET** 3 **OF** 3
START DATE 8/5/2013
FINISH DATE 8/6/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 144.8 ft msl
DATUM Local
TOTAL DEPTH 66.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Sandy GRAVEL with silt (GW), black to dark gray, 1/16 - 3/4" subrounded gravel, wet, 30-40% sand (f:m:c 20:40:40), 5-10% silty low plasticity fines, dense			5-12		15 10 30	40	100			Driller notes stiffening but smooth.
	SILTSTONE, olive with green tint, moist, very fine grained, highly weathered (W4), extremely weak (R0), moderately soft (H5), brittle		80	5-13		50/4"	50+	100			
65	End drilling at 66.5 ft bgs. 8/6/13 at 08:20. Boring backfilled by drilling contractor.										End drilling
70			75								
75			70								
80			65								
85			60								
90			55								

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2148.54
EASTING: 5550.41
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s in the morning, high temperature in the 80s to 90s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-06 **SHEET** 1 **OF** 3
START DATE 8/3/2013
FINISH DATE 8/3/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 144.5 ft msl
DATUM Local
TOTAL DEPTH 66.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Road base GRAVEL (GW), light brown and gray, dry to moist, 1/4 - 2" subrounded gravel, 20-30% nonplastic fines							0 0 0 21.0	7:30	2' with 4 1/4" HSA
5	CLAY fill (CH), mottled dark brown and gray, moist, medium to high plasticity, medium stiff	140	6-1		3 3 3	6	70			
10	Becomes stiff	135	6-2				90			Pocket pen: 2.8 tsf
15	CLAY fill (CH), mottled dark brown and gray, moist, medium to high plasticity, stiff	130	6-3 C		3 6 9	15	35	0 0 0 20.7	8:50	
20	Clayey SILT (MH), dark brown with gray mottle, moist, 5-10% fine sand, low to medium plasticity, stiff to firm	125	6-4				53			Pocket pen: 1.75 tsf
			6-5		3 4 5	9	100			
25	Clayey SILT (MH), dark brown with gray mottling, moist, 5-10% fine sand, low to medium plasticity, stiff to very stiff	120	6-6 C		4 8 12	20	40			
30		115								

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2381.3
EASTING: 5874.97
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani

NOTES: Partly cloudy and cool, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-06 **SHEET** 2 **OF** 3
START DATE 8/3/2013
FINISH DATE 8/3/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 144.5 ft msl
DATUM Local
TOTAL DEPTH 66.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Silty CLAY (CH), dark gray with brown mottling, moist, 5-10% fine sand, low plasticity, stiff		6-7				100			Pocket pen: 2.2 tsf
								0 0 0 20.6	10:00	
		110								
35	Same as above		6-8		3 3 5	8	100			
		105								
40	Same as above		6-9 B C		4 7 4	11	75			
	Silty CLAY to clayey SILT (CH-MH), dark gray with brown mottling, moist to wet, 10-15% fine sand, medium to high plasticity, stiff									Switch to 4 7/8" drill bit
								0 0 0 20.9	10:24	
		100								
45	Softer with depth		6-10				100			
										Pocket pen: 0.8 tsf
			6-11		0 0 0	0	100			
		95								
50	Clayey SILT (MH), mottled gray and brown, moist to wet, 10-15% fine sand, medium to high plasticity, medium stiff		6-12		2 4 4	8	90			
	Clayey GRAVEL with silt (GC), dark brown mottled with red, wet, 1/4 - 1" subrounded gravel, 10% fine to coarse sand (f:m:c 10:40:40), 20-30% plastic fines, medium dense		6-13		15 11 13	24	75	0 0 0 20.9	11:30	
		90								
55	Sandy GRAVEL with silt (GW), dark gray and red, 1/8 -3/4" subrounded gravel, 20-30% sand (f:m:c 10:40:40), 10-20% nonplastic fines, dense		6-14		18 20 18	38	80			
										Possible contact
		85								
60										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2381.3
EASTING: 5874.97
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani

NOTES: Partly cloudy and cool, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-06 **SHEET** 3 **OF** 3
START DATE 8/3/2013
FINISH DATE 8/3/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 144.5 ft msl
DATUM Local
TOTAL DEPTH 66.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Gravelly SILT with cobbles (ML), dark olive to gray with green tint, wet, 10-20% 1/2 - 2" subrounded gravel, 10% fine sand, low plasticity, very stiff, crushed rock in shoe			6-15 C		3 8 13	21	33			
			80								Driller notes rocky
65	SILTSTONE, olive with white specks, very fine grained, highly weathered (W4), extremely weak (R0), moderately soft (H5), horizontal, brittle			6-16		50/3"	50+		0 0 0 21.0	12:30	
	End drilling at 66.5 ft bgs. 8/3/13 at 12:30. Boring backfilled by drilling contractor.										
			75								
70											
			70								
75											
			65								
80											
			60								
85											
			55								
90											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2381.3
EASTING: 5874.97
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Partly cloudy and cool, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-16 **SHEET** 1 **OF** 2
START DATE 8/8/2013
FINISH DATE 8/8/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 126.9 ft msl
DATUM Local
TOTAL DEPTH 51.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Surface: brown grass and vegetation								11:20	
	Silty CLAY (CH), light to dark brown, moist, 5-10% fine sand, low to medium plasticity, stiff to very stiff	125	16-1 C		6 7 8	15	70			
	Same as above		16-2		5 6 6	12	80			
5	Silty CLAY (CH), dark brown to yellow, moist, 5-10% fine sand, medium to high plasticity, stiff		16-3				100			
		120								Pocket pen: 2.0 tsf
	Same as above		16-4		2 4 4	8	100			
10	Silty CLAY (CH), dark yellowish brown, moist, 10% fine sand, medium to high plasticity, stiff to very stiff		16-5 C		3 6 9	15	90			
	Same as above		16-6		2 3 5	8	100			
		115							13:20	
15	Silty CLAY (CL), dark yellowish brown with gray mottling, moist, 10% fine sand, low to medium plasticity, stiff		16-7				100			
	Silty CLAY (CH), dark gray with green tint, moist, 5% fine sand, medium to high plasticity, stiff	110								Pocket pen: 1.7 tsf
			16-8		3 3 4	7	100			
20	Same as above		16-9				100		14:00	
		105								Pocket pen: 2.1 tsf
			16-10		3 3 4	7	100			
25	Silty CLAY (CH), dark gray mottled with brown, moist to wet, 10% fine to medium coarse sand, medium to high plasticity, stiff		16-11 C		3 6 7	13	72			
		100								
30										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2313.98
EASTING: 5921.26
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani

NOTES: Sunny and warm, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-16 **SHEET** 2 **OF** 2
START DATE 8/8/2013
FINISH DATE 8/8/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 126.9 ft msl
DATUM Local
TOTAL DEPTH 51.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Sandy CLAY (CL), mottled dark gray and brown, wet, 30% fine sand, 60-70% medium plasticity clay, soft to medium stiff		16-12		0 0 0	0	100			Switch to 4 7/8" bit
		95	16-13				100			
										Pocket pen: 1.3 tsf
			16-14		0 13 34	47	100			
35	Sandy GRAVEL with silt (GW), dark black to reddish brown, wet, 1/8-3/4" subrounded gravel, 20-30% sand (f:m:c 40:40:20), 10-15% silty fines, low plasticity, dense to very dense									
		90								
40	Sandy GRAVEL (GW), dark black to reddish brown, wet, 3/4" minus subrounded gravel, 20-30% sand (f:m:c 30:40:30), 10% silty fines, very dense		16-15 B C		30 40 48	88	100			
		85								
										Driller notes rocky
45	SILTSTONE with gravel, olive with green tint, very fine grained, 20% 3/4" minus gravels, highly weathered (W4), extremely weak (R0), moderately hard (H5), brittle		16-16		12 29 50	79	100			
		80								
50	SILTSTONE, olive green with blue tint, very fine grained, highly weathered (W4), extremely weak (R0), moderately hard (H5), brittle		16-17		50/3.5"	50+	100		16:00	
	End drilling at 51.5 ft bgs. 8/8/13 at 16:00. Boring backfilled by drilling contractor.	75								
55										
		70								
60										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2313.98
EASTING: 5921.26
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-17 **SHEET** 1 **OF** 2
START DATE 8/9/2013
FINISH DATE 8/9/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 126.6 ft msl
DATUM Local
TOTAL DEPTH 52.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Surface: brown grasses and vegetation							0	7:45	
	CLAY with gravel (CH), dark to light brown, moist, 10% 1" minus subrounded gravels, medium to high plasticity, medium stiff	125	17-1 C		2 3 2	5	50			
	CLAY (CH), dark to light brown, moist, 5-10% fine sand, medium to high plasticity, firm		17-2		0 2 3	5	67			
5			17-3				60			
		120								Pocket pen: 1.5 tsf Switch to 5" wing bit
			17-4		3 3 5	8	90			
10	Silty CLAY (CH), light brown to dark brown with oxide mottling, moist, 5-10% fine sand, medium to high plasticity, stiff		17-5				100			
		115								Pocket pen: 1.4 tsf
	Same as above		17-6		1 2 2	4	100			
15	Silty CLAY (CH), dark brown with light brown to yellow mottling, moist to wet, 5-15% fine sand, medium to high plasticity, medium stiff		17-7 B C		1 2 2	4	89			
		110								
									9:00	
20	Sandy CLAY (CL), deep brown with dark gray mottle, moist to wet, 20-25% fine sand, medium to high plasticity, soft		17-8				100			
		105								Pocket pen: 0.4 tsf
	Same as above		17-9		0 0 0	0	100			
										Switch to 4 7/8" tricone
25	Silty CLAY with sand (CH), dark gray with blue tint, wet, 15-20% fine sand, medium to high plasticity, medium stiff		17-10 B C		1 3 4	7	100			
		100								
30										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2093.16
EASTING: 5586.49
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani

NOTES: Partly cloudy and cool, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT13-17 **SHEET** 2 **OF** 2
START DATE 8/9/2013
FINISH DATE 8/9/2013
LOCATION Riverbend Landfill
PROJECT 2013 Investigation
PROJECT NUMBER WG1772

ELEVATION DATA
GROUND SURFACE 126.6 ft msl
DATUM Local
TOTAL DEPTH 52.5 ft bgs
DEPTH TO WATER Not measured

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Sandy SILT (MH), dark gray with blue tint, wet, 30-40% fine sand, medium to high plasticity, soft			17-11		0 0 1	1	100			
	Silty SAND (SM), black, wet, fine to medium coarse, 10-15% fines, loose		95	17-12				0			Attempted pushing a shelby tube. Shelby tube met refusal, therefore, drove sampler.
	Sandy GRAVEL (GW), dark gray to reddish brown, wet, 1/2" minus subrounded gravel, 30-40% sand (f:m:c 20:40:40), 15-20% low plasticity fines, dense			17-13		12 20 19	39	100			
35	Sandy GRAVEL (GW), dark gray to reddish brown, wet, 1" minus subrounded gravel, 30-40% sand (f:m:c 30:40:30), 10-20% low plasticity fines, medium dense		90	17-14 C		12 16 13	29	70		10:30	
40	Sandy GRAVEL to gravel (GP-GW), first 6" clean 1/2" subrounded gravel, second 6" sandy gravel, reddish brown to dark gray, wet, 30% sand (f:m:c 20:40:40), 5-10% nonplastic fines, dense		85	17-15 C		11 21 22	43	70			
45	SILTSTONE with gravel, 15-20% 1/2" subrounded gravel, very fine grained, olive with blue-green tint, highly weathered (W4), extremely weak (R0), moderately hard (H5), brittle		80	17-16		9 50/4.5"	50+	90			
50	SILTSTONE, olive green with blue tint, very fine grained, moderately weathered (W3), very weak (R1), moderately hard (H5), brittle		75	17-17		50/1"	50+	100			
	End drilling at 51.5 ft bgs. 8/9/13 at 11:45. Boring backfilled by drilling contractor.										
55			70								
60											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods
HAMMER TYPE: See Notes
BOREHOLE DIAMETER: 5 in.

NORTHING: 2093.16
EASTING: 5586.49
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER B. Martinez **REVIEWER** F. Settepani
NOTES: Partly cloudy and cool, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./ 30 in.). Rope and cathead used for Modified California samples (300 lb./ 30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

APPENDIX H

2013 Energy Measurement

Robert Miner Dynamic Testing, Inc.

Dynamic Measurements and Analyses for Deep Foundations

October 1, 2013

Mr. Fabrizio Settepani
Geosyntec Consultants
1111 Broadway
Oakland, CA 94607

Re: Penetration Test Energy Measurements
Hard Core Rig 850, CME Automatic Hammer and Rope and Cathead
Borehole GT13-12, July 30, 2013
River Bend Landfill, McMinnville, OR RMDT Job No. 13F49

Dear Mr. Settepani,

This letter presents energy transfer measurements made during Standard Penetration Tests and California Modified Samples for the drill hole and drill rig referenced above. Robert Miner Dynamic Testing, Inc. (RMDT) made dynamic measurements with a Pile Driving Analyzer® as a hammer advanced the NW rod during sampling with a split spoon sampler and a California Modified sampler.

The purpose of RMDT's testing was the measurement of energy transferred to the drill rods. Measurements were made on a section of NW gauge rod at the top of the drill rod. Strain gages and accelerometers on the rod were connected to a Pile Driving Analyzer® (PDA) which generally processed acceleration and strain measurements from each hammer blow and stored both the measurements and computed results. Measurements and data processing generally followed the ASTM D 4633-10 standard. Energy transfer past the gage location, EFV, was computed by the PDA using force and velocity records as follows:

$$EFV = \int_a^b F(t)\ v(t)\ dt$$

The value "a" corresponds to the start of the record which is when the energy transfer begins and *"b"* is the time at which energy transferred to the rod reaches a maximum value. Appendix A contains more information on our measurement equipment and methods of analysis. The EFV energy calculation is identical to the EMX energy result discussed in Appendix A. The EFV and EMX values apply to the sensor location near the top of the rod.

TEST DETAILS

Testing occurred on July 30, 2013. Boring GT13-12 was advanced near the east embankment of the River Bend Landfill facility located in McMinnville, OR. An automatic hammer manufactured by Central Mine Equipment Co. (CME) containing a 140 lb ram was use to advance split spoon samples. A 300 lb ram operated by rope and cathead was used to advance

Mailing Address: P.O. Box 340, Manchester, WA, 98353, USA **Phone:** 360-871-5480
Location: 2288 Colchester Dr. E., Ste A, Manchester, WA, 98353 **Fax:** 360-871-5483

California Modified Samplers. NW size rod was used to advance both sample types. The drill rig was Hard Core Drilling's track-mounted Rig 850.

RESULTS

A summary of the results for tests conducted with the 140 lb and 300 lb rams are given in Tables 1 and 2, respectively. The tabulated results include the starting sample depth, the penetration resistance, the number of hammers blows in our data set, measured energy transfer, EFV, the computed transfer efficiency, ETR, and the hammer blow rate, BPM. Appendix B contains detailed numeric results for each individual test.

Energy measurements must be divided by the theoretical free fall energy of the hammer to obtain an efficiency. In anticipation of future site demands measurements were made with 140 lb and 300 lb rams in the Mobile Automatic Hammer. A 140 lb ram raised 30 inches above an impact surface has 350 lb-ft of potential energy. A 300 lb ram raised 30 inches above an impact surface has 750 lb-ft of potential energy. Thus, the transfer energy results for sampling with the 140 and 300 lb rams may be divided by 350 or 750 lb-ft to yield the ratio of the delivered energy to the nominal potential energy. This efficiency ratio, ETR, is given for each sample interval as a percent efficiency.

Table 1. Summary of Test Details and Results for the 140 lb ram and Split Spoon Sampler

Sample Name and Initial Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
5 ft	6/1 ft	6	272	78	52
10 ft	10/1 ft	10	290	83	46
20 ft	20/1 ft	20	312	89	50
27.5 ft	11/1 ft	11	310	89	50
40 ft	10/1 ft	10	320	91	50
50 ft	6/1 ft	6	326	93	50
65 ft	82/6 in	82	327	93	50
Average for Split Spoon samples*:			**319**	**91**	**50**

*Calculated average excludes data from the 5 and 10 ft samples

Seven sample returns were monitored while the 140 lb ram and standard split spoon sampler were in use. A summary of the test details are given in Table 1. Examination of summarized values in Table 1 suggest variations in the calculated EFV and ETR values analyzed at the 5 and 10 ft sample depth intervals are larger than those analyzed from deeper sample depths. It is the opinion of RMDT that the dynamic effects associated with advancing a sampler with rod lengths of 15 ft or less interferes with dynamic energy measurements and thus the calculation of CASE Method values. We suggest excluding the values associated with the 5 and 10 ft sample intervals from consideration. Excluding the 5 and 10 ft sample values, the average calculated ETR was 91 percent with an average hammer blow rate of 50 blows per minute.

Six additional sample returns were monitored while the 300 lb ram operated by rope and cathead to advance the California Modified Sampler were in use. A summary of the test details are given in Table 2.

Table 2. Summary of Test Details and Results for the 300-lb ram and California Modified Sampler

Sample Name and Initial Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
11.5 ft	16/1 ft	16	488	65	22
30 ft	12/1 ft	12	489	65	26
45 ft	14/1 ft	14	427	57	30
51.5 ft	24/1 ft	24	465	62	31
55 ft	29/1 ft	29	522	70	34
60 ft	50/6 in	49	487	65	39
		Average:	**480**	**64**	**30**

For the 300 lb ram the average ETR values within the sample intervals ranged from 57 to 70 percent with an overall average ETR value of 64 percent. Hammer Blow Rate within the sample intervals ranged from 22 to 39 blows per minute with an overall Hammer Blow Rate of 30 Blows Per minute. In our opinion the variation in blow rate displayed throughout our monitoring was typical of a rope and cathead operation.

It was a pleasure to assist you and to participate on this project with the staff of Hard Core Drilling. Please do not hesitate to contact us if you or your client have any questions about this report.

Sincerely,

Robert Miner Dynamic Testing, Inc.

Andrew Banas
Staff Engineer

Robert Miner
President

APPENDIX A
AN INTRODUCTION INTO DYNAMIC PILE TESTING METHODS

The following has been written by Goble Rausche Likins and Associates, Inc. and may only be copied with its written permission.

BACKGROUND

Modern procedures of design and construction control require verification of bearing capacity and integrity of deep foundations during preconstruction test programs and also production installation. Dynamic pile testing methods meet this need economically and reliably, and therefore, form an important part of a quality assurance program when deep foundations are executed. Several dynamic pile testing methods exist; they have different benefits and limitations and different requirements for proper execution.

The Case Method of dynamic pile testing, named after the Case Institute of Technology where it was developed between 1964 and 1975, requires that a substantial ram mass (such as that of a pile driving hammer) impacts the pile top such that the pile undergoes at least a small permanent set. The method is therefore also referred to as a "High Strain Method". The Case Method requires dynamic measurements on the pile or shaft under the ram impact and then an evaluation of various quantities based on closed form solutions of the wave equation, a partial differential equation describing the motion of a rod under the effect of an impact. Conveniently, measurements and analyses are done by a single piece of equipment: the Pile Driving Analyzer® (PDA). However, for bearing capacity evaluations an important additional method is CAPWAP® which performs a much more rigorous analysis of the dynamic records than the simpler Case Method.

A related analysis method is the "Wave Equation Analysis" which calculates a relationship between bearing capacity and pile stress and field blow count. The GRLWEAP™ program performs this analysis and provides a complete set of helpful information and input data.

The following description deals primarily with the Case Method or "High Strain Test" Method of pile testing, however, for the sake of completeness, the "Low Strain Test" performed with the Pile Integrity Test™ (PIT), mainly for pile integrity evaluation, will also be described.

RESULTS FROM DYNAMIC TESTING

There are two main objectives of high strain dynamic pile testing:

- *Dynamic Pile Monitoring* and
- *Dynamic Load Testing*.

Dynamic pile monitoring is conducted during the installation of impact driven piles to achieve a safe and economical pile installation. Dynamic load testing, on the other hand, has as its primary goal the assessment of pile bearing capacity. It is applicable to both cast *insitu* piles or drilled shafts and impact driven piles during restrike.

Dynamic Pile Monitoring

During pile installation, the sensors attached to the pile measure pile top force and velocity. A PDA conditions and processes these signals and calculates or evaluates:

- Bearing capacity at the time of testing, including an assessment of shaft resistance development and driving resistance. This information supports formulation of a driving criterion.

- Dynamic pile stresses, axial and averaged over the pile cross section, both tensile and compressive, during pile driving to limit the potential of damage either near the pile top or along its length. Bending stresses can be evaluated at the point of sensor attachment.

- Pile integrity assessment by the PDA is based on the recognition of certain wave reflections from along the pile. If detected early enough, a pile may be saved from complete destruction. On the other hand, once damage is recognized measures can be taken to prevent reoccurrence.

- Hammer performance parameters including the energy transferred to the pile, the hammer speed in blows per minute and the stroke of open ended diesel hammers.

© 1999, Goble Rausche Likins and Associates, Inc.

Dynamic Pile Load Testing

Bearing capacity testing of either driven piles or drilled shafts applies the same basic measurement approach of dynamic pile monitoring. However, the test is done independent of the pile installation process and therefore a pile driving hammer or other dynamic loading device may not be available. If a special ram has to be mobilized then its weight should be between 0.8 and 2% of the test load (e.g. between 4 and 10 tons for a 500 ton test load) to assure sufficient soil resistance activation.

For a successful test, it most important that the test is conducted after a sufficient waiting time following pile installation for soil properties approaching their long term condition or concrete to properly set. During testing, PDA results of pile/shaft stresses and transferred energy are used to maintain safe stresses and assure sufficient resistance activation. For safe and sufficient testing of drilled shafts, ram energies are often increased from blow to blow until the test capacity has been activated. On the other hand, restrike tests on driven piles may require a warm hammer so that the very first blow produces a complete resistance activation. Data must be evaluated by CAPWAP for bearing capacity.

After the dynamic load test has been conducted with sufficient energy and safe stresses, the CAPWAP analysis provides the following results:

- Bearing capacity i.e. the mobilized capacity present at the time of testing
- Resistance distribution including shaft resistance and end bearing components
- Stresses in pile or shaft calculated for both the static load application and the dynamic test. These stresses are averages over the cross section and do not include bending effects or nonuniform contact stresses, e.g. when the pile toe is on uneven rock.
- Shaft impedance vs depth; this is an estimate of the shaft shape if it differs substantially from the planned profile
- Dynamic soil parameters for shaft and toe, i.e. damping factors and quakes (related to the dynamic stiffness of the resistance at the pile/soil interface.)

MEASUREMENTS

PDA

The basis for the results calculated by the PDA are pile top strain and acceleration measurements which are converted to force and velocity records, respectively. The PDA conditions, calibrates and displays these signals and immediately computes average pile force and velocity thereby eliminating bending effects. Using closed form Case Method solutions, based on the one-dimensional linear wave equation, the PDA calculates the results described in the analytical solutions section below.

HPA

The ram velocity may be directly obtained using radar technology in the Hammer Performance Analyzer™. For this unit to be applicable, the ram must be visible. The impact velocity results can be automatically processed with a PC or recorded on a strip chart.

Saximeter™

For open end diesel hammers, the time between two impacts indicates the magnitude of the ram fall height or stroke. This information is not only measured and calculated by the PDA but also by the convenient, hand-held Saximeter.

PIT

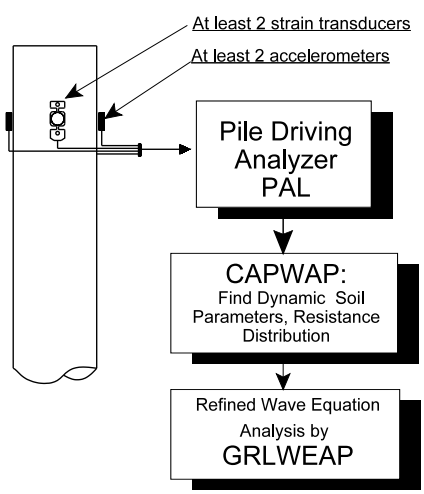
The Pile Integrity Tester™ (PIT) can be used to evaluate defects in concrete piles or shafts which may have occurred during driving or casting. Also timber piles of limited length can be tested in that manner. This so-called "Low Strain Method" or “Pulse-Echo Method” of integrity testing requires only the measurement of acceleration at the pile top. The stress wave producing impact is then generated by a small hand-held hammer and the records interpreted in the time domain. PIT also supports the so-called “Transient Response Method” which requires the additional measurement of the hammer force and an analysis in the frequency domain. This method may also be used to evaluate the unknown length of deep foundations under existing structures.

ANALYTICAL SOLUTIONS
BEARING CAPACITY

Wave Equation

GRL has written the GRLWEAP™ program which calculates a relationship between bearing capacity, pile stress and blow count. This relationship is often called the "bearing graph." Once the blow count is known from pile installation logs, the bearing graph yields the bearing capacity. This approach requires no measurements and therefore can be performed during the design stage of a project, for example for the selection of hammer, cushion and pile size.

After dynamic pile monitoring and/or dynamic load testing has been performed, the "Refined Wave Equation Analysis" or RWEA (see schematic below) is often performed by inputting the PDA and CAPWAP calculated parameters. Then the bearing graph from the RWEA is the basis for a safe and sufficient driving criteria.



Case Method

The Case Method is a closed form solution based on a few simplifying assumptions such as ideal plastic soil behavior and an ideally elastic and uniform pile. Given the measured pile top force F(t) and pile top velocity v(t), the total soil resistance is

$$R(t) = \tfrac{1}{2}\{[F(t) + F(t_2)] + Z[v(t) - v(t_2)]\} \qquad (1)$$

where

- t = a point in time after impact
- t_2 = time $t + 2L/c$
- L = pile length below gages
- c = $(E/\rho)^{1/2}$ is the speed of the stress wave
- ρ = pile mass density
- Z = EA/c is the pile impedance
- E = elastic modulus of the pile (ρc^2)
- A = pile cross sectional area

The total soil resistance consists of a dynamic (R_d) and a static (R_s) component. The static component is therefore

$$R_s(t) = R(t) - R_d(t) \qquad (2)$$

The dynamic component may be computed from a soil damping factor, J, and a pile toe velocity, $v_t(t)$ which is conveniently calculated for the pile toe. Using wave considerations, this approach leads immediately to the dynamic resistance

$$R_d(t) = J[F(t) + Zv(t) - R(t)] \qquad (3)$$

and finally to the static resistance by means of Equation 2.

There are a number of ways in which Eq. 1 through 3 can be evaluated. Most commonly, t_2 is set to that time at which the static resistance becomes maximum. The result is the so-called **RMX** capacity. Damping factors for RMX typically range between 0.5 for coarse grained materials to 1.0 for clays. The **RSP** capacity (this method is most commonly referred to in the literature, yet it is not very frequently used) requires damping factors between 0.1 for sand and 1.0 for clay. Another capacity, **RA2**, determines the capacity at a time when the pile is essentially at rest and thus damping is small; RA2

therefore requires no damping parameter. In any event, the proper Case Method and its associated damping parameter is most conveniently found after a CAPWAP analysis has been performed.

The static resistance calculated by Case Method or CAPWAP is the mobilized resistance at the time of testing. Consideration therefore has to be given to soil setup or relaxation effects and whether or not a sufficient set has been achieved under the test loading that would correspond to a full activation of the ultimate soil resistance.

The PDA also calculates an estimate of shaft resistance as the difference between force and velocity times impedance at the time immediately prior to the return of the stress wave from the pile toe. This shaft resistance is not reduced by damping effects and is therefore called the total shaft resistance **SFT**. A correction for damping effects produces the static shaft resistance estimate, **SFR**.

The Case Method solution is simple enough to be evaluated "in real time," i.e. between hammer blows, using the PDA. It is therefore possible to calculate all relevant results for all hammer blows and plot these results as a function of depth or blow number. This is done in the PDAPLOT program.

CAPWAP

The CAse Pile Wave Analysis Program combines the wave equation pile and soil model with the Case Method measurements. Thus, the solution includes not only the total and static bearing capacity values but also the shaft resistance, end bearing, damping factors and soil stiffnesses. The method iteratively calculates a number of unknowns by signal matching. While it is necessary to make hammer performance assumptions for a GRLWEAP analysis, the CAPWAP program works with the pile top measurements. Furthermore, while GRLWEAP and Case Method require certain assumptions regarding the soil behavior, CAPWAP calculates these soil parameters.

STRESSES

During pile monitoring, it is important that compressive stress maxima at pile top and toe and tensile stress maxima somewhere along the pile be calculated for each hammer blow.

At the pile top (location of sensors) both the maximum compression stress, **CSX**, and the maximum stress from individual strain transducers, **CSI**, are directly obtained from the measurements. Note that CSI is greater than or equal to CSX and the difference between CSI and CSX is a measure of bending in the plane of the strain transducers. Note also that all stresses calculated for locations below the sensors are averaged over the pile cross section and therefore do not include components from either bending or eccentric soil resistance effects.

The PDA calculates the compressive stress at the pile bottom, **CSB**, assuming (a) a uniform pile and (b) that the pile toe force is the maximum value of the total resistance R(t) minus the total shaft resistance, SFT. Again, for this stress estimation uniform resistance force are assumed (e.g. not a sloping rock.)

For concrete piles, the maximum tension stress, **TSX**, is also of great importance. It occurs at some point below the pile top. The maximum tension stress can be computed from the pile top measurements by finding the maximum tension wave (either traveling upward, W_U, or downward, W_d) and reducing it by the minimum compressive wave traveling in opposite direction.

$$W_u = ½[F(t) - Zv(t)] \quad (4)$$

$$W_d = ½[F(t) + Zv(t)] \quad (5)$$

CAPWAP also calculates tensile and compressive stresses along the pile and, in general, more accurately than the PDA. In fact, for non-uniform piles or piles with joints, cracks or other discontinuities, the closed form solutions from the PDA may be in error.

PILE INTEGRITY

High Strain Tests (PDA)

Stress waves in a pile are reflected wherever the pile impedance, $Z = EA/c = \rho cA = A \sqrt{(E \rho)}$, changes. Therefore, the pile impedance is a measure of the quality of the pile material (E, ρ, c) and the size of its cross section (A). The reflected waves arrive at the pile top at a time which is greater the farther away from the pile top the reflection occurs. The

magnitude of the change of the upward traveling wave (calculated from the measured force and velocity, Eq. 4) indicates the extent of the cross sectional change. Thus, with β_i (**BTA**) being a relative integrity factor which is unity for no impedance change and zero for the pile end, the following is calculated by the PDA.

$$\beta_i = (1 - \alpha_i)/(1 + \alpha_i) \tag{6}$$

with

$$\alpha_i = ½(W_{UR} - W_{UD})/(W_{Di} - W_{UR}) \tag{7}$$

where

W_{UR} is the upward traveling wave at the onset of the reflected wave. It is caused by resistance.

W_{UD} is the upwards traveling wave due to the damage reflection.

W_{Di} is the maximum downward traveling wave due to impact.

It can be shown that this formulation is quite accurate as long as individual reflections from different pile impedance changes have no overlapping effects on the stress wave reflections.

Without rigorous derivation, it has been proposed to consider as slight damage when β is above 0.8 and a serious damage when β is less than 0.6.

Low Strain Tests (PIT)

The pile top is struck with a held hand hammer and the resulting pile top velocity is measured, displayed and interpreted for signs of wave reflections. In general, a comparison of the reflected acceleration leads to a relative measure of extent of damage, again the location of the problem is indicated by the arrival time of the reflection. PIT records can also be interpreted by the β-Method. However, low strain tests do not activate much resistance which simplifies Eq. 7 since W_{UR} is then equal to zero.

For drilled shafts and PIT records that clearly show a toe reflection, an approximate shaft profile can be calculated from low strain records using the PITSTOP program's PROFILE routine.

HAMMER PERFORMANCE

The PDA calculates the energy transferred to the pile top from:

$$E(t) = \int_0^t F(t)v(t)\,dt \tag{8a}$$

The maximum of the E(t) curve is the most important information for an overall evaluation of the performance of a hammer and driving system. This **EMX** value allows for a classification of the hammer's performance when presented as the rated transfer efficiency, also called energy transfer ratio (**ETR**) or global efficiency

$$e_T = EMX/E_R \tag{8b}$$

where

E_R is the manufacturer's rated energy value.

Both Saximeter and PDA calculate the stroke (**STK**) of an open end diesel hammer using

$$STK = (g/8)\,T_B^2 - h_L \tag{9}$$

where

g is the earth's gravitational acceleration,
T_B is the time between two hammer blows,
h_L is a stroke loss value due to gas compression and time losses during impact (usually 0.3 ft or 0.1 m).

DETERMINATION OF WAVE SPEED

An important facet of dynamic pile testing is an assessment of pile material properties. Since in general force is determined from strain by multiplication with elastic modulus, E, and cross sectional area, A, the dynamic elastic modulus has to be determined for pile materials other than steel. In general, the records measured by the PDA clearly indicate a pile toe reflection as long as pile penetration per blow is greater than 1 mm or .04 inches. The time between the onset of the force and velocity records at impact and the onset of the reflection from the toe (usually apparent by a local maximum of the wave up curve) is the so-called wave travel time, T. Dividing 2L (L is here the length of the pile below sensors) by T leads to the stress wave speed in the pile:

$$c = 2L/T \tag{10}$$

The elastic modulus of the pile material is related to the wave speed according to the linear elastic wave equation theory by

$$E = c^2\rho \tag{11}$$

Since the mass density of the pile material, ρ, is usually well known (an exception is timber for which samples should be weighed), the elastic modulus is easily found from the wave speed. Note, however, that this is a dynamic modulus which is generally higher than the static one and that the wave speed depends to some degree on the strain level of the stress wave. For example, experience shows that the wave speed from PIT is roughly 5% higher than the wave speed observed during a high strain test.

Other Notes:

- If the pile material is nonuniform then the wave speed c, according to Eq. 10, is an average wave speed and does not necessarily reflect the pile material properties of the location where the strain sensors are attached to the pile top. For example, pile driving often causes fine tension cracks some distance below the top of concrete piles. Then the average c is slower than that at the pile top. It is therefore recommended to determine E in the beginning of pile driving and not adjust it when the average c changes.

- If the pile has such a high resistance that there is no clear indication of a toe reflection then the wave speed of the pile material must be determined either by assumption or by taking a sample of the concrete and measuring its wave speed in a simple free column test. Another possibility is to use the proportionality relationship, discussed under "DATA QUALITY CHECKS" to find c as the ratio between the measured velocity and measured strain.

DATA QUALITY CHECKS

Quality data is the first and foremost requirement for accurate dynamic testing results. It is therefore important that the measurement engineer performing PDA or PIT tests has the experience necessary to recognize measurement problems and take appropriate corrective action should problems develop. Fortunately, dynamic pile testing allows for certain data quality checks because two independent measurements are taken that have to conform to certain relationships.

Proportionality

As long as there is only a wave traveling in one direction, as is the case during impact when only a downward traveling wave exists in the pile, force and velocity measured at the pile top are proportional

$$F = v\,Z = v\,(EA/c) \tag{12a}$$

This relationship can also be expressed in terms of stress

$$\sigma = v\,(E/c) \tag{12b}$$

or strain

$$\epsilon = v / c \tag{12c}$$

This means that the early portion of strain times wave speed must be equal to the velocity unless the proportionality is affected by high friction near the pile top or by a pile cross sectional change not far below the sensors. Checking the proportionality is an excellent means of assuring meaningful measurements.

Measurements are always taken at opposite sides of the pile as a means of calculating the average force and velocity in the pile. The velocity on the two sides of the pile is very similar even when high bending exists. Thus, an independent check of the velocity measurements is easy and simple.

Strain measurements may differ greatly between the two sides of the pile when bending exists. It is even possible that tension is measured on one side while very high compression exists on the other side of the pile. In extreme cases, bending might be so high that it leads to a nonlinear stress distribution. The averaging of the two strain signals does then not lead to the average pile force and proportionality will not be achieved.

When testing drilled shafts, measurements of strain may also be affected by local concrete quality variations. It is then often necessary to use four strain transducers spaced at 90 degrees around the pile for an improved strain data quality. The use of four transducers is also recommended for large pile

diameters, particularly when it is difficult to mount the sensors at least two pile widths or diameters below the pile top.

LIMITATIONS, ADDITIONAL CONSIDERATIONS

Mobilization of capacity

Estimates of pile capacity from dynamic testing indicate the **mobilized pile capacity at the time of testing**. At very high blow counts (low set per blow), dynamic test methods tend to produce lower bound capacity estimates as not all resistance (particularly at and near the toe) is fully activated.

Time dependent soil resistance effects

Static pile capacity from dynamic method calculations provide an estimate of the axial pile capacity. Increases and decreases in the pile capacity with time typically occur (soil setup/relaxation). Therefore, **restrike testing usually yields a better indication of long term pile capacity than a test at the end of pile driving**. Often a wait period of one or two days between end of driving and restrike is satisfactory for a realistic prediction of pile capacity but this waiting time depends, among other factors, on the permeability of the soil.

(A) Soil setup

Because excess positive pore pressures often develop during pile driving in fine grained soil (clays, silts or even fine sands), the capacity of a pile at the time of driving may often be less than the long term pile capacity. These pore pressures reduce the effective stress acting on the pile thereby reducing the soil resistance to pile penetration, and thus the pile capacity at the time of driving. As these pore pressures dissipate, the soil resistance acting on the pile increases as does the axial pile capacity. This phenomena is routinely called soil setup or soil freeze.

(*B) Relaxation*

Relaxation (capacity reduction with time) has been observed for piles driven into weathered shale, and may take several days to fully develop. Pile capacity estimates based upon initial driving or short term restrike tests can significantly overpredict long term pile capacity. Therefore, piles driven into shale should be tested after a minimum one week wait either statically or dynamically (with particular emphasis than on the first few blows). Relaxation has also been observed for displacement piles driven into dense saturated silts or fine sands due to a negative pore pressure effect at the pile toe. Again, restrike tests should be used, with great emphasis on early blows.

Capacity results for open pile profiles

Larger diameter open ended pipe piles (or H-piles which do not bear on rock) may behave differently under dynamic and static loading conditions. Under dynamic loads the soil inside the pile or between its flanges may slip and produce internal friction while under static loads the plug may move with the pile, thereby creating end bearing over the full pile cross section. As a result both friction and end bearing components may be different under static and dynamic conditions.

CAPWAP Analysis Results

A portion of the soil resistance calculated on an individual soil segment in a CAPWAP analysis can usually be shifted up or down the shaft one soil segment without significantly altering the match quality. Therefore, use of the CAPWAP resistance distribution for uplift, downdrag, scour, or other geotechnical considerations should be made with an understanding of these analysis limitations.

Stresses

PDA and CAPWAP calculated stresses are average values over the cross section. Additional allowance has to be made for bending or non-uniform contact stresses. To prevent damage it is therefore important to maintain good hammer-pile alignment and to protect the pile toes using appropriate devices or an increased cross sectional area.

In the United States is has become generally acceptable to limit the dynamic installation stresses of driven piles to the following levels:

- 90% of yield strength for steel piles
- 85% of the concrete compressive strength - after subtraction of the effective prestress - for concrete piles in compression

100% of effective prestress plus ½ of the concrete's tension strength for prestressed piles in tension

70% of the reinforcement strength for regularly reinforced concrete piles in tension

300% of the static design allowable stress for timber

Note that the dynamic stresses may either be directly measured at the pile top by the PDA or calculated by the PDA for other locations along the pile based on the pile top measurements.

Additional design considerations

Numerous factors have to be considered in pile foundation design. Some of these considerations include

- additional pile loading from downdrag or negative skin friction,
- lateral and uplift loading requirements
- effective stress changes (due to changes in water table, excavations, fills or other changes in overburden),
- long term settlements in general and settlement from underlying weaker layers and/or pile group effects,

These factors have not been evaluated by GRL and have not been considered in the interpretation of the dynamic testing results. The foundation designer should determine if these or any other considerations are applicable to this project and the foundation design.

Wave equation analysis results

The results calculated by the wave equation analysis program depend on a variety of hammer, pile and soil input parameters. Although attempts have been made to base the analysis on the best available information, actual field conditions may vary and therefore stresses and blow counts may differ from the predictions reported. Capacity predictions derived from wave equation analyses should use restrike information. However, because of the uncertainties associated with restrike blow counts and restrike hammer energies, correlations of such results with static test capacities with have often displayed considerable scatter.

As for PDA and CAPWAP, the theory on which GRLWEAP is based is the one-dimensional wave equation. For that reason, stress predictions by the wave equation analysis can only be averages over the pile cross section. Thus, bending stresses or stress concentrations due to non-uniform impact or uneven soil or rock resistance are not considered in these results. Stress maxima calculated by the wave equation are usually subjected to the same limits as those measured directly or calculated from measurements by the PDA.

Appendix B

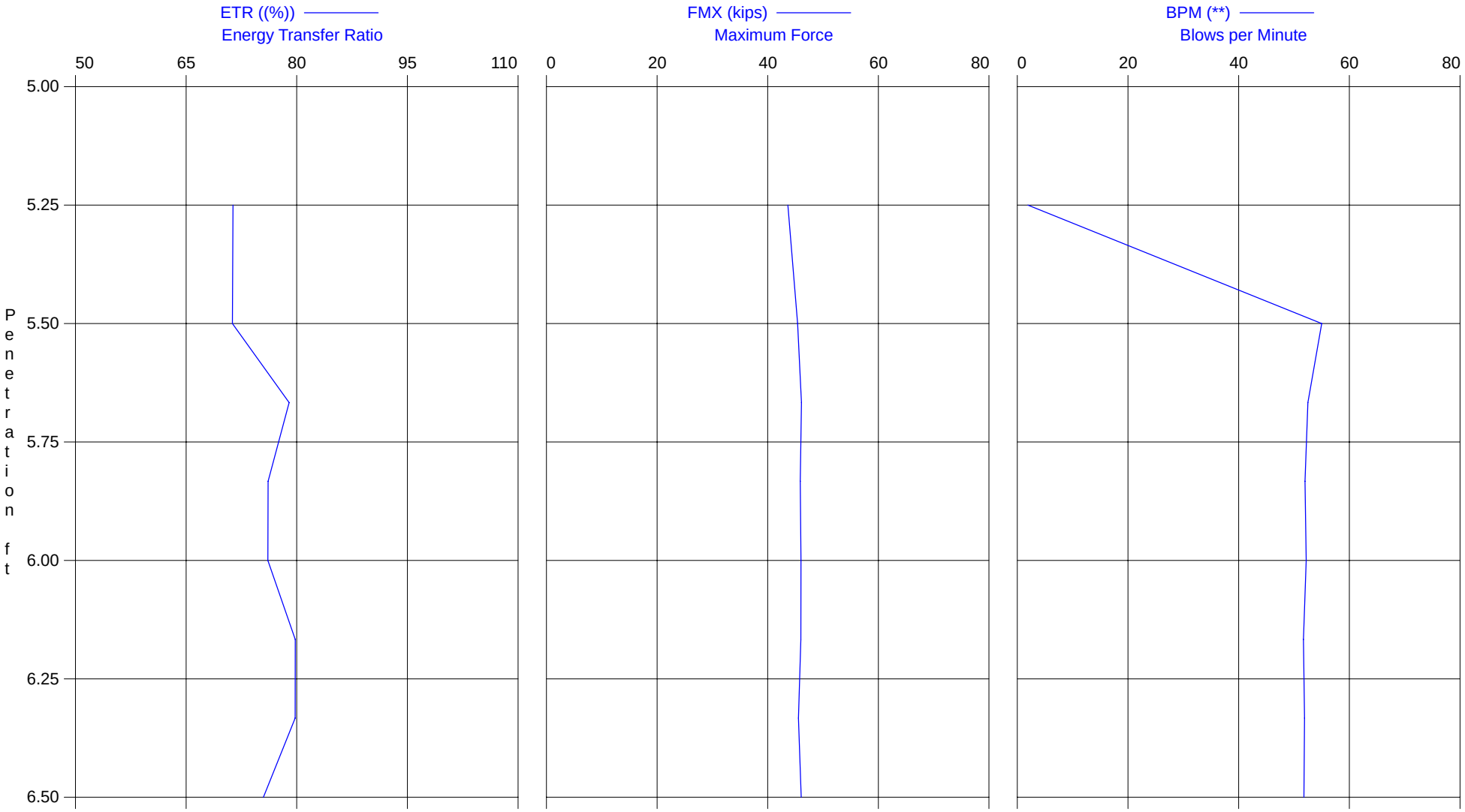
Summary of Case Method Field Results

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LAND - SAMPLE 5FTBHGT13-12, RIG 104-140LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LAND - SAMPLE 5FT

BHGT13-12, RIG 104-140LB

OP: RMDT

Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 9.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
3	6	33.8	32.5	0.276	79.0	52.5	46	14.9	24	0.374
4	6	33.1	32.3	0.266	76.1	52.0	46	15.6	26	0.378
5	6	33.2	32.4	0.266	76.1	52.2	46	15.3	27	0.377
6	6	33.0	32.4	0.279	79.8	51.7	46	15.3	27	0.377
7	6	32.4	32.1	0.279	79.8	51.9	46	15.5	26	0.374
8	6	32.7	32.4	0.264	75.5	51.8	46	15.2	25	0.375
Average		33.0	32.4	0.272	77.7	52.0	46	15.3	26	0.376
Std. Dev.		0.4	0.1	0.006	1.8	0.3	0	0.2	1	0.002
Maximum		33.8	32.5	0.279	79.8	52.5	46	15.6	27	0.378
Minimum		32.4	32.1	0.264	75.5	51.7	46	14.9	24	0.374

Total number of blows analyzed: 6

Time Summary

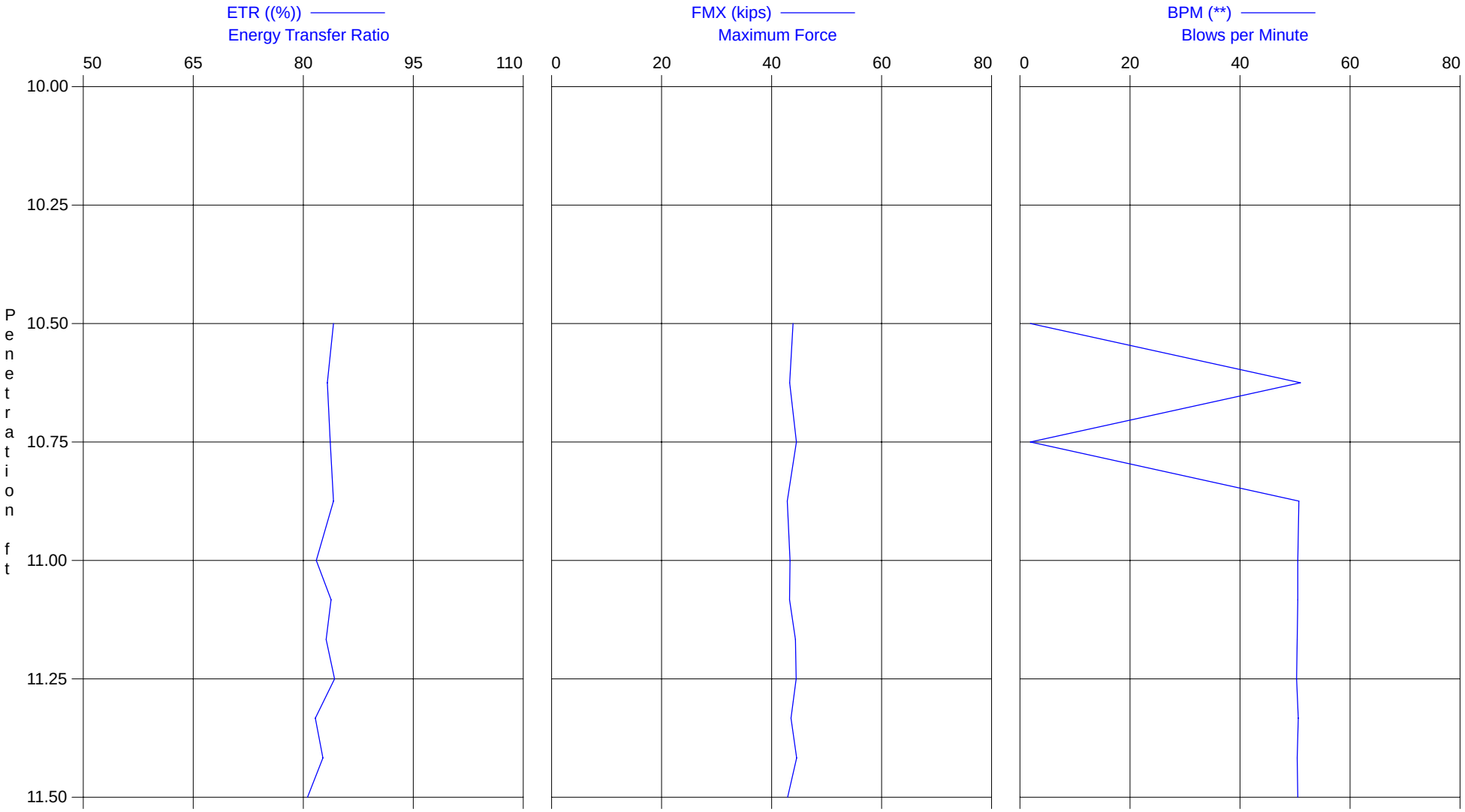
Drive 8 seconds 8:26:06 AM - 8:26:14 AM (7/30/2013) BN 1 - 8

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 10FTBHGT13-12, RIG 104-140LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 10FT

BHGT13-12, RIG 104-140LB

OP: RMDT

Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 14.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
2	8	31.8	30.5	0.292	83.3	51.0	43	16.4	32	0.393
3	8	32.5	31.3	0.293	83.7	1.9	45	16.1	19	0.400
4	8	32.0	30.2	0.294	84.1	50.7	43	15.8	29	0.392
5	8	32.0	30.5	0.286	81.8	50.5	43	14.6	30	0.388
6	12	31.8	30.5	0.293	83.8	50.5	43	14.6	26	0.387
7	12	32.9	31.2	0.291	83.1	50.4	44	14.6	20	0.389
8	12	32.6	31.3	0.295	84.3	50.3	44	14.4	27	0.395
9	12	31.9	30.7	0.286	81.6	50.6	44	14.4	30	0.387
10	12	32.5	31.4	0.289	82.7	50.4	45	14.3	31	0.395
11	12	31.4	30.2	0.282	80.6	50.5	43	14.0	31	0.382
Average		32.1	30.8	0.290	82.9	45.7	44	14.9	28	0.391
Std. Dev.		0.5	0.5	0.004	1.2	14.6	1	0.8	4	0.005
Maximum		32.9	31.4	0.295	84.3	51.0	45	16.4	32	0.400
Minimum		31.4	30.2	0.282	80.6	1.9	43	14.0	19	0.382

Total number of blows analyzed: 10

Time Summary

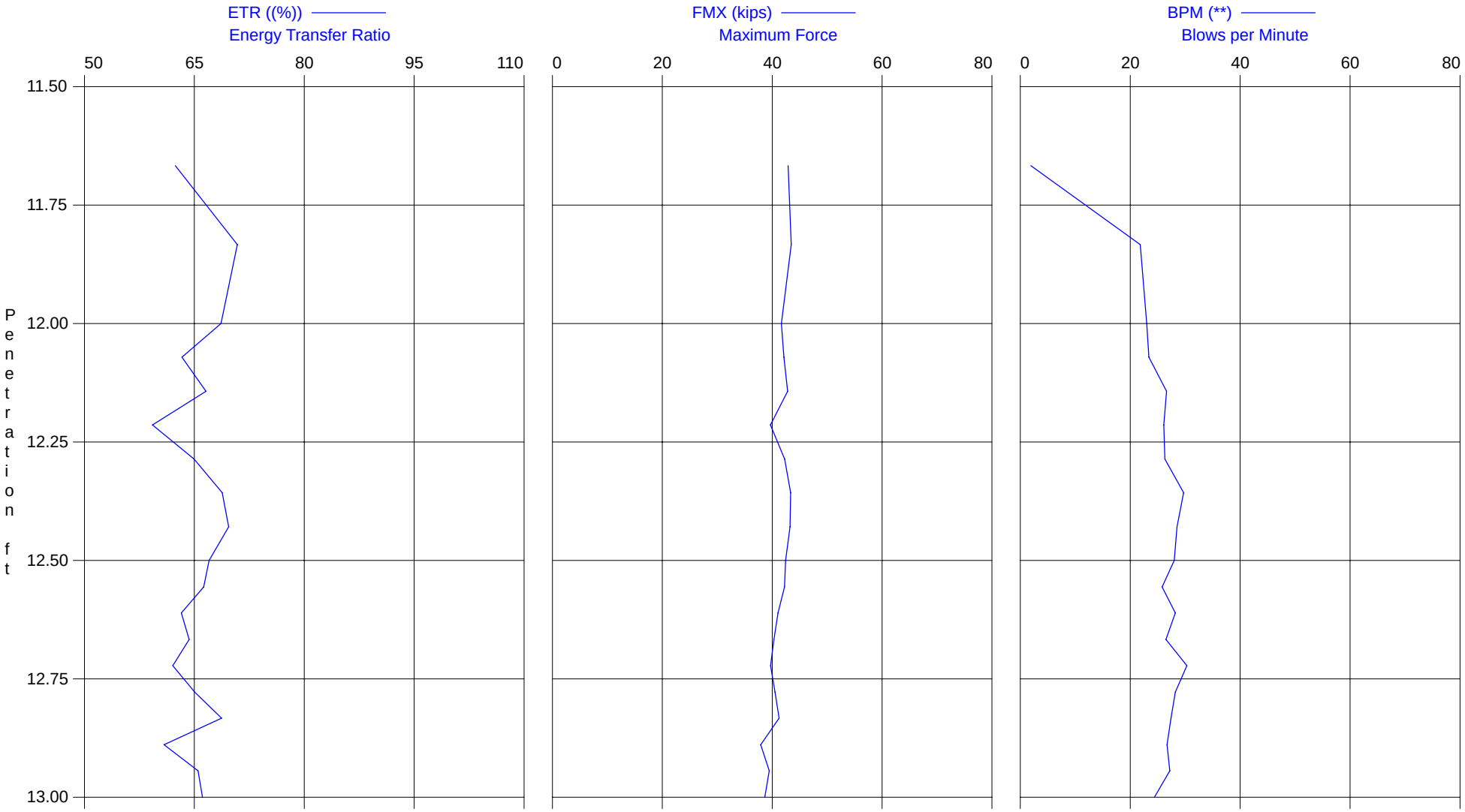
Drive 13 seconds 8:46:05 AM - 8:46:18 AM (7/30/2013) BN 1 - 11

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 11.5FTBHGT13-12, RIG 104-300LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 11.5FT
OP: RMDT

BHGT13-12, RIG 104-300LB
Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 19.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
4	14	29.9	29.7	0.475	63.3	23.4	42	15.4	21	0.564
5	14	30.6	30.2	0.499	66.6	26.6	43	15.9	22	0.585
6	14	28.2	28.0	0.445	59.3	26.1	40	14.4	23	0.508
7	14	30.2	29.8	0.487	65.0	26.3	42	16.1	22	0.346
8	14	31.0	30.5	0.516	68.8	29.7	43	16.2	24	0.365
9	14	31.0	30.5	0.523	69.7	28.5	43	16.5	22	0.365
10	14	30.1	29.9	0.503	67.0	28.0	42	15.9	23	0.346
11	18	30.5	29.7	0.497	66.3	25.8	42	16.1	22	0.576
12	18	29.2	28.9	0.474	63.2	28.2	41	15.5	24	0.549
13	18	29.0	28.4	0.482	64.3	26.5	40	15.8	22	0.541
14	18	28.1	28.0	0.465	62.1	30.3	40	15.1	23	0.518
15	18	28.7	28.5	0.488	65.0	28.2	41	16.2	23	0.543
16	18	29.2	29.1	0.515	68.7	27.4	41	17.0	24	0.576
17	18	26.9	26.7	0.457	60.9	26.7	38	16.0	23	0.506
18	18	28.1	27.8	0.491	65.5	27.2	39	16.8	23	0.548
19	18	27.3	27.2	0.496	66.1	24.4	39	16.9	24	0.550
Average		29.2	28.9	0.488	65.1	27.1	41	16.0	23	0.499
Std. Dev.		1.3	1.1	0.021	2.8	1.7	2	0.7	1	0.086
Maximum		31.0	30.5	0.523	69.7	30.3	43	17.0	24	0.585
Minimum		26.9	26.7	0.445	59.3	23.4	38	14.4	21	0.346

Total number of blows analyzed: 16

Time Summary

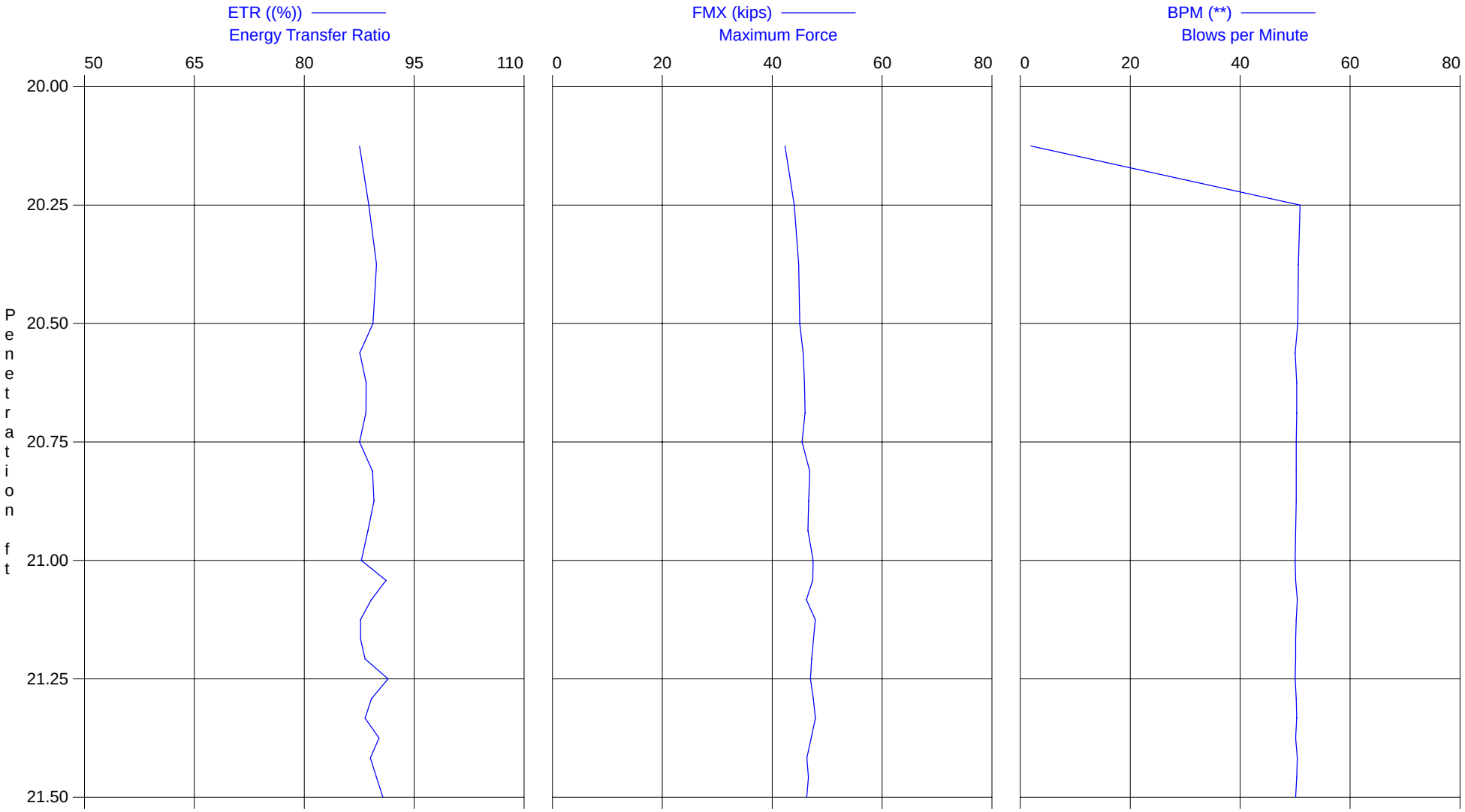
Drive 41 seconds 9:01:14 AM - 9:01:55 AM (7/30/2013) BN 1 - 19

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTECH, RIVERBEND LANDFILL - SAMPLE 20FTBHGT13-12, RIG 104-140LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTECH, RIVERBEND LANDFILL - SAMPLE 20FT

BHGT13-12, RIG 104-140LB

OP: RMDT

Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 25.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
5	16	33.3	32.1	0.307	87.6	50.0	46	15.0	24	0.442
6	16	33.9	32.3	0.310	88.4	50.3	46	14.7	26	0.441
7	16	33.1	32.4	0.309	88.4	50.3	46	13.8	23	0.442
8	16	33.5	32.0	0.306	87.5	50.2	45	14.9	26	0.446
9	16	33.6	33.0	0.313	89.3	50.2	47	13.3	24	0.441
10	16	33.7	32.9	0.313	89.5	50.2	47	13.5	23	0.444
11	16	33.7	32.8	0.310	88.7	50.1	47	13.8	23	0.445
12	16	34.2	33.4	0.307	87.8	50.0	47	13.7	27	0.443
13	24	34.5	33.4	0.319	91.2	50.1	47	15.3	26	0.463
14	24	33.4	32.6	0.312	89.2	50.4	46	13.8	23	0.446
15	24	34.5	33.7	0.307	87.7	50.2	48	13.6	25	0.444
16	24	34.3	33.5	0.307	87.7	50.1	48	13.7	25	0.446
17	24	34.0	33.2	0.309	88.3	50.1	47	13.6	24	0.446
18	24	33.8	33.1	0.320	91.4	50.0	47	13.5	21	0.449
19	24	34.2	33.4	0.312	89.2	50.2	47	13.1	23	0.452
20	24	33.9	33.7	0.309	88.3	50.3	48	13.6	24	0.448
21	24	34.1	33.2	0.316	90.2	50.1	47	13.6	25	0.449
22	24	33.7	32.6	0.312	89.0	50.4	46	13.2	22	0.444
23	24	34.2	32.8	0.315	89.9	50.3	47	14.3	23	0.454
24	24	34.0	32.6	0.318	90.7	50.1	46	14.4	23	0.449
Average		33.9	32.9	0.312	89.0	50.2	47	13.9	24	0.447
Std. Dev.		0.4	0.5	0.004	1.2	0.1	1	0.6	1	0.005
Maximum		34.5	33.7	0.320	91.4	50.4	48	15.3	27	0.463
Minimum		33.1	32.0	0.306	87.5	50.0	45	13.1	21	0.441

Total number of blows analyzed: 20

Time Summary

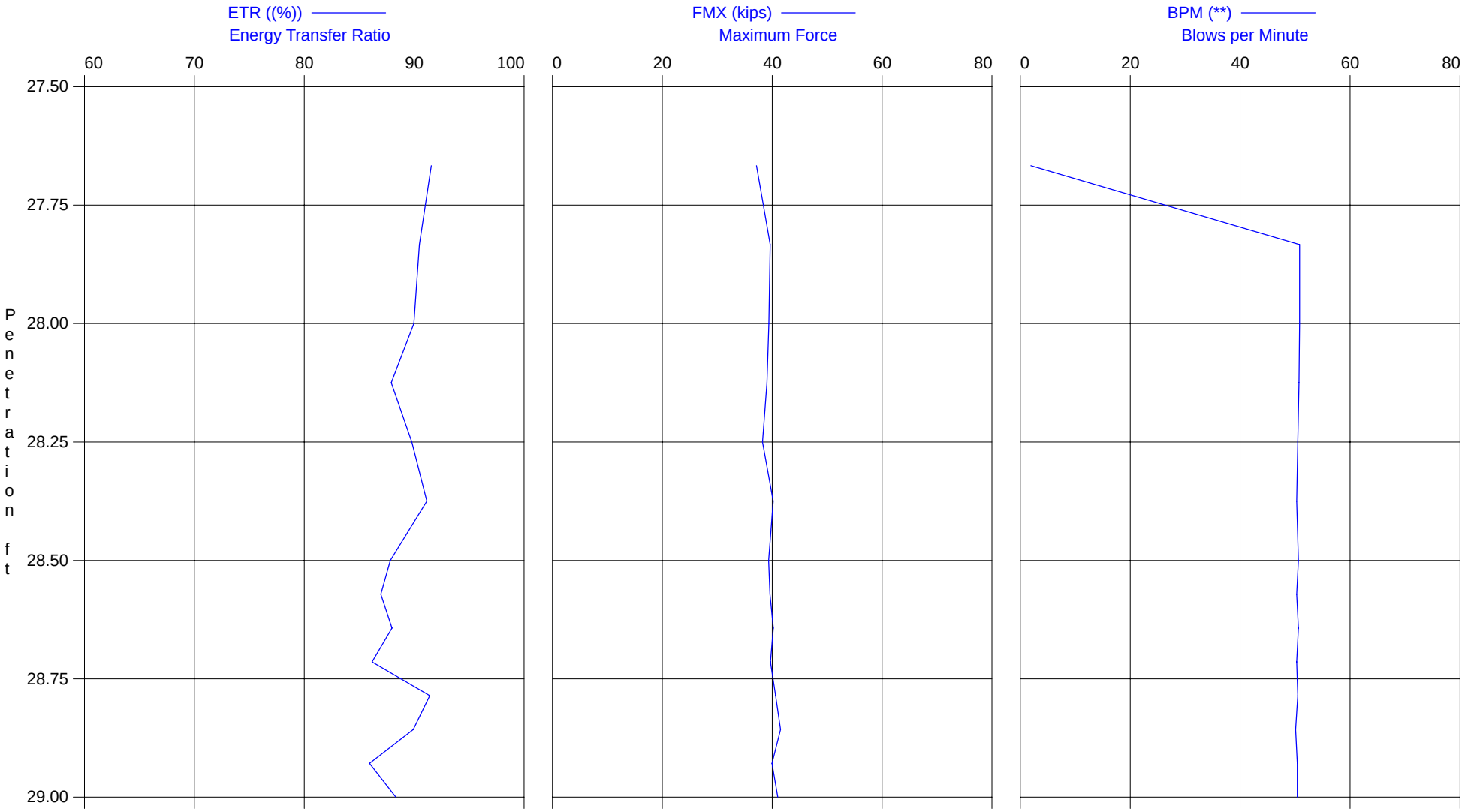
Drive 28 seconds 9:38:49 AM - 9:39:17 AM (7/30/2013) BN 1 - 25

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 27.5FTBHGT13-12, RIG 104-140LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 27.5FT

BHGT13-12, RIG 104-140LB

OP: RMDT

Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 33.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
4	8	28.4	27.5	0.308	87.9	50.7	39	14.3	18	0.412
5	8	27.4	26.9	0.314	89.8	50.5	38	14.2	17	0.408
6	8	28.5	28.3	0.319	91.2	50.3	40	15.8	19	0.421
7	8	28.7	27.7	0.307	87.8	50.6	39	15.6	18	0.415
8	14	28.4	27.9	0.304	87.0	50.3	40	16.3	18	0.413
9	14	29.4	28.3	0.308	88.0	50.6	40	16.2	19	0.412
10	14	28.1	27.9	0.302	86.2	50.3	40	14.4	17	0.409
11	14	29.2	28.6	0.320	91.4	50.5	41	14.4	16	0.419
12	14	29.8	29.2	0.315	89.9	50.1	42	17.0	19	0.422
13	14	28.3	28.2	0.301	85.9	50.4	40	15.3	18	0.416
14	14	29.4	28.9	0.309	88.3	50.4	41	16.4	19	0.421
Average		28.7	28.1	0.310	88.5	50.4	40	15.4	18	0.415
Std. Dev.		0.7	0.6	0.006	1.8	0.2	1	0.9	1	0.005
Maximum		29.8	29.2	0.320	91.4	50.7	42	17.0	19	0.422
Minimum		27.4	26.9	0.301	85.9	50.1	38	14.2	16	0.408

Total number of blows analyzed: 11

Time Summary

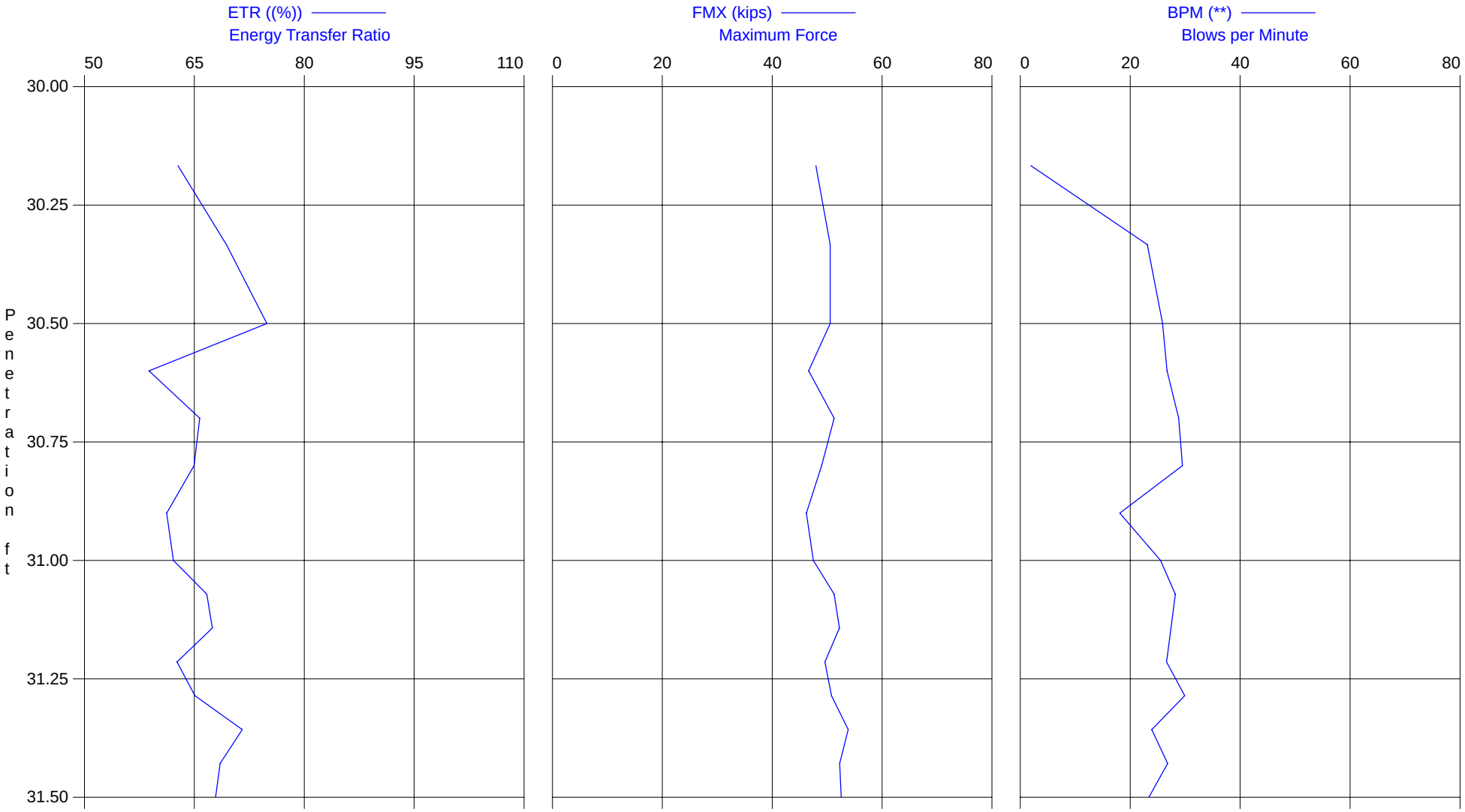
Drive 15 seconds 10:07:29 AM - 10:07:44 AM (7/30/2013) BN 1 - 14

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 30FTBHGT13-12, RIG 104-300LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 30FT
OP: RMDT

BHGT13-12, RIG 104-300LB
Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 35.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
4	10	33.6	32.8	0.441	58.8	26.7	47	16.0	33	0.565
5	10	36.7	36.1	0.493	65.7	28.8	51	17.4	36	0.655
6	10	34.8	34.5	0.487	65.0	29.5	49	16.2	31	0.605
7	10	32.7	32.6	0.459	61.2	18.1	46	15.4	23	0.532
8	10	33.7	33.4	0.466	62.1	25.5	47	16.0	28	0.640
9	14	36.6	36.1	0.500	66.7	28.2	51	17.4	35	0.659
10	14	37.4	36.8	0.506	67.4	27.4	52	17.3	32	0.764
11	14	35.1	34.9	0.470	62.6	26.6	50	16.1	28	0.671
12	14	36.3	35.8	0.488	65.1	29.9	51	17.1	31	0.632
13	14	38.0	37.9	0.537	71.5	23.9	54	17.4	39	0.801
14	14	37.4	36.8	0.514	68.5	26.8	52	17.6	35	0.661
15	14	37.0	37.0	0.509	67.9	23.4	53	16.5	34	0.656
Average		35.8	35.4	0.489	65.2	26.2	50	16.7	32	0.653
Std. Dev.		1.7	1.7	0.026	3.4	3.1	2	0.7	4	0.071
Maximum		38.0	37.9	0.537	71.5	29.9	54	17.6	39	0.801
Minimum		32.7	32.6	0.441	58.8	18.1	46	15.4	23	0.532

Total number of blows analyzed: 12

Time Summary

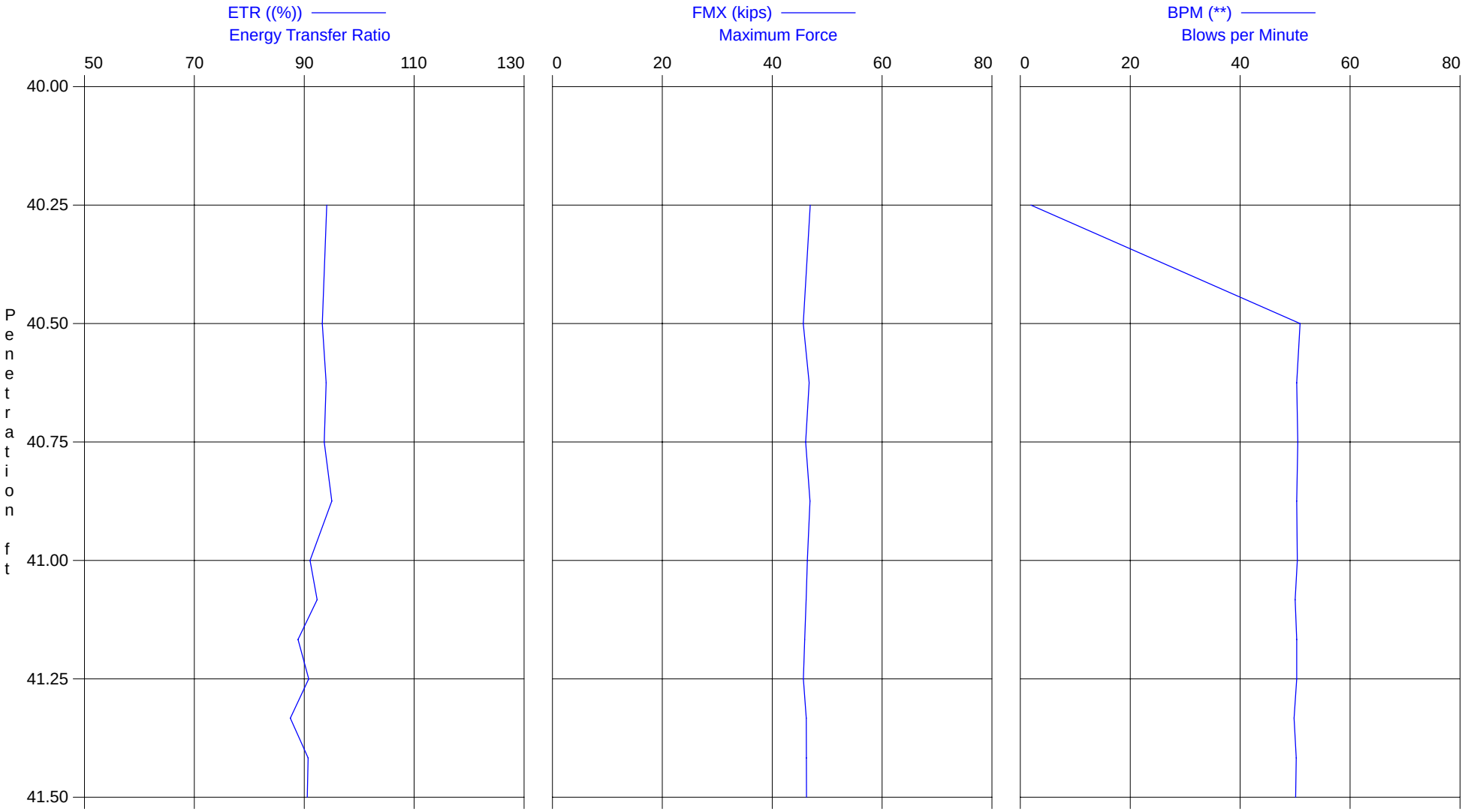
Drive 33 seconds 10:25:21 AM - 10:25:54 AM (7/30/2013) BN 1 - 15

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 40FTBHGT13-12, RIG 104-140LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 40FT
OP: RMDT

BHGT13-12, RIG 104-140LB
Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 44.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
3	8	33.4	32.9	0.329	94.0	50.3	47	16.1	21	0.469
4	8	33.2	32.5	0.328	93.6	50.5	46	15.3	20	0.465
5	8	33.4	33.0	0.333	95.0	50.3	47	15.3	21	0.471
6	8	33.3	32.7	0.319	91.1	50.4	46	15.0	22	0.464
7	12	33.0	32.5	0.323	92.4	50.0	46	14.1	21	0.467
8	12	33.0	32.3	0.311	88.9	50.3	46	14.0	21	0.464
9	12	32.9	32.2	0.318	90.8	50.3	46	14.5	21	0.467
10	12	32.9	32.5	0.306	87.5	49.8	46	14.1	21	0.467
11	12	32.7	32.6	0.318	90.7	50.2	46	14.5	21	0.461
12	12	33.0	32.6	0.317	90.6	50.1	46	13.4	21	0.463
Average		33.1	32.6	0.320	91.4	50.2	46	14.6	21	0.466
Std. Dev.		0.2	0.2	0.008	2.2	0.2	0	0.7	0	0.003
Maximum		33.4	33.0	0.333	95.0	50.5	47	16.1	22	0.471
Minimum		32.7	32.2	0.306	87.5	49.8	46	13.4	20	0.461

Total number of blows analyzed: 10

Time Summary

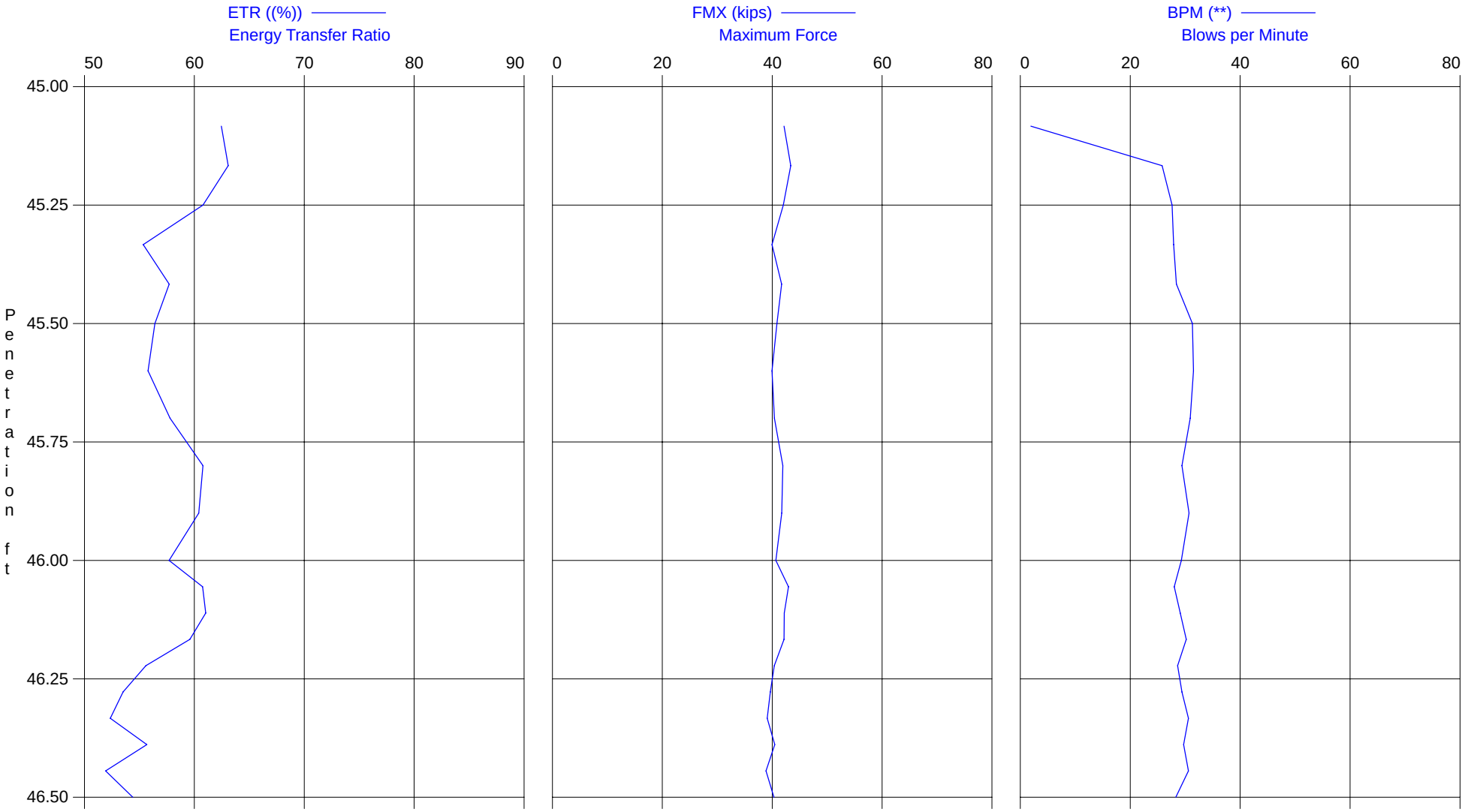
Drive 13 seconds 11:33:52 AM - 11:34:05 AM (7/30/2013) BN 1 - 12

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 45FTBHGT13-12, RIG 104-300LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 45FT
OP: RMDT

BHGT13-12, RIG 104-300LB
Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 52.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
7	10	29.2	28.2	0.418	55.8	31.5	40	13.9	24	0.511
8	10	29.3	28.4	0.433	57.8	30.9	40	14.0	24	0.538
9	10	30.3	29.5	0.456	60.8	29.4	42	15.0	25	0.557
10	10	29.9	29.4	0.453	60.4	30.7	42	14.9	24	0.556
11	10	29.2	28.6	0.433	57.7	29.3	41	14.4	24	0.527
12	18	30.7	30.3	0.456	60.8	28.0	43	15.1	31	0.579
13	18	30.3	29.7	0.458	61.0	29.1	42	14.9	25	0.571
14	18	30.3	29.7	0.447	59.6	30.2	42	15.0	23	0.567
15	18	29.0	28.4	0.417	55.6	28.6	40	14.2	23	0.525
16	18	28.6	27.9	0.401	53.5	29.4	40	13.7	23	0.509
17	18	28.1	27.5	0.393	52.4	30.6	39	13.8	22	0.502
18	18	29.3	28.5	0.418	55.7	29.7	40	14.3	25	0.528
19	18	28.2	27.4	0.389	51.9	30.6	39	14.0	26	0.502
20	18	28.9	28.4	0.408	54.4	28.3	40	14.2	27	0.523
Average		29.4	28.7	0.427	56.9	29.7	41	14.4	25	0.535
Std. Dev.		0.8	0.8	0.023	3.1	1.0	1	0.5	2	0.025
Maximum		30.7	30.3	0.458	61.0	31.5	43	15.1	31	0.579
Minimum		28.1	27.4	0.389	51.9	28.0	39	13.7	22	0.502

Total number of blows analyzed: 14

Time Summary

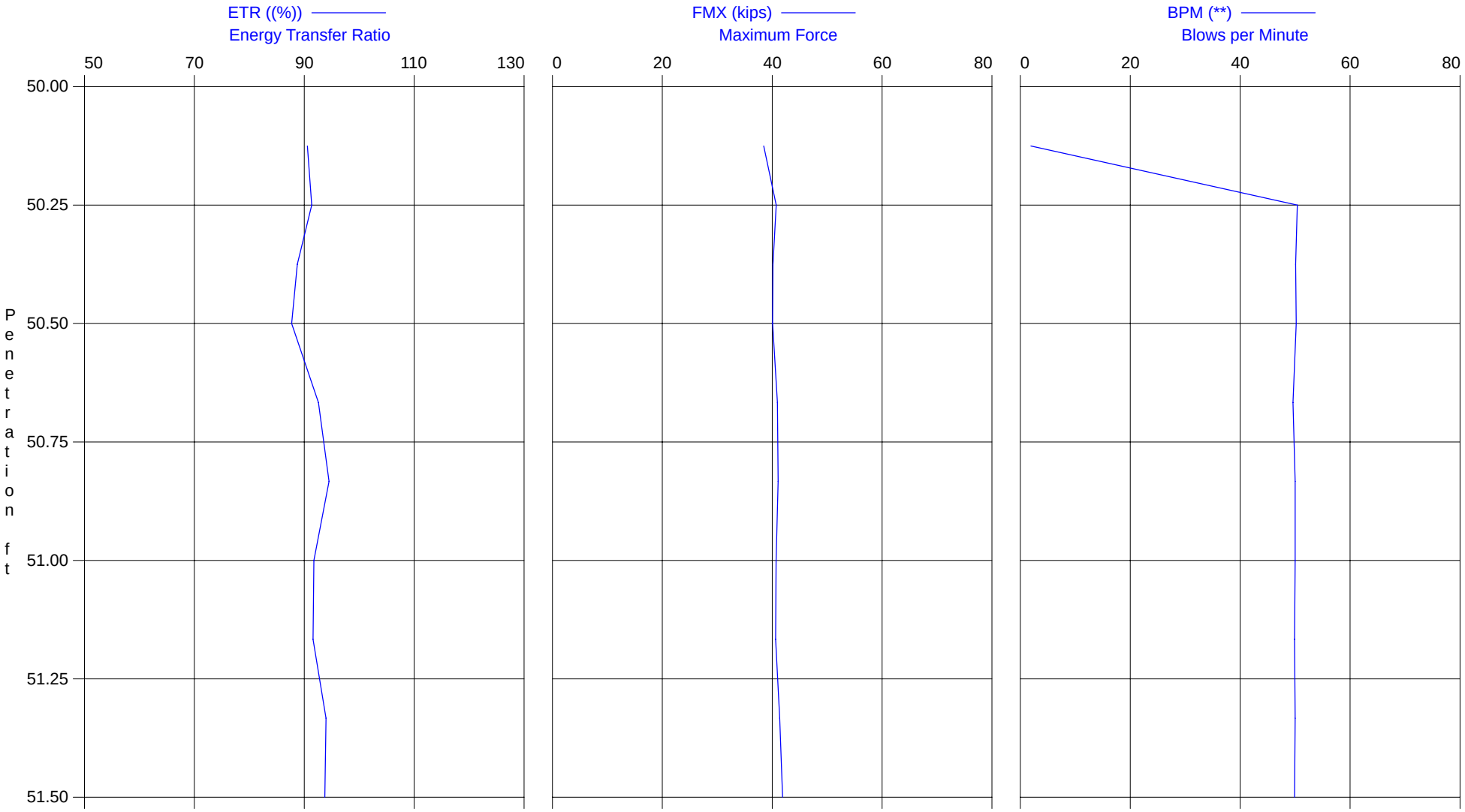
Drive 38 seconds 11:59:07 AM - 11:59:45 AM (7/30/2013) BN 1 - 20

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 50FTBHGT13-12, RIG 104-140LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 50FT

BHGT13-12, RIG 104-140LB

OP: RMDT

Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 57.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
5	6	29.7	28.8	0.324	92.6	49.6	41	15.1	19	0.437
6	6	29.9	28.9	0.331	94.5	50.0	41	15.0	17	0.436
7	6	29.5	28.7	0.321	91.8	50.0	41	14.6	17	0.431
8	6	29.4	28.6	0.321	91.6	49.9	41	14.7	17	0.434
9	6	30.2	29.1	0.329	94.0	50.0	41	14.8	17	0.437
10	6	30.4	29.5	0.328	93.7	49.9	42	15.0	18	0.449
Average		29.8	28.9	0.326	93.0	49.9	41	14.9	18	0.437
Std. Dev.		0.4	0.3	0.004	1.1	0.1	0	0.2	1	0.006
Maximum		30.4	29.5	0.331	94.5	50.0	42	15.1	19	0.449
Minimum		29.4	28.6	0.321	91.6	49.6	41	14.6	17	0.431

Total number of blows analyzed: 6

Time Summary

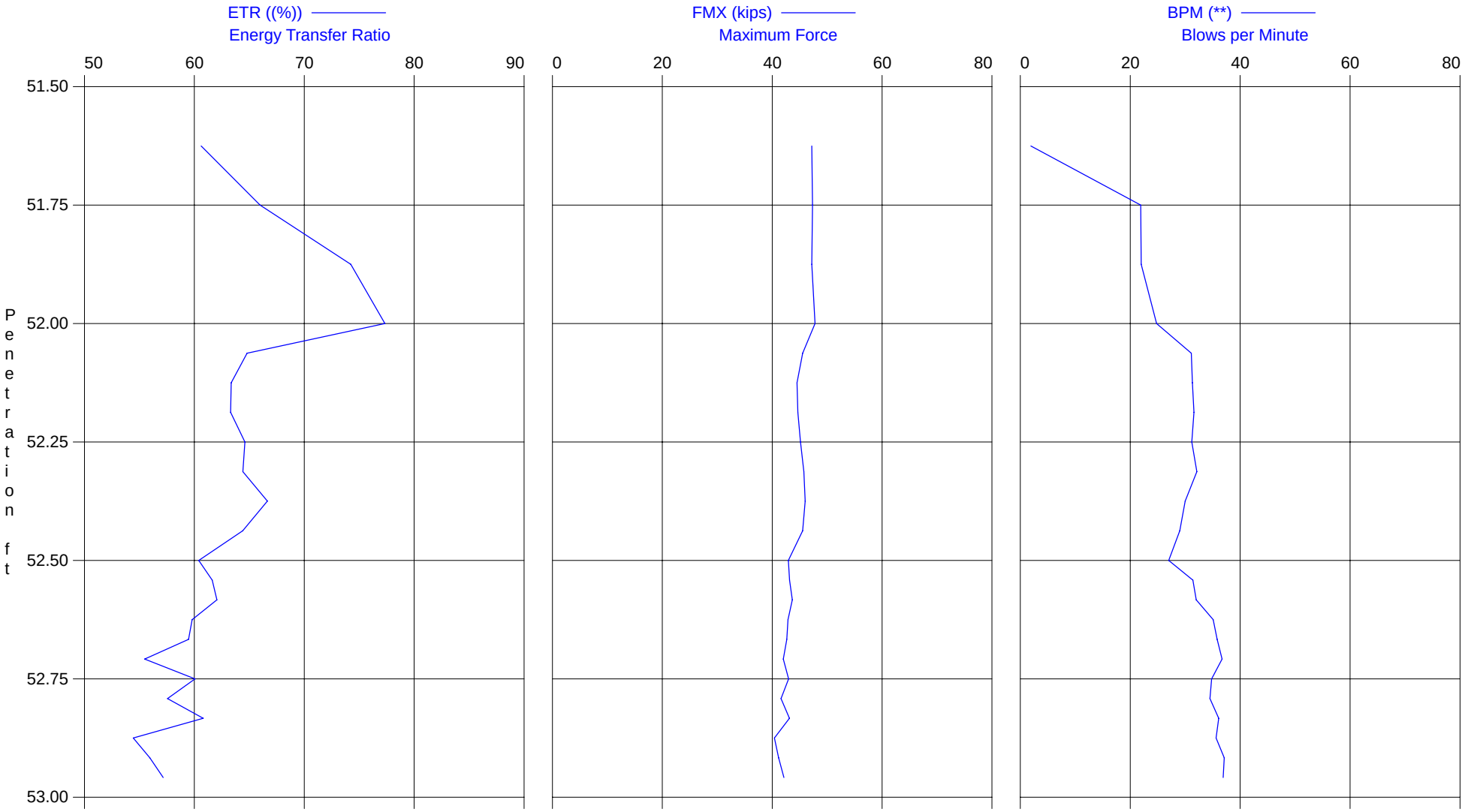
Drive 11 seconds 12:20:52 PM - 12:21:03 PM (7/30/2013) BN 1 - 10

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 51.5FTBHGT13-12, RIG 104-300LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 51.5FT

BHGT13-12, RIG 104-300LB

OP: RMDT

Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 59.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
1	8	34.3	33.2	0.455	60.6	1.9	47	15.0	32	0.804
2	8	33.9	33.3	0.495	66.0	21.9	47	15.7	31	0.818
3	8	34.6	33.2	0.557	74.2	22.0	47	15.2	22	0.807
4	8	35.1	33.7	0.580	77.3	24.8	48	15.4	26	0.811
5	16	33.5	32.1	0.486	64.8	31.1	46	14.6	23	0.741
6	16	32.6	31.3	0.475	63.4	31.3	45	14.9	25	0.717
7	16	33.0	31.5	0.475	63.3	31.6	45	14.6	23	0.707
8	16	33.0	31.8	0.484	64.6	31.2	45	14.9	19	0.701
9	16	33.6	32.2	0.483	64.4	32.1	46	14.6	21	0.707
10	16	33.9	32.4	0.500	66.6	30.0	46	14.9	24	0.756
11	16	33.6	32.1	0.483	64.4	29.0	46	14.7	20	0.703
12	16	31.3	30.2	0.453	60.4	27.0	43	14.8	26	0.639
13	24	31.5	30.4	0.462	61.6	31.4	43	14.8	24	0.641
14	24	32.2	30.7	0.465	62.1	32.0	44	14.4	17	0.665
15	24	31.5	30.2	0.448	59.8	35.1	43	14.2	14	0.619
16	24	31.3	30.0	0.446	59.5	35.8	43	14.2	15	0.632
17	24	30.9	29.6	0.416	55.5	36.7	42	14.5	25	0.592
18	24	31.9	30.3	0.450	60.1	34.8	43	14.1	20	0.612
19	24	30.6	29.3	0.432	57.6	34.5	42	14.6	20	0.612
20	24	31.6	30.4	0.456	60.8	36.1	43	14.3	20	0.619
21	24	29.6	28.4	0.408	54.4	35.6	40	14.5	22	0.558
22	24	30.5	29.0	0.420	55.9	37.1	41	14.1	17	0.566
23	24	31.2	29.7	0.429	57.2	36.9	42	14.2	15	0.590
24	24	29.1	28.2	0.399	53.2	34.4	40	14.3	18	0.541
Average		32.3	31.0	0.465	62.0	30.6	44	14.6	22	0.673
Std. Dev.		1.6	1.6	0.041	5.5	7.4	2	0.4	5	0.083
Maximum		35.1	33.7	0.580	77.3	37.1	48	15.7	32	0.818
Minimum		29.1	28.2	0.399	53.2	1.9	40	14.1	14	0.541

Total number of blows analyzed: 24

Time Summary

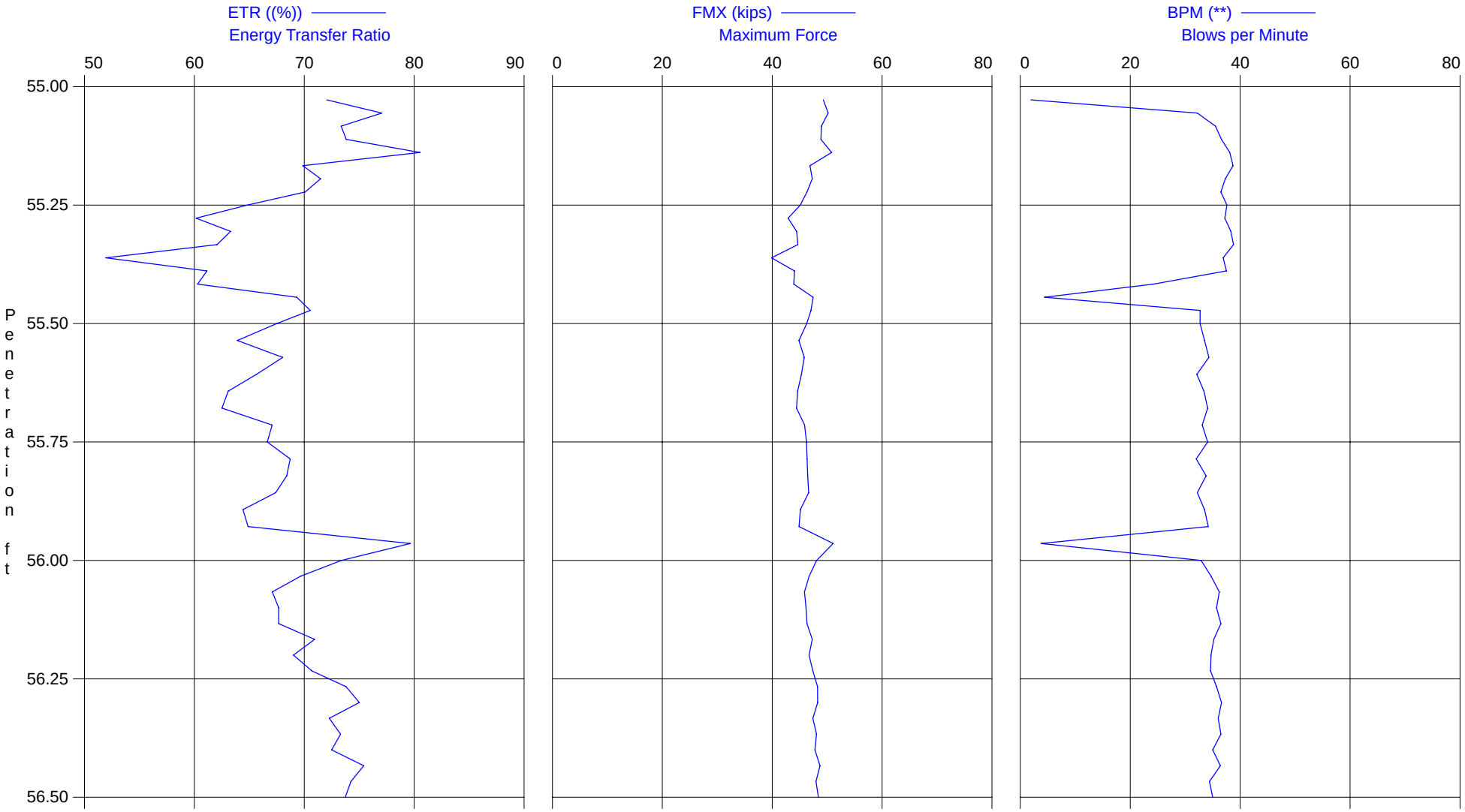
Drive 44 seconds 12:38:37 PM - 12:39:21 PM (7/30/2013) BN 1 - 24

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 55FTBHGT13-12, RIG 104-300LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 55FT
OP: RMDT

BHGT13-12, RIG 104-300LB
Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 61.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
19	28	31.7	31.6	0.479	63.9	33.5	45	15.4	22	0.667
20	28	32.4	32.3	0.510	68.0	34.3	46	16.0	23	0.699
21	28	32.1	31.9	0.492	65.7	32.1	45	15.5	23	0.686
22	28	31.5	31.4	0.473	63.1	33.4	45	15.2	23	0.660
23	28	31.5	31.3	0.469	62.5	34.1	44	15.0	23	0.651
24	28	32.5	32.3	0.503	67.1	33.1	46	15.6	24	0.701
25	28	33.1	32.6	0.500	66.6	34.1	46	15.7	25	0.695
26	28	32.7	32.6	0.515	68.7	32.0	46	15.8	24	0.713
27	28	32.9	32.7	0.513	68.4	33.8	46	15.8	23	0.715
28	28	33.1	32.8	0.505	67.4	32.2	47	15.7	24	0.702
29	28	32.1	31.8	0.483	64.4	33.5	45	15.6	23	0.669
30	28	31.8	31.6	0.487	64.9	34.2	45	15.7	22	0.672
31	28	36.7	36.0	0.597	79.7	3.8	51	17.5	26	0.824
32	28	34.3	33.9	0.550	73.4	32.9	48	16.2	23	0.772
33	30	33.0	32.9	0.523	69.7	34.7	47	15.9	22	0.722
34	30	32.5	32.3	0.503	67.1	36.2	46	15.7	22	0.686
35	30	32.7	32.5	0.508	67.7	35.7	46	15.7	23	0.686
36	30	33.0	32.6	0.508	67.7	36.5	46	15.8	23	0.694
37	30	33.8	33.3	0.532	70.9	35.2	47	16.3	24	0.718
38	30	33.1	32.9	0.518	69.0	34.7	47	16.2	24	0.700
39	30	33.7	33.4	0.530	70.7	34.6	47	16.6	24	0.711
40	30	34.5	34.0	0.554	73.8	35.7	48	17.0	24	0.747
41	30	34.3	34.0	0.563	75.0	36.6	48	17.0	23	0.749
42	30	34.0	33.4	0.542	72.3	36.0	47	16.6	23	0.730
43	30	34.2	33.8	0.550	73.3	36.5	48	16.9	23	0.734
44	30	34.1	33.6	0.544	72.5	35.0	48	16.8	23	0.733
45	30	34.9	34.3	0.566	75.4	36.4	49	17.3	24	0.752
46	30	34.2	33.8	0.557	74.3	34.4	48	17.1	23	0.739
47	30	34.5	34.1	0.553	73.7	35.0	48	17.2	23	0.741
Average		33.3	33.0	0.522	69.5	33.5	47	16.2	23	0.713
Std. Dev.		1.2	1.0	0.031	4.1	5.8	1	0.7	1	0.036
Maximum		36.7	36.0	0.597	79.7	36.6	51	17.5	26	0.824
Minimum		31.5	31.3	0.469	62.5	3.8	44	15.0	22	0.651

Total number of blows analyzed: 29

Time Summary

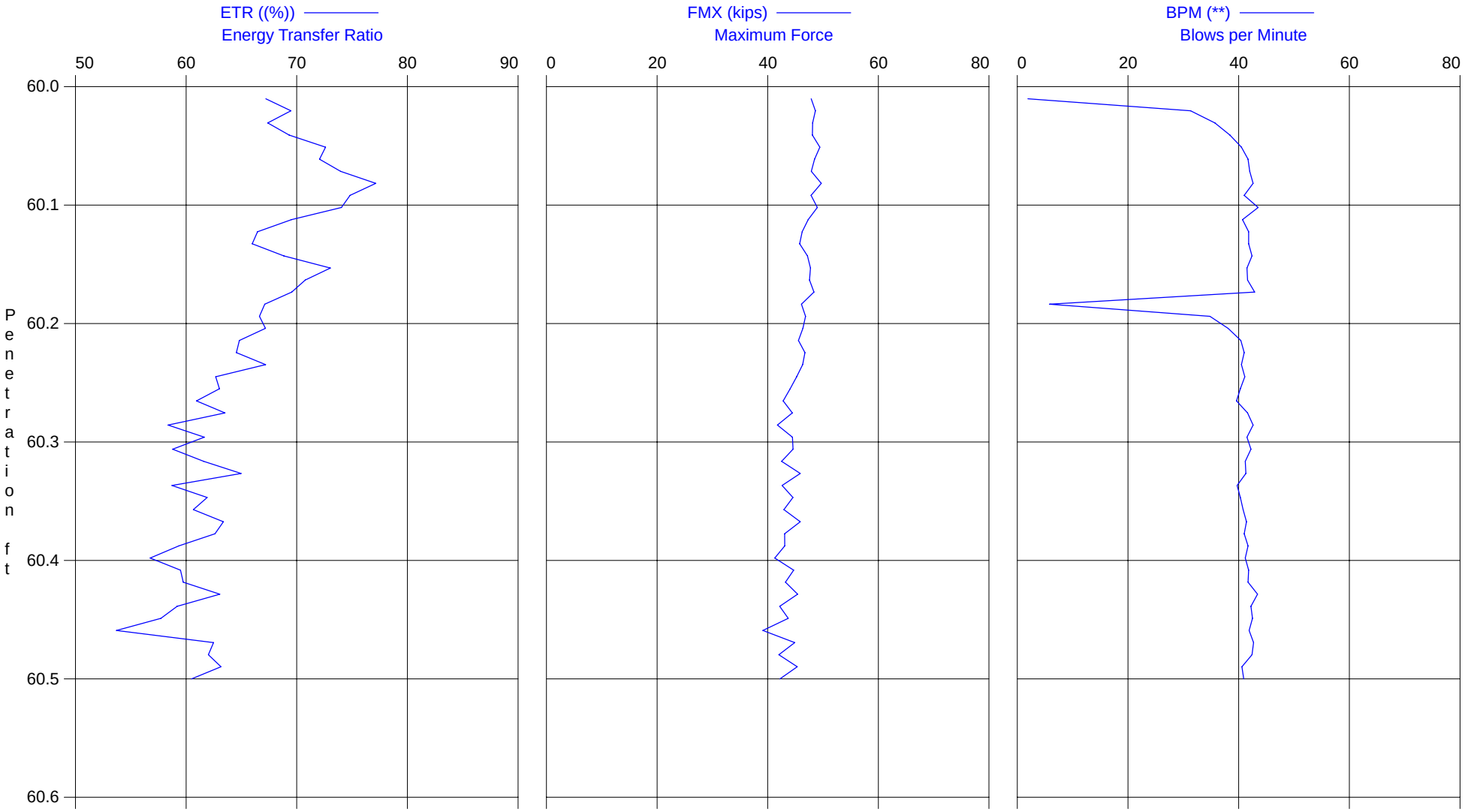
Drive 1 minute 45 seconds 12:58:04 PM - 12:59:49 PM (7/30/2013) BN 1 - 47

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 60FTBHGT13-12, RIG 104-300LB



Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 60FT
OP: RMDT

BHGT13-12, RIG 104-300LB
Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 66.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
1	98	34.6	33.7	0.504	67.2	1.9	48	16.2	24	0.790
2	98	35.2	34.3	0.521	69.5	31.3	49	17.1	24	0.807
3	98	34.7	33.9	0.505	67.4	35.7	48	17.1	22	0.773
4	98	34.9	33.9	0.520	69.3	38.4	48	17.2	23	0.779
5	98	36.2	34.8	0.545	72.6	40.5	49	17.3	24	0.817
6	98	35.8	34.1	0.540	72.1	41.7	48	17.0	24	0.795
7	98	35.0	33.7	0.555	74.0	42.0	48	17.0	23	0.787
8	98	36.0	35.0	0.579	77.1	42.6	50	17.9	24	0.822
9	98	35.3	33.7	0.561	74.8	41.0	48	17.0	23	0.813
10	98	35.1	34.5	0.555	74.0	43.5	49	17.4	22	0.811
11	98	34.3	33.3	0.522	69.5	40.7	47	16.5	22	0.748
12	98	33.8	32.6	0.498	66.5	41.8	46	16.4	23	0.726
13	98	32.9	32.2	0.495	66.0	41.8	46	16.5	21	0.719
14	98	33.7	33.2	0.516	68.8	42.4	47	17.0	22	0.747
15	98	34.4	33.6	0.548	73.0	41.5	48	17.4	23	0.813
16	98	34.3	33.5	0.531	70.8	41.6	48	17.1	22	0.761
17	98	35.0	34.1	0.522	69.5	42.9	48	16.6	21	0.764
18	98	33.3	32.5	0.503	67.1	5.8	46	16.1	20	0.722
19	98	33.6	33.0	0.500	66.6	34.8	47	15.9	20	0.719
20	98	33.0	32.7	0.504	67.2	38.1	46	16.3	20	0.713
21	98	32.8	32.1	0.486	64.8	40.4	46	16.5	21	0.714
22	98	33.5	32.9	0.484	64.5	41.0	47	15.7	20	0.704
23	98	33.2	32.6	0.504	67.2	40.5	46	16.7	21	0.724
24	98	32.5	31.9	0.470	62.7	41.1	45	15.3	20	0.685
25	98	32.0	31.0	0.473	63.0	40.3	44	15.9	20	0.672
26	98	31.2	30.1	0.457	60.9	39.6	43	15.5	19	0.628
27	98	32.0	31.3	0.476	63.5	41.6	44	16.4	20	0.677
28	98	29.9	29.4	0.438	58.4	42.6	42	15.3	19	0.603
29	98	32.3	31.3	0.462	61.6	41.5	44	15.4	19	0.653
30	98	31.9	31.4	0.441	58.8	42.2	45	15.2	19	0.647
31	98	30.5	30.0	0.462	61.6	41.2	43	15.8	19	0.635
32	98	33.2	32.3	0.487	65.0	41.3	46	15.6	19	0.705
33	98	30.9	30.0	0.440	58.7	39.7	43	15.8	20	0.642
34	98	32.2	31.4	0.464	61.9	40.3	45	15.1	19	0.656
35	98	30.8	30.2	0.455	60.7	40.8	43	16.2	20	0.650
36	98	33.1	32.3	0.475	63.4	41.4	46	15.2	20	0.686
37	98	31.3	30.3	0.470	62.6	41.0	43	15.6	19	0.648
38	98	31.5	30.3	0.445	59.3	41.7	43	14.9	18	0.626
39	98	29.8	29.1	0.426	56.8	41.2	41	15.6	19	0.601
40	98	31.9	31.5	0.446	59.5	41.8	45	15.7	19	0.651
41	98	31.0	30.4	0.448	59.7	41.7	43	16.0	19	0.631
42	98	32.5	32.0	0.473	63.1	43.4	45	15.6	19	0.686
43	98	30.7	29.7	0.444	59.2	42.2	42	15.4	19	0.624
44	98	31.3	30.8	0.433	57.7	42.5	44	15.0	19	0.618
45	98	28.3	27.6	0.403	53.7	41.9	39	15.1	18	0.554
46	98	32.1	31.6	0.469	62.5	42.7	45	15.7	18	0.650
47	98	30.5	29.6	0.465	62.0	42.4	42	16.0	18	0.634
48	98	32.3	31.9	0.474	63.2	40.6	45	15.6	19	0.670
49	98	30.4	29.7	0.454	60.5	40.9	42	15.8	17	0.612
Average		32.8	32.0	0.487	64.9	39.4	45	16.1	21	0.700
Std. Dev.		1.8	1.7	0.040	5.3	7.6	2	0.8	2	0.070
Maximum		36.2	35.0	0.579	77.1	43.5	50	17.9	24	0.822
Minimum		28.3	27.6	0.403	53.7	1.9	39	14.9	17	0.554

Total number of blows analyzed: 49

Time Summary

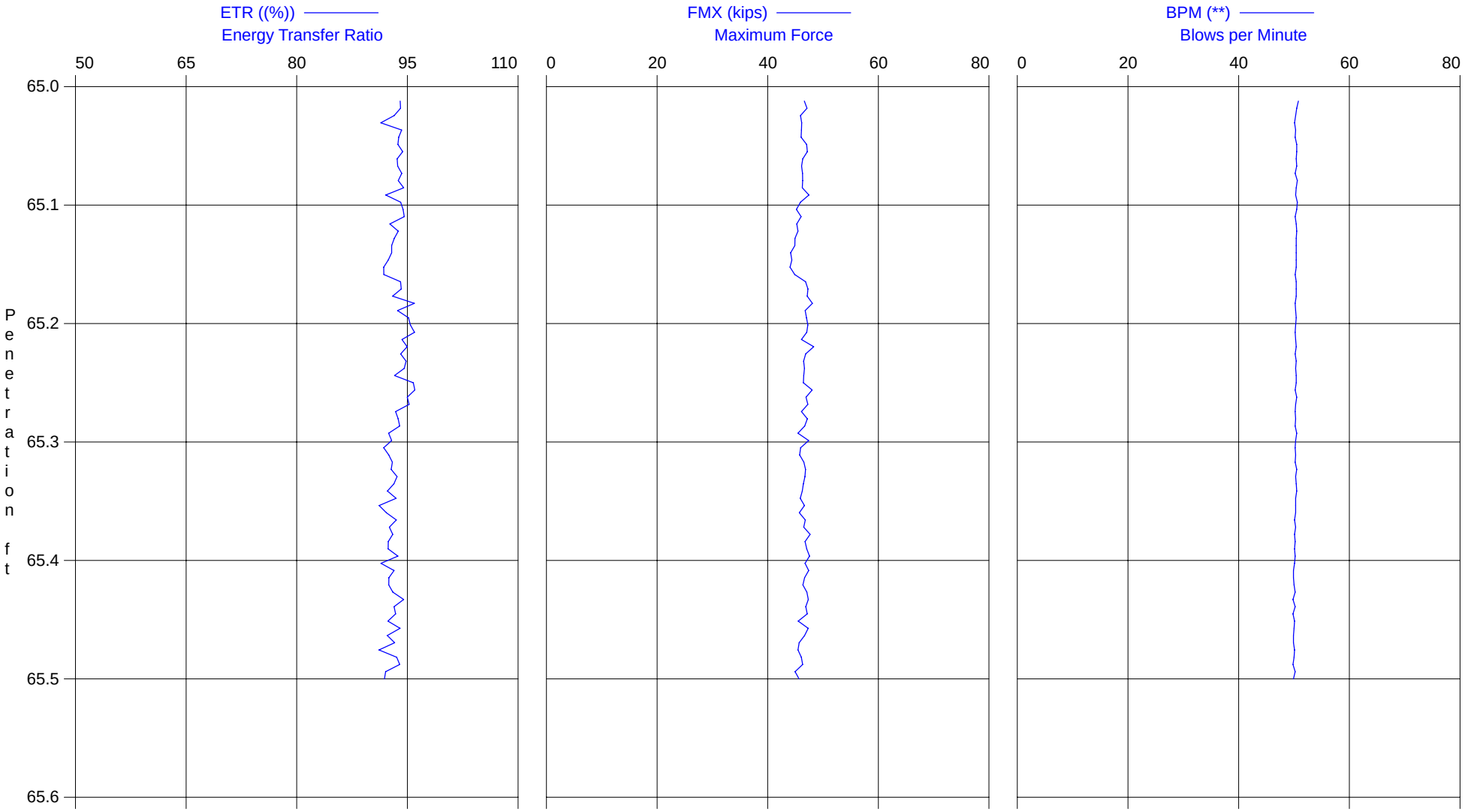
Drive 1 minute 20 seconds 1:53:50 PM - 1:55:10 PM (7/30/2013) BN 1 - 49

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2012.2 - Printed: 29-Aug-2013

Test date: 30-Jul-2013

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 65FTBHGT13-12, RIG 104-140LB



GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 65FT
OP: RMDT

BHGT13-12, RIG 104-140LB
Test date: 30-Jul-2013

AR: 1.42 in^2
LE: 71.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
SFT: Skin friction total
EF2: Energy of F^2

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
2	164	33.9	32.8	0.329	94.0	50.8	47	14.8	21	0.473
3	164	34.6	33.2	0.329	94.1	50.5	47	14.6	22	0.474
4	164	33.4	32.3	0.326	93.2	50.3	46	15.3	22	0.468
5	164	33.4	32.5	0.320	91.4	50.1	46	14.6	22	0.462
6	164	33.5	32.5	0.330	94.2	50.3	46	15.4	23	0.468
7	164	33.6	32.4	0.328	93.8	50.2	46	14.6	20	0.467
8	164	34.3	33.1	0.328	93.7	50.5	47	13.4	19	0.464
9	164	35.0	33.2	0.330	94.4	50.5	47	13.8	19	0.469
10	164	33.4	32.6	0.328	93.6	50.4	46	15.5	23	0.471
11	164	33.3	32.5	0.328	93.7	50.5	46	14.8	20	0.467
12	164	33.2	32.6	0.330	94.2	50.2	46	15.2	21	0.472
13	164	32.8	32.6	0.328	93.8	50.6	46	15.2	21	0.465
14	164	33.2	32.6	0.331	94.5	50.4	46	14.9	20	0.466
15	164	35.0	33.4	0.322	92.1	50.3	47	12.8	18	0.460
16	164	33.6	32.4	0.329	94.1	50.6	46	13.8	17	0.465
17	164	33.6	31.8	0.330	94.4	50.5	45	13.6	16	0.454
18	164	32.9	32.4	0.331	94.6	50.2	46	15.1	19	0.467
19	164	33.5	31.9	0.324	92.6	50.4	45	13.2	16	0.455
20	164	33.7	32.0	0.328	93.8	50.5	45	13.6	16	0.454
21	164	32.3	31.7	0.326	93.2	50.4	45	14.9	16	0.448
22	164	32.9	31.6	0.325	92.9	50.4	45	12.9	15	0.451
23	164	31.4	31.1	0.325	92.9	50.4	44	13.7	14	0.441
24	164	32.4	31.3	0.323	92.4	50.4	44	13.3	15	0.443
25	164	31.2	31.0	0.321	91.8	50.4	44	15.1	16	0.439
26	164	32.8	31.6	0.321	91.8	50.2	45	14.0	18	0.445
27	164	33.3	33.0	0.329	94.1	50.4	47	15.2	19	0.458
28	164	33.6	33.3	0.330	94.2	50.4	47	15.1	20	0.466
29	164	35.0	33.2	0.325	93.0	50.4	47	13.6	19	0.454
30	164	34.2	33.9	0.336	95.9	50.2	48	16.2	23	0.472
31	164	34.6	33.0	0.328	93.7	50.3	47	13.5	19	0.461
32	164	34.1	33.1	0.333	95.2	50.4	47	14.0	18	0.461
33	164	34.0	33.3	0.334	95.4	50.3	47	14.8	18	0.460
34	164	33.6	33.1	0.336	96.0	50.2	47	15.3	18	0.466
35	164	33.9	32.5	0.330	94.3	50.3	46	13.7	18	0.456
36	164	34.7	34.0	0.332	95.0	50.4	48	15.4	20	0.471
37	164	33.9	33.0	0.329	94.1	50.2	47	14.3	17	0.457
38	164	33.5	32.7	0.332	94.8	50.4	46	13.9	16	0.452
39	164	33.7	32.9	0.331	94.6	50.3	47	14.3	16	0.452
40	164	34.4	32.8	0.326	93.3	50.4	47	13.9	18	0.453
41	164	33.3	32.7	0.335	95.8	50.4	46	15.2	16	0.451
42	164	34.5	33.8	0.336	96.0	50.2	48	15.5	19	0.465
43	164	33.4	33.1	0.332	95.0	50.5	47	15.8	20	0.458
44	164	33.6	33.3	0.333	95.2	50.3	47	15.7	19	0.462
45	164	33.2	32.5	0.327	93.4	50.2	46	13.7	15	0.443
46	164	33.9	33.2	0.328	93.7	50.3	47	15.4	17	0.450
47	164	33.7	32.9	0.329	94.0	50.2	47	13.9	14	0.444
48	164	32.6	32.0	0.324	92.4	50.5	45	14.1	14	0.434
49	164	34.1	33.4	0.325	92.9	50.3	47	15.3	18	0.450
50	164	33.0	32.4	0.321	91.8	50.2	46	13.8	15	0.439
51	164	32.8	32.2	0.324	92.5	50.3	46	14.4	15	0.439
52	164	33.2	32.8	0.325	93.0	50.2	47	15.0	16	0.443
53	164	33.7	33.0	0.325	92.8	50.5	47	14.2	14	0.440
54	164	33.6	32.9	0.328	93.6	50.3	47	15.1	15	0.442
55	164	33.2	32.7	0.326	93.2	50.4	46	15.2	15	0.444
56	164	33.3	32.6	0.323	92.3	50.5	46	14.1	14	0.436
57	164	32.3	32.3	0.327	93.5	50.3	46	16.2	19	0.439
58	164	33.5	32.8	0.319	91.2	50.3	47	14.4	16	0.440
59	164	32.8	32.2	0.323	92.2	50.3	46	13.5	14	0.430
60	164	33.6	33.0	0.327	93.5	50.1	47	14.5	14	0.437
61	164	34.6	32.8	0.324	92.6	50.3	47	13.7	18	0.449
62	164	34.0	33.6	0.326	93.0	50.1	48	15.6	20	0.458
63	164	33.4	32.9	0.323	92.4	50.2	47	14.9	20	0.451
64	164	34.0	33.1	0.323	92.4	50.1	47	13.8	19	0.451
65	164	34.3	33.5	0.328	93.7	50.2	48	14.4	18	0.453
66	164	34.2	32.9	0.320	91.4	50.1	47	14.0	20	0.447

GEOSYNTEC, RIVERBEND LANDFILL - SAMPLE 65FT
OP: RMDT

BHGT13-12, RIG 104-140LB
Test date: 30-Jul-2013

BL#	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	SFT	EF2
	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	kips	k-ft
67	164	34.0	33.4	0.326	93.2	49.9	47	15.2	19	0.452
68	164	33.8	32.9	0.324	92.5	49.9	47	14.0	18	0.446
69	164	33.5	32.7	0.324	92.5	50.0	46	15.5	21	0.445
70	164	33.7	33.2	0.326	93.0	50.2	47	15.4	18	0.447
71	164	34.0	33.3	0.331	94.5	49.8	47	15.0	18	0.454
72	164	33.8	33.0	0.326	93.2	50.2	47	15.1	17	0.448
73	164	33.9	33.2	0.327	93.4	49.8	47	14.9	16	0.449
74	164	33.8	32.1	0.323	92.4	50.1	46	14.3	19	0.441
75	164	33.9	33.3	0.329	94.0	50.0	47	15.8	17	0.447
76	164	33.5	32.9	0.323	92.3	49.9	47	14.6	16	0.445
77	164	33.3	32.2	0.326	93.3	49.9	46	14.0	16	0.444
78	164	33.5	32.0	0.319	91.2	50.1	45	14.4	19	0.437
79	164	33.2	32.5	0.327	93.5	50.0	46	15.2	16	0.444
80	164	32.9	32.6	0.329	94.0	49.8	46	16.0	19	0.448
81	164	33.1	31.7	0.322	92.0	50.2	45	13.9	16	0.431
82	164	33.2	32.2	0.322	91.9	49.9	46	14.8	18	0.442
Average		33.6	32.7	0.327	93.4	50.3	46	14.6	18	0.453
Std. Dev.		0.7	0.6	0.004	1.1	0.2	1	0.8	2	0.011
Maximum		35.0	34.0	0.336	96.0	50.8	48	16.2	23	0.474
Minimum		31.2	31.0	0.319	91.2	49.8	44	12.8	14	0.430

Total number of blows analyzed: 81

Time Summary

Drive	1 minute 37 seconds	2:18:51 PM - 2:20:28 PM (7/30/2013) BN 1 - 82

APPENDIX I

2014 Boring Logs

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

PROJECT 2014 Investigation
PROJECT LOCATION Riverbend Landfill
PROJECT NUMBER WG1866

KEY SHEET - CLASSIFICATIONS AND SYMBOLS

GS FORM: 01-KEY/SYMBOLS

EMPIRICAL CORRELATIONS WITH STANDARD PENETRATION RESISTANCE N VALUES *

	N VALUE * (BLOWS/FT)	CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS/SQ FT)
FINE GRAINED SOILS	0 - 2	VERY SOFT	<0.25
	3 - 4	SOFT	0.25 - 0.50
	5 - 8	FIRM	0.50 - 1.00
	9 - 15	STIFF	1.00 - 2.00
	16 - 30	VERY STIFF	2.00 - 4.00
	31 - 50	HARD	>4.00
	>50	VERY HARD	

	N VALUE * (BLOWS/FT)	RELATIVE DENSITY
COARSE GRAINED SOILS	0 - 4	VERY LOOSE
	5 - 10	LOOSE
	11 - 30	MEDIUM DENSE
	31 - 50	DENSE
	>50	VERY DENSE

* ASTM D 1586; NUMBER OF BLOWS OF 140 POUND HAMMER FALLING 30 INCHES TO DRIVE A 2 IN. O.D., 1.4 IN. I.D. SAMPLER ONE FOOT.

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

MAJOR DIVISIONS			SYMBOLS	DESCRIPTIONS
COARSE GRAINED SOILS (MORE THAN 50% OF MATERIAL COARSER THAN NO. 200 SIEVE SIZE)	GRAVEL AND GRAVELLY SOILS (MORE THAN 50% OF COARSE FRACTION RETAINED ON NO.4 SIEVE)	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS (MORE THAN 50% OF COARSE FRACTION PASSING NO.4 SIEVE)	CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS (MORE THAN 50% OF MATERIAL FINER THAN NO. 200 SIEVE SIZE)	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENT

NOTE: DUAL SYMBOLS USED FOR BORDERLINE CLASSIFICATIONS

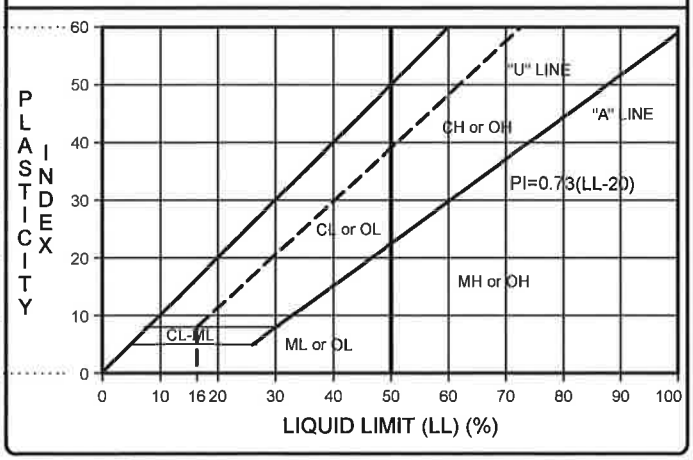
PARTICLE SIZE IDENTIFICATION

USCS (SOILS ONLY) *		SEDIMENTARY (ROCK ONLY)	
BOULDER	>300 mm	BOULDER	>256 mm
COBBLE	75 - 300 mm	COBBLE	64 - 256 mm
GRAVEL: COARSE	20 - 75 mm	PEBBLE	4 - 64 mm
GRAVEL: FINE	4.75 - 20 mm	GRANULE	2 - 4 mm
		SAND: V. COARSE	1 - 2 mm
SAND: COARSE	2 - 4.75 mm	SAND: COARSE	0.5 - 1 mm
SAND: MEDIUM	0.42 - 2 mm	SAND: MEDIUM	0.25 - 0.5 mm
SAND: FINE	0.074 - 0.42 mm	SAND: FINE	0.125 - 0.25 mm
		SAND: V. FINE	0.063 - 0.125 mm
SILT/CLAY	<0.074 mm	SILT	0.004 - 0.063 mm
		CLAY	<0.004 mm

* WELL GRADED - HAVING WIDE RANGE OF GRAIN SIZES AND APPRECIABLE AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES
* POORLY GRADED - PREDOMINANTLY ONE GRAIN SIZE, OR HAVING A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING

PERCENTAGE OF PARTICLE TYPE IN DECREASING ORDER OF PARTICLE SIZE (GRAVEL,SAND,FINES)

PLASTICITY CHART



OTHER MATERIAL SYMBOLS

- Conglomerate/ Agglomerate
- Sandstone
- Silty Sandstone
- Clayey Sandstone
- Sandy Siltstone
- Siltstone
- Claystone
- Clayey Siltstone/ Silty Claystone
- Sandy Claystone
- Granitic/Intrusive
- Volcanic/Extrusive
- Metamorphic
- Limestone
- Dolomite
- Glacial Till
- Landslide Debris
- Marker Bed
- Artificial Fill
- Refuse
- Concrete/Asphalt

WELL SYMBOLS

- CONCRETE
- GROUT
- BENTONITE SEAL
- TRANSITION SAND
- SAND/GRAVEL PACK
- NATIVE/SLUFF
- CENTRALIZER

SAMPLE TYPE AND OTHER SYMBOLS

- BULK SAMPLE
- STANDARD PENETRATION TEST
- MODIFIED CALIFORNIA SAMPLE
- CORE SAMPLE
- SHELBY TUBE
- DRIVE SAMPLE

- Water Level at Time Drilling, or as Shown
- Static Water Level
- Pump Inlet
- Loss of Drilling Fluid
- MSL: Mean Sea Level
- AGS: Above Ground Surface
- BGS: Below Ground Surface
- BTOC: Below Top of Casing
- HSA: Hollow Stem Auger

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-01 **SHEET** 1 **OF** 3
START DATE 7/15/2014
FINISH DATE 7/16/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 148.4 ft msl
DATUM Local
TOTAL DEPTH 77.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Surface: Gravelly SAND fill (SW), brown, dry, ~30% fine to medium gravel up to 6-inch dimater, ~10% fines										
	CLAY (CL), olive green, moist, low plasticity, firm		145	1-01		2 2 4	6	100		10:20	
5	SILT (ML), light olive brown, moist, low plasticity, firm			1-02				100	100 100 250 350 500		Pocket pen: 0.75 tsf
	Same as above		140	1-03		1 2 2	4	100			
10	SILT (ML), light brown, moist to wet, ~10% fine sand, low plasticity			1-04				100	100 150 200 250 350	11:15	Pocket pen: 1.0 tsf
	CLAY (CH), brown, wet, ~20% fine sand, soft		135	1-05		1 1 2	3	100			
15	Same as above			1-06 B		1 3 2	5	80			Pocket pen: 1.75 tsf
	CLAY (CL), brown to olive mottled with bronze, moist, medium plasticity, firm to stiff		130								
20	@20' about 20% fine sand			1-07				100	100 300 350 400 500		Pocket pen: 1.0 tsf
	CLAY (CH), dark gray, moist, firm to stiff		125	1-08		2 2 3	5	90			
25				1-09 B C		3 3 3	6	65		12:25	Pocket pen: 1.5 tsf
			120								
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 3825.72
EASTING: 3641.59
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Sunny and hot, 60s in the morning, high temperature in the 90s, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-01 **SHEET** 2 **OF** 3
START DATE 7/15/2014
FINISH DATE 7/16/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 148.4 ft msl
DATUM Local
TOTAL DEPTH 77.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Silty CLAY (CL), dark greenish gray, moist, trace sand, stiff			1-10				70	100 150 250 300 450		Pocket pen: 2.25 tsf
	Same as above		115	1-11		1 4 6	10	100		13:30	
35	Fat CLAY (CH), gray to olive, wet, high plasticity, hard			1-12 BC		5 15 21	36	80		8:15	Driller notes broken frame & engine trouble. Returns to Dundee for materials to repair. End drilling 7/15/2014. Resume drilling 7/16/2014
	Silty GRAVEL (GM) with clay, moist, well graded, 1/4" subangular gravel, ~20% nonplastic fines		110								
40	Clayey GRAVEL (GC), brown and gray, wet, ~30% fine gravel, 40% medium subangular gravel up to 1/2", ~30% clayey fines, very dense		105	1-13		21 31 50/4"	50+	50			
45	Sandy CLAY (CL) with some gravel, gray mottled with brown, wet, medium plasticity, hard		100	1-14		4 17 31	48	90			
50	Sandy GRAVEL (GW-GM), dark gray to black, moist 1/4" rounded to subrounded gravel, ~20% sand, ~10% nonplastic silty fines, very dense		95	1-15 BC		11 19 32	51	90			
55	Silty SAND with gravel (SM), black with brown streaks, subrounded gravel up to 3/8", ~30% medium plasticity silty fines, very dense		90	1-16		16 26 28	54	80			
60											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 3825.72
EASTING: 3641.59
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Sunny and hot, 60s in the morning, high temperature in the 90s, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-01 **SHEET** 3 **OF** 3
START DATE 7/15/2014
FINISH DATE 7/16/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 148.4 ft msl
DATUM Local
TOTAL DEPTH 77.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DESCRIPTION: 1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)

COMMENTS: 1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane

DEPTH (ft-bgs)	DESCRIPTION	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS
	Silty SAND (SM), dark gray to black, wet, ~10% subrounded gravel up to 1/4", ~20% low plasticity silty fines, medium dense		1-17		8 11 15	26	80			
	Transition to fat CLAY (CH), olive gray, moist, high plasticity, very stiff, trace sand	85								
65	Same as above; bluish-gray silt		1-18		7 10 11	22	80			
	Transition to Silty SAND (SM), black, fine sand, ~20% low plasticity silty fines, medium dense	80								
70	Elastic SILT (MH), gray to olive, moist to wet, high plasticity, stiff, trace sand		1-19		2 4 5	9	100			
		75								
75	Clayey SILT (MH), gray, moist, medium to high plasticity, very stiff		1-20				50	450 450 500 500 500	11:05	Pocket pen: 2.5 tsf
	Bottom of boring at 77.5 ft bgs. Boring backfilled by drilling contractor.	70								
80										
		65								
85										
		60								
90										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 3825.72
EASTING: 3641.59
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Sunny and hot, 60s in the morning, high temperature in the 90s, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-01 HSA **SHEET** 1 **OF** 1
START DATE 7/16/2014
FINISH DATE 7/16/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 148.5 ft msl
DATUM Local
TOTAL DEPTH 20 ft bgs
DEPTH TO WATER

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Surface: Silty CLAY (CL), brown, moist, low to medium plasticity										
			145								
5	Same as above										
			140								
10	CLAY (CL), light brown, moist to wet										
			135								
15	CLAY (CL), light brown, moist to wet, medium plasticity										
			130								
20	Bottom of boring at 20' bgs. Boring backfilled by drilling contractor.										
			125								
25											
			120								
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: Hollow Stem Auger
HAMMER TYPE: N/A
BOREHOLE DIAMETER: 4 1/4"

NORTHING: 3836.24
EASTING: 3646.01
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Sunny and hot, 60s in the morning, high temperature in the 90s, light wind.

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-02 **SHEET** 1 **OF** 3
START DATE 7/17/2014
FINISH DATE 7/18/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 144.0 ft msl
DATUM Local
TOTAL DEPTH 81.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Surface: Clayey GRAVEL (GC), brown, dry, angular to subangular cobbles up to 6-inch diameter									
		140								
5	Clayey SILT (ML), light brown to reddish brown, moist, ~10% fine sand, low plasticity, soft to firm		2-01		2 2 3	5	100		13:30	
			2-02				100	150 150 250 300 350		
		135								Pocket pen: 1.75 tsf
10			2-03		1 2 2	4	100			
		130								
15	Silty CLAY (CL), gray to greenish gray, moist, medium plasticity, stiff		2-04				70	150 250 350 450 550	14:10	
										Pocket pen: 2.75 tsf
	Same. Firm to stiff		2-05		4 8 8	16	70			
		125								
20	Silty CLAY (CL), dark gray, moist to wet, ~10% medium sand, medium to high plasticity, very stiff		2-06 B C		3 9 8	17	80			Pocket pen: 2.75 tsf
		120								
25			2-07				100	200 300 400 450 500	14:55	
										Pocket pen: 2.75 tsf
			2-08		3 4 3	7	100			
		115								
30										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 3424.88
EASTING: 3336.01
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Sunny and hot, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-02 **SHEET** 2 **OF** 3
START DATE 7/17/2014
FINISH DATE 7/18/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 144.0 ft msl
DATUM Local
TOTAL DEPTH 81.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Silty CLAY (CL), dark gray/olive with black mottling, moist to wet, low plasticity, firm to stiff		2-09		1 4 5	9	90			
		110								
35	Same as above		2-10				60	200 200 450 550/3"	15:40	
	Transition to Silty SAND (SM), dark gray, moist, ~80% sand (f:m:c 20:80:0), ~20% silty fines									2" diameter rock in shoe
	Sandy GRAVEL with silt (GW/GM), gray mottled with brown, moist, ~30% fine sand, ~50% 1/8" subrounded gravel with some larger stones up to 1", very dense		2-11 B C		10 38 24	62	60		16:10	
		105								Driller notes gravels
40	Clayey GRAVEL (GC), reddish brown, moist, ~60% subrounded gravel (f:m:c 40:40:20), ~20% medium sand, ~20% plastic fines, dense to very dense		2-12		14 24 22	46	80			
										End drilling 7/17/14 at 16:15
										Begin drilling 7/18/14. RMA on site for energy measurements
		100								
45			2-13		22 50/4"	50+	30		7:30	2" gravel in shoe
	Same as above, but subrounded gravels up to 1" diameter		2-14 B C		33 50/4"	50+	60			
		95								
50										
	Silty GRAVEL with sand (GM), dark gray to black, moist, ~60% gravel (f:m:c 20:30:50), mostly rounded to subrounded gravel with some angular pieces up to 1.5" diameter, very dense		2-15 B C		47 50/4"	50+	50		9:15	
		90								
55										Driller notes softer
	Change to finer gravel (f:m:c 40:40:20)		2-16		16 35 41	76	70		10:30	
		85								
60										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 3424.88
EASTING: 3336.01
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Sunny and hot, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-02 **SHEET** 3 **OF** 3
START DATE 7/17/2014
FINISH DATE 7/18/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 144.0 ft msl
DATUM Local
TOTAL DEPTH 81.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Same as above			2-17 BC		21 46 50/4"	50+	80			
65	Sandy SILT (ML), dark greenish gray, moist, 40% fine sand (f:m:c 90:10:0), 60% low plasticity fines, medium dense		80	2-18		12 12 16	28	70			
70	Silty SAND (SM), bluish gray, 55% fine sand (f:m:c 95:5:0), 45% low plasticity fines		75	2-19 BC		4 8 9	17	100		11:40	Driller notes harder
75	Silty SAND/sandy SILT (SM/ML), dark gray, moist to wet, ~50% fine sand, ~50% silt, stiff to very stiff, dense		70	2-20		12 16 24	40	60		12:05	RMA ends energy measurements and leaves site 12:15
80	Bottom of boring at 81.5 ft bgs. Boring backfilled by drilling contractor.		65	2-21		8 16 18	34	80		13:10	
85			60								
90			55								

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 3424.88
EASTING: 3336.01
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Sunny and hot, 60s in the morning, high temperature in the 80s, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-03 **SHEET** 1 **OF** 2
START DATE 7/23/2014
FINISH DATE 7/23/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 136.9 ft msl
DATUM Local
TOTAL DEPTH 50.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
5	Lean CLAY (CL), light brown to olive, moist, ~10% fine sand, low to medium plasticity, soft to firm		135	3-01				100	150 300 450 500 550	9:20	Pocket pen: 0.75 tsf
10			130	3-02		2 1 3	4	80			
15	Silty CLAY (CL), gray, moist, medium plasticity, stiff to very stiff		125	3-03				100	150 250 500 550 600	9:45	Pocket pen: 3.5 tsf
	Same as above		120	3-04		3 4 4	8	90			
20	CLAY (CH), dark gray, wet, medium to high plasticity, stiff to very stiff		115	3-05 BC		3 5 9	14	70			Pocket pen: 4.75 tsf
25			110	3-06				100	150 250 300 400 500	10:20	Pocket pen: 2.75 tsf
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2824.06
EASTING: 2686.7
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Overcast and cool, 50s in the morning, 60s in the afternoon, scattered showers. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-03 **SHEET** 2 **OF** 2
START DATE 7/23/2014
FINISH DATE 7/23/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 136.9 ft msl
DATUM Local
TOTAL DEPTH 50.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	CLAY with sand (CH), gray with greenish tint, ~10% gravel (f:m:c 80:20:0), 10-20% medium sand, medium plasticity, stiff		105	3-07		3 5 8	13	100		10:30	
35	Top: Clayey SAND (SC), reddish brown, wet, uniform fine sand, ~10-20% plastic fines			3-08 BC		13 26 32	58	70			Driller notes transition to sand
	@36' Clayey GRAVEL (GC), dark brown with some black and red streaks, wet, ~60% subangular gravel up to 1.5" (f:m:c 30:40:30), ~20% sand, 20% plastic fines, very dense		100								
40	Subangular to subrounded gravel (f:m:c 60:40:0)		95	3-09		19 23 28	51	90		11:10	
45	Same as above @46' change to black/dark gray, moist, ~60% 1/4-inch diameter subrounded gravels, ~20% sand, ~20% silty fines		90	3-10		14 21 26	47	80		12:05	
50	BASALT, black, moderately strong, slightly weathered, fine grained			3-11		50/3"	50+	10		12:30	Driller notes much harder, slower drilling
	Bottom of boring at 50.5 ft bgs. Boring backfilled by drilling contractor.		85								
55			80								
60											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2824.06
EASTING: 2686.7
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Overcast and cool, 50s in the morning, 60s in the afternoon, scattered showers. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-04 **SHEET** 1 **OF** 2
START DATE 7/21/2014
FINISH DATE 7/21/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 139.7 ft msl
DATUM Local
TOTAL DEPTH 51.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs): 5, 10, 15, 20, 25, 30

DESCRIPTION
1) Soil Name (USCS Sym.)
2) Color
3) Moisture
4) Grain Size
5) Percentage
6) Plasticity
7) Density/Consistency
8) Other (Mineral Content, Discoloration, Odor, etc.)

GRAPHIC LOG

ELEV. (ft): 135, 130, 125, 120, 115, 110

Surface: CLAY (CL), brown, dry, some organics

Silty CLAY (CL), light olive brown, wet, ~10-20% medium sand, low plasticity, firm to stiff

becomes dark olive gray, stiff, trace sand

Same as above

SAMPLE

SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS
4-01				100	150 200 250 300 400		Pocket pen: 1.25 tsf
4-02		2 2 3	5	90			
4-03				100	100 150 250 350 450	8:40	Pocket pen: 1.25 tsf
4-04		2 3 3	6	80			
4-05 B C		2 3 3	6	80			Pocket pen: 0.75 tsf
4-06				100	100 300 400 400 450	9:20	Pocket pen: 1.75 tsf
4-07 B C		2 3 5	8	100			Pocket pen: 1.5 tsf

COMMENTS
1) Rig Behavior
2) Air Monitoring
3) Pocket Pen
4) Tor Vane

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2568.93
EASTING: 2468.36
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Sunny and warm, 60s and partly cloudy in the morning, 80s and sunny in the afternoon, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-04 **SHEET** 2 **OF** 2
START DATE 7/21/2014
FINISH DATE 7/21/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 139.7 ft msl
DATUM Local
TOTAL DEPTH 51.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Top: Silty CLAY (CL), gray, wet to moist, medium plasticity, stiff		4-08				100	100 250 350 700 850	10:05	
	Bottom: Clayey GRAVEL with sand (GC/CL), ~50% fine gravel 1/8-inch diameter, ~50% clayey fines									Driller notes gravels
		105								
35	Same as above		4-09 BC		10 10 14	24	40			
	@35.5' Clay lense (CL), gray, moist, stiff, @36': 2.5-inch diameter rounded coarse gravel stuck in tube									Driller notes slightly softer
	@36.5' Clayey GRAVEL with sand (GC), light reddish brown with some oxidation, ~50% subrounded gravel (f:m:c 70:20:10), ~20% sand, ~30% clayey fines, medium dense									Driller notes soft drilling
		100								
40	SAND (SP), reddish brown with gray streaks, moist, some fine gravel up to 1/4-inch diameter, uniform fine sand, dense, some cementation		4-10		7 16 21	37	70			
		95								
45	Clayey GRAVEL with sand (GC), reddish brown with light brown streaks, ~60% subrounded gravel 1/4-inch diameter, very dense		4-11		21 32 34	66	60		11:30	
	Sharp transition at 46 ft bgs to bedrock: weathered SILTSTONE, laminated, weak									
		90								
50			4-12		21 28 33	61	50		11:45	
	Bottom of boring at 51.5 ft bgs. Boring backfilled by drilling contractor.									
		85								
55										
		80								
60										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2568.93
EASTING: 2468.36
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Sunny and warm, 60s and partly cloudy in the morning, 80s and sunny in the afternoon, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-05 **SHEET** 1 **OF** 2
START DATE 7/22/2014
FINISH DATE 7/22/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 133.8 ft msl
DATUM Local
TOTAL DEPTH 50.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
										Driller notes stiff material
		130								Driller notes softer
5	Top of tube: Lean CLAY with some gravel (CL), dark brown to gray, moist to wet. Bottom of tube: Silty CLAY (CL), gray mottled with light brown, moist to wet, medium plasticity, stiff		5-01				100	100 150 250 350 500	12:45	Pocket pen: 2.0 tsf
		125								
10			5-02		2 4 5	9	60			
		120								
15	Top: Lean CLAY (CL), light brown/gray		5-03				100	100 200 300 350 450	13:15	Pocket pen: 1.25 tsf
	Bottom: CLAY (CH), dark gray, moist to wet, high plasticity, stiff									
	SILT (ML), dark gray mottled with black, ~10% fine sand, low to medium plasticity, firm	115	5-04		1 2 3	5	100			
20	CLAY (CH), bluish gray, wet, high plasticity, firm to stiff		5-05				100	100 200 300 350 500	13:55	Pocket pen: 1.25 tsf
		110								
25	SILT (ML), dark bluish gray, moist, low plasticity, firm, trace sand		5-06 B C		1 2 3	5	80			Pocket pen: 1.0 tsf
		105								
30										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2640.46
EASTING: 2720.33
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Sunny and warm, 60s in the morning, high temperature in the 70s, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-05 **SHEET** 2 **OF** 2
START DATE 7/22/2014
FINISH DATE 7/22/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 133.8 ft msl
DATUM Local
TOTAL DEPTH 50.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Clayey SAND (SC), yellowish brown, moist, ~50% sand, ~50% clayey fines, medium plasticity, dense			5-07				20	500 800/3"	14:15	Refusal after 9-inches
	GRAVEL with sand and clay (GW/GC), ~80% subangular gravel up to 2-inch diameter (f:m:c 30:30:40), ~10% sand, ~10% low plasticity fines, very dense			5-08		12 23 21	44	60			
			100								
35	@35' ~30% sand, held together in clay matrix			5-09 B C		16 20 28	48	80		14:45	Sample inadvertently collected without liners; placed in bag
											@37.5-39 ft bgs driller notes softer, less gravels
			95								
40	Same as above. 2.5" subangular gravel in shoe			5-10 B C		14 29 28	57	90			
			90								Driller notes softer
45	Silty SAND (SM), light brown to gray, wet, 55% fine sand (f:m:c 90:10:0), 45% silty fines, loose			5-11		3 3 6	9	70		15:35	
	BASALT, dark gray to black, moderately weathered, moderately strong, fine grained			5-12		50/4"	50+	20			Driller notes stiffer
			85								
50				5-13		50/2"	50+	20		16:05	
	Bottom of boring at 50.5 ft bgs. Boring backfilled by drilling contractor.										
			80								
55											
			75								
60											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2640.46
EASTING: 2720.33
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s in the morning, high temperature in the 70s, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-06 **SHEET** 1 **OF** 2
START DATE 7/21/2014
FINISH DATE 7/22/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 133.5 ft msl
DATUM Local
TOTAL DEPTH 57.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
5	Silty CLAY (CL), brown, moist, ~10% sand, low to medium plasticity, very stiff	130	6-01				80	100 200 300 350 450	15:45	Pocket pen: 2.5 tsf
10	SILT (ML), gray, moist, low plasticity, stiff	125	6-02		3 5 6	11	80			
15	Silty CLAY (CL), gray, moist to wet, medium to high plasticity, stiff to very stiff	120	6-03				100	100 200 350 550 700	16:20	Pocket pen: 3.75 tsf
	SILT (ML), dark gray, moist, low plasticity, stiff, light cementation	115	6-04		3 6 7	13	80			End drilling 7/21/14 16:30 Resume drilling 7/22/14 7:50
20	Elastic SILT/CLAY (MH/CH), bluish gray, moist, medium to high plasticity, stiff		6-05				100	300 400 550 600 650	8:00	Pocket pen: 1.75 tsf
	Same as above	110	6-06		2 4 4	8	70			
25			6-07 B C		2 4 6	10	60			Pocket pen: 2.25 tsf Driller notes brown clay cuttings
30		105								

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2738.63
EASTING: 3018.91
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Sunny and warm, 60s in the morning, high temperature in the 70s, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-06 **SHEET** 2 **OF** 2
START DATE 7/21/2014
FINISH DATE 7/22/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 133.5 ft msl
DATUM Local
TOTAL DEPTH 57.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Top: Elastic SILT with sand (MH), olive gray with brown mottling, wet, ~10-20% sand (f:m:c 20:40:40), high plasticity, stiff			6-08				100	250 450 650 850 850	9:00	
	Bottom: SILT with sand (ML), light brown to olive, ~30% fine sand, low to medium plasticity, very stiff										Pocket pen: 3.25 tsf
	Silty SAND/Sandy SILT (SM-ML), bluish gray, moist to wet, medium plasticity silt, stiff, medium dense		100	6-09		4 6 8	14	90			
35	Clayey GRAVEL (GW/GC), light brown with black mottling, wet, ~50% subrounded gravel up to 2-inch diameter (f:m:c 30:40:30), ~40% sand, ~10% clayey fines, very dense		95	6-10 BC		21 50/4"	50+	50			
40											Driller notes large cobbles, slow drilling
	Silty GRAVEL with sand and cobbles (GW/GM), reddish brown with light gray mottling, moist, ~50% subrounded fine gravel 1/4-inch diameter with some angular gravel up to 2-inch diameter (f:m:c 20:50:30), ~30% sand, ~20% low plasticity silty fines, dense to very dense		90	6-11		17 24 28	52	90		9:50	End cobbles/softer drilling
45	Same as above		85	6-12		13 19 35	54	100			Driller notes softer
50	SILT/Silty SAND (SM/ML), top: mostly silt, bottom: ~50% silt, ~50% fine sand, bluish gray, wet, high plasticity, stiff, medium dense		80	6-13 BC		7 9 10	19	70			Driller notes harder Pocket pen: 4.0 tsf
55				6-14				0		10:50	Shelby tube meets refusal @6" Very hard drilling
	BASALT, hard, moderately weathered, fine grained			6-15		50/5"	50+	20		11:10	
	Bottom of boring at 57.5 ft bgs. Boring backfilled by drilling contractor.		75								
60											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2738.63
EASTING: 3018.91
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s in the morning, high temperature in the 70s, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-06 HSA — **SHEET** 1 **OF** 1
START DATE 7/21/2014
FINISH DATE 7/21/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 132.4 ft msl
DATUM Local
TOTAL DEPTH 20 ft bgs
DEPTH TO WATER

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Surface: CLAY/SILT (CL/ML), dark brown, dry to moist, contains organics		130								
5	SILT (ML), brown, moist, low plasticity, contains some organics		125	BULK-1							Bulk sample collected from 5-10 ft bgs ("BULK-1")
10	Same as above										
	Transition to gray		120								
15											
	Change to wet		115								
20	Bottom of boring at 20 ft bgs. Boring backfilled by drilling contractor.										
			110								
25											
			105								
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: Hollow Stem Auger
HAMMER TYPE: N/A
BOREHOLE DIAMETER: 4 1/4"

NORTHING: 2728.91
EASTING: 3018.67
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s and partly cloudy in the morning, 80s and sunny in the afternoon, light wind

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-07 **SHEET** 1 **OF** 3
START DATE 7/16/2014
FINISH DATE 7/17/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 133.2 ft msl
DATUM Local
TOTAL DEPTH 65.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Surface: CLAY with some gravel and organics, brown, dry to moist									
		130								
5	Lean CLAY (CL), light brown, moist, some gravel up to 1/2-inch diameter, low plasticity, stiff, trace sand		7-01				100	200 200 400 400 500	15:45	Pocket pen: 2.75 tsf
	Same as above, but no gravel	125	7-02		4 5 6	11	70			
10			7-03 BC		3 3 3	6	60			Pocket pen: 1.0 tsf
		120								
15	Top of tube: Lean CLAY (CL), light brown to greenish gray, wet, medium plasticity, trace sand		7-04				100	200 200 300 450 500		Pocket pen: 3.75 tsf
	Bottom of tube: Fat CLAY (CH), gray, medium to high plasticity, stiff to very stiff	115	7-05		3 4 6	10	100			
20	Same as above		7-06		4 3 5	8	100		15:40	
		110								
25	Becomes greenish gray, moist to wet, ~10% fine sand, medium to high plasticity, stiff		7-07				80	200 250 300 400 450	16:00	Pocket pen: 1.5 tsf
		105	7-08		3 6 7	13	100			
30										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2657.1
EASTING: 3519.83
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Sunny and warm, 60s and partly cloudy in the morning, 80s and sunny in the afternoon, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-07 **SHEET** 2 **OF** 3
START DATE 7/16/2014
FINISH DATE 7/17/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 133.2 ft msl
DATUM Local
TOTAL DEPTH 65.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Top: same as above (CH)		7-09 BC		3 6 10	16	100		16:30	Stop drilling 7/16/2014
	@30.5': Silty SAND with some gravel (SM), reddish brown with dark brown mottling, moist, 5% subrounded pea gravel, 65% sand (f:m:c 50:50:0), 30% silty fines, medium plasticity fines, very stiff								8:05	Resume drilling 7/17/2014
		100								
35	Clayey GRAVEL (GC), gray mottled with brown, moist, ~70% subangular to angular 1/2-inch diameter gravel, medium plasticity fines, very dense		7-10		50/5"	50+	20		8:20	Driller notes gravels
		95								37-39 ft bgs - driller notes softer
40	GRAVEL with sand and clay (GW/GC), reddish brown mottled with light brown and gray, moist, ~60-70% subrounded gravel up to 1/2-inch diameter with some angular particles, ~20% fine sand, ~10-20% clay and silt, very dense		7-11 BC		11 25 55	80	90		9:00	
		90								
45	Clayey GRAVEL (GW/GC), black and brown, moist, ~20% subangular 1/2-inch diameter gravel, ~30% 1/4-inch diameter, ~30% medium sand, ~20% clayey fines, dense		7-12 BC		14 14 27	41	100		9:40	Driller notes sand Silt lens at 46 ft bgs, gray, stiff, pocket pen: 4.5 tsf
		85								Driller notes sandy at 49 ft bgs
50	Silty SAND (SM), black to gray, moist, ~80% fine sand, ~20% silty fines, dense @51.5' change to silty SAND with gravel (SM), black to gray, dense		7-13		7 14 25	39	60			
		80								
55	Same as above		7-14		9 17 35	52	80			Some gravel in cuttings
	GRAVEL with SILT and sand (GM-SM), dark gray, moist to wet, ~50% subrounded medium dense gravel up to 3/8-inch diameter, ~20% fine to medium sand, ~30% medium to high plasticity silty fines, stiff, dense	75								
60										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2657.1
EASTING: 3519.83
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Sunny and warm, 60s and partly cloudy in the morning, 80s and sunny in the afternoon, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-07 **SHEET** 3 **OF** 3
START DATE 7/16/2014
FINISH DATE 7/17/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 133.2 ft msl
DATUM Local
TOTAL DEPTH 65.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Same. GRAVEL with silt and sand, dark gray to black, moist to wet, ~50% fine gravel approximately 1/8-inch diameter, ~30% coarse sand, ~20% silty fines, dense			7-15		18 20 24	44	50			62.5-63 ft bgs: driller notes gravels
65	SILTSTONE, black to dark gray, moderately weathered, platy			7-16		50/2"	50+	10		11:30	
	Bottom of boring at 65.5 ft bgs. Boring backfilled by drilling contractor.										

Elevation scale: 70, 65, 60, 55, 50, 45

Depth scale: 65, 70, 75, 80, 85, 90

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 4 7/8"

NORTHING: 2657.1
EASTING: 3519.83
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Sunny and warm, 60s and partly cloudy in the morning, 80s and sunny in the afternoon, light wind. Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-08 **SHEET** 1 **OF** 1
START DATE 10/30/2014
FINISH DATE 10/30/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 128.7 ft msl
DATUM Local
TOTAL DEPTH 24 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs) | DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.) | GRAPHIC LOG | ELEV. (ft) | SAMPLE: SAMPLE NO. | TYPE | BLOWS PER 6" | N VALUE | RECOVERY (%) | PRESSURE (PSF) | TIME (00:00) | COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane

DESCRIPTION	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS
Surface: Silty CLAY (CL), dark brown, wet, low plasticity, soft, contains organics	125								
Silty CLAY (CL), light brown, wet, low to medium plasticity, firm to stiff, trace sand (5)		8-01				70	100 250 350 400 450	9:30	Pocket pen: 1.25 tsf
SILT (ML), light brown with some black and bronze mottling, medium plasticity, firm to stiff, trace sand	120	8-02		2 3 5	8	50			
(10)		8-03				100	150 250 400 500 650	9:50	Pocket pen: 2.5 tsf
	115								
(15)		8-04 A B C		3 4 7	11	100		10:15	Pocket pen: 2.0 tsf
	110								Cuttings change to gray
CLAY (CH), dark bluish gray, moist, medium to high plasticity, firm to stiff, trace sand (20)		8-05				70	150 250 350 400 500	10:40	Pocket pen: 1.75 tsf
Same as above.	105	8-06		2 3 3	6	80			
Bottom of boring at 24 ft bgs. Boring backfilled by drilling contractor. (25)								11:00	
(30)	100								

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 5"

NORTHING: 2548.38
EASTING: 3672.53
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Overcast and drizzling in the morning (50s), mostly cloudy in the afternoon (60s). Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-09 **SHEET** 1 **OF** 1
START DATE 11/3/2014
FINISH DATE 11/3/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 154.6 ft msl
DATUM Local
TOTAL DEPTH 21.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Surface: SILT (ML), dark brown, wet, low to medium plasticity, firm, contains organics		150								
5	SILT (ML), light brown, dry to moist, low plasticity, stiff to very stiff			9-01				100	300 350 500 650 800	15:45	Pocket pen: 4.5 tsf
			145								
10	Silty CLAY (CL), light brown, moist, low to medium plasticity, firm			9-02		2 2 3	5	60			
			140								
15	Silty CLAY (CL), light brown to olive, moist, ~5% fine sand, low plasticity, stiff			9-03				100	200 200 200 200 500	10:40	Pocket pen: 2.75 tsf
			135								
20	SILT (ML), dark bluish gray, moist to wet, low to medium plasticity, stiff to very stiff			9-04 B C		3 7 9	16	70			Pocket pen: 2.75 tsf
	Bottom of boring at 21.5 ft bgs. Boring backfilled by drilling contractor.									11:05	
			130								
25											
			125								
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 5"

NORTHING: 2786.55
EASTING: 3319.86
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Rain in the morning (50s), mostly cloudy in the afternoon (60s). Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-10 **SHEET** 1 **OF** 1
START DATE 11/3/2014
FINISH DATE 11/3/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 147.0 ft msl
DATUM Local
TOTAL DEPTH 26.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Surface: CLAY/Gravel road base (CL/GW), dark brown to gray, low plasticity clay, ~50% subangular gravel up to 1 inch	145								
5	SILT (ML), light brown, moist, low plasticity, very stiff	140	10-01 BC		6 12 8	20	40		12:30	Pocket pen: 3.5 tsf
10		135	10-02				100	200 250 350 450 550	13:05	Pocket pen: 1.0 tsf
15	Silty CLAY (CL), light brown to olive, moist to wet, medium plasticity, soft to firm	130	10-03		2 2 2	4	80			
20	Top: CLAY (CL), light brown to olive Bottom: becomes dark bluish gray	125	10-04				100	175 200 250 300 450	13:35	Pocket pen: 2.0 tsf
25			10-05		4 5 4	9	80			
	Bottom of boring at 26.5 ft bgs. Boring backfilled by drilling contractor.	120							13:45	
30										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 5"

NORTHING: 3001.12
EASTING: 2876.82
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Rain in the morning (50s), mostly cloudy in the afternoon (60s). Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-11 **SHEET** 1 **OF** 1
START DATE 11/3/2014
FINISH DATE 11/3/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 149.1 ft msl
DATUM Local
TOTAL DEPTH 26.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Surface: Silty CLAY (CL), brown, wet, medium plasticity, firm to very stiff										
			145								
5				11-01		2 3 4	7	80			
			140								
10				11-02				100	50 200 200 300 350	8:35	Pocket pen: 3.25 tsf
			135								
15				11-03 BC		3 3 3	6	70			Pocket pen: 1.5 tsf
			130								
20	Becomes dark bluish gray			11-04				100	250 250 300 400 500	9:05	Pocket pen: 3.25 tsf
			125								
25	Same as above			11-05		6 5 11	16	60			
	Bottom of boring at 26.5 ft bgs. Boring backfilled by drilling contractor.									9:25	
			120								
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 5"

NORTHING: 3230.51
EASTING: 3091.22
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Rain in the morning (50s), mostly cloudy in the afternoon (60s). Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-12 **SHEET** 1 **OF** 1
START DATE 10/31/2014
FINISH DATE 10/31/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 147.9 ft msl
DATUM Local
TOTAL DEPTH 26.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Surface: SILT (ML), dark brown, moist, low plasticity, stiff to very stiff, contains organics										
			145								
5	trace fine sand			12-01		4 4 6	10	50		12:50	
			140								
10				12-02				100	200 200 200 300 350	13:05	Pocket pen: 3.0 tsf
			135								
15	CLAY (CL), light brown to olive, moist, low plasticity, stiff			12-03				100	150 200 200 400 500	13:30	Pocket pen: 2.75 tsf
			130								
20	Top: CLAY (CL), light brown, wet, medium plasticity, soft to firm Bottom: SILT (ML), dark bluish gray, moist, stiff			12-04 B C		6 5 7	12	60		13:40	Pocket pen: 2.5 tsf
			125								
25	moist to wet, stiff			12-05		5 6 13	19	80		13:55	
	Bottom of boring at 26.5 ft bgs. Boring backfilled by drilling contractor.		120								
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 5"

NORTHING: 3470.84
EASTING: 3190.84
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani
NOTES: Overcast in the morning (50s), mostly cloudy in the afternoon (60s). Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-13 **SHEET** 1 **OF** 2
START DATE 10/29/2014
FINISH DATE 10/29/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 144.6 ft msl
DATUM Local
TOTAL DEPTH 46.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Surface: Elastic SILT (MH), light yellowish brown, wet, medium to high plasticity, soft to stiff									
		140								
5			13-01				100	150 200 250 350 400	13:00	Pocket pen: 1.25 tsf
			13-02		1 1 1	2	70			
		135								
10	SILT (ML), yellowish brown, wet, low to medium plasticity, firm to stiff, trace sand		13-03				80	100 100 100 300 300	13:15	Pocket pen: 1.75 tsf
		130								Change to gray
15	Silty CLAY (CL), dark bluish gray, moist to wet, firm to stiff, medium plasticity		13-04 B C		3 4 4	8	60			Pocket pen: 1.25 tsf
		125								
20	Elastic SILT (MH), dark bluish gray, moist, medium to high plasticity, stiff		13-05				100	100 300 450 700 700	13:45	Pocket pen: 2.0 tsf
		120								
25	Silty CLAY (CL), dark greenish gray, moist to wet, medium plasticity, stiff		13-06				100	100 150 250 450 500	14:15	Pocket pen: 1.75 tsf Driller notes stiffer
		115								
30										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 5"

NORTHING: 3640.59
EASTING: 3484.2
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Overcast and drizzling in the morning (50s), overcast in the afternoon (60s). Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-13 **SHEET** 2 **OF** 2
START DATE 10/29/2014
FINISH DATE 10/29/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 144.6 ft msl
DATUM Local
TOTAL DEPTH 46.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane
	Silty CLAY (CL), dark bluish gray, medium plasticity, stiff			13-07		2 3 6	9	70			
			110								Gravels
35	Silty GRAVEL (GM), reddish brown with light gray streaks, ~50% subrounded gravel up to 1-inch diameter (f:m:c 20:20:60), ~35% sand, ~15% silty fines, medium dense to very dense			13-08 B C		11 9 11	20	70		15:00	
			105								
40				13-09 B C		46 50/3"	50+	40		15:25	
			100								
45	Silty GRAVEL (GM), reddish brown with some black gravels, moist to wet, ~70% subrounded to subangular gravel up to 1-inch diameter, ~10% sand, ~20% silty fines, very dense			13-10		17 23 23	46	80		16:00	
	Bottom of boring at 46.5 ft bgs. Boring backfilled by drilling contractor.										
			95								
50											
			90								
55											
			85								
60											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 5"

NORTHING: 3640.59
EASTING: 3484.2
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Overcast and drizzling in the morning (50s), overcast in the afternoon (60s). Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-14 **SHEET** 1 **OF** 2
START DATE 10/30/2014
FINISH DATE 10/31/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 145.4 ft msl
DATUM Local
TOTAL DEPTH 51.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DEPTH (ft-bgs)	DESCRIPTION (1) Soil Name (USCS Sym.) (2) Color (3) Moisture (4) Grain Size (5) Percentage (6) Plasticity (7) Density/Consistency (8) Other (Mineral Content, Discoloration, Odor, etc.)	GRAPHIC LOG	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS (1) Rig Behavior (2) Air Monitoring (3) Pocket Pen (4) Tor Vane
	Surface: CLAY (CL) with silt, dark brown, moist to wet, low plasticity, soft to firm		145								Driller notes soft Driller notes stiffer
5	Elastic SILT (MH), light brown, moist, medium to high plasticity, stiff to very stiff		140	14-01				100	300 350 500 600 750	13:05	
				14-02		3 4 4	8	40			Pocket pen: 4.0 tsf Driller notes stiffer
10	Sandy CLAY (CL), light brown, moist, ~20% fine sand, ~80% clay, low plasticity, firm		135	14-03				90	100 200 200 300 450	13:30	Pocket pen: 2.0 tsf
15	SILT (ML), light brown to olive, moist to wet, medium plasticity, soft to firm, trace sand		130	14-04				100	100 200 300 350 500	13:40	Pocket pen: 1.25 tsf
	Same as above			14-05		1 1 2	3	70			
20			125	14-06 BC		3 3 6	9	80			Pocket pen: 0.75 tsf
25	becomes dark greenish gray, stiff to very stiff		120	14-07				100	200 400 550 700 850	14:30	Pocket pen: 4.5 tsf End drilling 10/30/14 at 14:45 Begin drilling 10/31/14 at 8:30. RMA on site
				14-08		4 4 4	8	90			
30											

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 5"

NORTHING: 3115.52
EASTING: 3590.34
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Overcast and drizzling in the morning (50s), mostly cloudy in the afternoon (60s). Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
1111 Broadway, 6th Fl
Oakland, CA 94607
Phone: (510) 836-3034
Fax: (510) 836-3036

GS FORM: GEOTECH1 01/04

BOREHOLE LOG

BORING GT14-14 **SHEET** 2 **OF** 2
START DATE 10/30/2014
FINISH DATE 10/31/2014
LOCATION Riverbend Landfill
PROJECT 2014 Investigation
PROJECT NUMBER WG1866

ELEVATION DATA
GROUND SURFACE 145.4 ft msl
DATUM Local
TOTAL DEPTH 51.5 ft bgs
DEPTH TO WATER Not measured

DRAFT AS OF 31-JAN-2015

DESCRIPTION: 1) Soil Name (USCS Sym.) 2) Color 3) Moisture 4) Grain Size 5) Percentage 6) Plasticity 7) Density/Consistency 8) Other (Mineral Content, Discoloration, Odor, etc.)

COMMENTS: 1) Rig Behavior 2) Air Monitoring 3) Pocket Pen 4) Tor Vane

DEPTH (ft-bgs)	DESCRIPTION	ELEV. (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	N VALUE	RECOVERY (%)	PRESSURE (PSF)	TIME (00:00)	COMMENTS
	Silty CLAY (CL), dark bluish gray, wet, medium plasticity, stiff, trace fine sand	115	14-09 BC		5 6 9	15	70			Pocket pen: 1.5 tsf
35		110	14-10		3 5 5	10	80		9:15	
40	Sandy CLAY (CL), dark bluish gray to olive, ~30% fine sand, ~70% low plasticity fines, very stiff, lower fines content at bottom of sample	105	14-11 BC		4 7 9	16	70		9:45	Pocket pen: 2.0 tsf
45	Elastic SILT with sand (MH), yellowish brown with bronze streaking, wet, ~10% fine gravel, ~20% sand, ~70% silt, medium dense	100	14-12		12 8 13	21	80		10:10	Driller notes gravels
50	Silty GRAVEL (GM), brown with dark reddish brown mottling, wet, ~70% subangular gravel up to 1.5-inch diameter (f:m:c 20:30:50), ~10% medium sand, ~20% silty fines, low plasticity fines, dense to very dense	95	14-13 BC		38 37 50/4"	50+	70		10:40	RMA leaves site
	Bottom of boring at 51.5 ft bgs. Boring backfilled by drilling contractor.									
55		90								
60										

CONTRACTOR: Hard Core Drilling
EQUIPMENT: CME-850
DRILL MTHD: NWJ Rods, Mud Rotary
HAMMER TYPE: See notes
BOREHOLE DIAMETER: 5"

NORTHING: 3115.52
EASTING: 3590.34
COORDINATE SYSTEM: Local; Add 2.78 ft for NAVD88

LOGGER D. Umberg **REVIEWER** F. Settepani

NOTES: Overcast and drizzling in the morning (50s), mostly cloudy in the afternoon (60s). Automatic hammer used for SPT samples (140 lb./30 in.). Rope and cathead used for Modified California samples (300 lb./30 in.).

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

APPENDIX J

2014 Energy Measurement

Robert Miner Dynamic Testing, Inc.

Dynamic Measurements and Analyses for Deep Foundations

August 22, 2014

Mr. Fabrizio Settepani
Geosyntec Consultants
1111 Broadway
Oakland, CA 94607

Re: Penetration Test Energy Measurements
Hard Core Rig 850, CME Automatic Hammer and Rope and Cathead
Borehole GT14-02, July 18, 2014
Riverbend Landfill, McMinnville, OR RMDT Job No. 14F34

Dear Mr. Settepani,

This letter presents energy transfer measurements made during Standard Penetration Tests and California Modified Samples for the drill hole and drill rig referenced above. Robert Miner Dynamic Testing, Inc. (RMDT) made dynamic measurements with a Pile Driving Analyzer® as a hammer advanced the NWJ rod during sampling with a split spoon sampler and a California Modified sampler.

The purpose of RMDT's testing was the measurement of energy transferred to the drill rods. Measurements were made on a section of NWJ gauge rod at the top of the drill rod. Strain gages and accelerometers on the rod were connected to a Pile Driving Analyzer® (PDA) which generally processed acceleration and strain measurements from each hammer blow and stored both the measurements and computed results. Measurements and data processing generally followed the ASTM D 4633-10 standard. Energy transfer past the gage location, EFV, was computed by the PDA using force and velocity records as follows:

$$EFV = \int_a^b F(t)\ v(t)\ dt$$

The value "a" corresponds to the start of the record which is when the energy transfer begins and *"b"* is the time at which energy transferred to the rod reaches a maximum value. Appendix A contains more information on our measurement equipment and methods of analysis. The EFV energy calculation is identical to the EMX energy result discussed in Appendix A. The EFV and EMX values apply to the sensor location near the top of the rod.

TEST DETAILS

Testing occurred on July 18, 2014. Boring GT14-02 was advanced on the northwest flank of the Riverbend Landfill facility located in McMinnville, OR. An automatic hammer manufactured by Central Mine Equipment Co. (CME) containing a 140 lb ram was use to advance split spoon samples. A 300 lb ram operated by rope and cathead was used to advance California Modified

Mailing Address: P.O. Box 340, Manchester, WA, 98353, USA **Phone:** 360-871-5480
Location: 2288 Colchester Dr. E., Ste A, Manchester, WA, 98353 **Fax:** 360-871-5483

Samplers. NWJ size rod was used to advance both sample types. The drill rig was Hard Core Drilling's track-mounted CME Rig 850.

RESULTS

A summary of the results for tests conducted with the 140 lb and 300 lb rams are given in Tables 1 and 2, respectively. The tabulated results include the starting sample depth, the penetration resistance, the number of hammers blows in our data set, measured energy transfer, EFV, the computed transfer efficiency, ETR, and the hammer blow rate, BPM. Appendix B contains detailed numeric results for each individual test.

Energy measurements must be divided by the theoretical free fall energy of the hammer to obtain an efficiency. In anticipation of future site demands measurements were made with 140 lb and 300 lb rams. A 140 lb ram raised 30 inches above an impact surface has 350 lb-ft of potential energy. A 300 lb ram raised 30 inches above an impact surface has 750 lb-ft of potential energy. Thus, the transfer energy results for sampling with the 140 and 300 lb rams may be divided by 350 or 750 lb-ft to yield the ratio of the delivered energy to the nominal potential energy. This efficiency ratio, ETR, is given for each sample interval as a percent efficiency.

Table 1. Summary of Test Details and Results for the 140 lb ram and Split Spoon Sampler

Sample Name and Initial Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
45 ft	52/4 inch	52	298	85	51
57.5 ft	76/1ft	76	299	85	50
65 ft	28/1 ft	28	307	88	50
75 ft	40/1 ft	40	298	85	50
Average for Split Spoon Sampler:			**301**	**86**	**50**

Four sample returns were monitored while the 140 lb ram and standard split spoon sampler were in use. A summary of the test details is given in Table 1. Examination of summarized values in Table 1 yields consistent values across the sample intervals with an average calculated ETR of 86 percent and an average hammer blow rate of 50 blows per minute.

Four additional sample returns were monitored while the 300 lb ram operated by rope and cathead advanced the California Modified sampler. A summary of the test details is given in Table 2.

Table 2. Summary of Test Details and Results for the 300-lb ram and California Modified Sampler

Sample Name and Initial Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
47.5 ft	54/4 in	54	600	80	44
52.5 ft	51/4 in	51	591	79	45
60 ft	99/10 in	99	607	81	45
70 ft	17/1 ft	17	591	79	49
Average for California Modified Sampler :			**597**	**80**	**46**

For the 300 lb ram the average ETR values within the sample intervals ranged from 79 to 81 percent with an overall average ETR value of 80 percent. Hammer Blow Rate within the sample intervals ranged from 44 to 49 blows per minute with an overall average Hammer Blow Rate of 46 Blows Per minute. In our opinion the variation in transfer efficiency and blow rate displayed throughout our monitoring was typical of a rope and cathead operation.

It was a pleasure to assist you and to participate on this project with the staff of Geosyntec and Hard Core Drilling. Please do not hesitate to contact us if there are any questions regarding this report.

Sincerely,

Andrew Banas
Staff Engineer
Robert Miner Dynamic Testing, Inc.

Robert Miner
President
Robert Miner Dynamic Testing, Inc.

APPENDIX A
AN INTRODUCTION INTO DYNAMIC PILE TESTING METHODS

The following has been written by Goble Rausche Likins and Associates, Inc. and may only be copied with its written permission.

BACKGROUND

Modern procedures of design and construction control require verification of bearing capacity and integrity of deep foundations during preconstruction test programs and also production installation. Dynamic pile testing methods meet this need economically and reliably, and therefore, form an important part of a quality assurance program when deep foundations are executed. Several dynamic pile testing methods exist; they have different benefits and limitations and different requirements for proper execution.

The Case Method of dynamic pile testing, named after the Case Institute of Technology where it was developed between 1964 and 1975, requires that a substantial ram mass (such as that of a pile driving hammer) impacts the pile top such that the pile undergoes at least a small permanent set. The method is therefore also referred to as a "High Strain Method". The Case Method requires dynamic measurements on the pile or shaft under the ram impact and then an evaluation of various quantities based on closed form solutions of the wave equation, a partial differential equation describing the motion of a rod under the effect of an impact. Conveniently, measurements and analyses are done by a single piece of equipment: the Pile Driving Analyzer® (PDA). However, for bearing capacity evaluations an important additional method is CAPWAP® which performs a much more rigorous analysis of the dynamic records than the simpler Case Method.

A related analysis method is the "Wave Equation Analysis" which calculates a relationship between bearing capacity and pile stress and field blow count. The GRLWEAP™ program performs this analysis and provides a complete set of helpful information and input data.

The following description deals primarily with the Case Method or "High Strain Test" Method of pile testing, however, for the sake of completeness, the "Low Strain Test" performed with the Pile Integrity Test™ (PIT), mainly for pile integrity evaluation, will also be described.

RESULTS FROM DYNAMIC TESTING

There are two main objectives of high strain dynamic pile testing:

- *Dynamic Pile Monitoring* and
- *Dynamic Load Testing*.

Dynamic pile monitoring is conducted during the installation of impact driven piles to achieve a safe and economical pile installation. Dynamic load testing, on the other hand, has as its primary goal the assessment of pile bearing capacity. It is applicable to both cast *insitu* piles or drilled shafts and impact driven piles during restrike.

Dynamic Pile Monitoring

During pile installation, the sensors attached to the pile measure pile top force and velocity. A PDA conditions and processes these signals and calculates or evaluates:

- Bearing capacity at the time of testing, including an assessment of shaft resistance development and driving resistance. This information supports formulation of a driving criterion.

- Dynamic pile stresses, axial and averaged over the pile cross section, both tensile and compressive, during pile driving to limit the potential of damage either near the pile top or along its length. Bending stresses can be evaluated at the point of sensor attachment.

- Pile integrity assessment by the PDA is based on the recognition of certain wave reflections from along the pile. If detected early enough, a pile may be saved from complete destruction. On the other hand, once damage is recognized measures can be taken to prevent reoccurrence.

- Hammer performance parameters including the energy transferred to the pile, the hammer speed in blows per minute and the stroke of open ended diesel hammers.

© 1999, Goble Rausche Likins and Associates, Inc.

Dynamic Pile Load Testing

Bearing capacity testing of either driven piles or drilled shafts applies the same basic measurement approach of dynamic pile monitoring. However, the test is done independent of the pile installation process and therefore a pile driving hammer or other dynamic loading device may not be available. If a special ram has to be mobilized then its weight should be between 0.8 and 2% of the test load (e.g. between 4 and 10 tons for a 500 ton test load) to assure sufficient soil resistance activation.

For a successful test, it most important that the test is conducted after a sufficient waiting time following pile installation for soil properties approaching their long term condition or concrete to properly set. During testing, PDA results of pile/shaft stresses and transferred energy are used to maintain safe stresses and assure sufficient resistance activation. For safe and sufficient testing of drilled shafts, ram energies are often increased from blow to blow until the test capacity has been activated. On the other hand, restrike tests on driven piles may require a warm hammer so that the very first blow produces a complete resistance activation. Data must be evaluated by CAPWAP for bearing capacity.

After the dynamic load test has been conducted with sufficient energy and safe stresses, the CAPWAP analysis provides the following results:

- Bearing capacity i.e. the mobilized capacity present at the time of testing
- Resistance distribution including shaft resistance and end bearing components
- Stresses in pile or shaft calculated for both the static load application and the dynamic test. These stresses are averages over the cross section and do not include bending effects or nonuniform contact stresses, e.g. when the pile toe is on uneven rock.
- Shaft impedance vs depth; this is an estimate of the shaft shape if it differs substantially from the planned profile
- Dynamic soil parameters for shaft and toe, i.e. damping factors and quakes (related to the dynamic stiffness of the resistance at the pile/soil interface.)

MEASUREMENTS

PDA

The basis for the results calculated by the PDA are pile top strain and acceleration measurements which are converted to force and velocity records, respectively. The PDA conditions, calibrates and displays these signals and immediately computes average pile force and velocity thereby eliminating bending effects. Using closed form Case Method solutions, based on the one-dimensional linear wave equation, the PDA calculates the results described in the analytical solutions section below.

HPA

The ram velocity may be directly obtained using radar technology in the Hammer Performance Analyzer™. For this unit to be applicable, the ram must be visible. The impact velocity results can be automatically processed with a PC or recorded on a strip chart.

Saximeter™

For open end diesel hammers, the time between two impacts indicates the magnitude of the ram fall height or stroke. This information is not only measured and calculated by the PDA but also by the convenient, hand-held Saximeter.

PIT

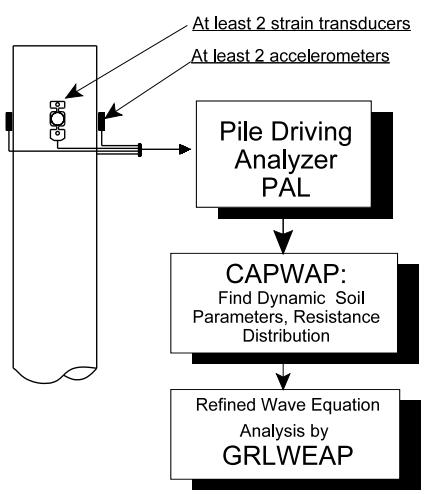
The Pile Integrity Tester™ (PIT) can be used to evaluate defects in concrete piles or shafts which may have occurred during driving or casting. Also timber piles of limited length can be tested in that manner. This so-called "Low Strain Method" or “Pulse-Echo Method” of integrity testing requires only the measurement of acceleration at the pile top. The stress wave producing impact is then generated by a small hand-held hammer and the records interpreted in the time domain. PIT also supports the so-called “Transient Response Method” which requires the additional measurement of the hammer force and an analysis in the frequency domain. This method may also be used to evaluate the unknown length of deep foundations under existing structures.

ANALYTICAL SOLUTIONS
BEARING CAPACITY

Wave Equation

GRL has written the GRLWEAP™ program which calculates a relationship between bearing capacity, pile stress and blow count. This relationship is often called the "bearing graph." Once the blow count is known from pile installation logs, the bearing graph yields the bearing capacity. This approach requires no measurements and therefore can be performed during the design stage of a project, for example for the selection of hammer, cushion and pile size.

After dynamic pile monitoring and/or dynamic load testing has been performed, the "Refined Wave Equation Analysis" or RWEA (see schematic below) is often performed by inputting the PDA and CAPWAP calculated parameters. Then the bearing graph from the RWEA is the basis for a safe and sufficient driving criteria.



Case Method

The Case Method is a closed form solution based on a few simplifying assumptions such as ideal plastic soil behavior and an ideally elastic and uniform pile. Given the measured pile top force F(t) and pile top velocity v(t), the total soil resistance is

$$R(t) = \tfrac{1}{2}\{[F(t) + F(t_2)] + Z[v(t) - v(t_2)]\} \qquad (1)$$

where

t = a point in time after impact
t_2 = time $t + 2L/c$
L = pile length below gages
c = $(E/\rho)^{1/2}$ is the speed of the stress wave
ρ = pile mass density
Z = EA/c is the pile impedance
E = elastic modulus of the pile ($\rho\, c^2$)
A = pile cross sectional area

The total soil resistance consists of a dynamic (R_d) and a static (R_s) component. The static component is therefore

$$R_s(t) = R(t) - R_d(t) \qquad (2)$$

The dynamic component may be computed from a soil damping factor, J, and a pile toe velocity, $v_t(t)$ which is conveniently calculated for the pile toe. Using wave considerations, this approach leads immediately to the dynamic resistance

$$R_d(t) = J[F(t) + Zv(t) - R(t)] \qquad (3)$$

and finally to the static resistance by means of Equation 2.

There are a number of ways in which Eq. 1 through 3 can be evaluated. Most commonly, t_2 is set to that time at which the static resistance becomes maximum. The result is the so-called **RMX** capacity. Damping factors for RMX typically range between 0.5 for coarse grained materials to 1.0 for clays. The **RSP** capacity (this method is most commonly referred to in the literature, yet it is not very frequently used) requires damping factors between 0.1 for sand and 1.0 for clay. Another capacity, **RA2**, determines the capacity at a time when the pile is essentially at rest and thus damping is small; RA2

therefore requires no damping parameter. In any event, the proper Case Method and its associated damping parameter is most conveniently found after a CAPWAP analysis has been performed.

The static resistance calculated by Case Method or CAPWAP is the mobilized resistance at the time of testing. Consideration therefore has to be given to soil setup or relaxation effects and whether or not a sufficient set has been achieved under the test loading that would correspond to a full activation of the ultimate soil resistance.

The PDA also calculates an estimate of shaft resistance as the difference between force and velocity times impedance at the time immediately prior to the return of the stress wave from the pile toe. This shaft resistance is not reduced by damping effects and is therefore called the total shaft resistance **SFT**. A correction for damping effects produces the static shaft resistance estimate, **SFR**.

The Case Method solution is simple enough to be evaluated "in real time," i.e. between hammer blows, using the PDA. It is therefore possible to calculate all relevant results for all hammer blows and plot these results as a function of depth or blow number. This is done in the PDAPLOT program.

CAPWAP

The CAse Pile Wave Analysis Program combines the wave equation pile and soil model with the Case Method measurements. Thus, the solution includes not only the total and static bearing capacity values but also the shaft resistance, end bearing, damping factors and soil stiffnesses. The method iteratively calculates a number of unknowns by signal matching. While it is necessary to make hammer performance assumptions for a GRLWEAP analysis, the CAPWAP program works with the pile top measurements. Furthermore, while GRLWEAP and Case Method require certain assumptions regarding the soil behavior, CAPWAP calculates these soil parameters.

STRESSES

During pile monitoring, it is important that compressive stress maxima at pile top and toe and tensile stress maxima somewhere along the pile be calculated for each hammer blow.

At the pile top (location of sensors) both the maximum compression stress, **CSX**, and the maximum stress from individual strain transducers, **CSI**, are directly obtained from the measurements. Note that CSI is greater than or equal to CSX and the difference between CSI and CSX is a measure of bending in the plane of the strain transducers. Note also that all stresses calculated for locations below the sensors are averaged over the pile cross section and therefore do not include components from either bending or eccentric soil resistance effects.

The PDA calculates the compressive stress at the pile bottom, **CSB**, assuming (a) a uniform pile and (b) that the pile toe force is the maximum value of the total resistance R(t) minus the total shaft resistance, SFT. Again, for this stress estimation uniform resistance force are assumed (e.g. not a sloping rock.)

For concrete piles, the maximum tension stress, **TSX**, is also of great importance. It occurs at some point below the pile top. The maximum tension stress can be computed from the pile top measurements by finding the maximum tension wave (either traveling upward, W_U, or downward, W_d) and reducing it by the minimum compressive wave traveling in opposite direction.

$$W_u = ½[F(t) - Zv(t)] \quad (4)$$

$$W_d = ½[F(t) + Zv(t)] \quad (5)$$

CAPWAP also calculates tensile and compressive stresses along the pile and, in general, more accurately than the PDA. In fact, for non-uniform piles or piles with joints, cracks or other discontinuities, the closed form solutions from the PDA may be in error.

PILE INTEGRITY

High Strain Tests (PDA)

Stress waves in a pile are reflected wherever the pile impedance, $Z = EA/c = \rho cA = A \sqrt{(E \rho)}$, changes. Therefore, the pile impedance is a measure of the quality of the pile material (E, ρ, c) and the size of its cross section (A). The reflected waves arrive at the pile top at a time which is greater the farther away from the pile top the reflection occurs. The

magnitude of the change of the upward traveling wave (calculated from the measured force and velocity, Eq. 4) indicates the extent of the cross sectional change. Thus, with β_i (**BTA**) being a relative integrity factor which is unity for no impedance change and zero for the pile end, the following is calculated by the PDA.

$$\beta_i = (1 - \alpha_i)/(1 + \alpha_i) \tag{6}$$

with

$$\alpha_i = ½(W_{UR} - W_{UD})/(W_{Di} - W_{UR}) \tag{7}$$

where

W_{UR} is the upward traveling wave at the onset of the reflected wave. It is caused by resistance.

W_{UD} is the upwards traveling wave due to the damage reflection.

W_{Di} is the maximum downward traveling wave due to impact.

It can be shown that this formulation is quite accurate as long as individual reflections from different pile impedance changes have no overlapping effects on the stress wave reflections.

Without rigorous derivation, it has been proposed to consider as slight damage when β is above 0.8 and a serious damage when β is less than 0.6.

Low Strain Tests (PIT)

The pile top is struck with a held hand hammer and the resulting pile top velocity is measured, displayed and interpreted for signs of wave reflections. In general, a comparison of the reflected acceleration leads to a relative measure of extent of damage, again the location of the problem is indicated by the arrival time of the reflection. PIT records can also be interpreted by the β-Method. However, low strain tests do not activate much resistance which simplifies Eq. 7 since W_{UR} is then equal to zero.

For drilled shafts and PIT records that clearly show a toe reflection, an approximate shaft profile can be calculated from low strain records using the PITSTOP program's PROFILE routine.

HAMMER PERFORMANCE

The PDA calculates the energy transferred to the pile top from:

$$E(t) = \int_0^t F(t)v(t)\,dt \tag{8a}$$

The maximum of the E(t) curve is the most important information for an overall evaluation of the performance of a hammer and driving system. This **EMX** value allows for a classification of the hammer's performance when presented as the rated transfer efficiency, also called energy transfer ratio (**ETR**) or global efficiency

$$e_T = EMX/E_R \tag{8b}$$

where

E_R is the manufacturer's rated energy value.

Both Saximeter and PDA calculate the stroke (**STK**) of an open end diesel hammer using

$$STK = (g/8)\,T_B^2 - h_L \tag{9}$$

where

g is the earth's gravitational acceleration,
T_B is the time between two hammer blows,
h_L is a stroke loss value due to gas compression and time losses during impact (usually 0.3 ft or 0.1 m).

DETERMINATION OF WAVE SPEED

An important facet of dynamic pile testing is an assessment of pile material properties. Since in general force is determined from strain by multiplication with elastic modulus, E, and cross sectional area, A, the dynamic elastic modulus has to be determined for pile materials other than steel. In general, the records measured by the PDA clearly indicate a pile toe reflection as long as pile penetration per blow is greater than 1 mm or .04 inches. The time between the onset of the force and velocity records at impact and the onset of the reflection from the toe (usually apparent by a local maximum of the wave up curve) is the so-called wave travel time, T. Dividing 2L (L is here the length of the pile below sensors) by T leads to the stress wave speed in the pile:

$$c = 2L/T \tag{10}$$

The elastic modulus of the pile material is related to the wave speed according to the linear elastic wave equation theory by

$$E = c^2\rho \tag{11}$$

Since the mass density of the pile material, ρ, is usually well known (an exception is timber for which samples should be weighed), the elastic modulus is easily found from the wave speed. Note, however, that this is a dynamic modulus which is generally higher than the static one and that the wave speed depends to some degree on the strain level of the stress wave. For example, experience shows that the wave speed from PIT is roughly 5% higher than the wave speed observed during a high strain test.

Other Notes:

- If the pile material is nonuniform then the wave speed c, according to Eq. 10, is an average wave speed and does not necessarily reflect the pile material properties of the location where the strain sensors are attached to the pile top. For example, pile driving often causes fine tension cracks some distance below the top of concrete piles. Then the average c is slower than that at the pile top. It is therefore recommended to determine E in the beginning of pile driving and not adjust it when the average c changes.

- If the pile has such a high resistance that there is no clear indication of a toe reflection then the wave speed of the pile material must be determined either by assumption or by taking a sample of the concrete and measuring its wave speed in a simple free column test. Another possibility is to use the proportionality relationship, discussed under "DATA QUALITY CHECKS" to find c as the ratio between the measured velocity and measured strain.

DATA QUALITY CHECKS

Quality data is the first and foremost requirement for accurate dynamic testing results. It is therefore important that the measurement engineer performing PDA or PIT tests has the experience necessary to recognize measurement problems and take appropriate corrective action should problems develop. Fortunately, dynamic pile testing allows for certain data quality checks because two independent measurements are taken that have to conform to certain relationships.

Proportionality

As long as there is only a wave traveling in one direction, as is the case during impact when only a downward traveling wave exists in the pile, force and velocity measured at the pile top are proportional

$$F = v\,Z = v\,(EA/c) \tag{12a}$$

This relationship can also be expressed in terms of stress

$$\sigma = v\,(E/c) \tag{12b}$$

or strain

$$\epsilon = v / c \tag{12c}$$

This means that the early portion of strain times wave speed must be equal to the velocity unless the proportionality is affected by high friction near the pile top or by a pile cross sectional change not far below the sensors. Checking the proportionality is an excellent means of assuring meaningful measurements.

Measurements are always taken at opposite sides of the pile as a means of calculating the average force and velocity in the pile. The velocity on the two sides of the pile is very similar even when high bending exists. Thus, an independent check of the velocity measurements is easy and simple.

Strain measurements may differ greatly between the two sides of the pile when bending exists. It is even possible that tension is measured on one side while very high compression exists on the other side of the pile. In extreme cases, bending might be so high that it leads to a nonlinear stress distribution. The averaging of the two strain signals does then not lead to the average pile force and proportionality will not be achieved.

When testing drilled shafts, measurements of strain may also be affected by local concrete quality variations. It is then often necessary to use four strain transducers spaced at 90 degrees around the pile for an improved strain data quality. The use of four transducers is also recommended for large pile

diameters, particularly when it is difficult to mount the sensors at least two pile widths or diameters below the pile top.

LIMITATIONS, ADDITIONAL CONSIDERATIONS

Mobilization of capacity

Estimates of pile capacity from dynamic testing indicate the **mobilized pile capacity at the time of testing**. At very high blow counts (low set per blow), dynamic test methods tend to produce lower bound capacity estimates as not all resistance (particularly at and near the toe) is fully activated.

Time dependent soil resistance effects

Static pile capacity from dynamic method calculations provide an estimate of the axial pile capacity. Increases and decreases in the pile capacity with time typically occur (soil setup/relaxation). Therefore, **restrike testing usually yields a better indication of long term pile capacity than a test at the end of pile driving**. Often a wait period of one or two days between end of driving and restrike is satisfactory for a realistic prediction of pile capacity but this waiting time depends, among other factors, on the permeability of the soil.

(A) Soil setup

Because excess positive pore pressures often develop during pile driving in fine grained soil (clays, silts or even fine sands), the capacity of a pile at the time of driving may often be less than the long term pile capacity. These pore pressures reduce the effective stress acting on the pile thereby reducing the soil resistance to pile penetration, and thus the pile capacity at the time of driving. As these pore pressures dissipate, the soil resistance acting on the pile increases as does the axial pile capacity. This phenomena is routinely called soil setup or soil freeze.

(*B) Relaxation*

Relaxation (capacity reduction with time) has been observed for piles driven into weathered shale, and may take several days to fully develop. Pile capacity estimates based upon initial driving or short term restrike tests can significantly overpredict long term pile capacity. Therefore, piles driven into shale should be tested after a minimum one week wait either statically or dynamically (with particular emphasis than on the first few blows). Relaxation has also been observed for displacement piles driven into dense saturated silts or fine sands due to a negative pore pressure effect at the pile toe. Again, restrike tests should be used, with great emphasis on early blows.

Capacity results for open pile profiles

Larger diameter open ended pipe piles (or H-piles which do not bear on rock) may behave differently under dynamic and static loading conditions. Under dynamic loads the soil inside the pile or between its flanges may slip and produce internal friction while under static loads the plug may move with the pile, thereby creating end bearing over the full pile cross section. As a result both friction and end bearing components may be different under static and dynamic conditions.

CAPWAP Analysis Results

A portion of the soil resistance calculated on an individual soil segment in a CAPWAP analysis can usually be shifted up or down the shaft one soil segment without significantly altering the match quality. Therefore, use of the CAPWAP resistance distribution for uplift, downdrag, scour, or other geotechnical considerations should be made with an understanding of these analysis limitations.

Stresses

PDA and CAPWAP calculated stresses are average values over the cross section. Additional allowance has to be made for bending or non-uniform contact stresses. To prevent damage it is therefore important to maintain good hammer-pile alignment and to protect the pile toes using appropriate devices or an increased cross sectional area.

In the United States is has become generally acceptable to limit the dynamic installation stresses of driven piles to the following levels:

90% of yield strength for steel piles

85% of the concrete compressive strength - after subtraction of the effective prestress - for concrete piles in compression

100% of effective prestress plus ½ of the concrete's tension strength for prestressed piles in tension

70% of the reinforcement strength for regularly reinforced concrete piles in tension

300% of the static design allowable stress for timber

Note that the dynamic stresses may either be directly measured at the pile top by the PDA or calculated by the PDA for other locations along the pile based on the pile top measurements.

Additional design considerations

Numerous factors have to be considered in pile foundation design. Some of these considerations include

- additional pile loading from downdrag or negative skin friction,
- lateral and uplift loading requirements
- effective stress changes (due to changes in water table, excavations, fills or other changes in overburden),
- long term settlements in general and settlement from underlying weaker layers and/or pile group effects,

These factors have not been evaluated by GRL and have not been considered in the interpretation of the dynamic testing results. The foundation designer should determine if these or any other considerations are applicable to this project and the foundation design.

Wave equation analysis results

The results calculated by the wave equation analysis program depend on a variety of hammer, pile and soil input parameters. Although attempts have been made to base the analysis on the best available information, actual field conditions may vary and therefore stresses and blow counts may differ from the predictions reported. Capacity predictions derived from wave equation analyses should use restrike information. However, because of the uncertainties associated with restrike blow counts and restrike hammer energies, correlations of such results with static test capacities with have often displayed considerable scatter.

As for PDA and CAPWAP, the theory on which GRLWEAP is based is the one-dimensional wave equation. For that reason, stress predictions by the wave equation analysis can only be averages over the pile cross section. Thus, bending stresses or stress concentrations due to non-uniform impact or uneven soil or rock resistance are not considered in these results. Stress maxima calculated by the wave equation are usually subjected to the same limits as those measured directly or calculated from measurements by the PDA.

Appendix B

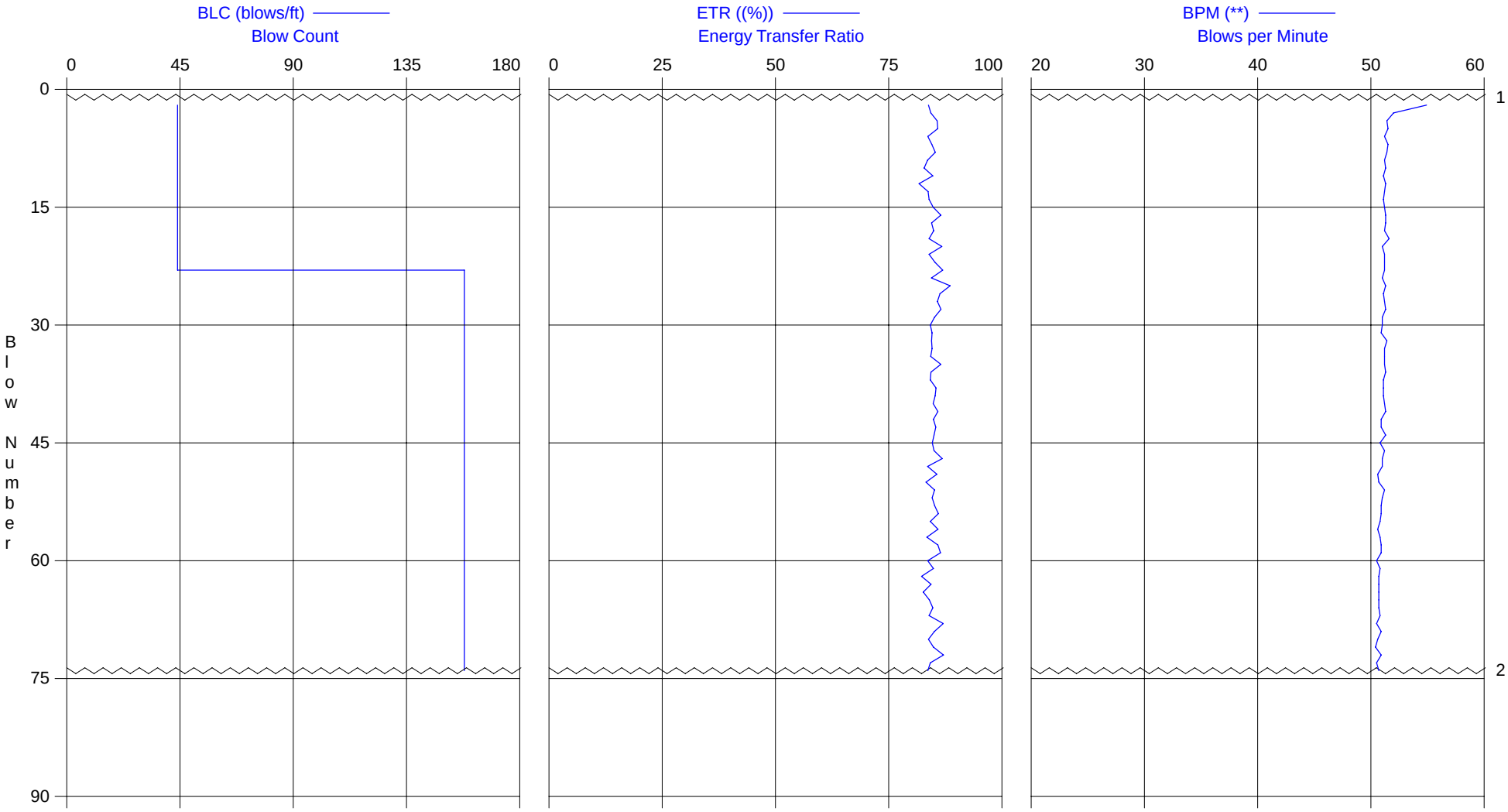
Summary of Case Method Field Results

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 21-Jul-2014

Test date: 18-Jul-2014

GEOSYNTEC, RIVERBEND LANDFILL - 45FT SAMPLE, SPTGT14-02



1 - Start of test on 7/18/2014 at 7:56:57 AM

2 - End of test on 7/18/2014 at 7:58:22 AM

GEOSYNTEC, RIVERBEND LANDFILL - 45FT SAMPLE, SPT
OP: RMDT

GT14-02
Test date: 18-Jul-2014

AR: 1.43 in^2
LE: 50.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]
23	45.51	158	31.4	31.1	0.304	86.9	51.2	44	11.7	0.9
24	45.51	158	32.1	32.0	0.295	84.4	51.0	46	12.5	0.9
25	45.52	158	31.9	31.9	0.310	88.6	51.3	46	12.5	0.9
26	45.53	158	32.0	31.7	0.302	86.3	51.1	45	12.2	0.9
27	45.53	158	32.3	32.1	0.300	85.8	51.2	46	12.6	0.9
28	45.54	158	32.2	31.9	0.303	86.6	51.3	46	12.6	0.9
29	45.54	158	32.0	31.7	0.298	85.1	51.0	45	12.5	0.9
30	45.55	158	32.0	31.8	0.295	84.2	51.0	45	12.3	0.9
31	45.56	158	32.2	31.9	0.296	84.6	50.9	46	11.3	0.8
32	45.56	158	31.7	31.0	0.296	84.4	51.4	44	11.7	0.9
33	45.57	158	32.6	32.1	0.296	84.6	51.2	46	11.8	0.9
34	45.58	158	32.2	32.1	0.295	84.3	51.2	46	12.3	0.9
35	45.58	158	32.2	31.8	0.303	86.5	51.2	46	11.9	0.8
36	45.59	158	31.9	31.9	0.295	84.3	51.3	46	12.1	0.9
37	45.60	158	32.4	32.1	0.295	84.2	51.1	46	11.8	0.8
38	45.60	158	32.5	32.1	0.299	85.4	51.1	46	12.1	0.9
39	45.61	158	32.0	31.7	0.298	85.2	51.1	45	12.1	0.9
40	45.61	158	32.8	32.5	0.297	84.8	51.2	47	12.3	0.9
41	45.62	158	32.3	32.0	0.300	85.9	51.3	46	12.2	0.9
42	45.63	158	32.6	32.1	0.297	84.9	50.9	46	12.3	0.9
43	45.63	158	32.7	32.2	0.299	85.4	50.9	46	12.3	0.9
44	45.64	158	32.3	31.8	0.298	85.0	51.3	45	11.4	0.8
45	45.65	158	33.1	32.6	0.296	84.6	50.8	47	12.2	0.9
46	45.65	158	32.4	31.9	0.298	85.0	51.2	46	11.6	0.9
47	45.66	158	31.8	31.4	0.304	86.8	51.0	45	12.0	0.9
48	45.67	158	32.7	32.1	0.293	83.6	51.0	46	11.4	0.8
49	45.67	158	32.0	31.5	0.300	85.6	50.6	45	11.4	1.0
50	45.68	158	32.9	32.3	0.291	83.2	50.7	46	11.6	0.8
51	45.68	158	32.3	31.9	0.298	85.1	51.2	46	12.5	0.9
52	45.69	158	31.9	31.4	0.296	84.6	51.0	45	11.1	0.8
53	45.70	158	32.1	31.7	0.298	85.2	50.9	45	12.2	0.9
54	45.70	158	32.4	32.0	0.301	86.0	50.9	46	12.3	0.9
55	45.71	158	32.2	31.7	0.295	84.2	50.8	45	11.1	0.8
56	45.72	158	32.8	32.4	0.301	85.9	50.6	46	12.3	0.8
57	45.72	158	32.0	31.5	0.292	83.4	50.8	45	11.0	0.9
58	45.73	158	32.3	32.0	0.300	85.9	50.9	46	12.4	0.9
59	45.74	158	32.0	31.7	0.303	86.4	50.9	45	12.3	1.0
60	45.74	158	32.3	31.8	0.293	83.6	50.5	46	12.0	0.9
61	45.75	158	32.3	32.0	0.297	84.9	50.8	46	12.4	0.9
62	45.75	158	31.7	31.3	0.288	82.2	50.7	45	11.8	0.9
63	45.76	158	32.1	31.6	0.295	84.4	50.7	45	11.5	0.8
64	45.77	158	32.1	31.6	0.289	82.6	50.7	45	11.7	0.9
65	45.77	158	32.4	31.9	0.294	84.0	50.7	46	11.5	0.9
66	45.78	158	31.9	31.5	0.297	84.7	50.7	45	11.3	0.9
67	45.79	158	32.5	32.1	0.294	83.9	50.8	46	11.9	0.9
68	45.79	158	32.2	31.8	0.305	87.0	50.5	45	12.6	0.9
69	45.80	158	31.9	31.4	0.298	85.1	50.9	45	11.2	0.8
70	45.81	158	33.0	32.6	0.293	83.8	50.6	47	12.2	0.9
71	45.81	158	32.0	31.7	0.297	84.9	50.4	45	12.1	0.9
72	45.82	158	32.3	31.9	0.305	87.1	50.9	46	12.1	0.9
73	45.82	158	32.2	31.8	0.295	84.2	50.5	45	12.4	0.9
74	45.83	158	31.8	31.2	0.293	83.6	50.7	45	11.5	0.9
		Average	32.2	31.8	0.298	85.0	50.9	46	12.0	0.9
		Std. Dev.	0.3	0.3	0.004	1.2	0.3	0	0.4	0.0

Total number of blows analyzed: 52

BL#	depth (ft)	Comments
1	45.02	Start of test on 7/18/2014 at 7:56:57 AM
74	45.83	End of test on 7/18/2014 at 7:58:22 AM

Time Summary

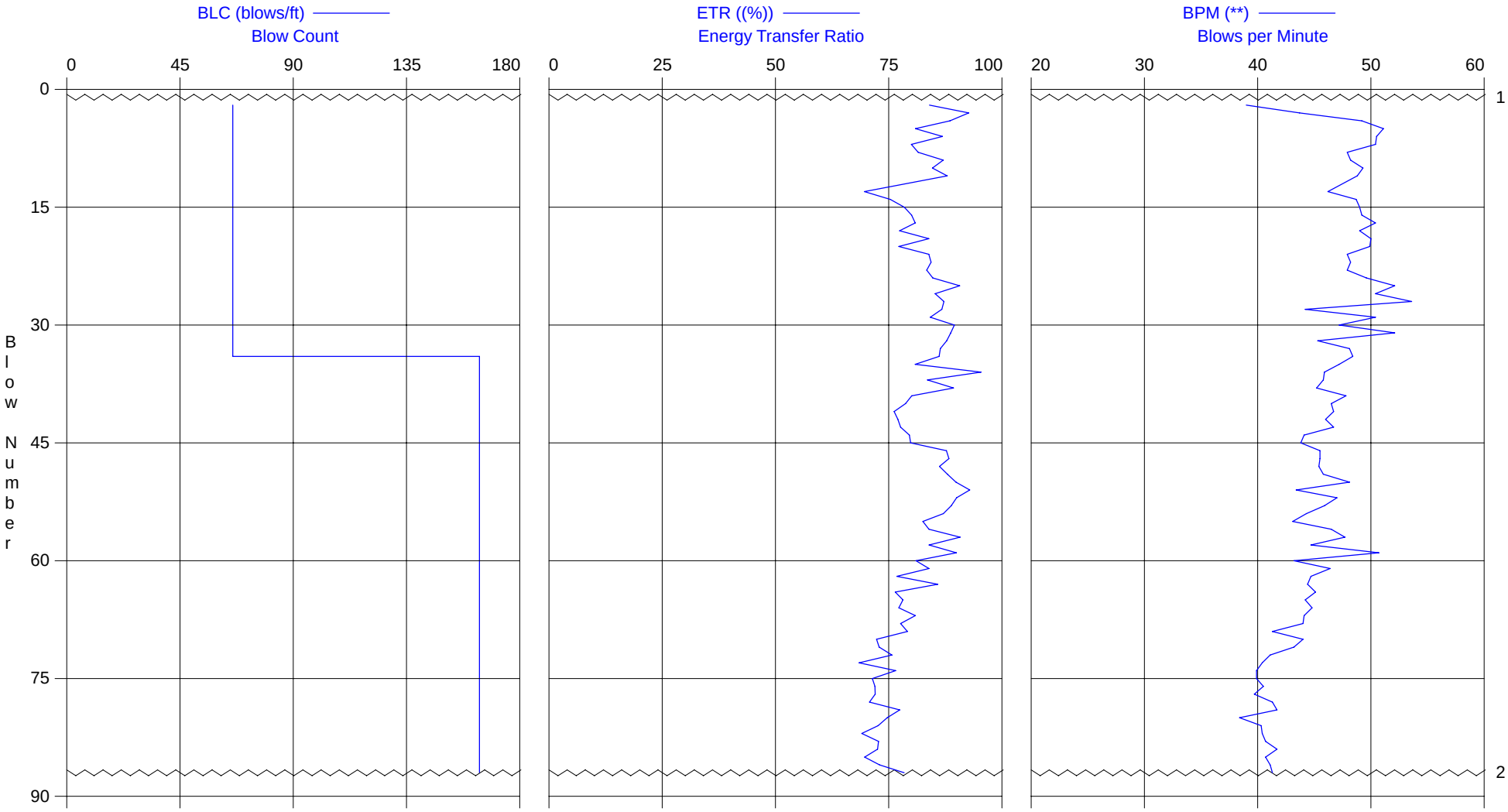
Drive	1 minute 25 seconds	7:56:57 AM - 7:58:22 AM (7/18/2014) BN 1 - 74

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 21-Jul-2014

Test date: 18-Jul-2014

GEOSYNTEC, RIVERBEND LANDFILL - 47.5FT SAMPLE, MCGT14-02, CME 850



1 - Start of test on 7/18/2014 at 8:27:29 AM

2 - End of test on 7/18/2014 at 8:29:28 AM

GEOSYNTEC, RIVERBEND LANDFILL - 47.5FT SAMPLE, MC
OP: RMDT

GT14-02, CME 850
Test date: 18-Jul-2014

AR: 1.43 in^2
LE: 51.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]
34	48.01	164	41.4	40.6	0.646	86.1	48.4	58	14.9	1.1
35	48.01	164	38.9	38.4	0.606	80.8	47.2	55	15.3	1.1
36	48.02	164	43.3	42.3	0.715	95.4	45.9	60	15.2	1.0
37	48.02	164	39.5	38.8	0.627	83.6	45.8	55	15.1	1.1
38	48.03	164	42.5	41.5	0.670	89.3	45.2	59	14.7	1.1
39	48.04	164	37.9	37.5	0.601	80.1	47.8	54	14.9	1.1
40	48.04	164	40.6	39.7	0.590	78.7	46.5	57	14.4	1.1
41	48.05	164	38.4	37.9	0.571	76.2	46.7	54	15.0	1.1
42	48.06	164	38.8	38.4	0.578	77.0	46.0	55	14.3	1.1
43	48.06	164	38.4	38.2	0.582	77.6	46.7	55	15.0	1.1
44	48.07	164	39.3	39.0	0.597	79.6	44.1	56	14.4	1.1
45	48.07	164	38.6	38.3	0.599	79.8	43.8	55	14.8	1.1
46	48.08	164	42.7	41.6	0.658	87.8	45.5	60	14.6	1.1
47	48.09	164	42.7	41.8	0.662	88.3	45.5	60	14.8	1.1
48	48.09	164	41.0	40.5	0.647	86.2	45.4	58	14.8	1.1
49	48.10	164	43.0	41.7	0.660	88.0	45.8	60	14.6	1.1
50	48.10	164	41.4	40.6	0.674	89.8	48.1	58	15.2	1.1
51	48.11	164	44.3	43.2	0.697	92.9	43.4	62	14.9	1.1
52	48.12	164	40.4	40.0	0.675	90.0	47.0	57	15.7	1.1
53	48.12	164	43.8	42.6	0.666	88.8	45.9	61	14.9	0.9
54	48.13	164	39.8	39.7	0.653	87.1	44.3	57	15.4	1.1
55	48.13	164	41.7	40.6	0.619	82.5	43.1	58	14.2	0.9
56	48.14	164	38.8	38.8	0.629	83.9	46.5	55	15.2	1.1
57	48.15	164	43.8	42.7	0.681	90.8	47.7	61	15.0	1.1
58	48.15	164	41.2	40.1	0.629	83.9	44.7	57	14.6	1.1
59	48.16	164	41.7	40.8	0.674	89.9	50.7	58	15.4	1.1
60	48.17	164	39.5	38.5	0.608	81.0	43.2	55	14.4	1.1
61	48.17	164	41.4	40.5	0.629	83.9	46.4	58	14.4	0.9
62	48.18	164	37.9	37.7	0.576	76.8	44.7	54	14.5	1.1
63	48.18	164	42.7	41.6	0.644	85.8	44.4	59	14.5	0.9
64	48.19	164	37.8	37.5	0.573	76.5	45.1	54	14.6	1.1
65	48.20	164	40.5	39.4	0.586	78.1	44.2	56	14.1	1.1
66	48.20	164	37.4	37.2	0.579	77.2	44.8	53	14.9	1.1
67	48.21	164	41.2	40.0	0.607	80.9	44.1	57	14.1	1.1
68	48.21	164	37.8	37.6	0.582	77.6	44.0	54	14.7	1.1
69	48.22	164	40.8	39.5	0.593	79.1	41.3	57	14.0	0.9
70	48.23	164	37.0	36.5	0.542	72.3	44.0	52	14.3	1.1
71	48.23	164	38.4	37.8	0.547	72.9	43.2	54	13.4	1.1
72	48.24	164	36.6	36.3	0.568	75.7	41.1	52	14.3	1.1
73	48.24	164	35.8	35.3	0.513	68.4	40.4	50	13.7	1.1
74	48.25	164	37.6	37.2	0.574	76.5	39.9	53	14.4	1.1
75	48.26	164	37.8	37.1	0.535	71.4	39.9	53	13.5	0.9
76	48.26	164	36.2	36.0	0.540	72.0	40.5	51	14.1	1.1
77	48.27	164	38.1	37.3	0.540	72.0	39.7	53	13.5	0.9
78	48.28	164	36.1	35.9	0.531	70.8	41.3	51	14.0	1.1
79	48.28	164	39.3	38.4	0.581	77.4	41.7	55	14.4	1.1
80	48.29	164	36.7	36.3	0.560	74.7	38.4	52	14.4	1.1
81	48.29	164	38.6	37.9	0.545	72.7	40.3	54	13.5	1.1
82	48.30	164	34.8	34.5	0.518	69.1	40.4	49	13.7	1.1
83	48.31	164	38.6	38.0	0.546	72.8	40.7	54	13.3	1.1
84	48.31	164	35.9	35.7	0.544	72.5	41.7	51	14.2	1.1
85	48.32	164	38.1	37.3	0.523	69.7	40.7	53	13.3	1.1
86	48.32	164	36.2	35.9	0.548	73.0	41.1	51	14.1	1.1
87	48.33	164	40.0	39.1	0.588	78.4	41.3	56	13.9	1.1
		Average	39.5	38.8	0.600	80.1	44.0	56	14.5	1.1
		Std. Dev.	2.3	2.1	0.051	6.8	2.7	3	0.6	0.1

Total number of blows analyzed: 54

BL#	depth (ft)	Comments
1	47.52	Start of test on 7/18/2014 at 8:27:29 AM
87	48.33	End of test on 7/18/2014 at 8:29:28 AM

Time Summary

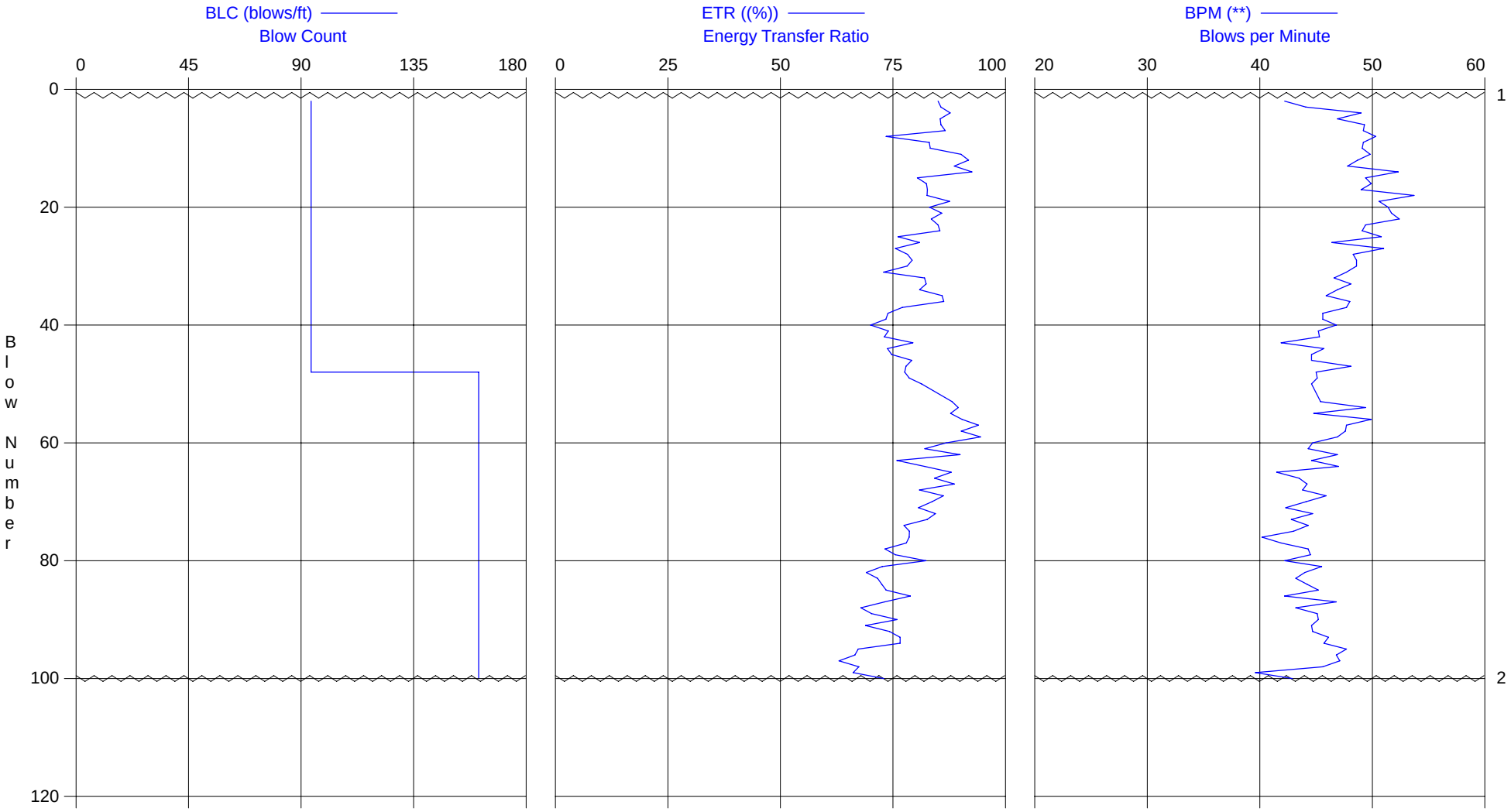
Drive	1 minute 59 seconds	8:27:29 AM - 8:29:28 AM (7/18/2014) BN 1 - 87

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 21-Jul-2014

Test date: 18-Jul-2014

GEOSYNTEC, RIVERBEND LANDFILL - 52.5FT SAMPLE, MCGT14-02, CME 850



1 - Start of test on 7/18/2014 at 9:16:16 AM

2 - End of test on 7/18/2014 at 9:18:32 AM

GEOSYNTEC, RIVERBEND LANDFILL - 52.5FT SAMPLE, MC
OP: RMDT

GT14-02, CME 850
Test date: 18-Jul-2014

AR: 1.43 in^2
LE: 56.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]
48	53.01	161	38.0	37.3	0.582	77.6	45.0	53	15.9	1.1
49	53.01	161	40.2	39.2	0.590	78.6	45.1	56	15.4	0.7
50	53.02	161	38.6	38.1	0.610	81.4	44.6	54	16.1	1.1
53	53.04	161	41.3	40.9	0.661	88.1	45.4	59	16.4	1.1
54	53.04	161	40.3	40.0	0.671	89.5	49.4	57	16.7	1.1
55	53.05	161	39.5	39.2	0.659	87.8	44.8	56	16.6	1.1
56	53.06	161	40.0	39.7	0.678	90.3	49.9	57	17.0	1.1
57	53.06	161	40.0	39.8	0.705	94.0	47.7	57	16.9	1.1
58	53.07	161	39.2	38.7	0.676	90.2	47.6	55	16.7	1.1
59	53.08	161	40.5	40.4	0.708	94.5	46.9	58	16.1	1.1
60	53.08	161	38.6	38.5	0.651	86.8	44.7	55	16.5	1.1
61	53.09	161	37.4	37.2	0.615	82.1	44.3	53	16.0	1.1
62	53.09	161	39.5	39.4	0.674	89.9	46.9	56	16.3	1.1
63	53.10	161	36.4	36.0	0.569	75.9	44.6	52	15.6	1.1
64	53.11	161	37.6	37.5	0.615	82.1	47.0	54	15.8	1.1
65	53.11	161	39.1	38.9	0.659	87.9	41.5	56	16.7	1.1
66	53.12	161	38.2	37.7	0.632	84.2	43.5	54	16.0	1.1
67	53.13	161	39.1	38.8	0.665	88.6	44.2	55	16.2	1.1
68	53.13	161	38.1	37.2	0.607	80.9	43.8	53	15.1	1.1
69	53.14	161	38.7	38.5	0.646	86.2	45.9	55	16.0	1.1
70	53.14	161	38.6	38.1	0.627	83.6	44.1	54	15.0	1.1
71	53.15	161	37.4	37.3	0.605	80.7	42.3	53	15.7	1.1
72	53.16	161	38.6	37.9	0.633	84.4	44.7	54	15.7	1.1
73	53.16	161	38.2	37.5	0.620	82.6	42.8	54	14.7	1.1
74	53.17	161	36.2	36.0	0.581	77.4	44.3	51	15.5	1.1
75	53.17	161	36.4	36.4	0.590	78.7	43.0	52	15.4	1.1
76	53.18	161	37.6	37.0	0.590	78.6	40.2	53	14.2	0.9
77	53.19	161	36.5	36.2	0.585	78.0	41.9	52	15.4	1.1
78	53.19	161	36.3	35.5	0.549	73.2	44.3	51	14.0	1.1
79	53.20	161	35.8	35.8	0.567	75.5	44.5	51	15.6	1.1
80	53.21	161	38.0	37.8	0.618	82.3	42.2	54	14.9	0.7
81	53.21	161	36.0	35.3	0.545	72.6	45.5	51	14.6	1.1
82	53.22	161	35.4	34.7	0.518	69.1	44.0	50	14.1	1.1
83	53.22	161	35.6	35.1	0.537	71.6	43.2	50	14.8	1.1
84	53.23	161	35.3	35.0	0.544	72.5	44.2	50	14.9	1.1
85	53.24	161	35.2	34.7	0.551	73.5	45.2	50	14.6	1.1
86	53.24	161	36.5	36.3	0.591	78.9	42.2	52	15.6	1.1
87	53.25	161	34.9	34.5	0.549	73.2	46.8	49	14.7	0.7
88	53.26	161	33.6	33.5	0.509	67.9	43.2	48	14.5	1.9
89	53.26	161	35.3	34.5	0.527	70.3	45.1	49	14.4	1.9
90	53.27	161	35.3	35.1	0.569	75.9	45.2	50	15.3	1.1
91	53.27	161	34.2	33.8	0.517	68.9	44.6	48	14.3	1.1
92	53.28	161	35.6	35.2	0.557	74.2	44.7	50	15.5	1.9
93	53.29	161	36.3	35.8	0.574	76.6	46.1	51	14.8	1.1
94	53.29	161	36.3	35.9	0.574	76.6	45.7	51	14.6	1.1
95	53.30	161	34.2	33.8	0.505	67.3	47.7	48	14.4	1.1
96	53.31	161	34.4	33.8	0.499	66.5	46.8	48	13.7	1.1
97	53.31	161	32.7	32.4	0.473	63.0	47.1	46	13.3	1.9
98	53.32	161	34.1	33.7	0.506	67.4	45.6	48	13.8	0.7
99	53.32	161	34.2	33.4	0.496	66.1	39.6	48	13.3	2.0
		Average	37.1	36.7	0.591	78.8	44.8	52	15.3	1.2
		Std. Dev.	2.1	2.1	0.059	7.8	2.0	3	0.9	0.3

Total number of blows analyzed: 51

BL#	depth (ft)	Comments
1	52.51	Start of test on 7/18/2014 at 9:16:16 AM
100	53.33	End of test on 7/18/2014 at 9:18:32 AM

Time Summary

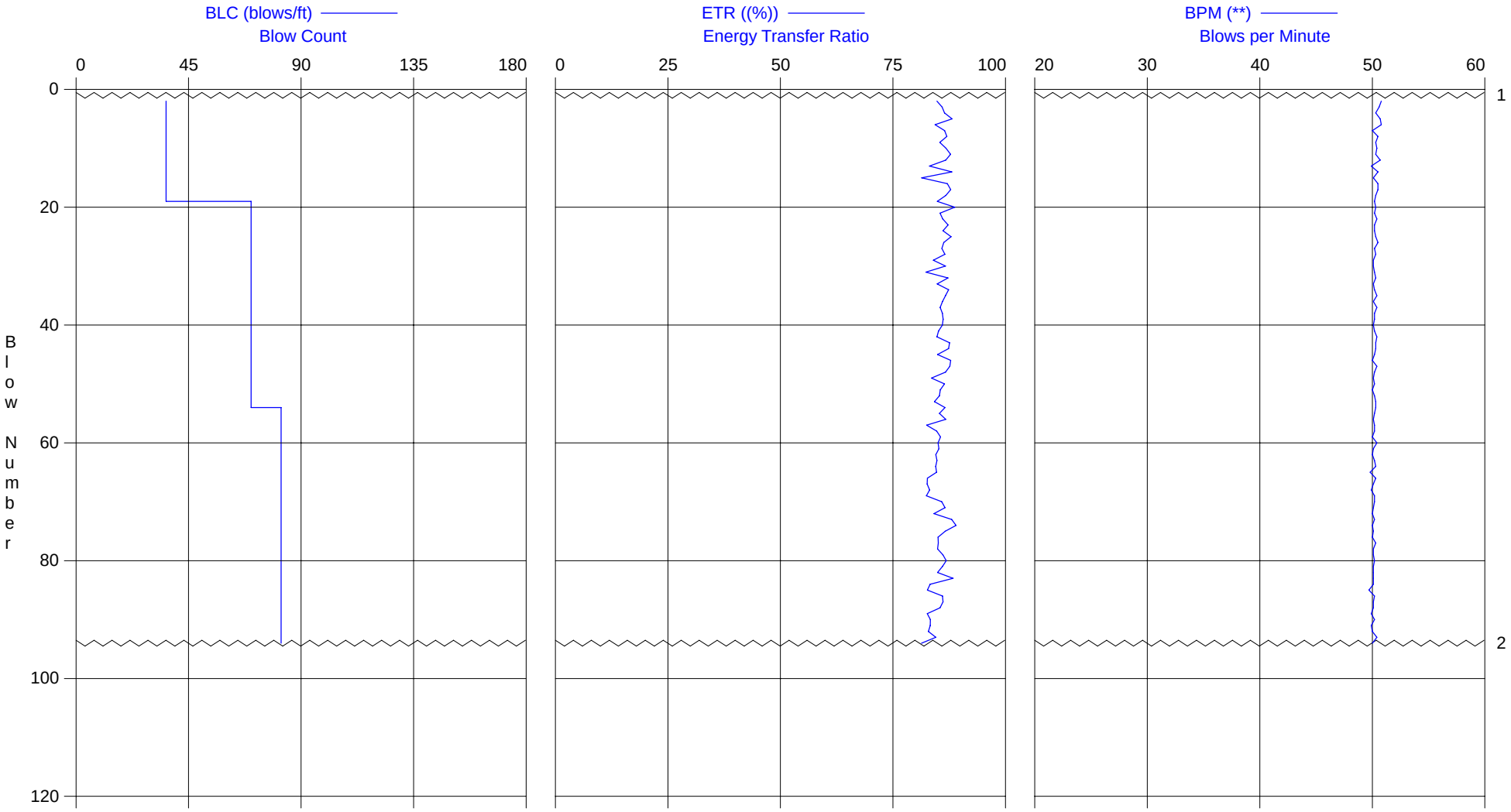
Drive 2 minutes 16 seconds 9:16:16 AM - 9:18:32 AM (7/18/2014) BN 1 - 100

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 21-Jul-2014

Test date: 18-Jul-2014

GEOSYNTEC, RIVERBEND LANDFILL - 57.5FT SAMPLE, STPGT14-02, CME 850



1 - Start of test on 7/18/2014 at 9:57:38 AM

2 - End of test on 7/18/2014 at 9:59:29 AM

GEOSYNTEC, RIVERBEND LANDFILL - 57.5FT SAMPLE, STP
OP: RMDT

GT14-02, CME 850
Test date: 18-Jul-2014

AR: 1.43 in^2
LE: 62.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]
19	58.01	70	32.1	32.1	0.297	84.8	50.2	46	11.7	0.5
20	58.03	70	32.8	32.7	0.311	88.7	50.3	47	12.1	0.5
21	58.04	70	32.1	32.0	0.299	85.5	50.2	46	11.7	0.5
22	58.06	70	33.1	32.5	0.301	86.1	50.4	46	11.5	0.7
23	58.07	70	32.8	32.6	0.305	87.3	50.2	47	12.0	0.5
24	58.09	70	32.8	32.6	0.301	86.1	50.2	47	12.0	0.4
25	58.10	70	32.5	32.0	0.308	87.9	50.3	46	11.8	0.5
26	58.11	70	32.1	31.4	0.302	86.3	50.5	45	11.7	0.5
27	58.13	70	32.2	32.1	0.301	85.9	50.2	46	11.7	0.5
28	58.14	70	32.2	31.9	0.303	86.5	50.3	46	11.7	0.5
29	58.16	70	32.4	32.0	0.294	84.0	50.1	46	11.3	0.7
30	58.17	70	32.6	32.5	0.303	86.7	50.1	46	12.0	0.5
31	58.19	70	31.6	31.1	0.288	82.3	50.2	44	11.2	0.9
32	58.20	70	33.4	32.8	0.305	87.2	50.3	47	11.6	0.6
33	58.21	70	32.0	31.3	0.297	84.8	50.1	45	11.7	0.5
34	58.23	70	32.4	32.2	0.306	87.4	50.2	46	11.9	0.5
35	58.24	70	32.1	31.8	0.303	86.7	50.4	45	11.7	0.5
36	58.26	70	32.2	32.0	0.301	86.0	50.1	46	11.9	0.5
37	58.27	70	32.3	31.5	0.299	85.5	50.4	45	11.6	0.7
38	58.29	70	32.3	32.2	0.301	86.0	50.2	46	12.0	0.4
39	58.30	70	32.3	32.2	0.301	86.1	50.2	46	12.0	0.5
40	58.31	70	32.5	32.3	0.301	86.0	50.1	46	11.9	0.5
41	58.33	70	32.1	31.8	0.298	85.1	50.2	46	11.6	0.5
42	58.34	70	32.6	32.4	0.297	84.8	50.4	46	12.1	0.5
43	58.36	70	32.7	32.5	0.307	87.6	50.3	46	12.3	0.5
44	58.37	70	32.4	31.8	0.306	87.3	50.3	46	11.9	0.7
45	58.39	70	32.5	31.6	0.297	84.9	50.2	45	11.3	0.5
46	58.40	70	32.4	32.2	0.307	87.8	50.0	46	12.0	0.5
47	58.41	70	32.6	32.4	0.307	87.6	50.4	46	12.1	0.5
48	58.43	70	32.4	32.2	0.303	86.6	50.2	46	12.1	0.5
49	58.44	70	32.1	31.3	0.292	83.6	50.1	45	11.3	0.9
50	58.46	70	32.3	31.4	0.303	86.5	50.2	45	11.6	0.9
51	58.47	70	32.9	32.6	0.299	85.5	50.0	47	12.1	0.5
52	58.49	70	32.7	32.4	0.299	85.3	50.2	46	12.0	0.4
53	58.50	70	31.7	31.5	0.295	84.2	50.3	45	11.4	0.5
54	58.51	82	32.7	32.6	0.303	86.5	50.3	47	12.3	0.5
55	58.52	82	32.0	31.7	0.299	85.3	50.2	45	11.7	0.5
56	58.54	82	32.5	32.4	0.304	86.7	50.1	46	12.1	0.5
57	58.55	82	31.4	31.3	0.289	82.5	50.2	45	11.3	0.5
58	58.56	82	32.3	31.7	0.296	84.7	50.2	45	11.5	0.7
59	58.57	82	32.5	32.3	0.299	85.6	50.0	46	12.0	0.5
60	58.59	82	32.1	31.9	0.298	85.0	50.4	46	11.7	0.6
61	58.60	82	32.0	31.6	0.298	85.2	50.1	45	11.5	0.5
62	58.61	82	31.7	31.1	0.296	84.5	50.0	45	11.4	0.5
63	58.62	82	31.7	31.6	0.297	84.8	50.2	45	11.6	0.7
64	58.63	82	31.8	31.5	0.296	84.5	50.3	45	11.5	0.5
65	58.65	82	31.9	31.5	0.296	84.7	49.8	45	11.5	0.5
66	58.66	82	31.4	31.4	0.289	82.6	50.3	45	11.4	0.8
67	58.67	82	31.6	31.5	0.289	82.6	50.1	45	11.4	0.6
68	58.68	82	31.3	31.2	0.291	83.1	49.9	45	11.5	0.5
69	58.70	82	31.7	31.5	0.288	82.4	50.2	45	11.4	1.0
70	58.71	82	32.6	32.3	0.300	85.8	50.2	46	12.0	0.5
71	58.72	82	32.3	32.2	0.303	86.6	50.1	46	11.9	0.5
72	58.73	82	32.1	32.0	0.294	84.1	50.0	46	11.8	0.7
73	58.74	82	32.9	32.8	0.308	88.0	50.2	47	12.3	0.5
74	58.76	82	32.3	32.2	0.311	89.0	50.0	46	12.0	0.5
75	58.77	82	32.7	32.5	0.303	86.6	50.1	47	12.3	0.5
76	58.78	82	32.3	32.1	0.297	85.0	50.0	46	11.9	0.5
77	58.79	82	32.0	32.0	0.298	85.1	50.3	46	12.0	0.6
78	58.81	82	32.3	32.2	0.297	84.9	50.1	46	11.7	0.5
79	58.82	82	32.1	32.1	0.301	86.1	50.1	46	12.1	0.5
80	58.83	82	32.6	32.6	0.304	86.9	50.2	47	12.3	0.5
81	58.84	82	32.6	32.5	0.301	86.0	50.1	47	12.3	0.5
82	58.85	82	32.4	32.3	0.297	84.9	50.1	46	11.9	0.6
83	58.87	82	32.9	32.8	0.309	88.4	50.1	47	12.4	0.5
84	58.88	82	31.5	31.4	0.291	83.3	50.1	45	11.4	0.5

GEOSYNTEC, RIVERBEND LANDFILL - 57.5FT SAMPLE, STP
OP: RMDT

GT14-02, CME 850
Test date: 18-Jul-2014

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]
85	58.89	82	31.6	31.5	0.289	82.7	49.7	45	11.6	0.5
86	58.90	82	32.9	32.9	0.301	86.0	50.2	47	12.0	0.7
87	58.92	82	33.1	33.1	0.301	86.1	50.1	47	12.3	0.5
88	58.93	82	32.6	32.1	0.299	85.5	50.1	46	11.6	0.7
89	58.94	82	31.5	31.5	0.289	82.6	49.9	45	11.8	0.5
90	58.95	82	31.9	31.8	0.292	83.3	50.2	45	11.9	0.6
91	58.96	82	31.9	31.8	0.291	83.3	49.9	46	11.6	0.5
92	58.98	82	31.3	31.1	0.290	82.9	50.0	44	11.6	0.5
93	58.99	82	32.0	32.0	0.296	84.5	50.4	46	11.6	0.7
94	59.00	82	31.1	31.0	0.285	81.3	50.0	44	11.4	0.7
		Average	32.2	32.0	0.299	85.4	50.2	46	11.8	0.5
		Std. Dev.	0.5	0.5	0.006	1.7	0.1	1	0.3	0.1

Total number of blows analyzed: 76

BL#	depth (ft)	Comments
1	57.53	Start of test on 7/18/2014 at 9:57:38 AM
94	59.00	End of test on 7/18/2014 at 9:59:29 AM

Time Summary

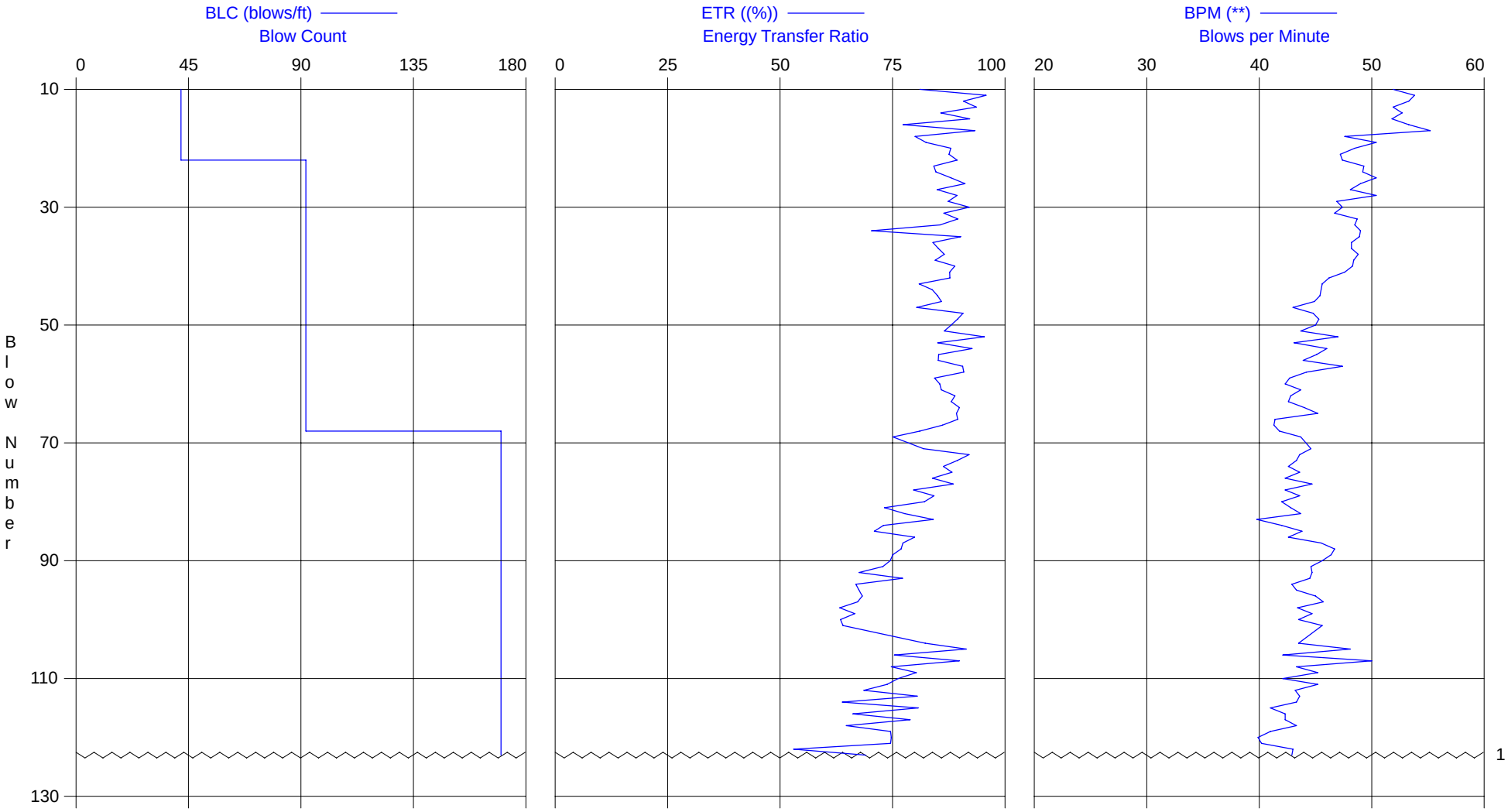
Drive	1 minute 51 seconds	9:57:38 AM - 9:59:29 AM (7/18/2014) BN 1 - 94

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 21-Jul-2014

Test date: 18-Jul-2014

GEOSYNTEC, RIVERBEND LANDFILL - 60 FT SAMPLE, MCGT14-02, CME 850



1 - End of test on 7/18/2014 at 10:29:07 AM

GEOSYNTEC, RIVERBEND LANDFILL - 60 FT SAMPLE, MC
OP: RMDT

GT14-02, CME 850
Test date: 18-Jul-2014

AR: 1.43 in^2
LE: 65.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]
22	60.51	92	42.0	41.4	0.670	89.3	47.4	59	15.0	0.6
23	60.52	92	41.0	40.2	0.631	84.2	49.3	57	15.6	0.8
24	60.53	92	39.1	38.5	0.635	84.6	49.2	55	15.2	0.9
25	60.54	92	38.5	37.7	0.660	88.0	50.4	54	17.1	0.9
26	60.55	92	42.6	41.6	0.683	91.1	49.0	60	15.2	0.6
27	60.57	92	42.4	41.1	0.637	84.9	48.1	59	15.2	0.9
28	60.58	92	42.0	41.1	0.670	89.4	50.4	59	15.6	0.6
29	60.59	92	40.8	40.4	0.655	87.4	46.9	58	16.1	0.9
30	60.60	92	42.2	41.1	0.691	92.1	47.4	59	15.6	0.6
31	60.61	92	40.2	39.4	0.648	86.4	46.7	56	15.7	0.9
32	60.62	92	44.0	43.0	0.671	89.5	48.7	61	15.1	0.6
33	60.63	92	41.3	40.6	0.642	85.5	48.5	58	15.5	0.9
34	60.64	92	37.1	36.7	0.528	70.3	49.0	52	13.5	0.8
35	60.65	92	43.7	42.3	0.676	90.1	48.9	61	15.8	0.9
36	60.66	92	41.7	40.8	0.630	84.0	48.2	58	14.4	0.6
37	60.67	92	41.6	40.4	0.639	85.2	48.2	58	15.6	0.6
38	60.69	92	40.7	39.5	0.649	86.5	48.8	56	15.3	0.6
39	60.70	92	40.8	40.0	0.633	84.5	48.4	57	15.6	1.1
40	60.71	92	43.4	42.4	0.666	88.8	48.3	61	14.7	0.6
41	60.72	92	41.8	40.6	0.658	87.7	47.6	58	15.5	0.9
42	60.73	92	42.5	41.3	0.658	87.7	46.2	59	15.0	0.6
43	60.74	92	39.7	38.9	0.607	80.9	45.6	56	14.9	0.9
44	60.75	92	40.3	39.6	0.629	83.8	45.5	57	14.7	0.6
45	60.76	92	39.1	38.3	0.637	85.0	45.4	55	15.9	1.1
46	60.77	92	41.6	40.5	0.644	85.9	44.9	58	15.0	0.6
47	60.78	92	37.8	37.2	0.603	80.4	43.0	53	15.3	1.1
48	60.79	92	42.0	40.7	0.680	90.6	44.8	58	16.1	1.1
49	60.80	92	40.6	40.2	0.671	89.4	45.3	58	15.5	0.6
50	60.82	92	42.6	41.2	0.660	88.0	45.0	59	15.2	0.6
51	60.83	92	37.2	36.9	0.649	86.5	43.7	53	16.6	1.1
52	60.84	92	43.2	42.4	0.715	95.4	47.0	61	16.1	0.6
53	60.85	92	36.8	36.4	0.638	85.0	43.1	52	16.5	1.1
54	60.86	92	40.7	39.9	0.695	92.7	46.0	57	16.0	1.1
55	60.87	92	39.3	39.0	0.639	85.2	45.1	56	15.6	0.9
56	60.88	92	39.6	38.5	0.639	85.1	43.9	55	15.7	1.1
57	60.89	92	39.6	39.0	0.679	90.6	47.4	56	16.3	0.9
58	60.90	92	41.6	40.3	0.681	90.8	44.2	58	15.9	0.6
59	60.91	92	41.1	40.3	0.632	84.3	42.7	58	15.4	0.9
60	60.92	92	40.8	40.3	0.641	85.5	42.3	58	15.5	0.6
61	60.94	92	39.4	39.1	0.644	85.8	43.7	56	15.5	0.9
62	60.95	92	42.5	41.4	0.666	88.9	42.8	59	15.8	1.1
63	60.96	92	40.4	40.0	0.660	88.0	42.6	57	15.5	0.6
64	60.97	92	42.1	40.7	0.674	89.9	44.0	58	15.9	0.6
65	60.98	92	41.9	41.6	0.669	89.2	45.2	59	15.9	0.6
66	60.99	92	42.2	40.4	0.671	89.5	41.4	58	16.0	0.6
67	61.00	92	41.7	40.7	0.646	86.1	41.3	58	15.2	0.6
68	61.01	170	37.7	37.3	0.608	81.1	41.8	53	15.5	1.1
69	61.01	170	36.8	36.3	0.563	75.1	43.7	52	14.9	0.9
71	61.02	170	41.1	40.2	0.614	81.9	44.6	58	14.6	0.9
72	61.03	170	40.0	39.4	0.690	92.0	43.6	56	16.4	1.1
74	61.04	170	38.8	38.3	0.647	86.3	42.6	55	16.4	0.9
76	61.05	170	38.2	37.5	0.629	83.9	42.3	54	15.8	1.1
78	61.07	170	39.1	38.5	0.597	79.7	42.3	55	14.8	0.9
80	61.08	170	41.2	40.2	0.615	82.1	42.0	57	14.6	0.6
82	61.09	170	39.8	38.7	0.583	77.7	43.7	55	15.3	0.6
84	61.10	170	37.5	37.2	0.547	73.0	42.0	53	15.1	1.1
86	61.11	170	37.6	37.3	0.599	79.9	42.6	53	16.3	1.1
88	61.12	170	37.4	36.6	0.577	76.9	46.7	52	15.2	1.1
90	61.14	170	37.9	37.4	0.559	74.5	45.6	54	14.8	1.1
92	61.15	170	36.7	36.4	0.507	67.6	44.7	52	14.8	1.1
94	61.16	170	38.2	37.6	0.501	66.8	42.9	54	14.8	1.1
96	61.17	170	39.6	38.9	0.512	68.3	45.0	56	14.7	1.1
98	61.18	170	37.4	36.7	0.474	63.2	43.4	52	14.2	1.1
100	61.19	170	37.5	37.2	0.476	63.4	43.5	53	14.1	1.1
104	61.22	170	39.7	38.9	0.617	82.2	43.5	56	14.9	1.1
106	61.23	170	41.4	40.2	0.565	75.4	42.1	58	15.5	1.1

GEOSYNTEC, RIVERBEND LANDFILL - 60 FT SAMPLE, MC
OP: RMDT

GT14-02, CME 850
Test date: 18-Jul-2014

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]
108	61.24	170	40.4	39.2	0.560	74.7	43.3	56	15.5	1.1
110	61.25	170	41.2	40.3	0.572	76.3	42.1	58	15.7	1.1
112	61.27	170	39.4	38.7	0.515	68.6	43.2	55	14.6	1.1
114	61.28	170	37.3	37.1	0.479	63.8	43.3	53	14.2	1.7
116	61.29	170	38.4	38.1	0.496	66.2	42.3	55	14.3	1.1
118	61.30	170	38.7	38.4	0.485	64.7	43.3	55	14.4	1.7
120	61.31	170	36.2	35.6	0.560	74.7	39.9	51	15.0	1.8
122	61.32	170	34.2	34.0	0.398	53.0	43.0	49	13.0	1.7
		Average	40.2	39.3	0.607	80.9	44.8	56	15.1	0.9
		Std. Dev.	2.0	1.8	0.065	8.7	2.5	3	0.8	0.3

Total number of blows analyzed: 99

BL#	depth (ft)	Comments
1	60.02	Start of test on 7/18/2014 at 10:26:13 AM
123	61.33	End of test on 7/18/2014 at 10:29:07 AM

Time Summary

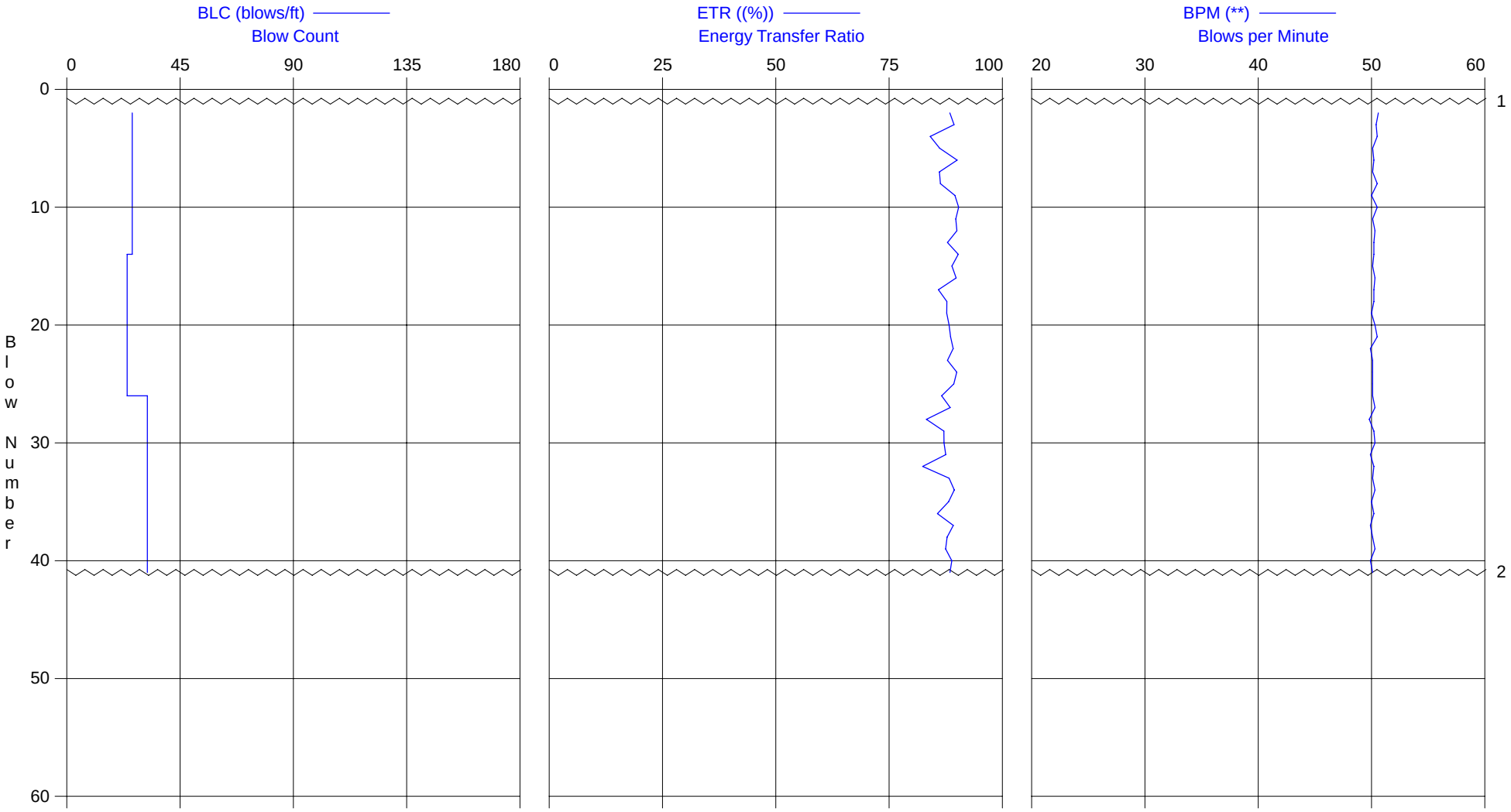
Drive	2 minutes 54 seconds	10:26:13 AM - 10:29:07 AM (7/18/2014) BN 1 - 123

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 21-Jul-2014

Test date: 18-Jul-2014

GEOSYNTEC, RIVERBEND LANDFILL - 65 FT SAMPLE, SPTGT14-02, CME 850



1 - Start of test on 7/18/2014 at 11:02:08 AM

2 - End of test on 7/18/2014 at 11:02:56 AM

GEOSYNTEC, RIVERBEND LANDFILL - 65 FT SAMPLE, SPT
OP: RMDT

GT14-02, CME 850
Test date: 18-Jul-2014

AR: 1.43 in^2
LE: 70.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]
14	65.54	24	32.8	32.5	0.316	90.3	50.2	47	11.8	0.6
15	65.58	24	32.3	32.2	0.311	88.9	50.1	46	11.8	0.6
16	65.63	24	32.6	32.3	0.314	89.8	50.3	46	11.7	0.5
17	65.67	24	33.3	33.1	0.301	85.9	50.2	47	11.4	0.6
18	65.71	24	32.6	32.4	0.307	87.7	50.2	46	11.7	0.6
19	65.75	24	31.5	31.5	0.307	87.7	50.0	45	11.5	0.6
20	65.79	24	32.4	32.4	0.309	88.2	50.3	46	11.7	0.6
21	65.83	24	32.7	32.6	0.310	88.5	50.5	47	11.7	0.5
22	65.88	24	32.3	32.2	0.312	89.1	49.9	46	11.7	0.6
23	65.92	24	32.8	32.0	0.308	87.9	50.1	46	11.4	0.6
24	65.96	24	32.7	32.4	0.315	89.9	50.1	46	11.6	0.6
25	66.00	24	32.9	32.5	0.312	89.3	50.1	46	11.6	0.6
26	66.03	32	32.2	32.1	0.303	86.6	50.1	46	11.8	0.6
27	66.06	32	32.9	32.6	0.310	88.5	50.3	47	11.8	0.5
28	66.09	32	31.4	30.8	0.291	83.2	49.8	44	12.0	0.6
29	66.13	32	32.0	31.8	0.305	87.1	50.2	45	12.0	0.6
30	66.16	32	31.8	31.6	0.305	87.1	50.3	45	12.1	0.6
31	66.19	32	32.1	32.0	0.306	87.5	49.9	46	12.0	0.6
32	66.22	32	32.5	32.3	0.288	82.4	50.2	46	11.9	0.6
33	66.25	32	32.4	32.4	0.309	88.2	50.1	46	12.0	0.6
34	66.28	32	32.1	32.1	0.313	89.4	50.3	46	12.2	0.6
35	66.31	32	32.8	32.7	0.308	88.1	50.0	47	12.0	0.5
36	66.34	32	32.3	32.1	0.300	85.6	50.2	46	11.9	0.6
37	66.38	32	32.8	32.7	0.312	89.2	49.9	47	12.2	0.5
38	66.41	32	32.5	32.4	0.307	87.8	50.1	46	12.1	0.5
39	66.44	32	32.4	32.3	0.306	87.5	50.3	46	12.1	0.6
40	66.47	32	31.6	31.5	0.311	88.8	49.9	45	12.4	0.6
41	66.50	32	32.4	32.3	0.309	88.4	50.1	46	12.2	0.6
		Average	32.4	32.2	0.307	87.8	50.1	46	11.9	0.6
		Std. Dev.	0.4	0.5	0.006	1.8	0.2	1	0.3	0.0

Total number of blows analyzed: 28

BL#	depth (ft)	Comments
1	65.04	Start of test on 7/18/2014 at 11:02:08 AM
41	66.50	End of test on 7/18/2014 at 11:02:56 AM

Time Summary

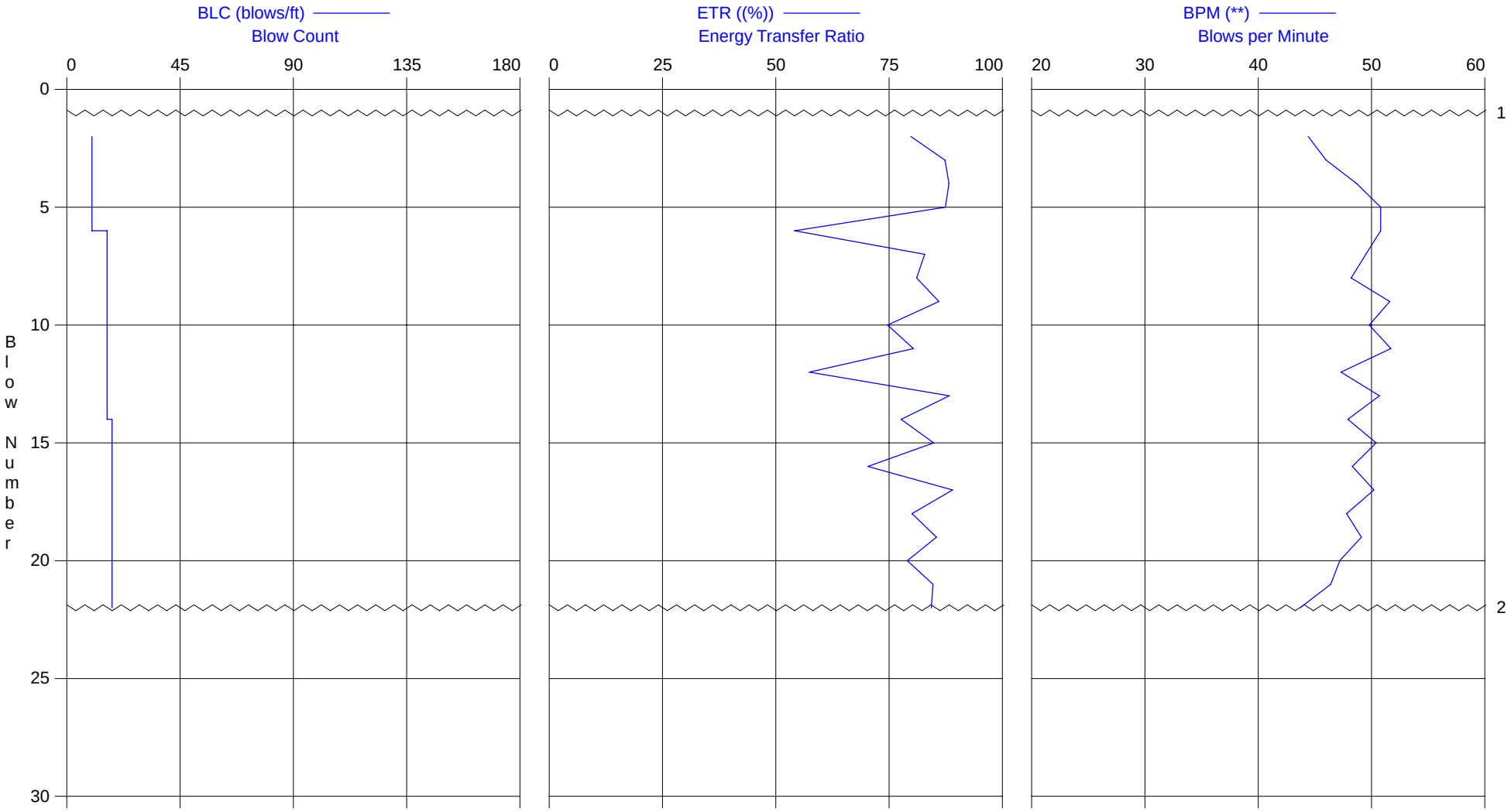
Drive	48 seconds	11:02:08 AM - 11:02:56 AM (7/18/2014) BN 1 - 41

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 21-Jul-2014

Test date: 18-Jul-2014

GEOSYNTEC, RIVERBEND LANDFILL - 70 FT SAMPLE, MCGT14-02, CME 850



1 - Start of test on 7/18/2014 at 11:33:59 AM

2 - End of test on 7/18/2014 at 11:34:25 AM

GEOSYNTEC, RIVERBEND LANDFILL - 70 FT SAMPLE, MC
OP: RMDT

GT14-02, CME 850
Test date: 18-Jul-2014

AR: 1.43 in^2
LE: 75.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]
6	70.56	16	31.1	30.5	0.406	54.2	50.8	44	12.8	0.7
7	70.63	16	39.5	39.0	0.621	82.9	49.5	56	14.9	0.7
8	70.69	16	38.0	37.7	0.608	81.1	48.2	54	15.4	0.9
9	70.75	16	39.8	39.1	0.645	86.0	51.6	56	15.3	0.7
10	70.81	16	37.3	37.0	0.560	74.7	49.8	53	14.5	0.9
11	70.88	16	37.9	37.1	0.603	80.4	51.7	53	14.8	0.9
12	70.94	16	33.0	32.7	0.431	57.4	47.3	47	13.1	0.7
13	71.00	16	40.5	39.9	0.662	88.3	50.7	57	15.7	0.6
14	71.06	18	39.1	38.0	0.582	77.6	47.9	54	14.9	0.6
15	71.11	18	38.8	38.5	0.636	84.8	50.4	55	15.1	0.6
16	71.17	18	35.7	35.2	0.527	70.3	48.3	50	14.6	0.7
17	71.22	18	40.0	39.7	0.668	89.0	50.2	57	15.6	0.6
18	71.28	18	37.8	37.3	0.600	80.0	47.8	53	15.5	1.1
19	71.33	18	39.9	39.6	0.641	85.5	49.1	57	14.9	0.6
20	71.39	18	37.3	36.8	0.593	79.0	47.2	53	15.3	0.7
21	71.44	18	39.7	39.4	0.635	84.7	46.4	56	15.2	0.5
22	71.50	18	38.7	37.8	0.632	84.3	43.7	54	15.8	0.7
		Average	37.9	37.4	0.591	78.8	48.9	53	14.9	0.7
		Std. Dev.	2.5	2.5	0.072	9.6	2.0	4	0.8	0.1

Total number of blows analyzed: 17

BL#	depth (ft)	Comments
1	70.10	Start of test on 7/18/2014 at 11:33:59 AM
22	71.50	End of test on 7/18/2014 at 11:34:25 AM

Time Summary

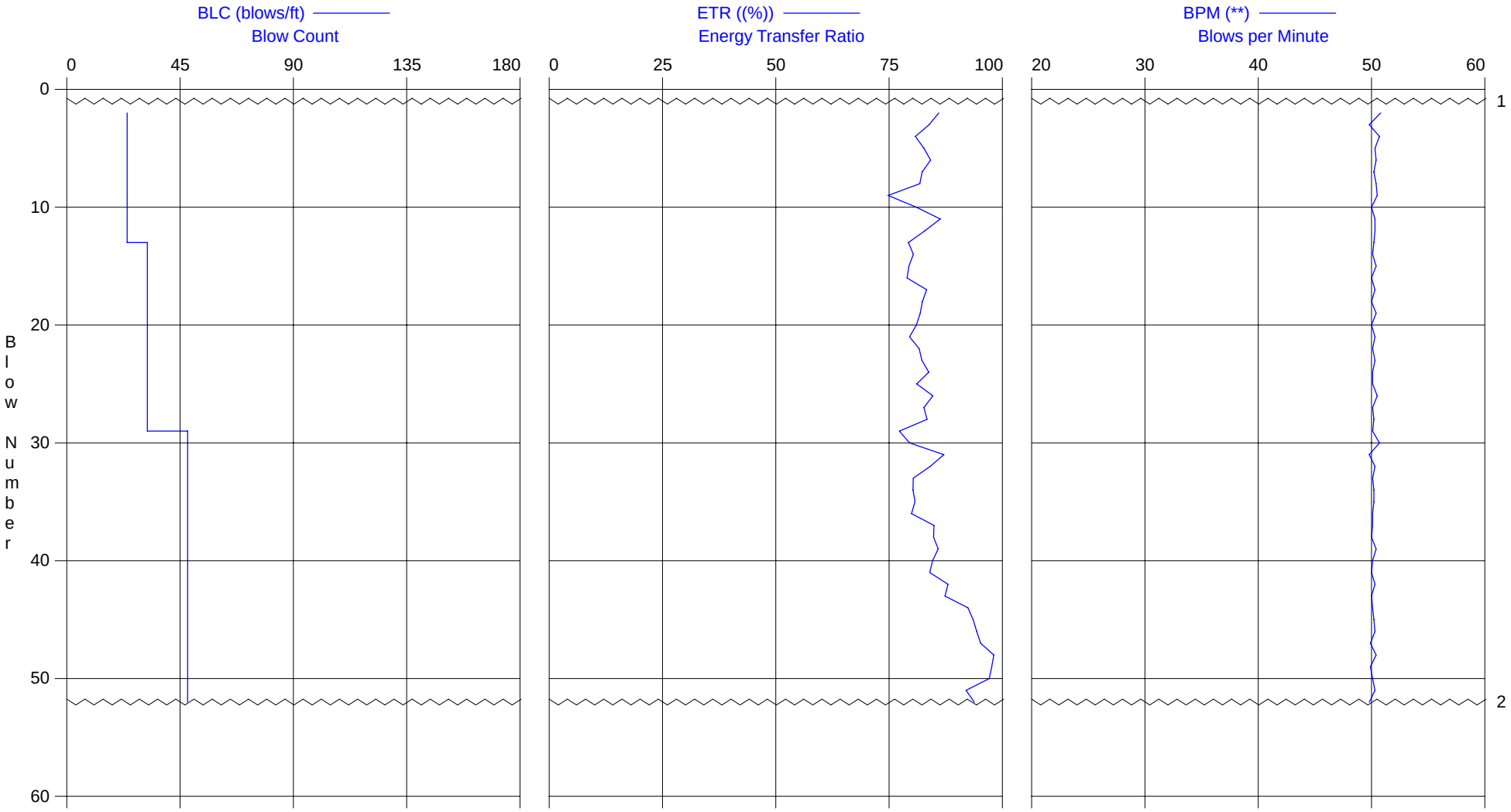
Drive 26 seconds 11:33:59 AM - 11:34:25 AM (7/18/2014) BN 1 - 22

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 21-Jul-2014

Test date: 18-Jul-2014

GEOSYNTEC, RIVERBEND LANDFILL - 75 FT SAMPLE, SPTGT14-02, CME 850



1 - Start of test on 7/18/2014 at 12:00:00 PM

2 - End of test on 7/18/2014 at 12:01:01 PM

GEOSYNTEC, RIVERBEND LANDFILL - 75 FT SAMPLE, SPT
OP: RMDT

GT14-02, CME 850
Test date: 18-Jul-2014

AR: 1.43 in^2
LE: 80.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio

BPM: Blows per Minute
FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]
13	75.53	32	32.1	30.9	0.277	79.3	50.2	44	12.2	0.3
14	75.56	32	32.9	32.8	0.281	80.3	50.1	47	12.1	0.3
15	75.59	32	31.1	31.0	0.278	79.4	50.4	44	11.6	0.3
16	75.63	32	32.1	31.3	0.276	79.0	50.0	45	11.4	0.3
17	75.66	32	32.0	31.3	0.291	83.3	50.3	45	11.7	0.3
18	75.69	32	32.3	31.5	0.288	82.4	50.0	45	11.5	0.3
19	75.72	32	32.3	31.7	0.286	81.8	50.4	45	11.8	0.3
20	75.75	32	31.9	31.1	0.284	81.0	50.0	45	11.8	0.3
21	75.78	32	31.9	30.9	0.278	79.5	50.3	44	11.4	0.3
22	75.81	32	32.2	31.5	0.286	81.6	50.1	45	11.9	0.3
23	75.84	32	31.9	31.5	0.288	82.2	50.3	45	11.5	0.3
24	75.88	32	32.6	32.0	0.293	83.8	50.1	46	11.6	0.3
25	75.91	32	32.3	31.4	0.284	81.1	50.1	45	11.6	0.3
26	75.94	32	32.9	32.5	0.296	84.7	50.5	46	11.5	0.3
27	75.97	32	32.7	31.6	0.289	82.7	50.1	45	11.5	0.3
28	76.00	32	32.9	32.8	0.292	83.4	50.2	47	11.6	0.3
29	76.02	48	32.2	31.5	0.270	77.3	50.1	45	11.5	0.3
30	76.04	48	32.5	31.8	0.278	79.5	50.7	45	11.5	0.3
31	76.06	48	32.5	32.5	0.305	87.1	49.8	46	11.5	0.3
32	76.08	48	32.7	31.7	0.294	84.1	50.3	45	11.3	0.3
33	76.10	48	31.9	31.3	0.281	80.3	50.1	45	11.3	0.3
34	76.13	48	31.5	31.0	0.281	80.3	50.2	44	11.6	0.3
35	76.15	48	32.7	32.3	0.283	80.7	50.2	46	11.6	0.3
36	76.17	48	31.6	30.5	0.280	79.9	50.1	44	11.2	0.3
37	76.19	48	32.3	31.8	0.297	84.9	50.1	46	11.5	0.3
38	76.21	48	31.3	30.7	0.297	84.8	50.0	44	11.6	0.4
39	76.23	48	31.8	31.5	0.300	85.8	50.4	45	11.7	0.3
40	76.25	48	31.4	31.4	0.296	84.6	50.1	45	11.6	0.3
41	76.27	48	33.1	32.5	0.294	84.0	50.0	46	11.7	0.3
42	76.29	48	32.8	31.8	0.308	88.0	50.3	45	11.6	0.4
43	76.31	48	32.8	31.4	0.306	87.3	50.0	45	11.6	0.4
44	76.33	48	33.0	31.3	0.323	92.4	50.1	45	11.6	0.3
45	76.35	48	33.1	32.1	0.327	93.5	50.2	46	11.4	0.6
46	76.38	48	33.8	32.8	0.330	94.3	50.3	47	11.6	0.4
47	76.40	48	32.4	31.6	0.333	95.2	49.9	45	11.4	0.7
48	76.42	48	32.1	31.2	0.343	98.1	50.4	45	11.6	0.7
49	76.44	48	32.9	32.5	0.342	97.7	49.9	46	11.7	0.6
50	76.46	48	32.4	31.0	0.340	97.1	50.1	44	11.8	0.7
51	76.48	48	32.9	32.3	0.322	92.0	50.3	46	11.7	0.3
52	76.50	48	32.3	31.3	0.328	93.8	49.8	45	11.5	0.6
		Average	32.4	31.6	0.298	85.2	50.2	45	11.6	0.4
		Std. Dev.	0.6	0.6	0.020	5.8	0.2	1	0.2	0.1

Total number of blows analyzed: 40

BL#	depth (ft)	Comments
1	75.04	Start of test on 7/18/2014 at 12:00:00 PM
52	76.50	End of test on 7/18/2014 at 12:01:01 PM

Time Summary

Drive	1 minute 1 second	12:00:00 PM - 12:01:01 PM (7/18/2014) BN 1 - 52

Robert Miner Dynamic Testing, Inc.

Dynamic Measurements and Analyses for Deep Foundations

November 6, 2014

Mr. Fabrizio Settepani
Geosyntec Consultants
1111 Broadway
Oakland, CA 94607

Re: Penetration Test Energy Measurements
Hard Core Rig No. 104, CME Automatic Hammer and Rope and Cathead
Borehole GT14-14, October 31, 2014
Riverbend Landfill, McMinnville, OR RMDT Job No. 14F34b

Dear Mr. Settepani,

This letter presents energy transfer measurements made during Standard Penetration Tests and California Modified Samples for the drill hole and drill rig referenced above. Robert Miner Dynamic Testing, Inc. (RMDT) made dynamic measurements with a Pile Driving Analyzer® as a hammer advanced the NWJ rod during sampling with a split spoon sampler and a California Modified sampler.

The purpose of RMDT's testing was the measurement of energy transferred to the drill rods. Measurements were made on a section of NW gauge rod at the top of the drill rod. Strain gages and accelerometers on the rod were connected to a Pile Driving Analyzer® (PDA) which generally processed acceleration and strain measurements from each hammer blow and stored both the measurements and computed results. Measurements and data processing generally followed the ASTM D 4633-10 standard. Energy transfer past the gage location, EFV, was computed by the PDA using force and velocity records as follows:

$$EFV = \int_a^b F(t)\ v(t)\ dt$$

The value "a" corresponds to the start of the record which is when the energy transfer begins and *"b"* is the time at which energy transferred to the rod reaches a maximum value. Appendix A contains more information on our measurement equipment and methods of analysis. The EFV energy calculation is identical to the EMX energy result discussed in Appendix A. The EFV and EMX values apply to the sensor location near the top of the rod.

TEST DETAILS

Testing occurred on October 31, 2014. Boring GT14-14 was advanced in the proposed western expansion area at the Riverbend Landfill facility located in McMinnville, OR. An automatic hammer manufactured by Central Mine Equipment Co. (CME) containing a 140 lb ram was use to advance split spoon samples. A 300 lb ram operated by rope and cathead was used to

Mailing Address: P.O. Box 340, Manchester, WA, 98353, USA **Phone:** 360-871-5480
Location: 2288 Colchester Dr. E., Ste A, Manchester, WA, 98353 **Fax:** 360-871-5483

advance California Modified Samplers. NWJ size rod was used to advance both sample types. The drill rig was Hard Core Drilling's track-mounted CME Rig No. 104.

RESULTS

A summary of the results for tests conducted with the 140 lb and 300 lb rams are given in Tables 1 and 2, respectively. The tabulated results include the starting sample depth, the penetration resistance, the number of hammers blows in our data set, measured energy transfer, EFV, the computed transfer efficiency, ETR, and the hammer blow rate, BPM. Appendix B contains detailed numeric results for each individual test.

Energy measurements must be divided by the theoretical free fall energy of the hammer to obtain an efficiency. In anticipation of future site demands measurements were made with 140 lb and 300 lb rams. A 140 lb ram raised 30 inches above an impact surface has 350 lb-ft of potential energy. A 300 lb ram raised 30 inches above an impact surface has 750 lb-ft of potential energy. Thus, the transfer energy results for sampling with the 140 and 300 lb rams may be divided by 350 or 750 lb-ft to yield the ratio of the delivered energy to the nominal potential energy. This efficiency ratio, ETR, is given for each sample interval as a percent efficiency.

Table 1. Summary of Test Details and Results for the 140 lb ram and Split Spoon Sampler

Sample Name and Initial Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
27.5 ft	8/1 ft	8	302	86	54
35.0 ft	10/1 ft	10	292	83	51
45.0 ft	21/1 ft	21	295	84	50
Average for Split Spoon Sampler:			**296**	**84**	**52**

Three sample returns were monitored while the 140 lb ram and standard split spoon sampler were in use. A summary of the test details is given in Table 1. Examination of summarized values in Table 1 yields consistent values across the sample intervals with an average calculated ETR of 84 percent and an average hammer blow rate of 52 blows per minute.

Three additional sample returns were monitored while the 300 lb ram operated by rope and cathead advanced the California Modified sampler. A summary of the test details is given in Table 2.

Table 2. Summary of Test Details and Results for the 300-lb ram and California Modified Sampler

Sample Name and Initial Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
30.0 ft	15/1 ft	15	308	41	37
40.0 ft	16/1 ft	14	396	54	39
50.0 ft	87/.83 ft	84	463	62	46
Average for California Modified Sampler :			**389**	**52**	**41**

For the 300 lb ram the average ETR values within the sample intervals ranged from 30 to 70 percent with an overall average ETR value of 52 percent. Hammer Blow Rate within the sample intervals ranged from 33 to 60 blows per minute with an overall average Hammer Blow Rate of 52 Blows Per minute. Intermittent blow rate values of less than 15 blows per minute were recorded and likely represent brief pauses during the sampling process. In our opinion the transfer efficiency and blow rate recorded during the early portion of the 30 ft sample are lower than typically expected for rope and cathead operation. The low blow rate and variation in measures transfer energy suggests an inconsistent ram drop height. Variations in transfer efficiency and blow rate decreased during rope and cathead sampling in the later portion of the 30 ft depth sample and during sampling at the 40 and 50 ft depth intervals.

It was a pleasure to assist you and to participate on this project with the staff of Geosyntec and Hard Core Drilling. Please do not hesitate to contact us if there are any questions regarding this report.

Sincerely,

Andrew Banas
Staff Engineer
Robert Miner Dynamic Testing, Inc.

Robert Miner
President
Robert Miner Dynamic Testing, Inc.

APPENDIX A
AN INTRODUCTION INTO DYNAMIC PILE TESTING METHODS

The following has been written by Goble Rausche Likins and Associates, Inc. and may only be copied with its written permission.

BACKGROUND

Modern procedures of design and construction control require verification of bearing capacity and integrity of deep foundations during preconstruction test programs and also production installation. Dynamic pile testing methods meet this need economically and reliably, and therefore, form an important part of a quality assurance program when deep foundations are executed. Several dynamic pile testing methods exist; they have different benefits and limitations and different requirements for proper execution.

The Case Method of dynamic pile testing, named after the Case Institute of Technology where it was developed between 1964 and 1975, requires that a substantial ram mass (such as that of a pile driving hammer) impacts the pile top such that the pile undergoes at least a small permanent set. The method is therefore also referred to as a "High Strain Method". The Case Method requires dynamic measurements on the pile or shaft under the ram impact and then an evaluation of various quantities based on closed form solutions of the wave equation, a partial differential equation describing the motion of a rod under the effect of an impact. Conveniently, measurements and analyses are done by a single piece of equipment: the Pile Driving Analyzer® (PDA). However, for bearing capacity evaluations an important additional method is CAPWAP® which performs a much more rigorous analysis of the dynamic records than the simpler Case Method.

A related analysis method is the "Wave Equation Analysis" which calculates a relationship between bearing capacity and pile stress and field blow count. The GRLWEAP™ program performs this analysis and provides a complete set of helpful information and input data.

The following description deals primarily with the Case Method or "High Strain Test" Method of pile testing, however, for the sake of completeness, the "Low Strain Test" performed with the Pile Integrity Test™ (PIT), mainly for pile integrity evaluation, will also be described.

RESULTS FROM DYNAMIC TESTING

There are two main objectives of high strain dynamic pile testing:

- *Dynamic Pile Monitoring* and
- *Dynamic Load Testing*.

Dynamic pile monitoring is conducted during the installation of impact driven piles to achieve a safe and economical pile installation. Dynamic load testing, on the other hand, has as its primary goal the assessment of pile bearing capacity. It is applicable to both cast *insitu* piles or drilled shafts and impact driven piles during restrike.

Dynamic Pile Monitoring

During pile installation, the sensors attached to the pile measure pile top force and velocity. A PDA conditions and processes these signals and calculates or evaluates:

- Bearing capacity at the time of testing, including an assessment of shaft resistance development and driving resistance. This information supports formulation of a driving criterion.

- Dynamic pile stresses, axial and averaged over the pile cross section, both tensile and compressive, during pile driving to limit the potential of damage either near the pile top or along its length. Bending stresses can be evaluated at the point of sensor attachment.

- Pile integrity assessment by the PDA is based on the recognition of certain wave reflections from along the pile. If detected early enough, a pile may be saved from complete destruction. On the other hand, once damage is recognized measures can be taken to prevent reoccurrence.

- Hammer performance parameters including the energy transferred to the pile, the hammer speed in blows per minute and the stroke of open ended diesel hammers.

© 1999, Goble Rausche Likins and Associates, Inc.

Dynamic Pile Load Testing

Bearing capacity testing of either driven piles or drilled shafts applies the same basic measurement approach of dynamic pile monitoring. However, the test is done independent of the pile installation process and therefore a pile driving hammer or other dynamic loading device may not be available. If a special ram has to be mobilized then its weight should be between 0.8 and 2% of the test load (e.g. between 4 and 10 tons for a 500 ton test load) to assure sufficient soil resistance activation.

For a successful test, it most important that the test is conducted after a sufficient waiting time following pile installation for soil properties approaching their long term condition or concrete to properly set. During testing, PDA results of pile/shaft stresses and transferred energy are used to maintain safe stresses and assure sufficient resistance activation. For safe and sufficient testing of drilled shafts, ram energies are often increased from blow to blow until the test capacity has been activated. On the other hand, restrike tests on driven piles may require a warm hammer so that the very first blow produces a complete resistance activation. Data must be evaluated by CAPWAP for bearing capacity.

After the dynamic load test has been conducted with sufficient energy and safe stresses, the CAPWAP analysis provides the following results:

- Bearing capacity i.e. the mobilized capacity present at the time of testing
- Resistance distribution including shaft resistance and end bearing components
- Stresses in pile or shaft calculated for both the static load application and the dynamic test. These stresses are averages over the cross section and do not include bending effects or nonuniform contact stresses, e.g. when the pile toe is on uneven rock.
- Shaft impedance vs depth; this is an estimate of the shaft shape if it differs substantially from the planned profile
- Dynamic soil parameters for shaft and toe, i.e. damping factors and quakes (related to the dynamic stiffness of the resistance at the pile/soil interface.)

MEASUREMENTS

PDA

The basis for the results calculated by the PDA are pile top strain and acceleration measurements which are converted to force and velocity records, respectively. The PDA conditions, calibrates and displays these signals and immediately computes average pile force and velocity thereby eliminating bending effects. Using closed form Case Method solutions, based on the one-dimensional linear wave equation, the PDA calculates the results described in the analytical solutions section below.

HPA

The ram velocity may be directly obtained using radar technology in the Hammer Performance Analyzer™. For this unit to be applicable, the ram must be visible. The impact velocity results can be automatically processed with a PC or recorded on a strip chart.

Saximeter™

For open end diesel hammers, the time between two impacts indicates the magnitude of the ram fall height or stroke. This information is not only measured and calculated by the PDA but also by the convenient, hand-held Saximeter.

PIT

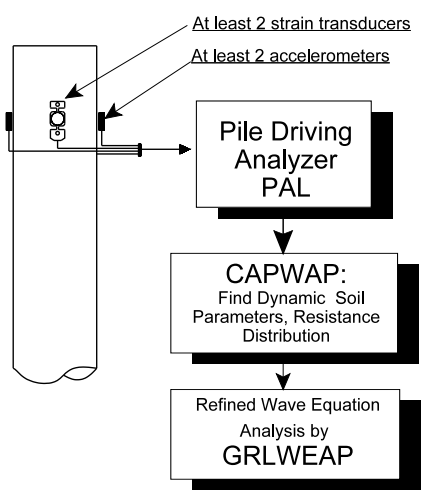
The Pile Integrity Tester™ (PIT) can be used to evaluate defects in concrete piles or shafts which may have occurred during driving or casting. Also timber piles of limited length can be tested in that manner. This so-called "Low Strain Method" or “Pulse-Echo Method” of integrity testing requires only the measurement of acceleration at the pile top. The stress wave producing impact is then generated by a small hand-held hammer and the records interpreted in the time domain. PIT also supports the so-called “Transient Response Method” which requires the additional measurement of the hammer force and an analysis in the frequency domain. This method may also be used to evaluate the unknown length of deep foundations under existing structures.

ANALYTICAL SOLUTIONS
BEARING CAPACITY

Wave Equation

GRL has written the GRLWEAP™ program which calculates a relationship between bearing capacity, pile stress and blow count. This relationship is often called the "bearing graph." Once the blow count is known from pile installation logs, the bearing graph yields the bearing capacity. This approach requires no measurements and therefore can be performed during the design stage of a project, for example for the selection of hammer, cushion and pile size.

After dynamic pile monitoring and/or dynamic load testing has been performed, the "Refined Wave Equation Analysis" or RWEA (see schematic below) is often performed by inputting the PDA and CAPWAP calculated parameters. Then the bearing graph from the RWEA is the basis for a safe and sufficient driving criteria.



Case Method

The Case Method is a closed form solution based on a few simplifying assumptions such as ideal plastic soil behavior and an ideally elastic and uniform pile. Given the measured pile top force F(t) and pile top velocity v(t), the total soil resistance is

$$R(t) = \tfrac{1}{2}\{[F(t) + F(t_2)] + Z[v(t) - v(t_2)]\} \qquad (1)$$

where

- t = a point in time after impact
- t_2 = time $t + 2L/c$
- L = pile length below gages
- c = $(E/\rho)^{1/2}$ is the speed of the stress wave
- ρ = pile mass density
- Z = EA/c is the pile impedance
- E = elastic modulus of the pile (ρc^2)
- A = pile cross sectional area

The total soil resistance consists of a dynamic (R_d) and a static (R_s) component. The static component is therefore

$$R_s(t) = R(t) - R_d(t) \qquad (2)$$

The dynamic component may be computed from a soil damping factor, J, and a pile toe velocity, $v_t(t)$ which is conveniently calculated for the pile toe. Using wave considerations, this approach leads immediately to the dynamic resistance

$$R_d(t) = J[F(t) + Zv(t) - R(t)] \qquad (3)$$

and finally to the static resistance by means of Equation 2.

There are a number of ways in which Eq. 1 through 3 can be evaluated. Most commonly, t_2 is set to that time at which the static resistance becomes maximum. The result is the so-called **RMX** capacity. Damping factors for RMX typically range between 0.5 for coarse grained materials to 1.0 for clays. The **RSP** capacity (this method is most commonly referred to in the literature, yet it is not very frequently used) requires damping factors between 0.1 for sand and 1.0 for clay. Another capacity, **RA2**, determines the capacity at a time when the pile is essentially at rest and thus damping is small; RA2

therefore requires no damping parameter. In any event, the proper Case Method and its associated damping parameter is most conveniently found after a CAPWAP analysis has been performed.

The static resistance calculated by Case Method or CAPWAP is the mobilized resistance at the time of testing. Consideration therefore has to be given to soil setup or relaxation effects and whether or not a sufficient set has been achieved under the test loading that would correspond to a full activation of the ultimate soil resistance.

The PDA also calculates an estimate of shaft resistance as the difference between force and velocity times impedance at the time immediately prior to the return of the stress wave from the pile toe. This shaft resistance is not reduced by damping effects and is therefore called the total shaft resistance **SFT**. A correction for damping effects produces the static shaft resistance estimate, **SFR**.

The Case Method solution is simple enough to be evaluated "in real time," i.e. between hammer blows, using the PDA. It is therefore possible to calculate all relevant results for all hammer blows and plot these results as a function of depth or blow number. This is done in the PDAPLOT program.

CAPWAP

The CAse Pile Wave Analysis Program combines the wave equation pile and soil model with the Case Method measurements. Thus, the solution includes not only the total and static bearing capacity values but also the shaft resistance, end bearing, damping factors and soil stiffnesses. The method iteratively calculates a number of unknowns by signal matching. While it is necessary to make hammer performance assumptions for a GRLWEAP analysis, the CAPWAP program works with the pile top measurements. Furthermore, while GRLWEAP and Case Method require certain assumptions regarding the soil behavior, CAPWAP calculates these soil parameters.

STRESSES

During pile monitoring, it is important that compressive stress maxima at pile top and toe and tensile stress maxima somewhere along the pile be calculated for each hammer blow.

At the pile top (location of sensors) both the maximum compression stress, **CSX**, and the maximum stress from individual strain transducers, **CSI**, are directly obtained from the measurements. Note that CSI is greater than or equal to CSX and the difference between CSI and CSX is a measure of bending in the plane of the strain transducers. Note also that all stresses calculated for locations below the sensors are averaged over the pile cross section and therefore do not include components from either bending or eccentric soil resistance effects.

The PDA calculates the compressive stress at the pile bottom, **CSB**, assuming (a) a uniform pile and (b) that the pile toe force is the maximum value of the total resistance R(t) minus the total shaft resistance, SFT. Again, for this stress estimation uniform resistance force are assumed (e.g. not a sloping rock.)

For concrete piles, the maximum tension stress, **TSX**, is also of great importance. It occurs at some point below the pile top. The maximum tension stress can be computed from the pile top measurements by finding the maximum tension wave (either traveling upward, W_U, or downward, W_d) and reducing it by the minimum compressive wave traveling in opposite direction.

$$W_u = ½[F(t) - Zv(t)] \quad (4)$$

$$W_d = ½[F(t) + Zv(t)] \quad (5)$$

CAPWAP also calculates tensile and compressive stresses along the pile and, in general, more accurately than the PDA. In fact, for non-uniform piles or piles with joints, cracks or other discontinuities, the closed form solutions from the PDA may be in error.

PILE INTEGRITY

High Strain Tests (PDA)

Stress waves in a pile are reflected wherever the pile impedance, $Z = EA/c = \rho cA = A \sqrt{(E \rho)}$, changes. Therefore, the pile impedance is a measure of the quality of the pile material (E, ρ, c) and the size of its cross section (A). The reflected waves arrive at the pile top at a time which is greater the farther away from the pile top the reflection occurs. The

magnitude of the change of the upward traveling wave (calculated from the measured force and velocity, Eq. 4) indicates the extent of the cross sectional change. Thus, with β_i (**BTA**) being a relative integrity factor which is unity for no impedance change and zero for the pile end, the following is calculated by the PDA.

$$\beta_i = (1 - \alpha_i)/(1 + \alpha_i) \tag{6}$$

with

$$\alpha_i = ½(W_{UR} - W_{UD})/(W_{Di} - W_{UR}) \tag{7}$$

where

W_{UR} is the upward traveling wave at the onset of the reflected wave. It is caused by resistance.

W_{UD} is the upwards traveling wave due to the damage reflection.

W_{Di} is the maximum downward traveling wave due to impact.

It can be shown that this formulation is quite accurate as long as individual reflections from different pile impedance changes have no overlapping effects on the stress wave reflections.

Without rigorous derivation, it has been proposed to consider as slight damage when β is above 0.8 and a serious damage when β is less than 0.6.

Low Strain Tests (PIT)

The pile top is struck with a held hand hammer and the resulting pile top velocity is measured, displayed and interpreted for signs of wave reflections. In general, a comparison of the reflected acceleration leads to a relative measure of extent of damage, again the location of the problem is indicated by the arrival time of the reflection. PIT records can also be interpreted by the β-Method. However, low strain tests do not activate much resistance which simplifies Eq. 7 since W_{UR} is then equal to zero.

For drilled shafts and PIT records that clearly show a toe reflection, an approximate shaft profile can be calculated from low strain records using the PITSTOP program's PROFILE routine.

HAMMER PERFORMANCE

The PDA calculates the energy transferred to the pile top from:

$$E(t) = \int_0^t F(t)v(t)\,dt \tag{8a}$$

The maximum of the E(t) curve is the most important information for an overall evaluation of the performance of a hammer and driving system. This **EMX** value allows for a classification of the hammer's performance when presented as the rated transfer efficiency, also called energy transfer ratio (**ETR**) or global efficiency

$$e_T = EMX/E_R \tag{8b}$$

where

E_R is the manufacturer's rated energy value.

Both Saximeter and PDA calculate the stroke (**STK**) of an open end diesel hammer using

$$STK = (g/8)\,T_B^2 - h_L \tag{9}$$

where

g is the earth's gravitational acceleration,
T_B is the time between two hammer blows,
h_L is a stroke loss value due to gas compression and time losses during impact (usually 0.3 ft or 0.1 m).

DETERMINATION OF WAVE SPEED

An important facet of dynamic pile testing is an assessment of pile material properties. Since in general force is determined from strain by multiplication with elastic modulus, E, and cross sectional area, A, the dynamic elastic modulus has to be determined for pile materials other than steel. In general, the records measured by the PDA clearly indicate a pile toe reflection as long as pile penetration per blow is greater than 1 mm or .04 inches. The time between the onset of the force and velocity records at impact and the onset of the reflection from the toe (usually apparent by a local maximum of the wave up curve) is the so-called wave travel time, T. Dividing 2L (L is here the length of the pile below sensors) by T leads to the stress wave speed in the pile:

$$c = 2L/T \tag{10}$$

The elastic modulus of the pile material is related to the wave speed according to the linear elastic wave equation theory by

$$E = c^2\rho \tag{11}$$

Since the mass density of the pile material, ρ, is usually well known (an exception is timber for which samples should be weighed), the elastic modulus is easily found from the wave speed. Note, however, that this is a dynamic modulus which is generally higher than the static one and that the wave speed depends to some degree on the strain level of the stress wave. For example, experience shows that the wave speed from PIT is roughly 5% higher than the wave speed observed during a high strain test.

Other Notes:

- If the pile material is nonuniform then the wave speed c, according to Eq. 10, is an average wave speed and does not necessarily reflect the pile material properties of the location where the strain sensors are attached to the pile top. For example, pile driving often causes fine tension cracks some distance below the top of concrete piles. Then the average c is slower than that at the pile top. It is therefore recommended to determine E in the beginning of pile driving and not adjust it when the average c changes.

- If the pile has such a high resistance that there is no clear indication of a toe reflection then the wave speed of the pile material must be determined either by assumption or by taking a sample of the concrete and measuring its wave speed in a simple free column test. Another possibility is to use the proportionality relationship, discussed under "DATA QUALITY CHECKS" to find c as the ratio between the measured velocity and measured strain.

DATA QUALITY CHECKS

Quality data is the first and foremost requirement for accurate dynamic testing results. It is therefore important that the measurement engineer performing PDA or PIT tests has the experience necessary to recognize measurement problems and take appropriate corrective action should problems develop. Fortunately, dynamic pile testing allows for certain data quality checks because two independent measurements are taken that have to conform to certain relationships.

Proportionality

As long as there is only a wave traveling in one direction, as is the case during impact when only a downward traveling wave exists in the pile, force and velocity measured at the pile top are proportional

$$F = v\,Z = v\,(EA/c) \tag{12a}$$

This relationship can also be expressed in terms of stress

$$\sigma = v\,(E/c) \tag{12b}$$

or strain

$$\epsilon = v / c \tag{12c}$$

This means that the early portion of strain times wave speed must be equal to the velocity unless the proportionality is affected by high friction near the pile top or by a pile cross sectional change not far below the sensors. Checking the proportionality is an excellent means of assuring meaningful measurements.

Measurements are always taken at opposite sides of the pile as a means of calculating the average force and velocity in the pile. The velocity on the two sides of the pile is very similar even when high bending exists. Thus, an independent check of the velocity measurements is easy and simple.

Strain measurements may differ greatly between the two sides of the pile when bending exists. It is even possible that tension is measured on one side while very high compression exists on the other side of the pile. In extreme cases, bending might be so high that it leads to a nonlinear stress distribution. The averaging of the two strain signals does then not lead to the average pile force and proportionality will not be achieved.

When testing drilled shafts, measurements of strain may also be affected by local concrete quality variations. It is then often necessary to use four strain transducers spaced at 90 degrees around the pile for an improved strain data quality. The use of four transducers is also recommended for large pile

diameters, particularly when it is difficult to mount the sensors at least two pile widths or diameters below the pile top.

LIMITATIONS, ADDITIONAL CONSIDERATIONS

Mobilization of capacity

Estimates of pile capacity from dynamic testing indicate the **mobilized pile capacity at the time of testing**. At very high blow counts (low set per blow), dynamic test methods tend to produce lower bound capacity estimates as not all resistance (particularly at and near the toe) is fully activated.

Time dependent soil resistance effects

Static pile capacity from dynamic method calculations provide an estimate of the axial pile capacity. Increases and decreases in the pile capacity with time typically occur (soil setup/relaxation). Therefore, **restrike testing usually yields a better indication of long term pile capacity than a test at the end of pile driving**. Often a wait period of one or two days between end of driving and restrike is satisfactory for a realistic prediction of pile capacity but this waiting time depends, among other factors, on the permeability of the soil.

(A) Soil setup

Because excess positive pore pressures often develop during pile driving in fine grained soil (clays, silts or even fine sands), the capacity of a pile at the time of driving may often be less than the long term pile capacity. These pore pressures reduce the effective stress acting on the pile thereby reducing the soil resistance to pile penetration, and thus the pile capacity at the time of driving. As these pore pressures dissipate, the soil resistance acting on the pile increases as does the axial pile capacity. This phenomena is routinely called soil setup or soil freeze.

(*B) Relaxation*

Relaxation (capacity reduction with time) has been observed for piles driven into weathered shale, and may take several days to fully develop. Pile capacity estimates based upon initial driving or short term restrike tests can significantly overpredict long term pile capacity. Therefore, piles driven into shale should be tested after a minimum one week wait either statically or dynamically (with particular emphasis than on the first few blows). Relaxation has also been observed for displacement piles driven into dense saturated silts or fine sands due to a negative pore pressure effect at the pile toe. Again, restrike tests should be used, with great emphasis on early blows.

Capacity results for open pile profiles

Larger diameter open ended pipe piles (or H-piles which do not bear on rock) may behave differently under dynamic and static loading conditions. Under dynamic loads the soil inside the pile or between its flanges may slip and produce internal friction while under static loads the plug may move with the pile, thereby creating end bearing over the full pile cross section. As a result both friction and end bearing components may be different under static and dynamic conditions.

CAPWAP Analysis Results

A portion of the soil resistance calculated on an individual soil segment in a CAPWAP analysis can usually be shifted up or down the shaft one soil segment without significantly altering the match quality. Therefore, use of the CAPWAP resistance distribution for uplift, downdrag, scour, or other geotechnical considerations should be made with an understanding of these analysis limitations.

Stresses

PDA and CAPWAP calculated stresses are average values over the cross section. Additional allowance has to be made for bending or non-uniform contact stresses. To prevent damage it is therefore important to maintain good hammer-pile alignment and to protect the pile toes using appropriate devices or an increased cross sectional area.

In the United States is has become generally acceptable to limit the dynamic installation stresses of driven piles to the following levels:

- 90% of yield strength for steel piles
- 85% of the concrete compressive strength - after subtraction of the effective prestress - for concrete piles in compression

100% of effective prestress plus ½ of the concrete's tension strength for prestressed piles in tension

70% of the reinforcement strength for regularly reinforced concrete piles in tension

300% of the static design allowable stress for timber

Note that the dynamic stresses may either be directly measured at the pile top by the PDA or calculated by the PDA for other locations along the pile based on the pile top measurements.

Additional design considerations

Numerous factors have to be considered in pile foundation design. Some of these considerations include

- additional pile loading from downdrag or negative skin friction,
- lateral and uplift loading requirements
- effective stress changes (due to changes in water table, excavations, fills or other changes in overburden),
- long term settlements in general and settlement from underlying weaker layers and/or pile group effects,

These factors have not been evaluated by GRL and have not been considered in the interpretation of the dynamic testing results. The foundation designer should determine if these or any other considerations are applicable to this project and the foundation design.

Wave equation analysis results

The results calculated by the wave equation analysis program depend on a variety of hammer, pile and soil input parameters. Although attempts have been made to base the analysis on the best available information, actual field conditions may vary and therefore stresses and blow counts may differ from the predictions reported. Capacity predictions derived from wave equation analyses should use restrike information. However, because of the uncertainties associated with restrike blow counts and restrike hammer energies, correlations of such results with static test capacities with have often displayed considerable scatter.

As for PDA and CAPWAP, the theory on which GRLWEAP is based is the one-dimensional wave equation. For that reason, stress predictions by the wave equation analysis can only be averages over the pile cross section. Thus, bending stresses or stress concentrations due to non-uniform impact or uneven soil or rock resistance are not considered in these results. Stress maxima calculated by the wave equation are usually subjected to the same limits as those measured directly or calculated from measurements by the PDA.

Appendix B

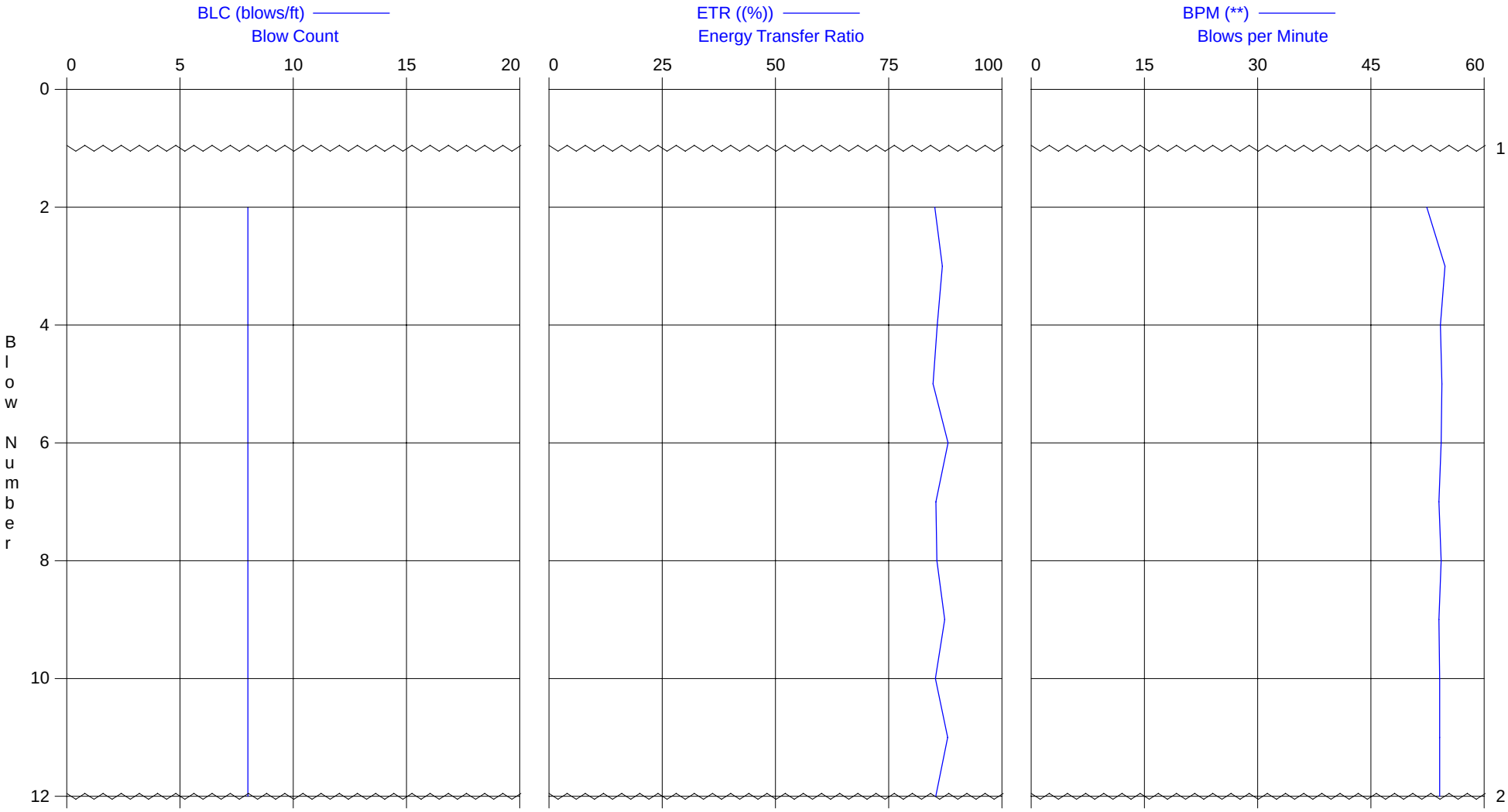
Summary of Case Method Field Results

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 3-Nov-2014

Test date: 31-Oct-2014

GEOSYNTEC, RIVERBEND - 27.5FT, SPT, 140 LB GT14-14



1 - Start of test on 10/31/2014 at 8:31:19 AM

2 - End of test on 10/31/2014 at 8:31:31 AM

GEOSYNTEC, RIVERBEND - 27.5FT, SPT, 140 LB
OP: RMDT

GT14-14
Test date: 31-Oct-2014

AR: 1.43 in^2
LE: 30.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT	RX9
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]	kips
5	28.13	8	32.5	32.5	0.297	84.8	54.4	46	12.9	0.8	12
6	28.25	8	33.2	33.2	0.308	88.1	54.3	47	14.2	0.8	11
7	28.38	8	33.2	33.2	0.299	85.4	54.0	48	13.1	0.8	12
8	28.50	8	33.2	33.2	0.300	85.6	54.3	47	13.0	0.8	13
9	28.63	8	33.7	33.7	0.306	87.4	54.0	48	13.6	0.8	11
10	28.75	8	33.6	33.6	0.299	85.3	54.1	48	13.3	0.8	13
11	28.88	8	33.4	33.4	0.308	88.0	54.1	48	14.2	0.8	11
12	29.00	8	33.1	33.1	0.299	85.4	54.1	47	13.0	0.8	11
		Average	33.2	33.2	0.302	86.3	54.2	48	13.4	0.8	12
		Std. Dev.	0.4	0.4	0.004	1.3	0.1	1	0.5	0.0	1
		Maximum	33.7	33.7	0.308	88.1	54.4	48	14.2	0.8	13

Total number of blows analyzed: 8

BL#	depth (ft)	Comments
1	27.63	Start of test on 10/31/2014 at 8:31:19 AM
12	29.00	End of test on 10/31/2014 at 8:31:31 AM

Time Summary

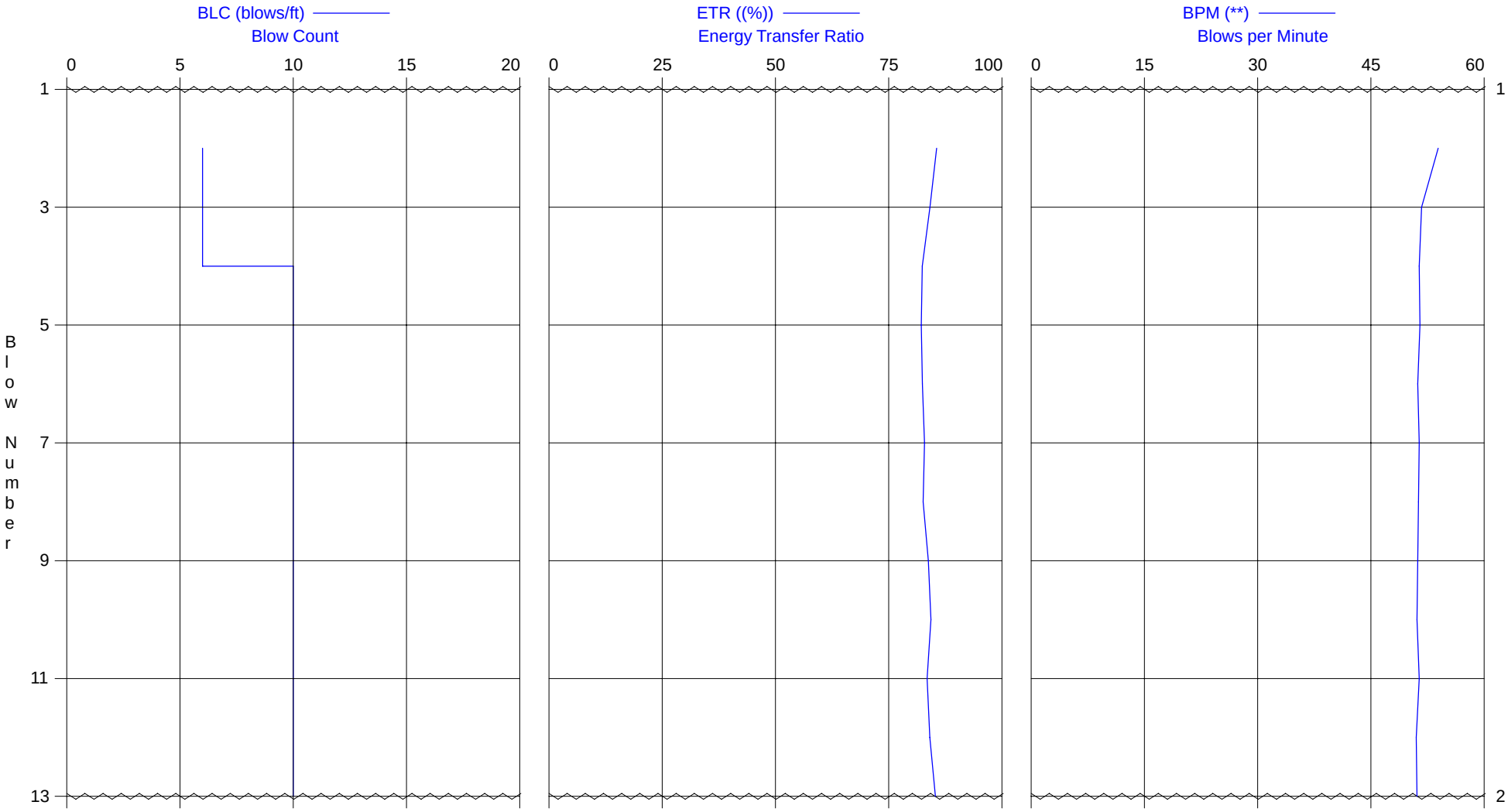
Drive 12 seconds 8:31:19 AM - 8:31:31 AM (10/31/2014) BN 1 - 12

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 3-Nov-2014

Test date: 31-Oct-2014

GEOSYNTEC, RIVERBEND - 35.0FT, SPT, 140LB GT14-14



1 - Start of test on 10/31/2014 at 9:15:24 AM

2 - End of test on 10/31/2014 at 9:15:38 AM

GEOSYNTEC, RIVERBEND - 35.0FT, SPT, 140LB
OP: RMDT

GT14-14
Test date: 31-Oct-2014

AR: 1.43 in^2
LE: 39.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT	RX9
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]	kips
4	35.60	10	33.6	32.2	0.288	82.4	51.4	46	12.3	0.6	3
5	35.70	10	33.7	32.2	0.288	82.2	51.5	46	11.7	0.6	4
6	35.80	10	34.3	33.0	0.289	82.5	51.2	47	12.3	0.7	6
7	35.90	10	35.0	33.3	0.290	82.9	51.4	48	12.5	0.7	6
8	36.00	10	35.1	33.4	0.289	82.6	51.3	48	12.3	0.7	6
9	36.10	10	34.6	33.1	0.293	83.7	51.2	47	12.3	0.6	6
10	36.20	10	35.0	33.3	0.295	84.3	51.1	48	12.3	0.7	6
11	36.30	10	35.5	33.8	0.292	83.5	51.4	48	12.0	0.7	4
12	36.40	10	33.3	32.6	0.294	84.1	51.0	47	11.8	0.7	3
13	36.50	10	34.7	33.1	0.299	85.3	51.1	47	12.6	0.7	4
		Average	34.5	33.0	0.292	83.3	51.3	47	12.2	0.7	5
		Std. Dev.	0.7	0.5	0.003	1.0	0.2	1	0.3	0.0	1
		Maximum	35.5	33.8	0.299	85.3	51.5	48	12.6	0.7	6

Total number of blows analyzed: 10

BL#	depth (ft)	Comments
1	35.17	Start of test on 10/31/2014 at 9:15:24 AM
13	36.50	End of test on 10/31/2014 at 9:15:38 AM

Time Summary

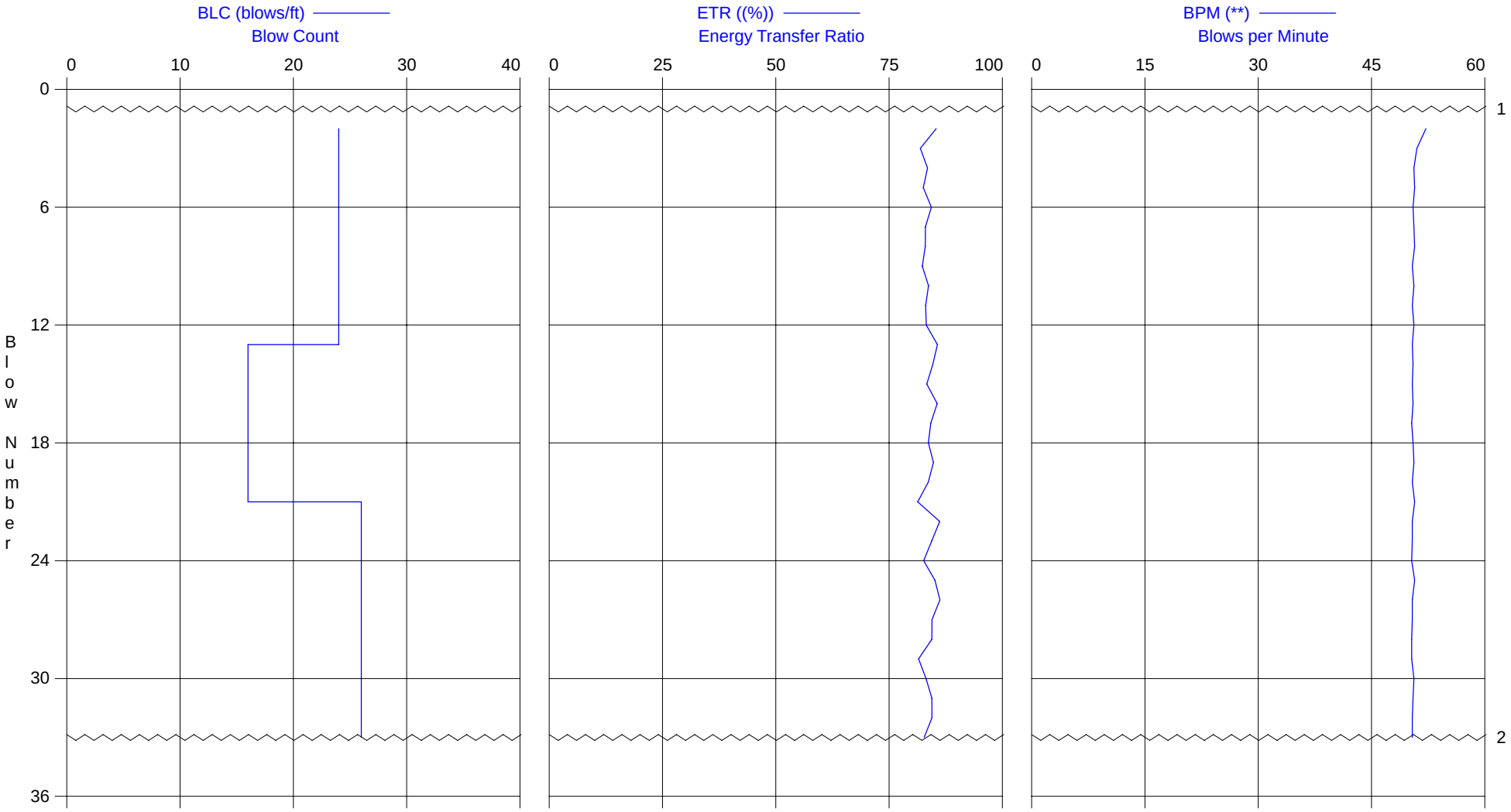
Drive 14 seconds 9:15:24 AM - 9:15:38 AM (10/31/2014) BN 1 - 13

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 3-Nov-2014

Test date: 31-Oct-2014

GEOSYNTEC, RIVERBEND - 45.0 FT, SPT, 140LB GT14-14



1 - Start of test on 10/31/2014 at 10:10:35 AM

2 - End of test on 10/31/2014 at 10:11:13 AM

GEOSYNTEC, RIVERBEND - 45.0 FT, SPT, 140LB
OP: RMDT

GT14-14
Test date: 31-Oct-2014

AR: 1.43 in^2
LE: 50.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT	RX9
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]	kips
13	45.56	16	33.7	32.7	0.300	85.7	50.4	47	12.6	0.7	4
14	45.63	16	33.4	32.3	0.296	84.7	50.5	46	12.6	0.7	4
15	45.69	16	33.6	32.6	0.292	83.3	50.4	47	12.4	0.7	4
16	45.75	16	33.7	32.6	0.300	85.6	50.5	47	12.8	0.6	5
17	45.81	16	33.5	32.6	0.295	84.2	50.3	47	12.7	0.7	5
18	45.88	16	33.2	32.4	0.293	83.7	50.5	46	12.8	0.7	6
19	45.94	16	32.8	32.0	0.297	84.8	50.6	46	12.7	0.7	5
20	46.00	16	33.4	32.4	0.293	83.6	50.4	46	12.8	0.7	5
21	46.04	26	32.5	31.4	0.285	81.3	50.7	45	11.2	0.7	6
22	46.08	26	34.1	32.9	0.302	86.2	50.4	47	12.7	0.7	6
23	46.12	26	33.6	32.7	0.295	84.4	50.4	47	12.6	0.6	9
24	46.15	26	33.2	31.9	0.289	82.6	50.3	46	12.2	0.8	6
25	46.19	26	33.8	32.5	0.298	85.1	50.7	46	12.3	0.8	6
26	46.23	26	34.2	33.2	0.302	86.2	50.4	47	12.7	0.6	5
27	46.27	26	33.4	32.6	0.296	84.5	50.4	47	12.0	0.7	6
28	46.31	26	32.4	31.6	0.296	84.4	50.3	45	11.6	0.7	6
29	46.35	26	32.2	31.2	0.285	81.5	50.3	45	11.2	0.7	7
30	46.38	26	32.6	31.5	0.291	83.2	50.6	45	11.4	0.6	7
31	46.42	26	33.1	31.9	0.295	84.4	50.5	46	11.9	0.6	7
32	46.46	26	32.2	31.4	0.296	84.5	50.4	45	11.1	0.7	7
33	46.50	26	32.5	31.7	0.290	82.7	50.4	45	11.6	0.7	8
		Average	33.2	32.2	0.295	84.1	50.4	46	12.2	0.7	6
		Std. Dev.	0.6	0.5	0.005	1.3	0.1	1	0.6	0.1	1
		Maximum	34.2	33.2	0.302	86.2	50.7	47	12.8	0.8	9

Total number of blows analyzed: 21

BL#	depth (ft)	Comments
1	45.04	Start of test on 10/31/2014 at 10:10:35 AM
33	46.50	End of test on 10/31/2014 at 10:11:13 AM

Time Summary

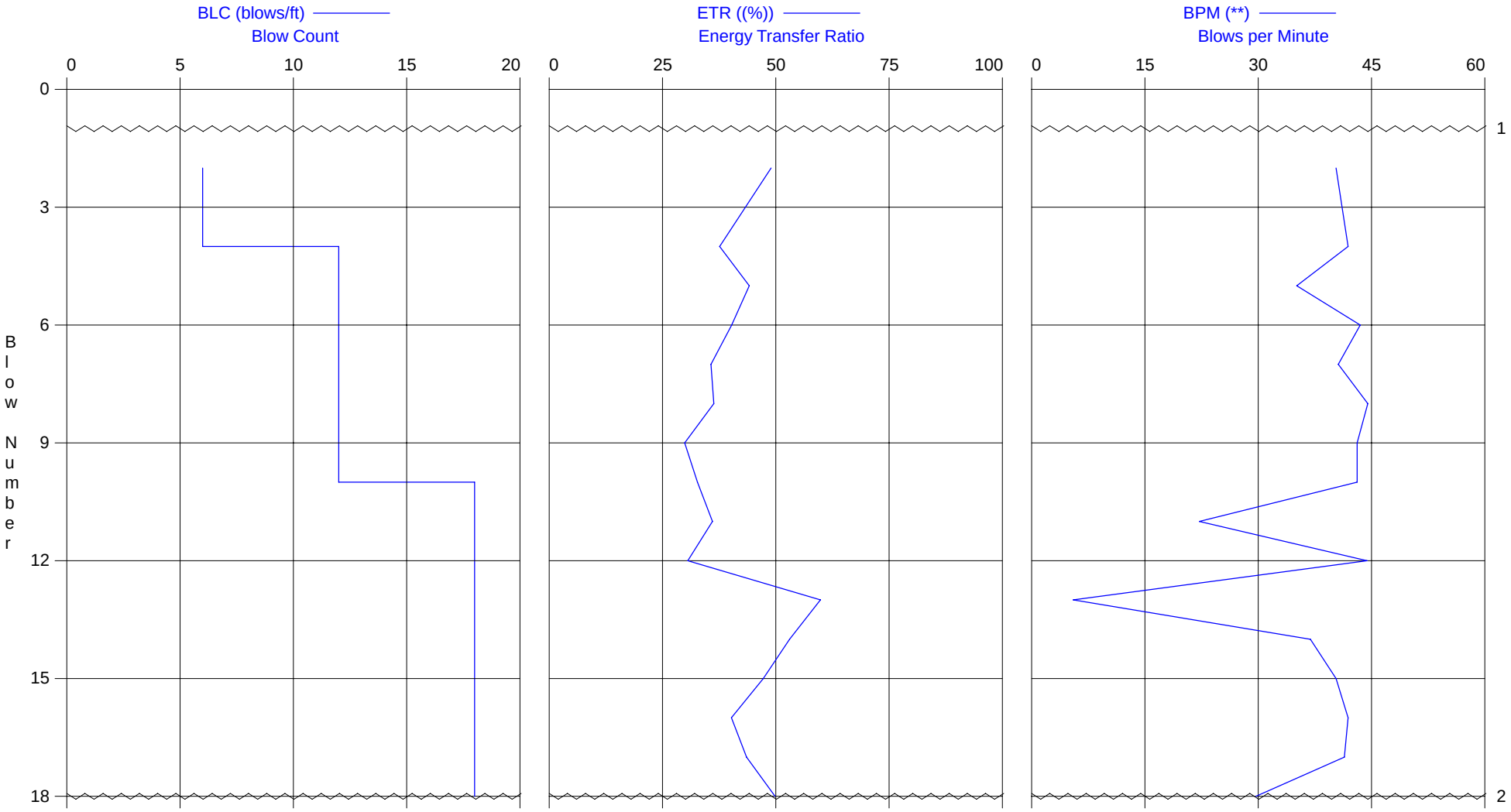
Drive	38 seconds	10:10:35 AM - 10:11:13 AM (10/31/2014) BN 1 - 33

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 3-Nov-2014

Test date: 31-Oct-2014

GEOSYNTEC, RIVERBEND - 30.0 FT, MODCAL, 300LBGT14-14



1 - Start of test on 10/31/2014 at 8:52:57 AM

2 - End of test on 10/31/2014 at 8:53:38 AM

GEOSYNTEC, RIVERBEND - 30.0 FT, MODCAL, 300LB
OP: RMDT

GT14-14
Test date: 31-Oct-2014

AR: 1.43 in^2
LE: 35.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT	RX9
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]	kips
4	30.58	12	27.6	27.6	0.282	37.6	41.9	39	9.9	1.2	11
5	30.67	12	29.7	29.7	0.331	44.1	35.1	42	10.8	1.2	11
6	30.75	12	27.9	27.9	0.302	40.3	43.5	40	10.1	0.7	6
7	30.83	12	24.9	24.9	0.268	35.7	40.6	36	9.1	0.8	6
8	30.92	12	25.5	25.5	0.272	36.3	44.5	36	9.1	0.7	6
9	31.00	12	22.8	22.8	0.224	29.9	43.1	33	8.3	0.7	6
10	31.06	18	25.2	25.2	0.245	32.7	43.1	36	8.6	1.2	7
11	31.11	18	26.4	26.4	0.270	36.0	22.2	38	9.4	0.7	9
12	31.17	18	24.3	24.3	0.229	30.6	44.4	35	8.7	0.8	7
13	31.22	18	35.5	35.5	0.449	59.8	5.5	51	12.3	1.2	12
14	31.28	18	32.9	32.9	0.398	53.0	36.9	47	11.6	1.3	9
15	31.33	18	30.3	30.3	0.354	47.2	40.3	43	10.9	0.8	9
16	31.39	18	27.9	27.9	0.301	40.2	41.9	40	10.0	0.7	7
17	31.44	18	29.4	29.4	0.327	43.5	41.4	42	10.2	0.7	7
18	31.50	18	31.3	31.3	0.374	49.8	29.7	45	11.1	0.7	12
		Average	28.1	28.1	0.308	41.1	36.9	40	10.0	0.9	8
		Std. Dev.	3.4	3.4	0.062	8.2	10.3	5	1.1	0.2	2
		Maximum	35.5	35.5	0.449	59.8	44.5	51	12.3	1.3	12

Total number of blows analyzed: 15

BL#	depth (ft)	Comments
1	30.17	Start of test on 10/31/2014 at 8:52:57 AM
18	31.50	End of test on 10/31/2014 at 8:53:38 AM

Time Summary

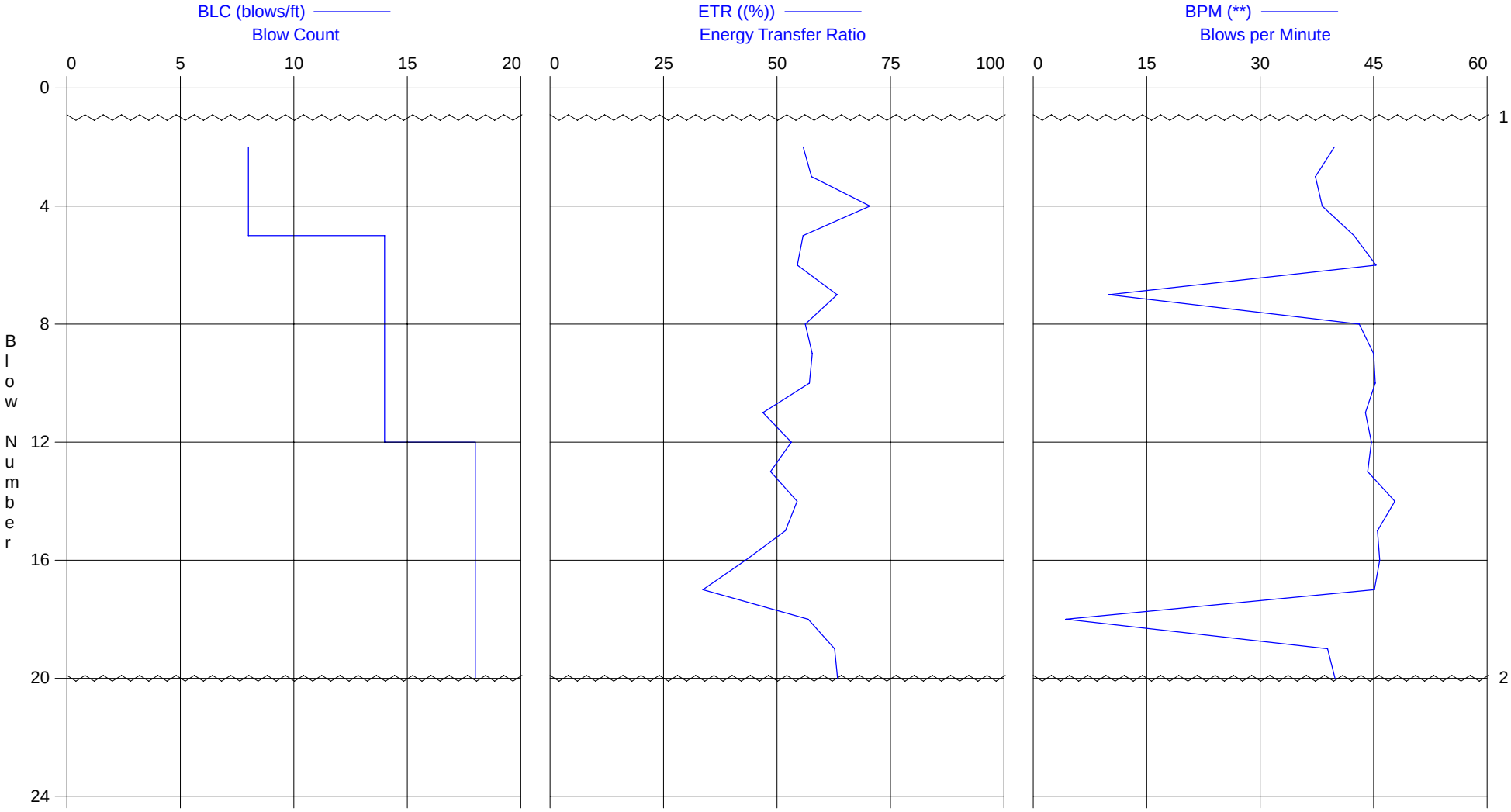
Drive 41 seconds 8:52:57 AM - 8:53:38 AM (10/31/2014) BN 1 - 18

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 3-Nov-2014

Test date: 31-Oct-2014

GEOSYNTEC, RIVERBEND - 40.0 FT, MODCAL, 300LBGT14-14



1 - Start of test on 10/31/2014 at 9:45:40 AM

2 - End of test on 10/31/2014 at 9:46:24 AM

Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 3-Nov-2014

GEOSYNTEC, RIVERBEND - 40.0 FT, MODCAL, 300LB

GT14-14

OP: RMDT

Test date: 31-Oct-2014

AR: 1.43 in^2
LE: 45.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT	RX9
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]	kips
5	40.57	14	32.1	31.1	0.418	55.8	42.4	44	12.2	0.8	16
6	40.64	14	32.1	31.8	0.409	54.5	45.3	45	11.9	0.8	17
7	40.71	14	34.3	32.9	0.474	63.2	10.0	47	12.5	0.8	18
8	40.79	14	32.1	31.4	0.422	56.2	43.1	45	11.9	0.8	15
9	40.86	14	32.8	32.0	0.433	57.8	45.0	46	12.1	1.2	16
10	40.93	14	33.0	32.8	0.429	57.2	45.2	47	12.1	0.8	17
11	41.00	14	29.0	28.4	0.352	46.9	43.9	41	10.9	1.2	14
12	41.06	18	31.1	30.7	0.399	53.2	44.7	44	11.7	0.8	16
13	41.11	18	29.5	29.3	0.364	48.6	44.2	42	11.0	0.8	16
14	41.17	18	31.5	31.0	0.408	54.4	47.8	44	11.9	0.8	16
15	41.22	18	30.0	29.9	0.389	51.9	45.5	43	11.1	1.2	15
16	41.28	18	27.6	26.7	0.323	43.1	45.8	38	10.4	1.2	14
17	41.33	18	24.1	23.4	0.253	33.7	45.1	33	9.2	0.8	11
18	41.39	18	32.3	31.4	0.427	56.9	4.3	45	11.9	0.8	14
19	41.44	18	34.1	33.8	0.470	62.7	38.9	48	12.7	0.8	16
20	41.50	18	35.3	34.0	0.475	63.3	39.9	49	13.0	0.8	17
		Average	31.3	30.7	0.403	53.7	39.4	44	11.7	0.9	16
		Std. Dev.	2.7	2.6	0.056	7.5	12.4	4	0.9	0.2	2
		Maximum	35.3	34.0	0.475	63.3	47.8	49	13.0	1.2	18

Total number of blows analyzed: 16

BL#	depth (ft)	Comments
1	40.13	Start of test on 10/31/2014 at 9:45:40 AM
20	41.50	End of test on 10/31/2014 at 9:46:24 AM

Time Summary

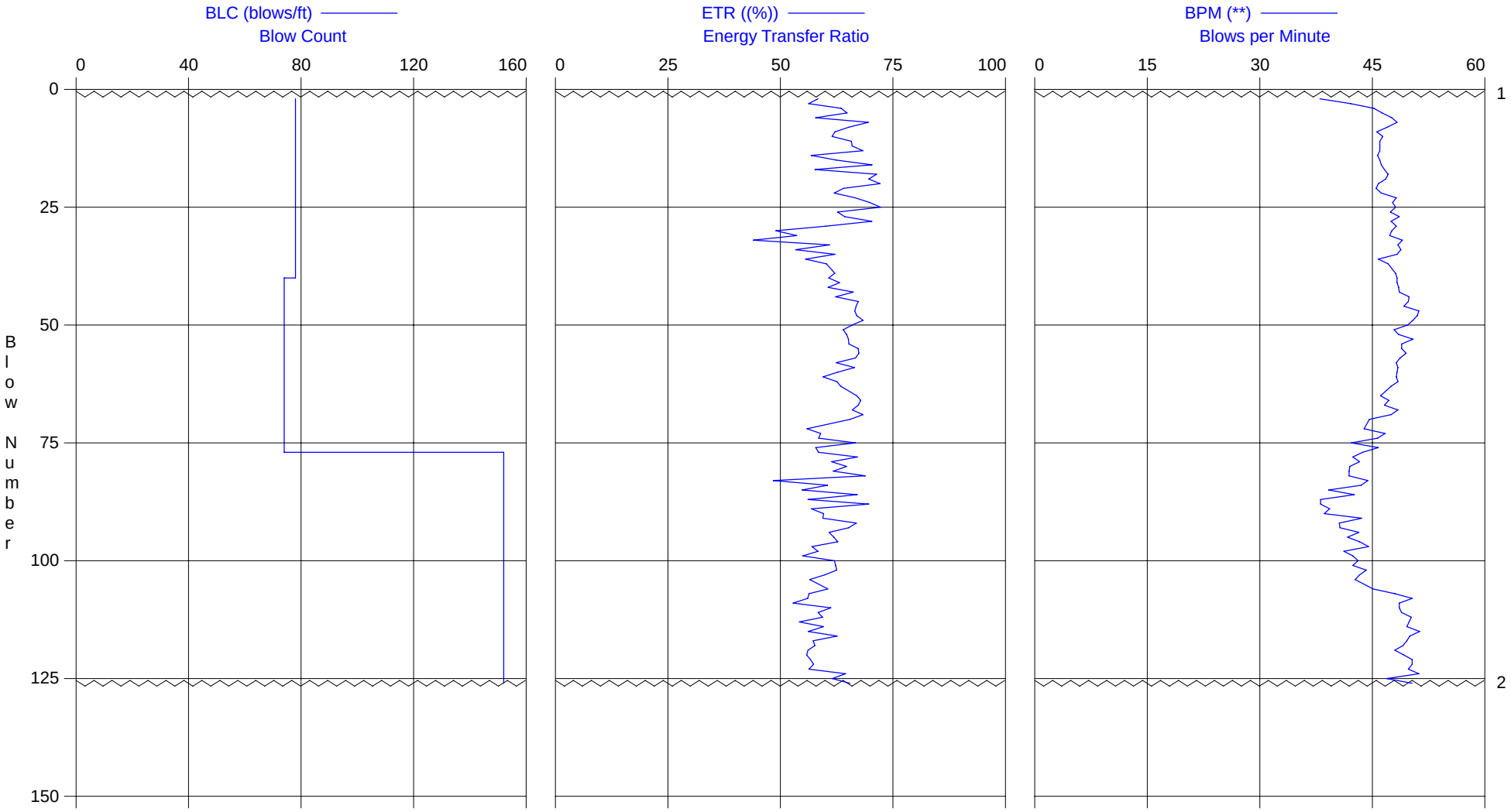
Drive 44 seconds 9:45:40 AM - 9:46:24 AM (10/31/2014) BN 1 - 20

Robert Miner Dynamic Testing, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 3-Nov-2014

Test date: 31-Oct-2014

GEOSYNTEC, RIVERBEND - 50.0 FT, MODCAL, 300LBGT14-14



1 - Start of test on 10/31/2014 at 10:37:41 AM

2 - End of test on 10/31/2014 at 10:40:55 AM

GEOSYNTEC, RIVERBEND - 50.0 FT, MODCAL, 300LB
OP: RMDT

GT14-14
Test date: 31-Oct-2014

AR: 1.43 in^2
LE: 55.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.35

CSI: Max F1 or F2 Compr. Stress
CSX: Max Measured Compr. Stress
EFV: Energy of FV
ETR: Energy Transfer Ratio
BPM: Blows per Minute

FMX: Maximum Force
VMX: Maximum Velocity
RAT: SPT Length Ratio
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT	RX9
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]	kips
40	50.51	74	34.8	33.8	0.455	60.7	48.3	48	12.7	0.8	19
41	50.53	74	35.1	34.4	0.473	63.1	48.3	49	12.8	0.8	20
42	50.54	74	34.5	33.8	0.454	60.6	48.5	48	12.5	0.9	19
43	50.55	74	36.0	34.7	0.496	66.2	48.6	50	13.1	0.8	19
44	50.57	74	35.0	34.1	0.467	62.3	49.9	49	12.8	0.8	21
45	50.58	74	37.4	35.8	0.505	67.3	49.8	51	12.9	0.9	21
46	50.59	74	35.8	35.6	0.501	66.8	49.2	51	12.9	0.8	21
47	50.61	74	36.4	35.9	0.499	66.5	51.2	51	13.1	0.8	20
48	50.62	74	36.1	35.9	0.502	67.0	51.0	51	13.2	0.8	22
49	50.64	74	36.4	35.7	0.513	68.3	50.4	51	13.0	0.8	21
50	50.65	74	35.9	35.3	0.494	65.9	49.7	51	12.7	0.8	19
51	50.66	74	34.9	34.8	0.480	63.9	47.9	50	12.5	0.8	18
52	50.68	74	35.2	35.1	0.485	64.7	48.5	50	12.6	0.9	20
53	50.69	74	35.6	35.6	0.488	65.1	50.4	51	12.8	0.8	21
54	50.70	74	34.3	34.3	0.489	65.2	48.9	49	12.5	0.8	20
55	50.72	74	35.4	35.0	0.505	67.3	48.9	50	12.9	0.8	21
56	50.73	74	36.1	36.1	0.506	67.4	49.5	52	12.8	0.9	22
57	50.74	74	35.7	35.6	0.500	66.7	48.7	51	12.8	0.8	21
58	50.76	74	34.6	34.4	0.468	62.4	48.2	49	12.4	0.8	20
59	50.77	74	35.4	35.1	0.498	66.5	48.4	50	12.9	0.8	21
60	50.78	74	35.0	34.5	0.471	62.7	48.3	49	12.6	0.8	20
61	50.80	74	34.0	33.7	0.446	59.5	48.2	48	12.3	0.8	19
62	50.81	74	34.2	33.9	0.469	62.5	48.4	49	12.8	0.8	21
63	50.82	74	34.9	33.9	0.476	63.4	47.5	48	12.7	0.8	21
65	50.85	74	35.8	35.4	0.502	67.0	46.1	51	12.8	0.8	20
66	50.86	74	35.9	35.3	0.509	67.8	47.2	51	13.0	0.8	20
67	50.88	74	36.3	35.7	0.505	67.3	46.6	51	13.1	0.8	21
68	50.89	74	36.1	36.0	0.495	66.0	48.4	51	12.9	0.8	20
69	50.91	74	36.5	36.2	0.513	68.4	47.5	52	13.3	0.9	22
70	50.92	74	34.8	34.7	0.491	65.5	44.6	50	12.9	0.8	19
72	50.95	74	32.9	32.7	0.419	55.9	43.9	47	11.8	0.8	18
73	50.96	74	34.0	33.5	0.442	58.9	46.7	48	12.0	0.8	21
74	50.97	74	33.9	33.7	0.439	58.5	45.7	48	11.9	0.8	19
75	50.99	74	35.5	35.3	0.500	66.6	42.2	50	12.6	0.8	20
76	51.00	74	32.9	32.6	0.434	57.8	45.8	47	11.5	0.8	19
77	51.01	152	33.7	33.3	0.439	58.5	43.7	48	12.0	0.8	22
78	51.01	152	36.6	36.0	0.503	67.1	42.4	52	12.3	0.8	23
79	51.02	152	34.3	34.2	0.460	61.4	43.3	49	12.5	0.8	23
80	51.03	152	34.6	34.3	0.485	64.7	42.0	49	12.1	0.9	23
81	51.03	152	34.0	33.7	0.463	61.7	41.9	48	12.4	0.8	22
82	51.04	152	33.6	33.2	0.516	68.9	41.9	47	11.8	0.9	23
83	51.05	152	29.7	29.1	0.363	48.4	44.4	42	11.0	0.8	23
84	51.05	152	31.6	30.7	0.454	60.5	43.5	44	11.4	0.9	25
85	51.06	152	31.8	31.7	0.411	54.8	39.2	45	11.5	0.8	24
86	51.07	152	32.4	32.2	0.503	67.1	42.6	46	12.4	0.9	25
87	51.07	152	32.0	31.8	0.421	56.1	38.1	45	11.5	0.8	25
88	51.08	152	36.2	35.6	0.522	69.6	38.1	51	13.2	0.8	26
89	51.09	152	31.8	31.6	0.427	56.9	39.3	45	11.7	0.8	25
90	51.09	152	32.4	32.3	0.447	59.6	38.6	46	11.9	0.8	27
91	51.10	152	33.1	32.9	0.445	59.4	43.6	47	12.1	0.8	28
93	51.11	152	34.3	34.2	0.489	65.2	40.7	49	12.6	0.8	26
95	51.13	152	33.9	33.8	0.464	61.8	41.7	48	12.7	0.8	26
97	51.14	152	32.9	32.8	0.428	57.0	44.5	47	11.9	0.8	26
99	51.15	152	31.7	31.6	0.412	55.0	42.4	45	11.6	0.8	28
101	51.17	152	34.2	34.0	0.467	62.3	42.4	49	12.2	0.8	28
103	51.18	152	33.3	32.9	0.449	59.8	43.3	47	12.3	0.8	27
106	51.20	152	29.0	28.5	0.454	60.6	45.1	41	11.0	0.9	27
108	51.21	152	29.5	29.5	0.420	56.0	50.3	42	11.1	0.8	26
110	51.22	152	29.6	29.4	0.459	61.2	48.6	42	11.7	0.9	26
112	51.24	152	29.3	28.9	0.445	59.4	50.2	41	11.4	0.8	27
114	51.25	152	30.0	29.5	0.447	59.6	49.6	42	11.3	0.9	27
116	51.26	152	30.5	30.3	0.469	62.6	50.0	43	11.5	0.8	27
118	51.28	152	30.8	30.6	0.432	57.6	49.1	44	10.1	0.8	26
120	51.29	152	32.1	31.7	0.419	55.8	49.2	45	11.9	0.8	26
122	51.30	152	32.2	31.7	0.430	57.4	50.3	45	11.3	0.8	26

GEOSYNTEC, RIVERBEND - 50.0 FT, MODCAL, 300LB
OP: RMDT

GT14-14
Test date: 31-Oct-2014

BL#	depth	BLC	CSI	CSX	EFV	ETR	BPM	FMX	VMX	RAT	RX9
	ft	bl/ft	ksi	ksi	k-ft	(%)	**	kips	f/s	[]	kips
124	51.32	152	33.9	33.7	0.484	64.5	51.2	48	12.3	0.8	29
126	51.33	152	34.2	33.9	0.491	65.4	50.3	48	12.2	0.8	27
		Average	33.6	33.3	0.463	61.7	46.3	48	12.2	0.8	23
		Std. Dev.	2.0	2.0	0.034	4.5	3.6	3	0.6	0.0	3
		Maximum	37.4	36.2	0.522	69.6	51.3	52	13.3	0.9	29

Total number of blows analyzed: 84

BL#	depth (ft)	Comments
1	50.01	Start of test on 10/31/2014 at 10:37:41 AM
126	51.33	End of test on 10/31/2014 at 10:40:55 AM

Time Summary

Drive	3 minutes 14 seconds	10:37:41 AM - 10:40:55 AM (10/31/2014)	BN 1 - 126

APPENDIX K

MASW Surveys

Zonge International
8366 SW Nimbus Ave
Beaverton, OR 97008
503-992-6723 (ph)
503-746-7094 (fx)

September 21, 2012

Hari Sharma
Geosyntec Consultants
1111 Broadway, 6th Floor
Oakland, California 94607

Zonge Project No. 12173

Subject: Final Geophysical Investigation Report – Riverbend Landfill, McMinnville, Oregon

Mr. Sharma:

A geophysical survey was at Waste Management's Riverbend landfill in McMinnville, Oregon in August of 2012. The purpose of this investigation was to provide shear wave velocity data along two-dimensional profiles for aid in engineering design and site assessment. The geophysical method used during this investigation consisted of the multichannel analysis of surface wave (MASW) technique. The MASW measurements were used to obtain the shear (S-wave) velocities. MASW data were collected along two linear alignments. Locations of the test locations are shown in the attached Figure 1.

This report provides an overview of the geophysical methodology, summarizes data acquisition parameters and field methods for the investigation, and also includes brief sections on data processing, and results/interpretations.

MASW Overview

The surface wave technique used during this investigation consisted of the linear multi-channel analysis of surface waves (MASW) methods. The MASW method utilizes a small portable seismic source (such as a sledgehammer) located at a known fixed distance from the receiver array, similar to the seismic refraction technique. This method is a standard methodology for determining shear wave velocity (V_S) profiles (Louie, 2001; Park et al., 1999a and 1999b). Typically, passive surface wave techniques, which typically image greater depths, are used to supplement the MASW data, but passive methods require some source of random surface acoustic noise, such as vehicular traffic or tidal energy. Surface wave techniques are non-invasive and non-destructive, with all testing performed on the ground surface and data are representative of the elastic strain range.

The basis of surface wave methods is the dispersive characteristic of Rayleigh waves when propagating in a layered medium. The phase velocity, V_R, depends primarily on the material properties (V_S, mass density, and Poisson's ratio or compression wave velocity). Waves of different wavelengths, λ, (or frequencies, f) sample different depths. As a result of the variance in the shear stiffness of the layers, waves with different wavelengths travel at different phase velocities; hence, dispersion. A surface wave dispersion curve, or dispersion curve for short, is the variation of V_R with λ or f. MASW testing consists

of collecting multi-channel seismic data in the field and applying a wavefield transform to obtain the dispersion curve and data modeling. Ground motions are recorded by multiple geophones aligned in a predetermined array and connected to a seismograph.

MASW equipment used during this investigation consisted of a 48-channel seismograph system, 4.5 Hz vertical geophones, seismic cable with 10-foot takeouts, a truck-mounted accelerated weight drop, 16-lb sledge hammer and aluminum strike plate. Each MASW line consisted of 48 geophones spaced 7 feet apart for a total line length of 329 feet. All geophone and shot point locations were measured using a tape measure. Relative elevations of each geophone location were not required along Line 1 based on minimal local relief; elevation data for Line 2 were collected using an automatic level and survey rod.

The accelerated weight drop was used to generate surface wave energy along Line 1, as the entirety of the line was accessible by vehicle. Line 2 was not accessible by vehicle and the 16-lb sledgehammer source was used. This yielded weaker energy and higher frequency data, resulting in a diminished depth of investigation.

The two dimensional (2D) MASW technique consists of generating multiple 1D MASW soundings and combining them into a 2D model of seismic velocity versus depth and distance. The sledgehammer was used as the seismic source at each shot location. Each seismic record consisted of multiple "hits" to improve data quality. The first shot per profile was located at a fixed distance beyond the end of the array, and subsequent shots were "rolled" along the profile in 14 foot intervals (or less, as needed).

Data Reduction and Summary

An iterative forward modeling process was used to generate S-wave velocity models for each sounding. During this process an initial velocity model was generated based on general characteristics of the dispersion curve. The theoretical dispersion curve was then generated using the modeling algorithm (Rayleigh wave dispersion module) and compared to the field dispersion curve. Adjustments are then made to the thickness and velocities of each layer and the process repeated until an acceptable fit to the field data is obtained. The 1-D soundings were then combined and modeled in two dimensions for a cross-sectional model of seismic velocity versus depth.

MASW data were processed using the Surfseis v3 software produced by the Kansas Geological survey. Rayleigh (surface) waves were separated from the body (compressional P-wave and shear S-wave) wave via a waveform transform. Picking a dispersion curve in frequency domain yields a Rayleigh wave velocity curve.

The theoretical model used to interpret the dispersion data is based on an assumption that the survey medium is laterally homogeneous beneath the section of the survey array used for each shot location, and consists of horizontally-layered homogeneous materials. While these experimental assumptions are not expected to be true at any given field site, the results of surface wave testing provide a good "global" estimate of the material properties along the array. The results may be more representative of the site than a borehole "point" estimate (Martin, et al., 2005).

Results

The locations of MASW Lines 1 and 2 are shown on Figure 1. This orientation of Line 1 was South to North along the entrance road; Line 2's orientation was West to East. The western half of Line 2 was conducted in a wooded area. There near surface velocity decreases from east to west along the profile. In addition, there is a low velocity zone at about 18 meters below the surface.

Quality of the seismic data ranged from fair-good. Traffic noise from the operating landfill degraded

signal quality, as did the limited access for the heavier truck-mounted accelerated weight drop. Our survey methodology and receiver array was designed to image depths of 100 feet below the ground surface (BGS). However, noise from the operating landfill, proximity to the haul trucks, and other noise interferences limited the depth of reliable data to a depth of approximately 80 feet. Depths were more limited along Line 2 where the sledgehammer source was used.

Overall S-wave velocities ranged from 500-2200 feet per second. The boring information provided by Geosyntec was used to calibrate Vs models as ground truth. Limited boring logs existed along the seismic lines and bedrock was only identified in a single coincident boring (GT12-05A) where siltstone is identified at the termination of the boring (70 feet BGS). This corresponds to a steep velocity gradient observed in the 2D MASW model where shear-wave velocity is modeled at approximately 1500 feet per second (IBC Classification very dense soil / soft rock). This velocity contour along MASW Lines 1 and 2 is observed at a depth of 65-80 feet BGS. Geophysically, this seismic velocity is not commonly associated with competent rock. The provided well log for EW-1 (location shown in Figure 1) indicates deeply weathered, fractured basalt. Well logs for other borings in the area (MW-8B, TB-21, and MW-17B) indicate the presence of siltstone overlying basalt.

MASW models for both lines indicate a velocity gradient along the approximate 1000 feet per second contour. This correlates well with the limited borehole information where stiffer materials are observed at a depth of approximately 35 feet BGS.

If you have any questions regarding the seismic field procedures, analysis techniques, or the geophysical results and interpretations presented herein, please do not hesitate to contact us. Data quality ranged from good to excellent; therefore we have high confidence in the results presented herein. We appreciate working with you and look forward to providing you with geophysical services in the future.

Respectfully submitted by

JB Shawver

JB Shawver
Zonge International, Inc.

* This geophysical investigation was conducted under Zonge International protocols and procedures using industry standard methods and equipment. Highly professional In-house quality control standards were observed during each phase of this project, from field activities through data processing and reporting.

REFERENCES

Louie, J.N., 2001, "Faster, Better: Shear-Wave Velocity to 100 Meters Depth from Refraction Microtremor Arrays", Bulletin of the Seismological Society of America, vol. 91, no. 2, p. 347-364.

Martin, A.J., Shawver, J.B. and Diehl, J.D., 2005, "Combined Use of Active and Passive Surface Waves for Cost Effective UBC/IBC Site Classifications", *Proceedings of the 2005 Annual Meeting on the Association of Environmental and Engineering Geologists.*

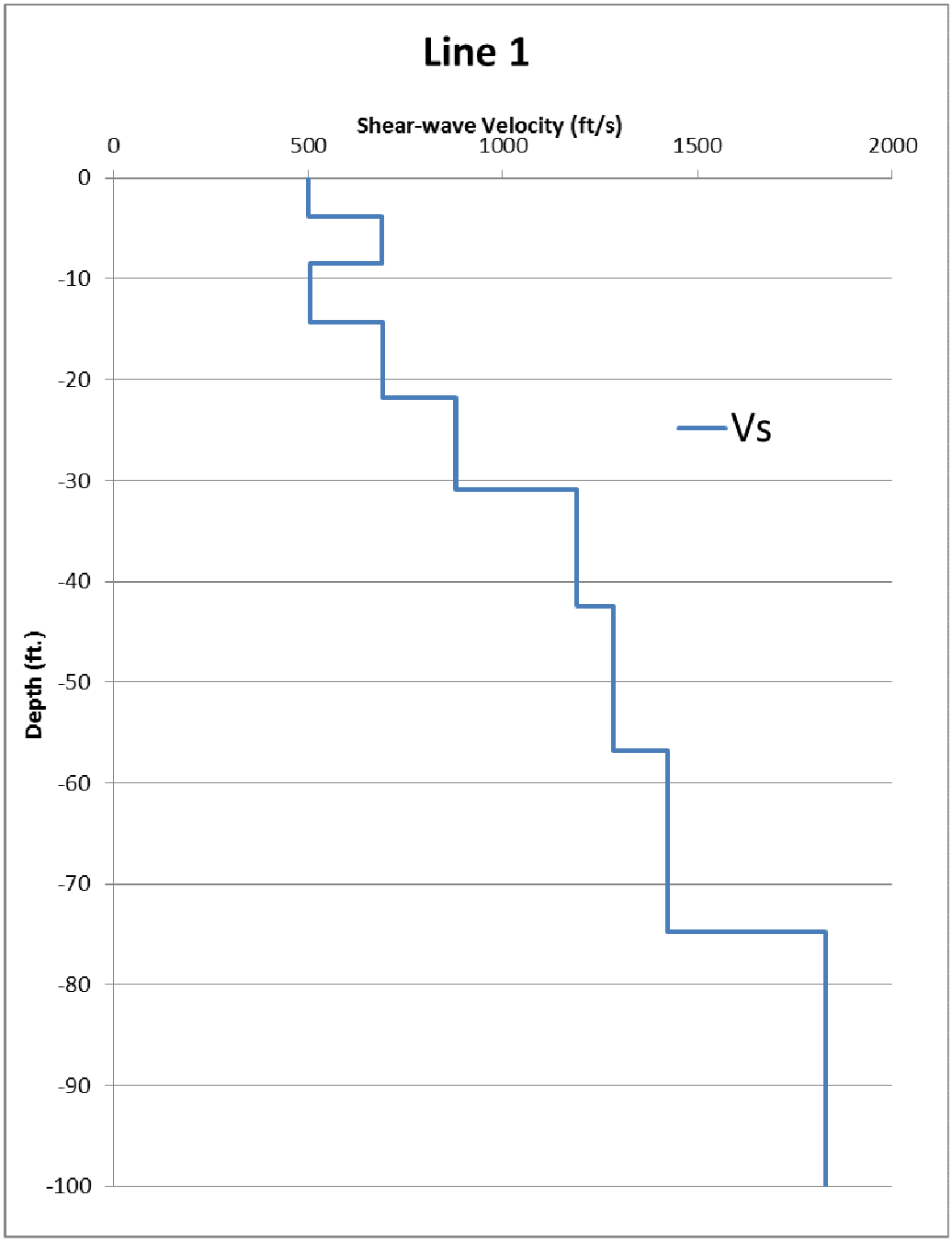
Park, C.B., Miller, R.D. and Xia, J., 1999a, "Multimodal analysis of high frequency surface waves", *Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems '99*, 115-121.

Park, C.B., Miller, R.D. and Xia, J., 1999b, "Multichannel analysis of surface waves", Geophysics, Vol 64, No. 3, 800-808.

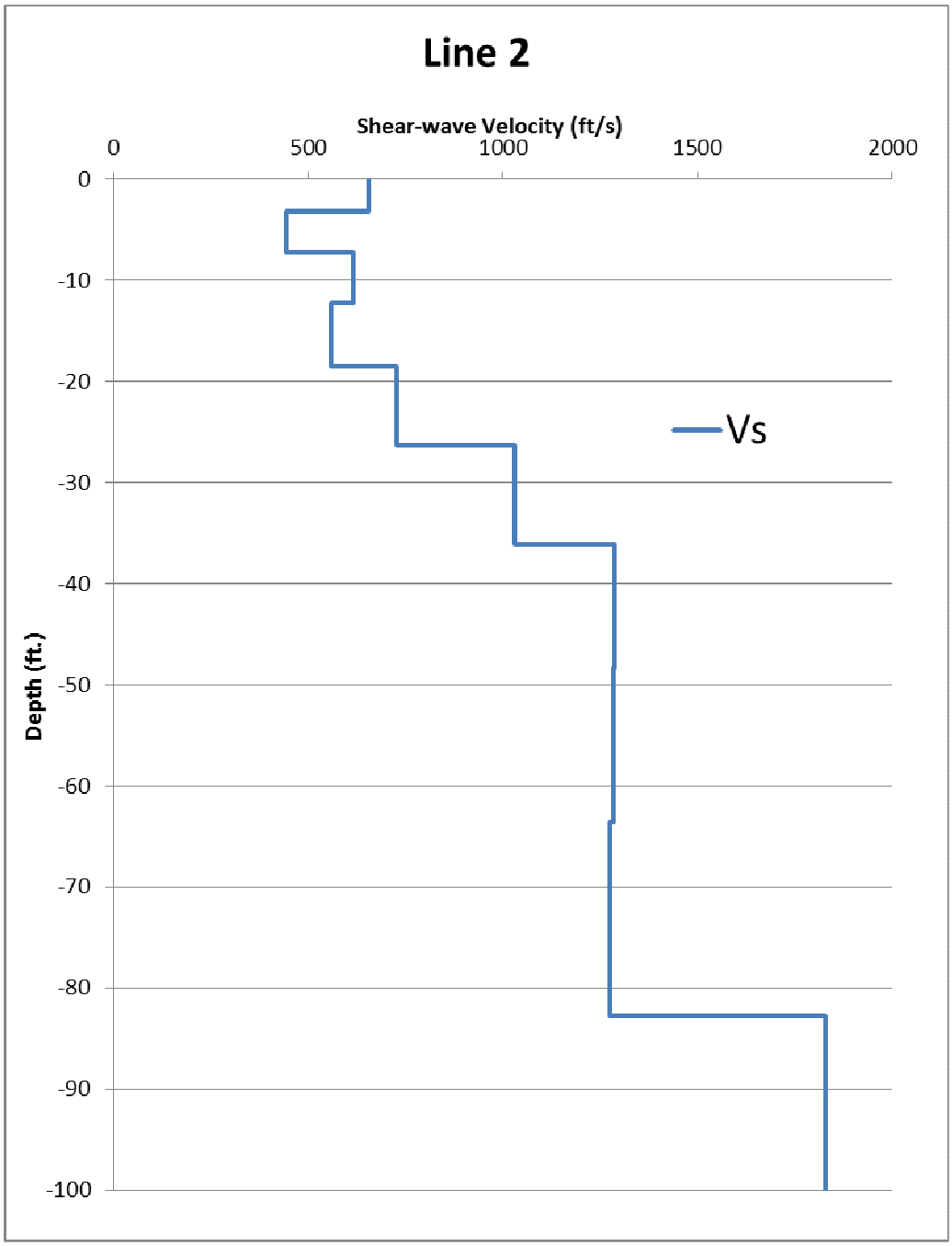
APPENDIX A

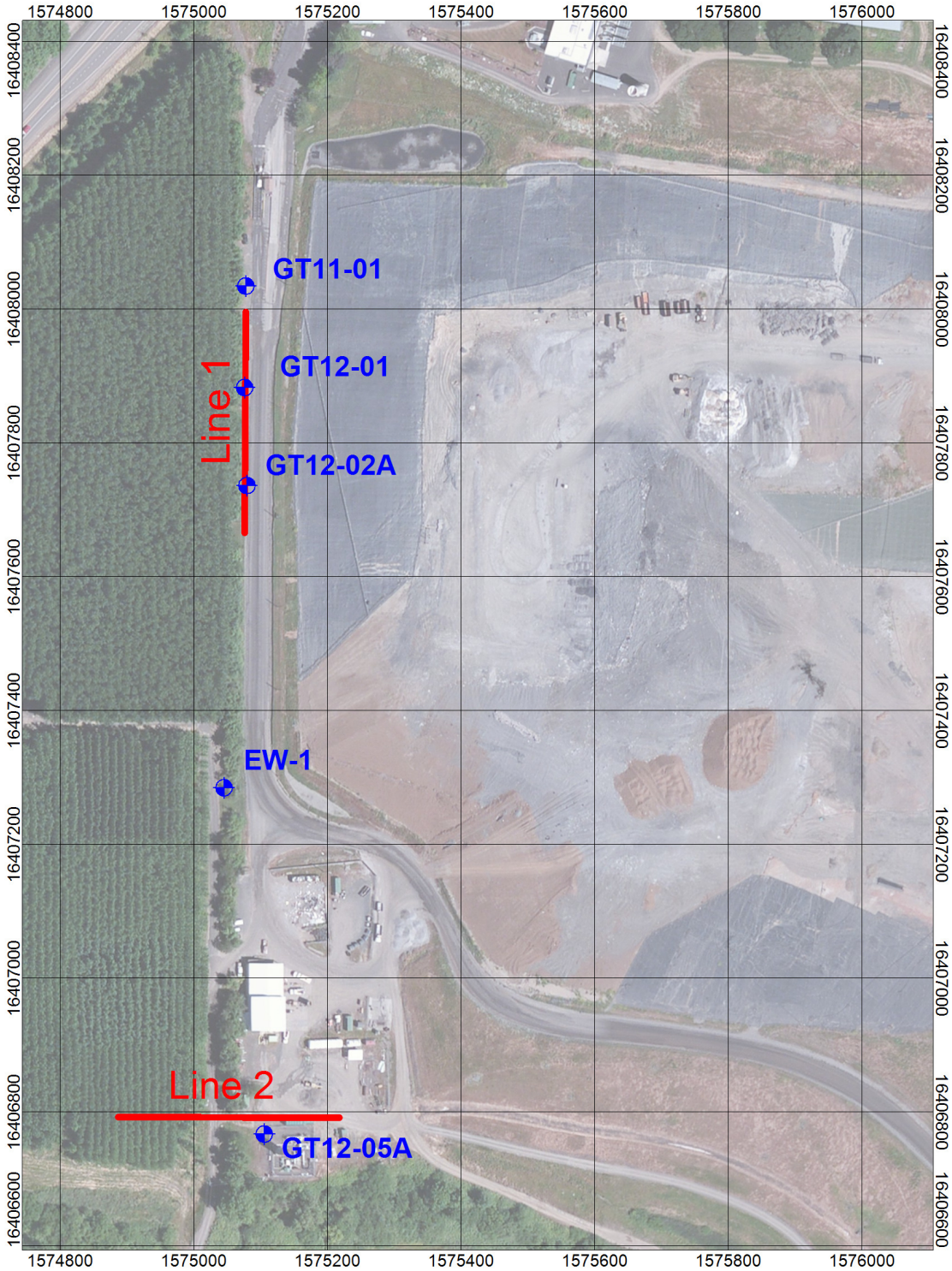
GRAPHICAL MASW DATA PROFILES

Average Vs Profile MASW Line 1



Average Vs Profile MASW Line 2





100 0 100 200 300

(feet)

WGS 84 / UTM zone 10N

LEGEND

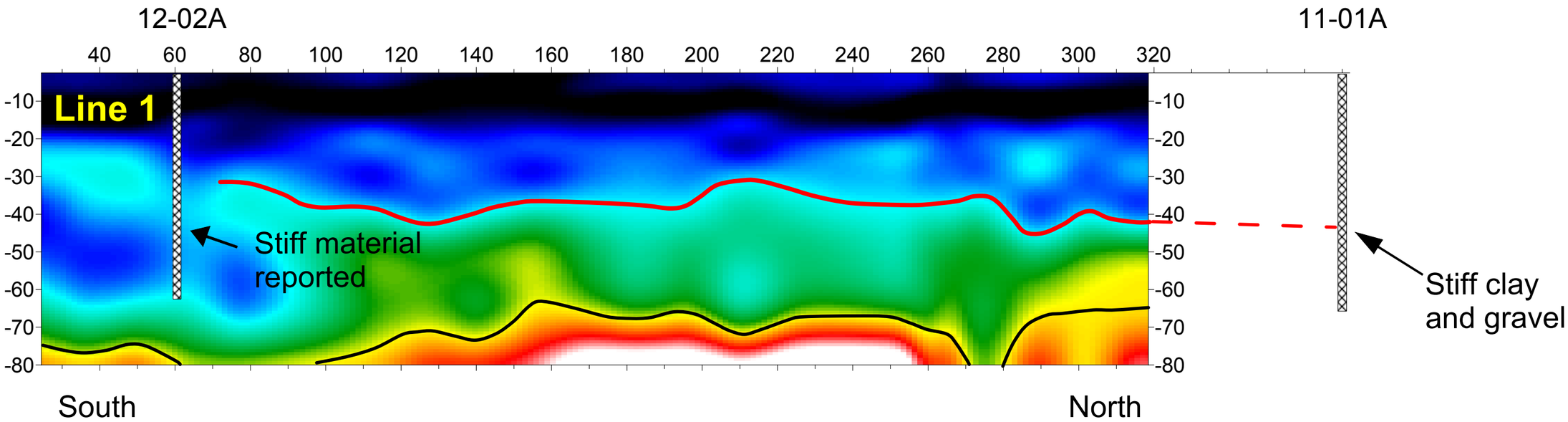
GT12-00 Boring or Test Pit Stake

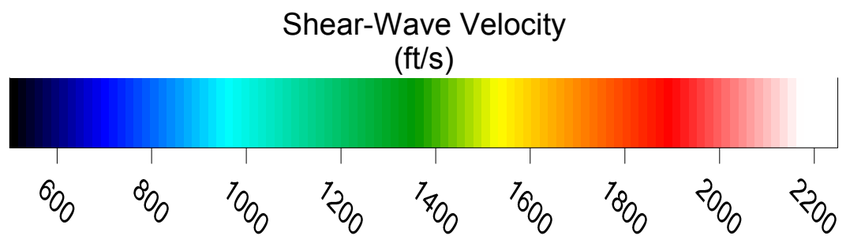
MASW Line

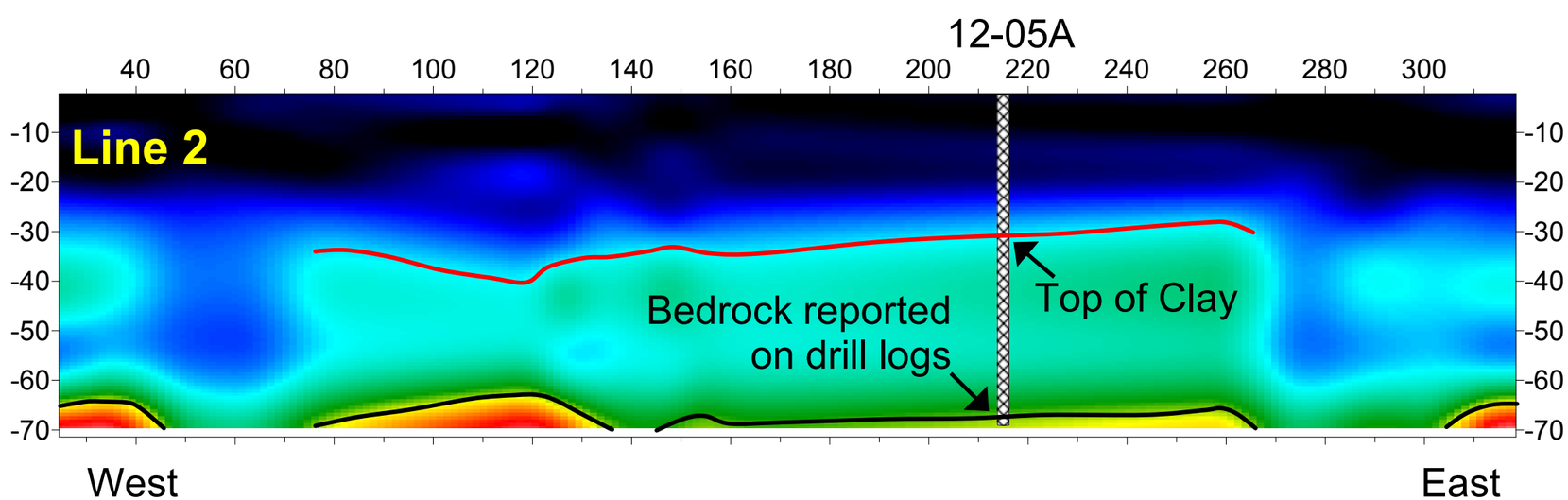
FIGURE 1

LINE LOCATION MAP

RIVERBEND LANDFILL







LEGEND

12-99

Projected Boring Location

Gradient / Velocity Transition (Dashed when inferred)

Gradient / Velocity Transition (Dashed when inferred)

Geosyntec Consultants
Riverbend Landfill Project
Seismic Lines 1 & 2
2D Smooth-Model Inversion
MASW Data

FIGURE 2

PROJECT	DRAWN	DATE	H.SCALE	V.SCALE
12173	JBS	09/07/12	1" = 20'	1" = 20'
REF: ML-1 ML-2				

Zonge International, Inc.
Parkside Business Center, Bldg. 1-B
3866 SW Nimbus Avenue
Beaverton, OR 97008
phone: (503) 992-6723

November 6, 2013
Ref: 13138

Fabrizio Settepani
Geosyntec Consultants, Inc.
1111 Broadway, 6th Floor
Oakland, CA 94607

Re: ***Final Report, MASW Survey***
Riverbend Landfill,
Yamhill County, Oregon

Dear Mr. Settepani,

Zonge International, Inc. (Zonge) conducted a multi-channel analysis of surface wave (MASW) survey in support of a geotechnical investigation being conducted at the Riverbend Landfill in Yamhill County, near McMinnville, Oregon. Data were collected along two profiles, each approximately 600 feet in length.

TECHNICAL APPROACH

Surface-wave seismic methods examine the dispersion curve (velocity as a function of frequency) of Rayleigh surface waves to determine the near-surface, shear-wave velocity structure. A surface-wave's motion extends approximately ½ wavelength into the earth, its amplitude decaying exponentially with depth. Hence, shorter wavelengths (higher frequencies) are affected by shallow materials, and longer wavelengths (lower frequencies) are affected by deeper soils and/or rock. By measuring changes in phase velocity with frequency we can determine the velocity structure with depth. The inversion process involves creating a hypothetical layered earth velocity model, calculating the theoretical surface-wave response, and iteratively adjusting the velocities of the layers to minimize error between the calculated and observed response.

For two-dimensional analysis, the MASW uses an active impulsive source (e.g., a sledgehammer or propelled energy generator (PEG)) and a linear array of geophones. With an impulsive source, the surface wave train can be selected from the seismic records while omitting early arriving body waves (P-waves) from the analysis.

This surface-wave analysis method is presented in greater detail in an attached information sheet.

SURFACE-WAVE FIELD SURVEY

Zonge acquired surface-wave data over two profiles (Seismic Line 1 and Seismic Line 2) shown on Figure 1. Data were acquired using a land streamer of twenty-four 4.5-Hz geophones with a 5-foot geophone spacing. Data were recorded with a Geometrics Geode seismograph. The seismic source was a 16-pound sledgehammer striking an aluminum plate. Data were processed to obtain shear-wave velocity profiles using SeisImager software from OYO/Geometrics.

RESULTS & INTERPRETATION

Shear-wave velocity plots are shown in Figures 2 for both Seismic Lines 1 and 2. Data for both lines were acquired atop the berms surround the fill areas. Locations are shown in Figure 1. Geosyntec boring locations are shown on both figures. Figures 3 and 4 are plots of velocity versus depth for select locations on SL1 and SL2 respectively.

We have drawn our interpretation of two geologic horizons on the profiles of Figure 2. Geologic interpretation of the velocity structure is based on borehole logs provided by Geosyntec. The upper unit of silty clay is presumably the constructed berm material with typical shear-wave velocities less than 800 feet/second. Below that is a predominately sand and gravel unit with velocities 800 to 1000 feet/second. Siltstone bedrock is interpreted with shear-wave velocities of 1200 to 1500 feet/second.

Seismic Line 1

Seismic Line 1 is at the northeast corner of the landfill. Shear wave velocities in the upper 40-50 feet are 500 to 800 feet/second across the profile. Presumably this is the silty clay of the constructed berm material. Below that velocities increase to 800 or 1200 feet/second. The siltstone unit is not well resolved but from boring GT13-12 we have correlated the top of siltstone with the 1200 feet/second contour.

Below about 70 feet the velocities were not well resolved due to limitations in the MASW technique and lack of low frequency signal. The dashed line in Figure 2, and the faded color contours below, represents a gradational limit to the model resolution based on the frequency content of the observed surface waves.

Seismic Line 2

Seismic Line 2 is at the southwest portion of the landfill. Again, shear wave velocities in the upper 40-50 feet are 500 to 800 feet/second across the profile, presumably the silty clay of the constructed berm material. Below that velocities increase to 800 or 1200 feet/second. There is some indication of faster velocities, up to 1500 feet/second, below 75 feet, especially at the west end of the line. For Seismic Line 2 we have correlated the 1250 feet/second contour with the top of the siltstone although that horizon is not well resolved.

CLOSURE

Zonge International, Inc. has performed this work in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, express or implied, beyond exercise of reasonable care and professional diligence, is made. This report is intended for use only in accordance with the purposes of the study described within.

We appreciate the opportunity to perform this geophysical investigation. Should you require further information concerning the field investigation, or this report, please contact us at your convenience.

Sincerely,

Zonge International, Inc.

Rowland B, French, R.G.
Program Geophysicist

Attachments: Figures 1 - 4, MASW Info

File: Zonge Riverbend 2013 rpt02.dotx
Zonge Project: 13138

BASE IMAGE FROM BING MAPS

LEGEND

SEISMIC LINE 1 (400, 300, 200, 100, 0) — SEISMIC PROFILE with DISTANCES IN FEET

GT-13-13 — GEOSYNTEC GEOTECHNICAL BORING

TRENCH or DRAINAGE FEATURE

N

Scale 1:4800

250 0 250 500 750

US survey foot

NAD83 / Oregon North (ft)

FIGURE 1

GEOPHYSICIAL EXPLORATION PLAN

MASW Survey
Riverbend Landfill
Yamhill County, Oregon

Prepared By:

Zonge TRUSTED GEOPHYSICS.

Prepared For:

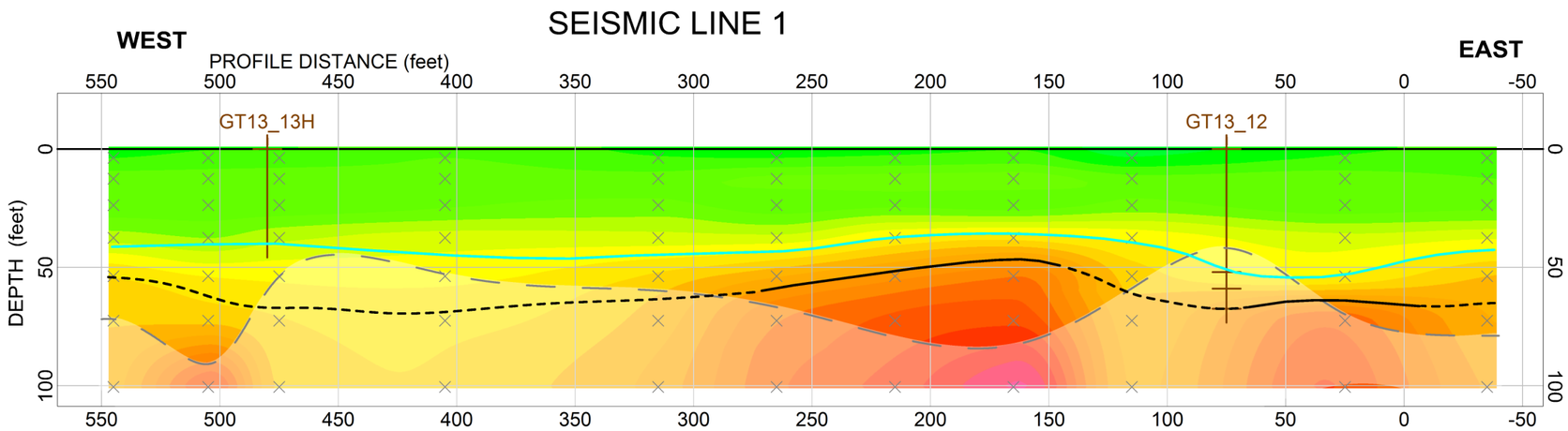
Geosyntec Consultants, Inc.

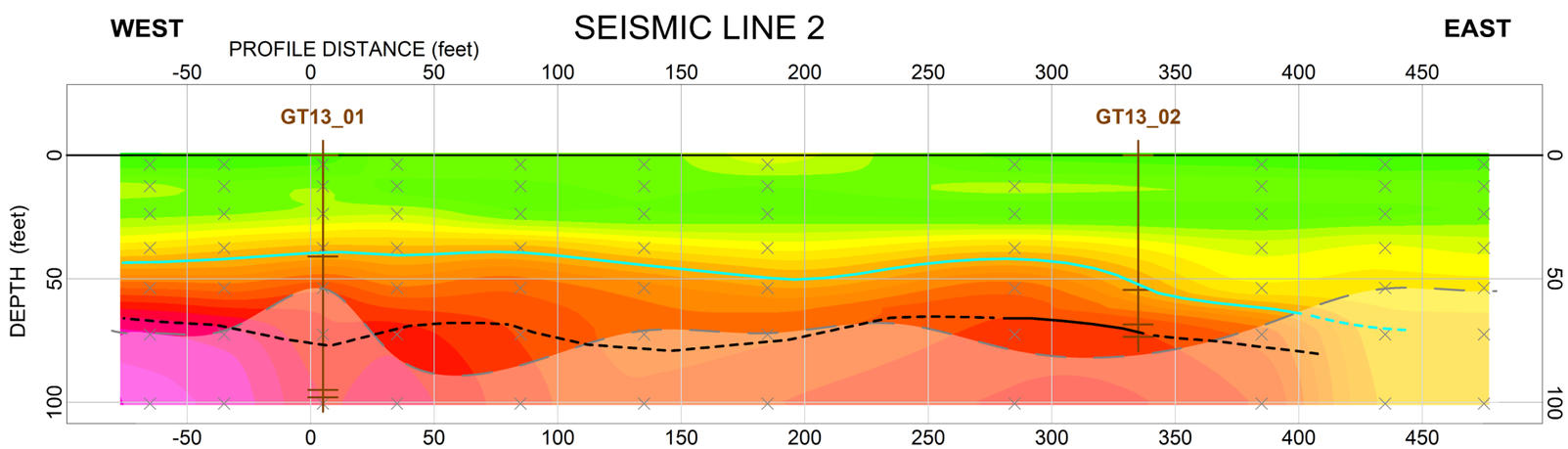
REVISION: A-10-OCT-13

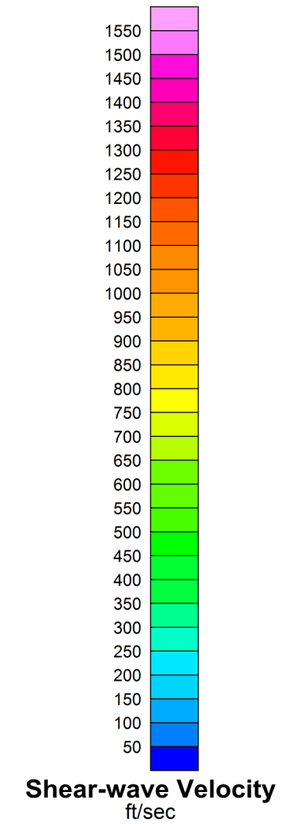
DATE: OCTOBER 2013

FILE: Riverbend Site.map

ZONGE PROJECT: 13138







LEGEND

Scale 1:720

25 0 25 50 75 100 125 150

(feet)

DEPTH LIMIT OF MODEL RESOLUTION

× MODEL DATA POINT

INTERPERETED HORIZONS

TOP OF SAND & GRAVEL

TOP OF BEDROCK (SILTSTONE)

DASHED WHERE NOT RESOLVED

FIGURE 2

SHEAR-WAVE VELOCITY PROFILES

MASW Survey
Riverbend Landfill
Yamhill County, Oregon

Prepared By:

Zonge TRUSTED GEOPHYSICS

Prepared For:

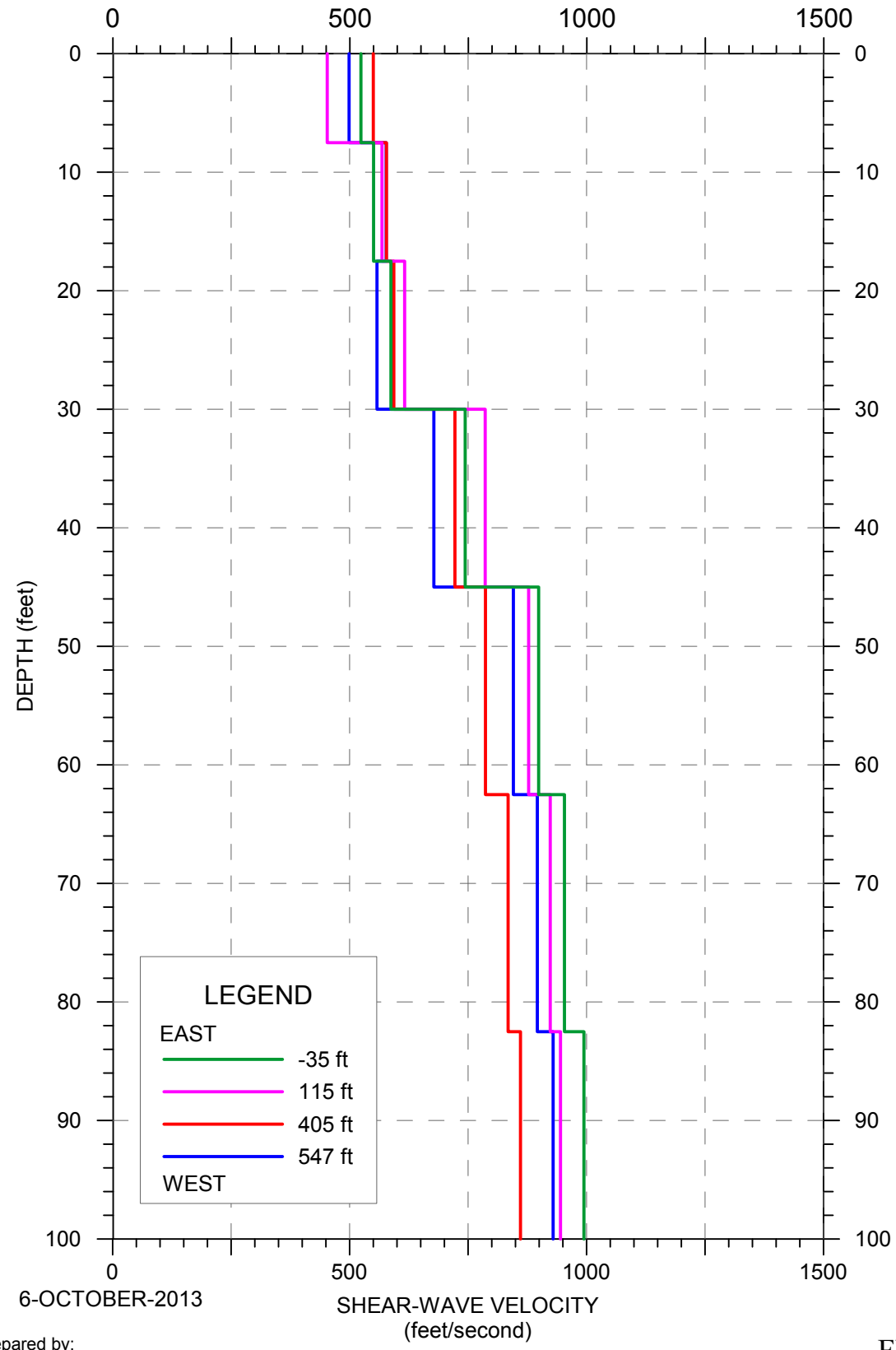
Geosyntec Consultants, Inc.

REVISION: B-05-NOV-13

DATE: OCTOBER 2013

FILE: Vs Profiles.map

ZONGE PROJECT: 13138



6-OCTOBER-2013

REVISION: A-4-NOV-13

FILE: MASW Plot_SL1.grf

ZONGE Project #: 13138

Prepared by:

Zonge TRUSTED GEOPHYSICS

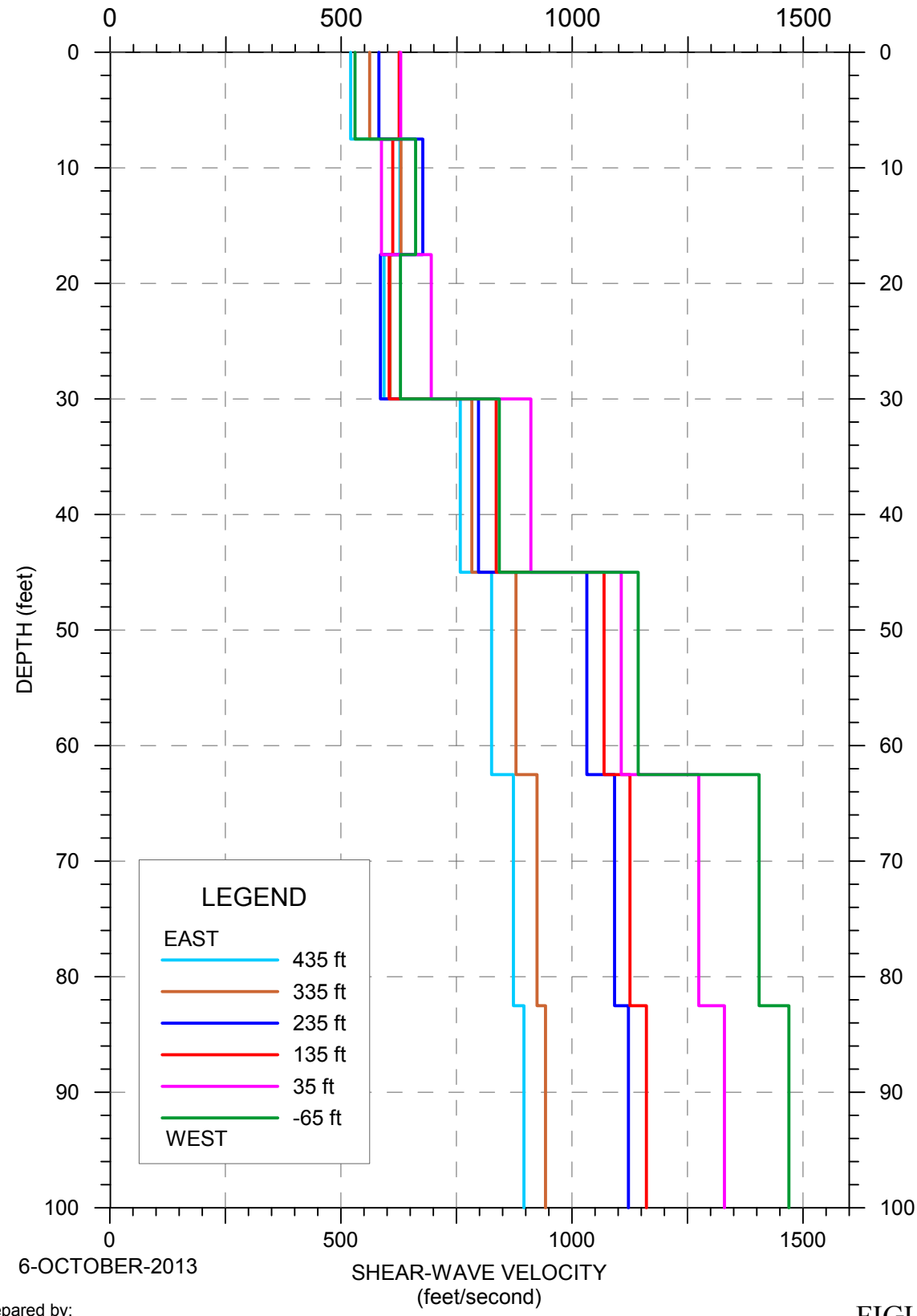
Prepared for:

Geosyntec Consultants, Inc.

MASW Survey
Riverbend Landfill
Yamhill County, Oregon

SEISIMIC LINE 1
INTERPRETED
SHEAR WAVE VELOCITY

FIGURE 3



REVISION: A-4-NOV-13

FILE: MASW Plot_SL1.grf

ZONGE Project #: 13138

6-OCTOBER-2013

Prepared by:

Zonge TRUSTED GEOPHYSICS

Prepared for:

Geosyntec Consultants, Inc.

MASW Survey
Riverbend Landfill
Yamhill County, Oregon

SEISIMIC LINE 2
INTERPRETED
SHEAR WAVE VELOCITY

FIGURE 4

TRUSTED GEOPHYSICS™

Environmental • Groundwater • Geotechnical

Seismic Surface Wave Analysis

Applications of MASW

- Vertical Shear Wave Profile
- VS30 Determination
- 2D Shear Wave Profiling
- Site Response Moduli
- Geologic Mapping & Interpretation
- Void Detection

Benefits of MASW

- Low Cost
- No drilling required

INTRODUCTION

Seismic surface waves can be used to estimate shear-wave velocities in the near-surface strata. From those shear-wave velocities, the average shear-wave velocity in the upper 30 meters (VS30) can be calculated and the seismic site classification of the International Building Code (IBC) determined.

Surface wave analysis is inexpensive and does not require boreholes. A sledgehammer or other active source can provide a clear surface wavetrain for analysis. A 2D array can utilize surface waves incident from all angles. While surface wave analysis does not have the resolution of downhole or cross-hole seismic surveys, it often can provide the required information without drilling and casing boreholes.

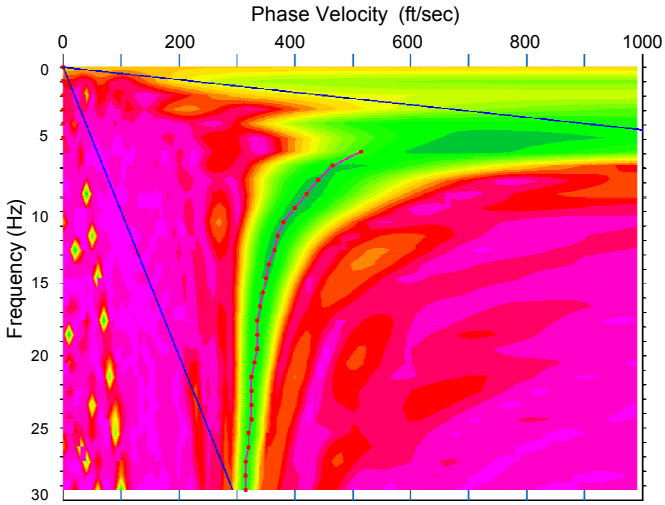


FIGURE 1: MASW DISPERSION CURVE

PHYSICAL PRINCIPLES

Surface wave methods examine the dispersion curve (velocity as a function of frequency) of Rayleigh surface waves to examine the near-surface, shear-wave velocity structure. Surface wave motion extends approximately ½ wavelength into the earth, the amplitude decaying exponentially with depth. Hence, higher frequencies (shorter wavelengths) are affected by the shallow materials, and the longer wavelengths are affected by deeper soils and/or rock. Thus, by measuring the changes in phase velocity with frequency we can determine the velocity structure with depth.

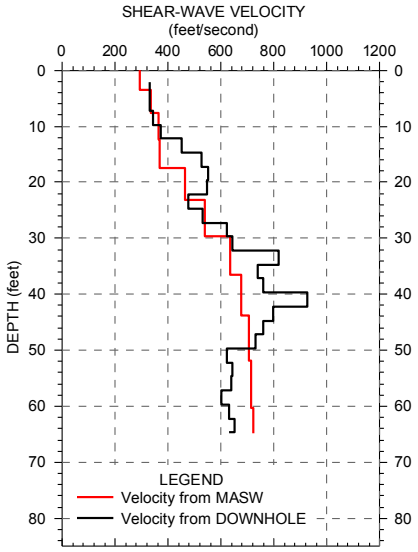


FIGURE 2: DOWNHOLE SEISMIC - MASW COMPARISON

FIELD IMPLEMENTATION

For Surface Wave analysis, NGA employs a combination of Multi-channel Analysis Surface Wave (MASW) and Micro-tremor Array Measurements (MAM). For the higher frequency, and shallow depth of investigation, the MASW uses an active impulsive source (e.g., a hammer) and a linear array of geophones. With the impulsive source, the surface wave train can be selected from the seismic records, omitting the earlier body waves (P-waves) from the analysis.

(Continued on next page)

Zonge International, Inc.
8366 SW Nimbus Avenue, Beaverton, OR 97008
(503) 992-6723 Fax: (503) 746-7094
Email: zongeor@zonge.com

Seismic Surface Wave Analysis

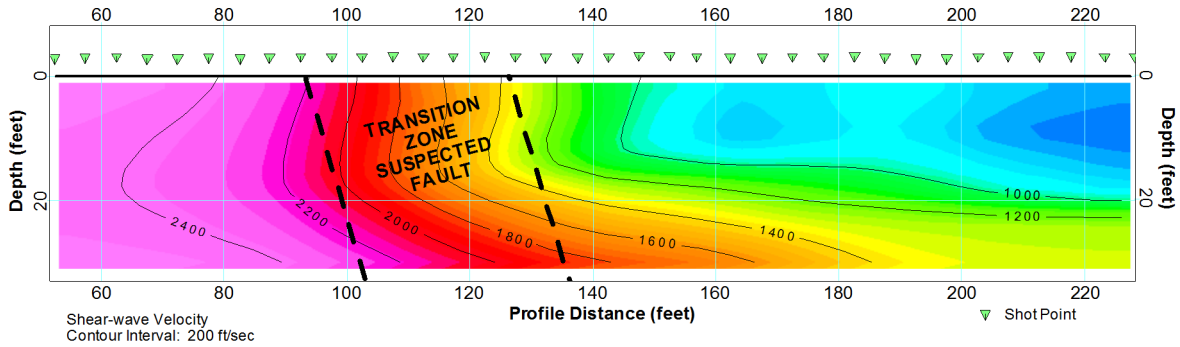


FIGURE 3: INTERPRETED 2D MASW PROFILE

For the lower frequencies, and greater depth of investigation uses passive noise (e.g., traffic noise) and a 2 dimensional, L-shaped array. The L-shaped array allows determination of the direction of incidence of the signal onto the array. The passive techniques are often referred to as Micro-tremor Array Measurements (MAM).

1D VERTICAL SOUNDING

A one dimensional profile or sounding of shear-wave velocity versus depth can readily be obtained at one or two locations for a building site. Active seismic source data from a sledge hammer and passive seismic source data from ocean surf or road traffic are used for MASW vertical profiling data collection.

MASW data are collected in a linear array using a sledge hammer source. MAM data are collected using a two dimensional L-shaped array. The two dimensional aspect of the method utilized by the MAM method is important in that it allows an azimuth to be determined on the passive surface wave.

Combining the active and passive source data yields a dispersion curve. Inversion processing the combined MASW data produces a 1D vertical profile of shear-wave velocity versus depth.

2D MASW PROFILES

The MASW technique can be extended to obtain a series of dispersion curves by moving the array laterally and repeating the data acquisition process. The resulting one-dimensional models can then be put together in a profile to produce a 2D shear-wave velocity profile.

In practice this is done, laying out a linear array of geophones and “shooting” into the array, i.e. hammering along the array between every 1 or 2 geophones. Traces which have a common midpoint (CMP) between the source and receiver are then collected (gathered) into one record. Each trace in the gather will have a different distance between source and receiver. The dispersion curve is then evaluated for each gather and the resulting velocity model plotted at the midpoint.

DATA PROCESSING AND INTERPRETATION

NGA uses SeisImager Wave Equation software by Geometrics of San Jose, California, and SurfSeis Surface Wave Processing Software by Kansas Geological Survey of Lawrence, Kansas to process surface wave data. In these processing suites, a dispersion curve of the phase velocity of the surface waves as a function of frequency is generated for each MASW shot point and for the combined records of the MAM data. The dispersion curves for the MASW and MAM data are then merged and smoothed. A least squares inversion using forward modeling is then used to approximate earth structure.

ATTACHMENT 7

Noise Analysis Update Report
(Prepared by Michael Minor & Associates)

Michael Minor & Associates
Sound . Vibration . Air
4923 SE 36th Avenue
Portland, Oregon 97202
503.220.0495 ~ fax 866.847.0495

Prepared for:	Riverbend Landfill
Prepared by:	Michael A. Minor
Date:	October 30, 2014
Subject:	Noise Analysis Update
Project:	Riverbend Landfill Noise Analysis

Introduction

This memorandum provides an updated noise analysis for the Riverbend Landfill. The previous full report, *Riverbend Landfill Noise Analysis*, MM&A, November 2, 2009 (Noise Memorandum, 2009), is provided as supporting information in Attachment A. This update was performed because some of the operational characteristics at the site have changed since the initial report was published. Changes include relocation of the maintenance shop, reduced operational hours, modified expansion plans, and updated list of landfill related equipment.

Additional data and information, including an introduction to acoustics, summary of noise regulations, measured noise levels and pervious projections of noise levels at nearby noise sensitive properties from the Noise Memorandum (2009) report are provided in Attachment A. This update focuses on the revisions to operations, modified expansions plans, and changes in equipment being used at the facility.

Summary of Findings

Due to changes in the operations at the landfill, an updated noise impacts analysis was performed. The analysis relies on the previously measured noise levels to verify compliance with Oregon Department of Environmental Quality (ODEQ) noise criteria. The sound level measurements used in this analysis were taken early on a Sunday morning, when the site was closed, and therefore remain an accurate measure of the lower ambient noise levels at noise sensitive properties near the site.

To verify compliance with Oregon Department of Environmental Quality (ODEQ) noise criteria, a noise levels analysis was performed for the same nine representative residential properties used in the previous analysis. One site was to the north on SW Masonville Rd, four were along Highway 18, west of the landfill, one was at the recreational vehicle park, and the last three were east of the landfill.

There was no exceedance of the ODEQ ambient criteria noted. Noise from landfill operations is predicted to be below the existing ambient noise levels for all noise sensitive properties, except R6, west, south and north of the site due to noise from Highway 18. Noise levels at R6 are predicted to increase by up to 4 dB, which is still well below the 10 dBA criteria. There are also three residences east of the landfill where operational noise levels sometimes equal or exceed existing ambient noise levels by approximately 1 to 2 dB or less, however the noise levels from landfill operations are still well below the 10 dBA ODEQ criteria.

Noise Regulations

The ODEQ noise control program was eliminated on July 1, 1991; however the state noise regulations were not rescinded. The ODEQ sets standards for new and existing industrial and commercial noise sources. The ODEQ noise ordinance is given in Table 1.

Table 1. Oregon DEQ Industrial and Commercial Noise Source Standards

Statistical Descriptor	Existing Noise Source		New Noise Source	
	7am – 10pm	10pm – 7am	7am – 10pm	10pm – 7am
L_{50}	55	50	55	50
L_{10}	60	55	60	55
L_{01}	75	60	75	60

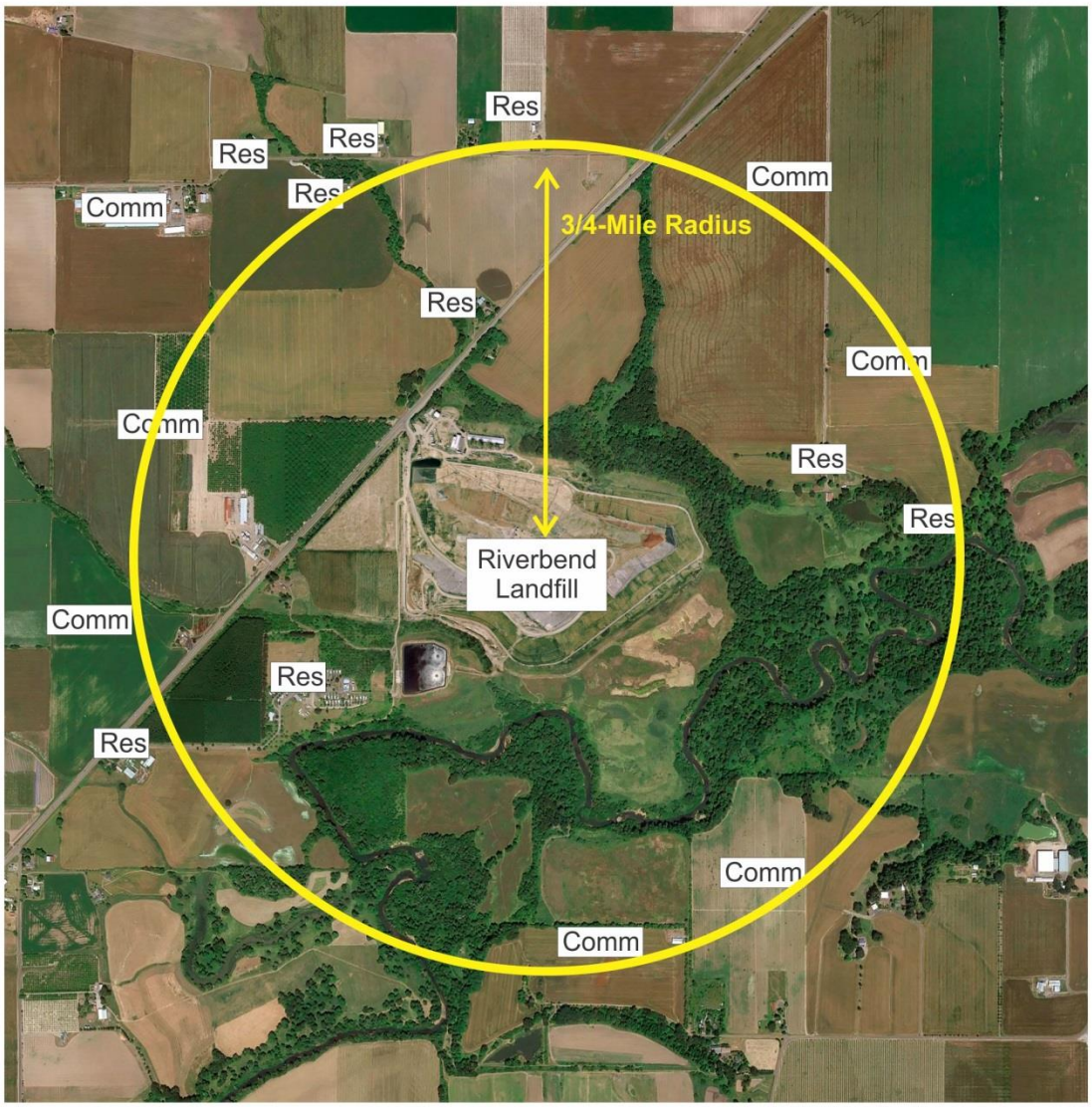
Based on the start year of 1981 for Riverbend Landfill, the project site would be considered a new industrial noise source because it was commenced after January 1, 1975. The ODEQ also has an ambient degradation criterion that limits the change in ambient noise levels to no more than 10 dBA for the L_{10} and L_{50} statistical descriptors in any one hour.

Analysis Methodology

Noise monitoring was performed at Riverbend Landfill between Thursday, August 27, and Tuesday September 1, 2009. The measurements included a Sunday measurement when the site is closed, to establish accurate existing ambient noise levels. Because the monitoring data used to establish the ambient noise levels was taken early on a Sunday morning when the land fill was not in operation, and there are no other notable noise sources in this area, this data remains valid for this analysis update.

Noise monitoring also captured a variety of landfill related noise sources including the unloading of large dump trucks, garbage trucks and tractor trailers, noise from trucks climbing the hill to the current landfill area, and dozers in use moving and compacting garbage.

Figure 1 is an overview of the landfill site with sensitive land uses within a 3/4-mile radius of the site identified. Figure 2 is a detailed site view with the noise monitoring locations, tipper and nearest residence identified. Complete data and additional information from the noise monitoring is provided in Noise Memorandum (2009) in Attachment A.



Land Use: Res = Residential; Comm = Commercial/Undeveloped/Farm

0 750 1500 3000
1.00 in
Approximate Scale 1 inch to 1500 feet

N

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 1
Project Area Overview & Land Use
Riverbend Landfill

Monitoring Site Descriptions

Site M1 was located near the main activity, and includes measurements of the tipper, a large mechanical device that empties tractor trailers full of garbage. This device has the potential to produce a loud bang when the rear door of the trailer slams shut. A photo of the tipper is shown in Figure 2. Site M2 is located just north of the current operations, slightly down hill, with a clear line-of-sight to the operations. Site M3 was used primarily to obtain truck noise while climbing the hill to the landfill. Site M4 is located approximately 1300 feet to the east of the current landfill operations area, also with a clear line-of-sight to landfill operation.

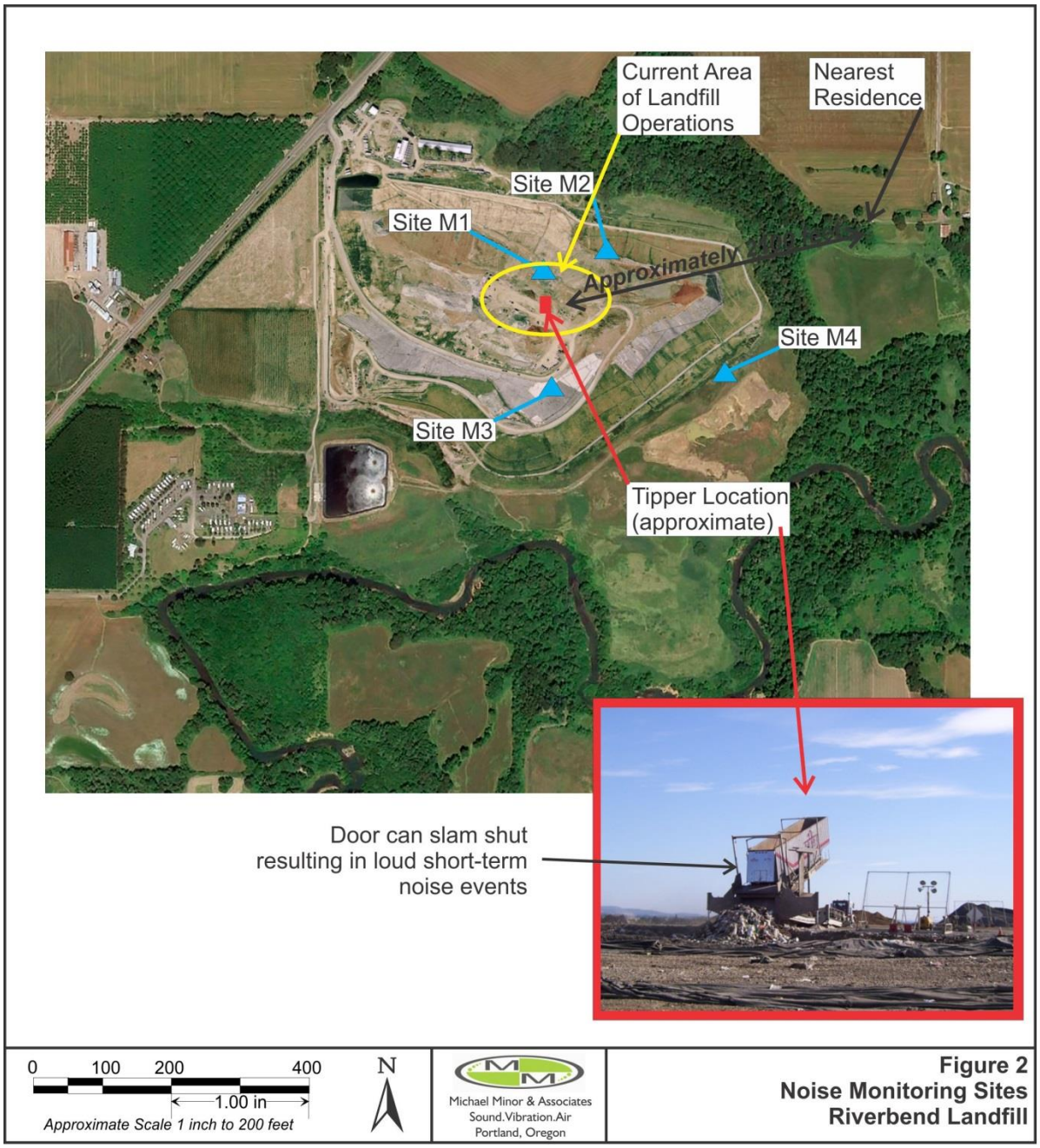


Figure 2
Noise Monitoring Sites
Riverbend Landfill

Noise Impact Analysis

There are several steps that need to be completed in order to accurately assess noise from the landfill operations, including:

1. Establishing accurate existing ambient noise levels;
2. Obtaining accurate reference measurements of the noise producing activities; and
3. Determining the statistical contribution of operational noise and early morning increase in noise levels at the nearby residences.

Each of these steps are outlined in the following sections. The results of the noise analysis under the Oregon DEQ regulations are also provided.

Ambient Noise Levels

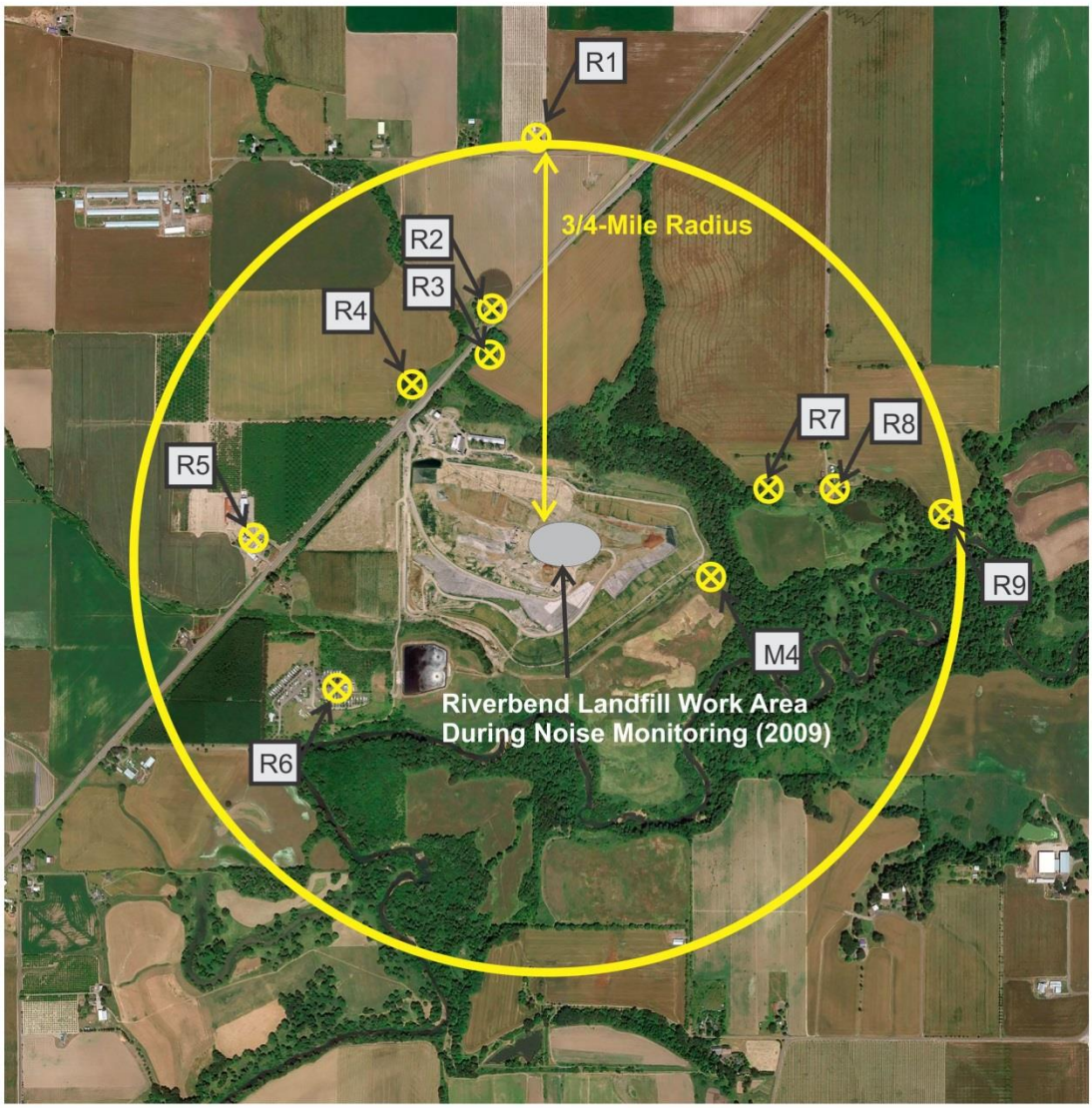
The existing ambient noise at and near the site was determined from measured data between Saturday, August 29 at 10:00 pm and Monday, August 30, 2009 at 4:00 am. At the time of these measurements, the landfill operated Monday through Saturday, from around 4:30 am until 5:00 pm, and therefore, the only reasonable time to measure ambient noise levels was on a Sunday or holiday. The data measured between 7:00 pm on Saturday evening and 4:00 am Monday morning was used to establish the existing ambient noise levels. This data is still considered valid, as the landfill is the only major noise source in the area, and noise levels during early morning hours would not be expected to have changed since this data was taken.

The land use surrounding the site was inspected and noise sensitive land uses within ¾ mile were identified. Nine (9) representative noise sensitive properties surrounding the landfill were selected for a detailed noise analysis. The analysis was performed for start-up noise that occurs early in the morning hours when noise from the landfill would have the most severe effects on residents.

Ambient noise levels for each of the sites was derived from the Sunday morning ambient noise measurements. Details on the measurements are included in the Noise Memorandum (2009) attached in Attachment A. Receivers R1 through R9 that are used in this analysis are shown in Figure 3. Table 2 provides a summary of the predicted ambient L_{10} and L_{50} noise levels between 3:45 and 6:45 am. As is described, landfill operational hours were modified, and therefore the measurements between 3:45 and 5:45 AM (grayed shading) are not used for the analysis, as the facility is closed during these hours.

Table 2: Receiver Locations and Extrapolated Ambient Noise Levels

Rec#[1]	Site Description	Distance (ft)	Ambient Noise Levels on Sunday Morning					
			3:45 – 4:45 am		4:45 – 5:45 am		5:45 – 6:45 am	
			L_{10}	L_{50}	L_{10}	L_{50}	L_{10}	L_{50}
M4	East of landfill	1300	32.9	30.9	38.6	35.2	40.0	36.5
R1	SW Masonville Rd	3950	51.3	47.0	52.3	48.6	54.0	49.5
R2	NW of site on H-18	2380	58.8	54.5	59.8	56.1	61.5	57.0
R3	NW of site on H-18	1960	58.0	53.7	59.0	55.3	60.7	56.2
R4	NW of site on H-18	2090	58.4	54.1	59.4	55.7	61.1	56.6
R5	West of site on H-18	2900	57.9	53.6	58.9	55.2	60.6	56.1
R6	SE of site (RV park)	2560	50.8	46.5	51.8	48.1	53.5	49.0
R7	Two Residences east of site (same property)	2110	32.9	30.9	38.6	35.2	40.0	36.5
R8		2550	32.9	30.9	38.6	35.2	40.0	36.5
R9	East most residence	3650	32.9	30.9	38.6	35.2	40.0	36.5



Land Use: Res = Residential; Comm = Commercial/Undeveloped/Farm

0 750 1500 3000
1.00 in
Approximate Scale 1 inch to 1500 feet

N

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 3
Noise Analysis Locations
Riverbend Landfill

Landfill Operations

Noise measurements from monitoring sites M1, M2 and M3 were used to quantify noise from operations at the landfill. Close proximity measurements of the tipper and general landfill operations, including dozer operations, garbage trucks, back-up beepers, and other miscellaneous noise sources were taken at Sites M1 and M2. Pass-by measurements of off-road dump trucks were taken at Site M3, which was on an uphill grade to the top of the landfill. Measurement data from site M4 was used to establish noise propagation characteristics of the equipment and to establish ambient levels based on a Sunday morning measurement.

Riverbend landfill uses equipment typically found at landfill sites. This includes heavy use of a landfill dozer, compactor, off-road trucks, garbage trucks, a tipper and other miscellaneous supporting equipment. The major noise producing equipment would be the dozer, compactor, off-road trucks, and the gates on garbage trucks slamming when on the tipper.

One of the revisions to operations at the landfill was a modification of the equipment list. Major changes include replacing the larger Caterpillar D8H dozer with a slightly smaller Caterpillar D7R dozer, and using a Caterpillar D6R dozer for a spare instead of the Caterpillar D7R dozer. The landfill also replaced the Caterpillar 836G compactor with a smaller Caterpillar 826G compactor. Although the new dozer and compactor are smaller than the previous version, no change was made to the reference noise levels, as the actual difference in noise levels between the units is typically only 1 to 2 dB, a level that is typically not perceptible. Using the measured data with the louder equipment will assure a conservative noise impact analysis.

An updated summary of the equipment used at the landfill, typical usage and noise levels at 50 feet are provided in Table 3. For comparison, see Noise Memorandum (2009), in Attachment A for the equipment used in the previous analysis.

Table 3. Landfill Equipment List with Site Usage and Typical Noise Levels

Equipment Type	Model	Usage	Typical Maximum Noise Level at 50 ft.
Dozer	D7R	Fairly consistently during operational hours	88 - 94 dBA @ 50 ft
Dozer	D6R	Spare – normally only used if the D7R is in service	88 - 92 dBA @ 50 ft
Off Road Haul Truck	Volvo A-25	Some daytime hauling	86 dBA @ 35 mph
Off Road Haul Truck	Cat 730	Some daytime hauling	86 dBA @ 35 mph
Hydraulic Excavator	Cat 325	Rarely	82 - 88 dBA @ 50 ft
Waste Compactor	Cat 826G	Fairly consistently during operational hours	88 - 92 dBA @ 50 ft
Waste Compactor	Cat 826C	Spare	88 - 92 dBA @ 50 ft
Tipper	Columbia	Fairly consistently during operational hours	Worst case banging levels of 86 to 95 dBA

In addition to the equipment changes, the landfill also modified the operational hours, which are now Monday through Friday 6:00 AM to 4:30 PM, and 7:00 am to 3:30 PM on Saturday, with full closure on Sundays. Previously, landfill began operations at approximately 4:30 AM and continued till 5:00 PM, Monday through Saturday.

In addition to the changes provided above, the maintenance shop, which used to be located in the south-west quadrant of the property was relocated the north-west quadrant of the property, near the main office buildings. Although this facility does produce some noise, it is not a significant source when compared to the noise from the landfill operations.

Finally, the expansion plans for the facility have also changed. The current proposed expansion includes a small extension to the north, called Module 10, with a second expansion to the west, called Module 11, which is toward SR 18 remaining north of the stream. Figure 4

provides a view of the proposed expansion areas, location of the shop facility, and the location of landfill noise sources for the ODEQ analysis.

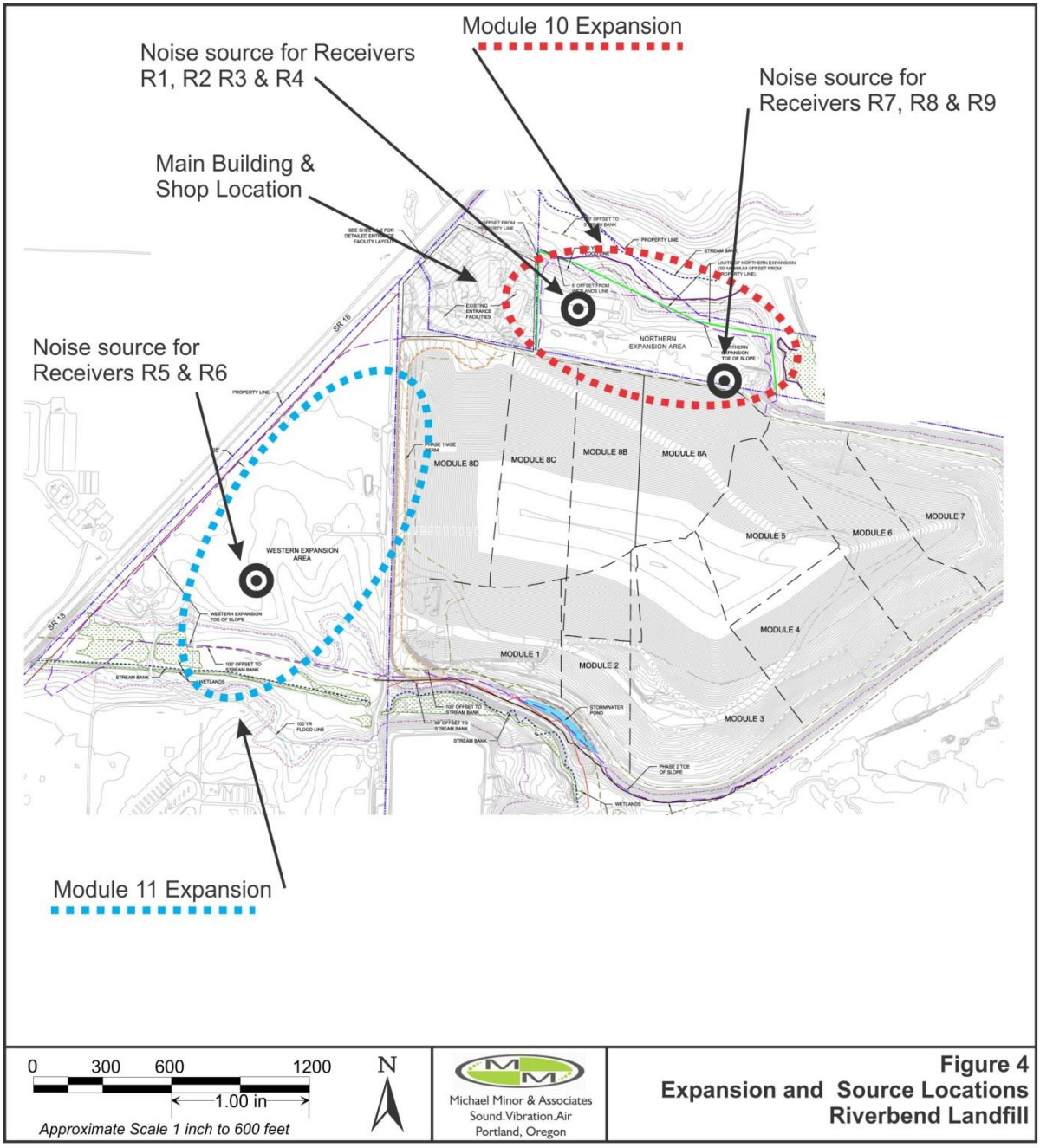


Figure 4
Expansion and Source Locations
Riverbend Landfill

ODEQ Noise Level Analysis

To show compliance with the ODEQ regulations, ambient noise level analysis was performed for the 9 representative residential properties within ¾ mile of the landfill. Site R1 is directly north of the site along SW Masonville Rd, approximately 750 feet from Highway 18, and 2,900 feet from the northern expansion. Noise levels at this residence are dominated by traffic along Highway 18 and no noise impacts were identified, with a maximum increase in noise levels of only 1.7 dB using the worst case Sunday morning ambient data. The results of the analysis for R1 are provided in Table 4.

Table 4: ODEQ Noise Analysis for R1

One-Hour Start Time	Sunday Ambient (dBA)		Operational Levels (dBA)		Change	
Friday						
	L_{10}	L_{50}	L_{10}	L_{50}	L_{10}	L_{50}
5:45 AM	54.0	49.5	50.9	44.6	1.7	1.2
Saturday						
	L_{10}	L_{50}	L_{10}	L_{50}	L_{10}	L_{50}
5:45 AM	54.0	49.5	35.4	33.9	0.1	0.1
Monday						
	L_{10}	L_{50}	L_{10}	L_{50}	L_{10}	L_{50}
5:45 AM	54.0	49.5	45.6	42.1	0.6	0.7
Tuesday						
	L_{10}	L_{50}	L_{10}	L_{50}	L_{10}	L_{50}
5:45 AM	54.0	49.5	44.2	36.8	0.4	0.2

Receivers R2 through R5 are all single family residences located along highway 18, within 135 and 165 feet of the highway. As with receiver R1, the dominant noise source at all four of these locations is traffic noise from Highway 18. There were no exceedances of the ODEQ ambient criteria, and all noise from the landfill is predicted to be below the existing ambient at all four residences, with a worst case increase of 1.6 dB L10, and 1.2 dB L50. Tables 5 through 8 provide the results for Receivers R2 through R5.

Table 5: ODEQ Noise Analysis for R2						
Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	61.5	57.0	53.9	47.6	0.7	0.5
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	61.5	57.0	38.4	36.9	0.0	0.0
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	61.5	57.0	48.6	45.1	0.2	0.3
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	61.5	57.0	47.2	39.8	0.2	0.1

Table 6: ODEQ Noise Analysis for R3						
Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	60.7	56.2	55.7	49.4	1.2	0.8
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	60.7	56.2	40.2	38.7	0.0	0.1
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	60.7	56.2	50.4	46.9	0.4	0.5
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	54.0	49.5	49.0	41.6	0.3	0.1

Table7: ODEQ Noise Analysis for R4						
Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	61.1	56.6	54.2	47.9	0.8	0.5
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	61.1	56.6	38.7	37.2	0.0	0.0
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	61.1	56.6	48.9	45.4	0.3	0.3
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	61.1	56.6	47.5	40.1	0.2	0.1

Table 8: ODEQ Noise Analysis for R5						
Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	60.6	56.1	57.3	51.0	1.6	1.2
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	60.6	56.1	41.8	40.3	0.1	0.1
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	60.6	56.1	52.0	48.5	0.6	0.7
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	60.6	56.1	50.6	43.2	0.4	0.2

Receiver R6 is a recreational vehicle park located on landfill property. The site is approximately 2,500 feet from current operations. Noise from landfill operations at the RV park are predicted to have a worst case increase of 4.4 dB for the L10, and 3.4 for the L50, both are well below the ODEQ 10 dB increase criteria. These increases would only occur when landfill operations were located in the south west section of the landfill. The results of the ODEQ analysis for Receiver R6 are provided in Table 9.

Table 9: ODEQ Noise Analysis for R6						
Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	53.5	49.0	55.9	49.6	4.4	3.4
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	53.5	49.0	40.4	38.9	0.2	0.4
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	53.5	49.0	50.6	47.1	1.8	2.2
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	53.5	49.0	49.2	41.8	1.4	0.8

Sites R7 through R9 are located to the east of the landfill, with substantial distance and physical shielding from traffic noise on Highway 18. At receiver R7, the closest site to the landfill, the existing L10 was increased by 2.2 to 3.4 dBA, and the L50 increased by 1.7 to 3.6 dB. None of the noise readings meet, or exceed the ODEQ 10 dBA increase criteria. Data for Receivers R7 through R9 are provided in Tables 10 through 12.

Table 10: ODEQ Noise Analysis for R7						
Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	38.3	34.6	2.2	2.2
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	38.3	33.3	2.2	1.7
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	40.1	37.7	3.1	3.6
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	40.8	30.3	3.4	0.9

Table 11: ODEQ Noise Analysis for R8						
Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	36.9	33.2	1.7	1.7
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	36.9	31.9	1.7	1.3
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	38.7	36.3	2.4	2.9
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	39.4	28.9	2.7	0.7

Table 12: ODEQ Noise Analysis for R9						
Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	35.5	31.8	1.3	1.3
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	35.5	30.5	1.3	1.0
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	37.3	34.9	1.9	2.3
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
5:45 AM	40.0	36.5	38.0	27.5	2.1	0.5

Conclusion

Noise from landfill operations does not, and is not, projected to meet or exceed the ODEQ noise level criteria at properties near the landfill:

- For all noise sensitive properties west, south and north of the site, noise from landfill operations was determined to be below the existing ambient noise levels.
- For three residences east of the landfill where operational noise levels sometimes exceed existing ambient noise levels, the maximum noise level increase is well below the 10 dBA ODEQ criteria.

Attachment A

Riverbend Landfill Noise Report November 2009

Michael Minor & Associates
Sound . Vibration . Air
4923 SE 36th Avenue
Portland, Oregon 97202
503.220.0495 ~ fax 866.847.0495

Prepared for:	Tommy Brooks
Prepared by:	Michael A. Minor
Date:	Monday, November 02, 2009
Subject:	Noise Monitoring Results
Project:	Riverbend Landfill Noise Analysis

This memorandum summarizes the findings of noise monitoring and projections from the Riverbend Landfill. Included is an introduction to acoustics, summary of noise regulations, measured noise levels and projections of noise levels at nearby noise sensitive properties.

Summary of Findings:

Noise monitoring was performed over a four day period, including two weekend days. Noise data was measured near the current landfill operations area and included several measurements of the tipper and the D8N dozer during normal operations. General landfill operations were also measured at approximately 500 feet from the main dumping area. Pass-by measurements of off-road trucks and other garbage related delivery vehicles were also performed. Finally, normal landfill operations were measured at approximately 1300 feet from the site, with a clear line-of-sight to operations.

Sound level measurements taken on Sunday morning, when the site is closed, were used to establish the ambient noise levels at, and around the site. The ambient data from Sunday measurements, along with normal operational noise levels measured around the landfill, were used to predict noise levels at noise sensitive properties near the site.

To verify compliance with Oregon Department of Environmental Quality (ODEQ) noise criteria, an ambient noise levels analysis was performed for nine representative residential properties within ¾ mile of the landfill. One site was to the north on SW Masonville Rd, four were along Highway 18, west of the landfill, one was at the recreational vehicle park, and the last three were east of the landfill. Ambient noise levels were also measured at the measurement site that is 1300 feet from the current landfill work site.

There was no exceedance of the ODEQ ambient criteria noted. Noise from landfill operations is predicted to be below the existing ambient noise levels for all noise sensitive properties west, south and north of the site due to noise from Highway 18. There are three residences east of the landfill where operational noise levels sometimes exceed existing ambient noise levels, however the maximum noise level only exceeded the existing ambient by 3.7 dBA, and is well below the 10 dBA ODEQ criteria. There are no noise sensitive properties that currently meet or exceed the ODEQ criteria.

Introduction to Acoustics

Human response to sound levels is subjective and can vary greatly from person to person. Factors that can influence individual response include the loudness, frequency, the amount of background noise present before an intruding noise and the nature of the work or activity (e.g., sleeping) that the noise affects.

Sound is defined as any pressure variation that the human ear can detect, from barely perceptible sounds to sound levels that can cause hearing damage. The magnitude of the variations of the air pressure from the static or normal air pressure is a measure of the sound level. The number of cyclic pressure variations per second is the frequency of sound.

The unit used to measure the loudness of noise is the decibel (dB). To better approximate the sensitivity of the human ear to sounds of different frequencies, the A-weighted decibel scale was developed. Because the human ear is less sensitive to higher and lower frequencies, the A-weighted scale reduces the sound level contributions of these frequencies. When the A-weighted scale is used, the decibel levels are denoted as dBA.

A 10-dBA change in noise levels is judged by most people as a doubling of sound level. The smallest change in noise level that a human ear can perceive is about 3 dBA, and increases of 5 dBA or more are clearly noticeable. Normal conversation ranges between 44 and 65 dBA when speakers are 3 to 6 feet apart.

Noise levels in a quiet rural area at night are typically between 32 and 35 dBA. Quiet urban nighttime noise levels range from 40 to 50 dBA. Noise levels during the day in a noisy urban area are frequently as high as 70 to 80 dBA. Noise levels above 110 dBA become intolerable and then painful, while levels higher than 80 dBA over continuous periods can result in hearing loss. Table 1 shows sound levels for some common noise sources and compares their relative loudness to that of an 80 dBA source such as a garbage disposal or food blender. Constant noises tend to be less noticeable than irregular or periodic noises.

Noise levels used in this analysis are stated as sound pressure levels in terms of decibels on the A-scale (dBA). The A-scale is used in most ordinances and standards. To account for the time-varying nature of noise several noise metrics are useful. The equivalent sound pressure level (L_{eq}) is defined as the average noise level, on an energy basis, for a stated time period (for example, hourly).

Other commonly used noise descriptors include the L_n, L_{max}, and L_{min}. The L_{max} and L_{min} are the greatest and smallest RMS (root-mean square) sound levels, in dBA, measured during a specified measurement period. The sound level descriptor L_n is defined as the sound level exceeded “n” percent of the time. For example, the L_{25} is the sound level exceeded 25 percent of the time; therefore during a 1-hour measurement, an L_{25} of 60 dBA means the sound level equaled or exceeded 60 dBA for 15 minutes during that hour.

Table 1: Sound Levels and Relative Loudness of Typical Noise Sources

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (human judgment of different sound levels)
Jet aircraft takeoff from carrier (50 ft)	140	Threshold of pain	64 times as loud
50-hp siren (100 ft)	130		32 times as loud
Loud rock concert near stage Jet takeoff (200 ft)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 ft)	110		8 times as loud
Jet takeoff (2,000 ft)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 ft)	90		2 times as loud
Kitchen garbage disposal, food blender (2 ft), Pneumatic drill (50 ft)	**80**	**Moderately loud**	**Reference loudness**
Vacuum cleaner (10 ft) Passenger car at 65 mph (25 ft)	70		1/2 as loud
Large store air-conditioning unit (20 ft)	60		1/4 as loud
Light auto traffic (100 ft)	50	Quiet	1/8 as loud
Bedroom or quiet living room Bird calls	40		1/16 as loud
Quiet library, soft whisper (15 ft)	30	Very quiet	
High quality recording studio	20		
Acoustic Test Chamber	10	Just audible	
	0	Threshold of hearing	

Sources: Beranek (1988) and EPA (1971)

Noise Propagation

There are several factors that determine how sound levels decrease over a distance. Under ideal conditions, a point noise source in free space will attenuate at a rate of 6 dB each time the distance from the source doubles (using the inverse square law). An ideal line source (such as constant flowing traffic on a busy highway) reduces at a rate of approximately 3 dB each time the distance doubles. Under real-life conditions, however, interactions of sound waves with the ground often result in attenuation that is slightly higher than the *ideal* reduction factors given above. Other factors that affect the attenuation of sound with distance include existing structures; topography; foliage; ground cover; and atmospheric conditions such as wind, temperature, and relative humidity. The potential effects of these factors on sound propagation are described below.

Attenuation refers to the reduction in loudness, or amplitude, of noise as it moves away from the noise source.

- Existing structures can substantially affect noise levels. Structures can reduce noise by physically blocking the sound transmission and, under special circumstances, may cause an increase in noise levels if the sound is reflected off the structure and transmitted to a nearby receiver location. Measurements have shown that a single-

story house has the potential, through shielding, to reduce noise levels by as much as 10 dB or greater. The actual noise reduction will depend greatly on the geometry of the noise source, receiver, and location of the structure. Increases in noise caused by reflection are normally 3 dB or less, which is the minimum change in noise levels that can be noticed by the human ear.

- Topography includes existing hills, berms, and other surface features between the noise source and receiver location. As with structures, topography can potentially reduce or increase sound, depending on the geometry of the area. When placed between the noise source and receiver, hills and berms can have an effect on noise levels. In many situations, berms are used as noise mitigation because they physically block the noise source from the receiver location. In some locations, however, the topography can cause an overall increase in sound levels by either reflecting or channeling the noise towards a sensitive receiver location.
- Dense foliage can slightly reduce noise levels. The Federal Highway Administration (FHWA) assumes up to a 5 dBA reduction in traffic noise for locations that have at least 100 feet of dense evergreen foliage.
- Ground cover between the receiver and the noise source can also affect noise transmission. For example, sound will travel very well across reflective surfaces such as water and pavement, but can be attenuated when the ground cover is field grass, lawn, or even loose soil.
- Atmospheric conditions that can affect the transmission of noise include wind, temperature, humidity, and precipitation. Wind can increase sound levels if it is blowing from the noise source to the receiver; conversely, it can reduce noise levels if blowing in the opposite direction. Noise propagation can also be affected when the temperature gradient is such that an inversion is formed. Other atmospheric conditions such as humidity and precipitation are rarely severe enough to result in noticeable changes in noise level propagation. Because weather conditions frequently change, it is not realistic to consider atmospheric conditions in many (since this is not a traffic noise study?) noise studies.

Noise Regulations

The ODEQ noise control program was eliminated on July 1, 1991; however the state noise regulations were not rescinded. The ODEQ sets standards for new and existing industrial and commercial noise sources. The ODEQ noise ordinance is given in Table 2.

Table 2: Oregon DEQ Industrial and Commercial Noise Source Standards

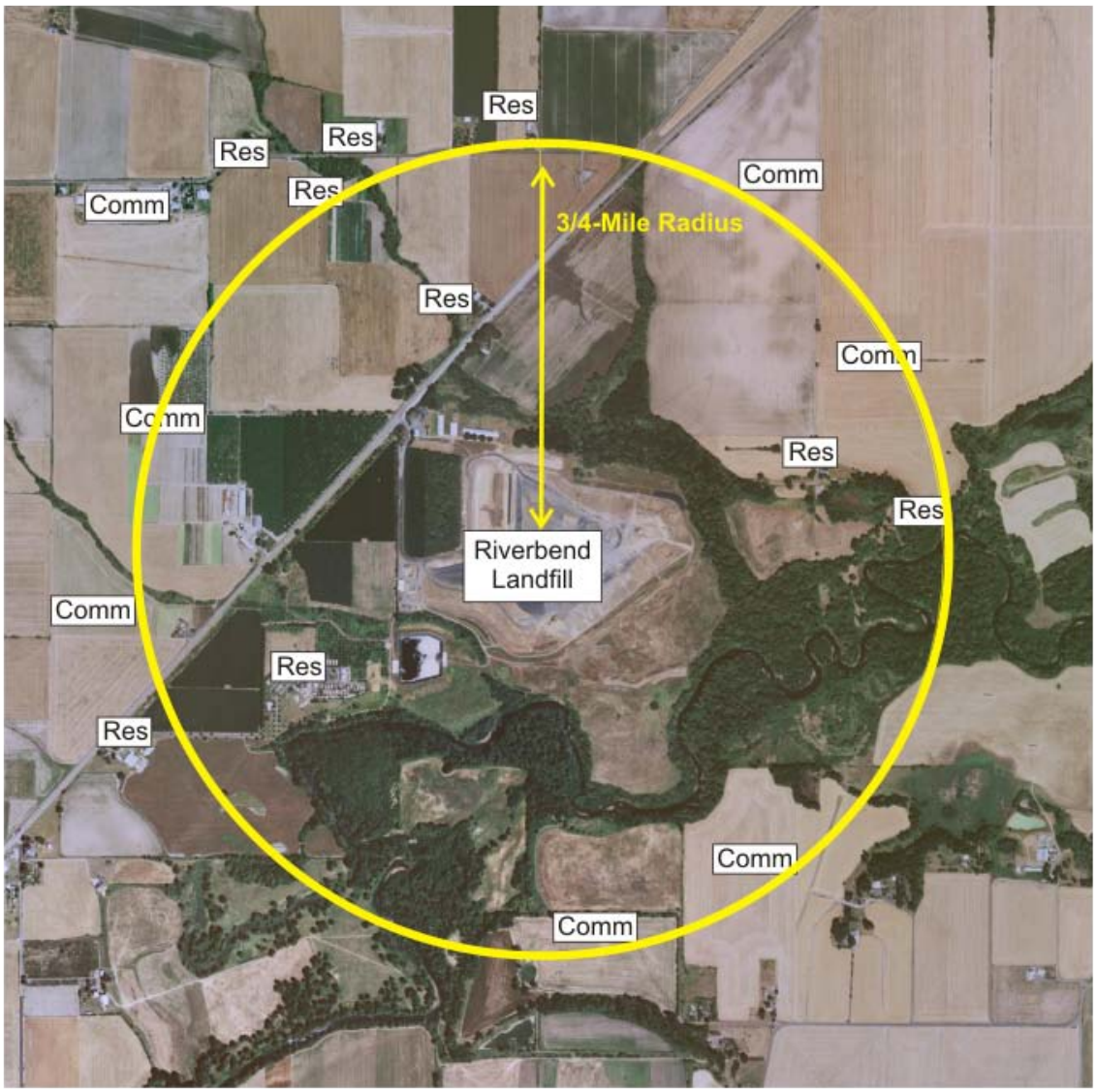
Statistical Descriptor	Existing Noise Source		New Noise Source	
	7am – 10pm	10pm – 7am	7am – 10pm	10pm – 7am
L_{50}	55	50	55	50
L_{10}	60	55	60	55
L_{01}	75	60	75	60

Based on the start year of 1981 for the Riverbend Landfill, the project site would be considered a new industrial noise source because it was commenced after January 1, 1975. The ODEQ also has an ambient degradation criterion that limits the change in ambient noise levels to no more than 10 dBA for the L_{10} and L_{50} statistical descriptors in any one hour.

Analysis Methodology

Noise monitoring was performed at four locations around the Riverbend Landfill. Monitoring was performed between Thursday, August 27, and Tuesday September 1, 2009. The measurements included a Sunday measurement when the site is closed, to establish accurate existing ambient noise levels. The sites were selected to capture a variety of noise coming from the site, including the unloading of large dump trucks, garbage trucks and tractor trailers, noise from trucks climbing the hill to the current landfill area and dozers moving and compacting garbage. Figure 1 is an overview of the landfill site with sensitive land uses within a 3/4-mile radius of the site identified. Figure 2 is a detailed site view with the noise monitoring locations, tipper and nearest residence identified.

All noise measurements were taken in accordance with the American National Standards Institute (ANSI) procedures for community noise measurements. The measurement locations were at least 5 feet from any solid structure to prevent acoustical reflections and at a height of 5 feet of the ground. The equipment used for noise monitoring included a Bruel & Kjaer Type 2260 Sound Level Meter equipped with statistical analysis and sound recording and three Bruel & Kjaer Type 2236 Sound Level Meters. The meters were calibrated prior to, and after the measurement period using a Bruel & Kjaer Type 4231 Sound Level Calibrator. All systems meet or exceed the requirements for an ANSI Type 1 noise measurement system.



Land Use: Res = Residential; Comm = Commercial/Undeveloped/Farm

0 750 1500 3000
1.00 in
Approximate Scale 1 inch to 1500 feet

N

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 1
Project Area Overview & Land Use
Riverbend Landfill

Monitoring Site Descriptions

Site M1 was located near the main activity, and includes measurements of the tipper, a large mechanical device that empties tractor trailers full of garbage. This device has the potential to produce a loud bang when the rear door of the trailer slams shut. A photo of the tipper is shown in Figure 2. Site M2 is located just north of the current operations, slightly down hill, with a clear line-of-sight to the operations. Site M3 was used primarily to obtain truck noise while climbing the hill to the landfill. Site M4 is located approximately 1300 feet to the east of the current landfill operations area, also with a clear line-of-sight to landfill operation.

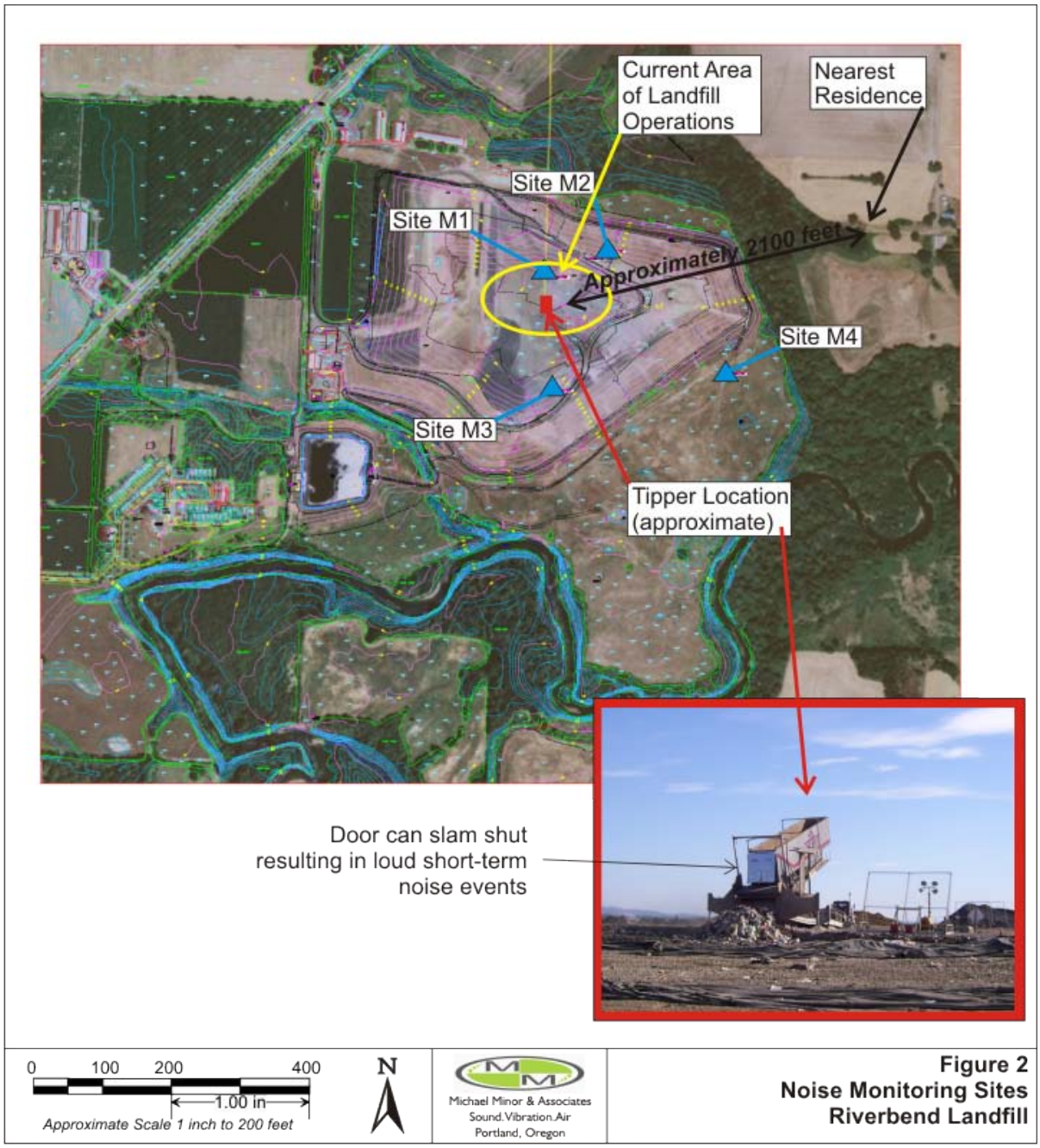


Figure 2
Noise Monitoring Sites
Riverbend Landfill

Noise Monitoring Results

There are several steps that need to be completed in order to accurately assess noise from the landfill operations, including:

1. Establishing accurate existing ambient noise levels;
2. Obtaining accurate reference measurements of the noise producing activities; and
3. Determining the statistical contribution of operational noise and early morning increase in noise levels at the nearby residences.

The existing ambient noise at and near the site was determined from measured data between Saturday, August 29 at 10:00 pm and Monday, August 30, 2009 at 4:00 am. Because the

landfill operates Monday through Saturday, from around 4:30 am until 5:00 pm, the only reasonable time to measure ambient noise levels was on a Sunday or holiday. Therefore, the data measured between 7:00 pm on Saturday evening and 4:00 am Monday morning was used to establish the existing ambient noise levels.

Data from sites M2 and M4 were selected to establish the existing ambient noise levels. Site M2 would provide ambient noise levels for locations that may have some noise from traffic on Highway 18. Site M4, which is well shielded from Highway 18 by the landfill, provides ambient noise levels for locations with shielding from Highway 18, or that are located farther away from the highway. For a baseline reference, hourly L_{eq}, L_{01}, L_{10} and L_{50} were calculated using Bruel & Kjaer Type 7820 Sound Analysis software (BK-7820). Figures 3 and 4 are plots of the measured noise levels at the two sites between 7:00 pm on Saturday evening and 4:00 am Monday morning.

Figure 3: Site M2 Ambient Noise Levels
(Saturday evening through Monday Morning)

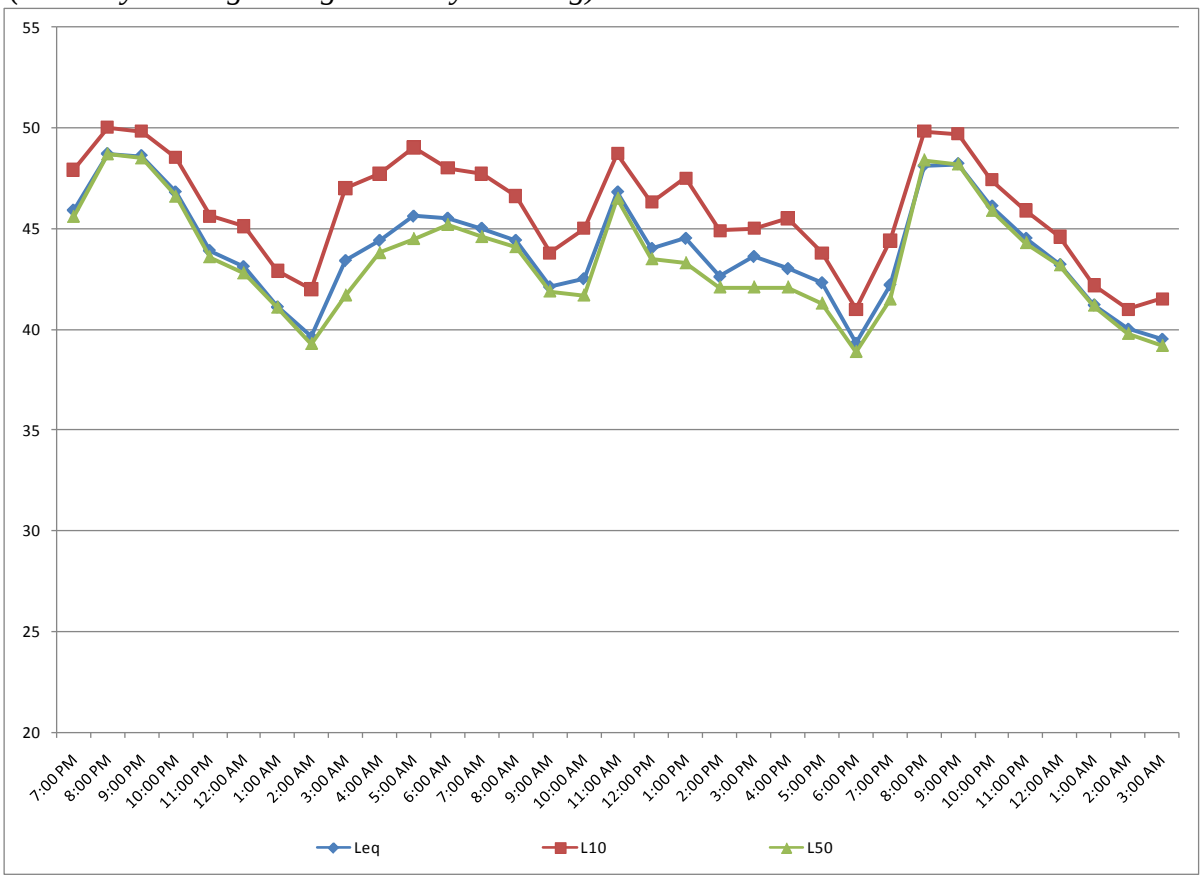


Figure 4: Site M4 Ambient Noise Levels
(Saturday evening through Monday Morning)

The ambient noise levels at site M2 ranged from 40 to 49 dBA L_{eq}, with the statistical L_{10} and L_{50} varying from 41 to 50 dBA (L_{10}) and 40 to 49 dBA (L_{50}). There were some notable peaks around 8:00 pm that are attributed to aircraft flyovers based on audio recordings taken at site M1. Site M4, which is shielded from Highway 18 by the landfill berm, has hourly L_{eq} noise levels ranging from 32 to 48 dBA, with L_{10} levels of 33 to 49 dBA and L_{50} levels of 31 to 48 dBA. Noise levels in this range are typical for a rural undeveloped area that is not near any major highways.

Nighttime Ambient Noise Levels

The main concern for site operation is early morning noise from the initial start-up, which occurs around 4:30 am. Therefore, it was important to extract and examine the early morning noise levels for comparison with the ODEQ regulations. Nighttime hourly energy average noise levels (L_{eq}) ranged from 40 to 47 dBA at Site M2, and 32 to 43 dBA at Site M4. The higher noise levels at Site M2 are due to the closer proximity to Highway 18. Tables 3 and 4 provide a summary of the nighttime ambient noise levels near and at the landfill, including the hourly L_{eq}, L_{01}, L_{10} and L_{50} noise levels all in dBA for Sites M2 and M4 respectively.

Table 3: Site M2 Nighttime Ambient Noise Levels (dBA)				
Start Time	**L_{eq}**	**L_{01}**	**L_{10}**	**L_{50}**
10:00 PM	47	50	49	47
11:00 PM	44	47	46	44
12:00 AM	43	46	45	43
1:00 AM	41	44	43	41
2:00 AM	40	45	42	39
3:00 AM	43	50	47	42
4:00 AM	44	49	48	44
5:00 AM	46	52	49	45
6:00 AM	46	51	48	45
Minimum	**40**	**44**	**42**	**39**
Maximum	**47**	**52**	**49**	**47**

Table 4: Site M4 Nighttime Ambient Noise levels dBA)				
Start Time	**L_{eq}**	**L_{01}**	**L_{10}**	**L_{50}**
10:00 PM	43	45	45	43
11:00 PM	41	43	42	41
12:00 AM	39	42	41	39
1:00 AM	37	39	38	37
2:00 AM	34	37	36	34
3:00 AM	32	35	33	31
4:00 AM	32	37	35	32
5:00 AM	37	41	40	36
6:00 AM	37	42	40	37
Minimum	**32**	**35**	**33**	**31**
Maximum	**43**	**45**	**45**	**43**

At site M2, the L_{10} ranged from 42 to 49 dBA and the L_{50} from 39 to 47 dBA. At site M4, the L_{10} ranged from 33 to 45 dBA and the L_{50} from 31 to 43 dBA. The lower readings at M4 are due to the shielding from Highway 18.

The ODEQ regulations allow any 1-hour period to be used for compliance verification. That is, if an ODEQ standard is exceeded in any 1-hour period, that standard has not been met. Therefore, for the purpose of proper analysis, three operational hours in the morning were compared in order to determine the worst case hour to be used for compliance with the ODEQ regulations. Because landfill activities begin between 4:30 and 4:45 am, the existing ambient noise was predicted for the hours of 3:45 – 4:44 am; 4:45 – 5:44 am; and 5:45 – 6:44 am. This allows for a comparison of the initial morning landfill operations when existing ambient noise levels are lowest. Table 5 provides the $L_{eq,}$ L_{01}, L_{10}, and L_{50} for Site M4 for the hours indicated.

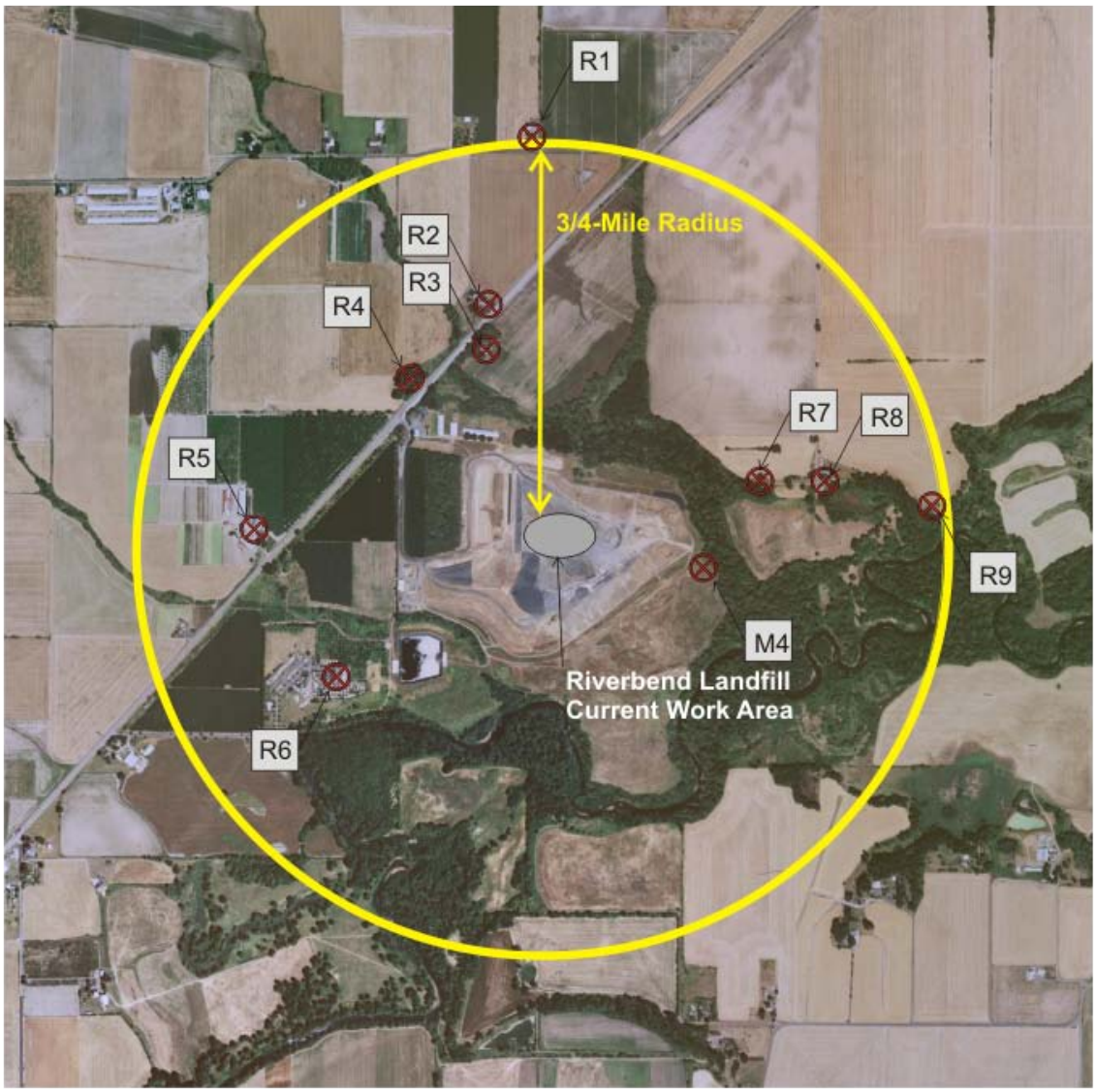
Table 5: Site M4 Nighttime Ambient Noise levels (dBA)				
Start Time	**L_{eq}**	**L_{01}**	**L_{10}**	**L_{50}**
3:45 AM	31	34	33	31
4:45 AM	36	40	39	35
5:45 AM	37	42	40	37
Minimum	**31**	**34**	**33**	**31**
Maximum	**37**	**42**	**40**	**37**

Morning Ambient Noise Levels

The land use surrounding the site was inspected and noise sensitive land uses within ¾ mile were identified. Nine (9) representative noise sensitive properties surrounding the landfill along with monitoring site M4 were selected for a detailed noise analysis. The analysis was performed for start-up noise that occurs early in the morning hours when noise from the landfill would have the most severe effects on residents.

Ambient noise levels for sites along Highway 18 are derived from the Sunday morning ambient noise measurements at Site M2. Three receivers located to the east of the site had the ambient level determined by measured data at site M4, also taken on Sunday morning. The receivers, R1 through R9, are shown in Figure 5 and Table 6 provides a summary of each location and the measured (at M4) and predicted (at R1 through R9) ambient L_{10} and L_{50} noise levels between 3:45 and 6:45 am.

Table 6: Receiver Locations and Extrapolated Ambient Noise Levels								
Rec#[1]	**Site Description**	**Distance (ft)**	**Ambient Noise Levels on Sunday Morning**					
			3:45 – 4:45 am		4:45 – 5:45 am		5:45 – 6:45 am	
			L_{10}	L_{50}	L_{10}	L_{50}	L_{10}	L_{50}
M4	East of landfill	1300	32.9	30.9	38.6	35.2	40.0	36.5
R1	SW Masonville Rd	3950	51.3	47.0	52.3	48.6	54.0	49.5
R2	NW of site on H-18	2380	58.8	54.5	59.8	56.1	61.5	57.0
R3	NW of site on H-18	1960	58.0	53.7	59.0	55.3	60.7	56.2
R4	NW of site on H-18	2090	58.4	54.1	59.4	55.7	61.1	56.6
R5	West of site on H-18	2900	57.9	53.6	58.9	55.2	60.6	56.1
R6	SE of site (RV park)	2560	50.8	46.5	51.8	48.1	53.5	49.0
R7	Two Residences east of site (same property)	2110	32.9	30.9	38.6	35.2	40.0	36.5
R8		2550	32.9	30.9	38.6	35.2	40.0	36.5
R9	East most residence	3650	32.9	30.9	38.6	35.2	40.0	36.5



Land Use: Res = Residential; Comm = Commercial/Undeveloped/Farm

0 750 1500 3000
1.00 in
Approximate Scale 1 inch to 1500 feet

N

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 5
Noise Analysis Locations
Riverbend Landfill

Operational Noise Levels

Noise measurements from monitoring sites M1, M2 and M3 were used to quantify noise from operations at the landfill. Close proximity measurements of the tipper and general landfill operations, including dozer operations, garbage trucks, back-up beepers, and other miscellaneous noise sources were taken at Sites M1 and M2. Pass-by measurements of off-road dump trucks were taken at Site M3, which was on an uphill grade to the top of the landfill. Measurement data from site M4 was used to establish noise propagation characteristics of the equipment and to establish ambient levels based on a Sunday morning measurement.

Riverbend landfill uses equipment typically found at landfill sites. This includes heavy use of a landfill dozer, off-road trucks, garbage trucks, a tipper and other miscellaneous supporting equipment. The major noise producing equipment would be the dozer, off-road trucks, and the gates on garbage trucks slamming when on the tipper. A summary of the equipment used at the landfill, typical usage and noise levels at 50 feet are provided in Table 7.

Table 7. Landfill Equipment List with Site Usage and Typical Noise Levels

Equipment Type	Model	Usage	Typical Maximum Noise Level at 50 ft.
Dozer	D8N	Fairly consistently during operational hours	88 - 94 dBA @ 50 ft
Dozer	D6H	Spare – normally only used if the D8N is in service	88 - 92 dBA @ 50 ft
Dozer	D7	Rarely	88 - 92 dBA @ 50 ft
Off Road Haul Truck	Volvo A-25	Some daytime hauling	86 dBA @ 35 mph
Off Road Haul Truck	Volvo A-35	Some daytime hauling	86 dBA @ 35 mph
Hydraulic Excavator	Cat 325	Rarely	
Waste Compactor	Cat 836G	Fairly consistently during operational hours	88 - 92 dBA @ 50 ft
Waste Compactor	Cat 826C	Spare	88 - 92 dBA @ 50 ft
Tipper	Columbia	Fairly consistently during operational hours	Worst case banging levels of 86 to 95 dBA

ODEQ Noise Level Analysis

An early morning analysis of site M4 was performed using the ODEQ ambient increase criteria. Site M4 is approximately 1300 feet east of current landfill operations. The measured ambient L_{10} and L_{50} from Sunday morning was compared to normal operational noise levels for a typical Friday, Saturday, Monday and Tuesday morning startup. In addition, this site was also used as a reference site for ambient noise levels for locations that are well shielded from Highway 18.

Hourly L_{10} and L_{50} noise levels for normal operations on Friday, Saturday, Monday and Tuesday, August 28, 29 and September 1 and 2 were calculated using BK-7820 software. The results were compared to the ambient noise levels in Table 6. The results of the analysis are provided in Table 8.

The analysis shows that at 1300 feet from the active landfill site, there are no increases of the ambient L_{10} or L_{50} over the ODEQ 10.0 dBA criteria, and therefore the site is within the ODEQ ambient increase criteria. During operational hours, the maximum increase over the Sunday ambient was 6 dBA for the L_{10} on Tuesday morning. For those hours where the operational noise levels from the landfill are equal to or lower than the ambient noise levels measured on Sunday morning, the site change in noise levels is noted as “No Change.”

Table 8: ODEQ Noise Analysis at Site M4

Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	38.3	34.8	5.4	3.9
4:45 AM	38.6	35.2	42.0	36.9	3.4	1.7
5:45 AM	40.0	36.5	40.0	36.3	No Change	No Change
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	32.9	31.0	No Change	0.1
4:45 AM	38.6	35.2	34.3	30.8	No Change	No Change
5:45 AM	40.0	36.5	40.0	35.0	No Change	No Change
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	41.7	37.9	8.8	7.0
4:45 AM	38.6	35.2	41.9	39.4	3.3	4.2
5:45 AM	40.0	36.5	41.8	39.4	1.8	2.9
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	37.6	34.7	4.7	3.8
4:45 AM	38.6	35.2	44.6	36.4	6.0	1.2
5:45 AM	40.0	36.5	42.5	32.0	2.5	No Change

Nearby Residential Sites

In addition to performing the ODEQ analysis at site M4, ODEQ ambient noise level analysis was also performed for the 9 representative residential properties within ¾ mile of the landfill. Site R1 is directly north of the site along SW Masonville Rd, approximately 750 feet from Highway 18. At no time was the noise from the landfill predicted to meet, or exceed the existing ambient noise levels in this area. Noise levels at this residence would be dominated by traffic along Highway 18. It is important to note that the ambient data was collected at a time when there is typically less traffic on the highway, and therefore the ambient noise levels would be lower than what would be expected on weekdays or Saturday. The results of the analysis for R1 are provided in Table 9.

Receivers R2 through R5 are all single family residences located along highway 18, within 135 and 165 feet of the near lanes. As with receiver R1, the dominant noise source at all four of these locations is traffic noise from Highway 18. There were no exceedances of the ODEQ ambient criteria, and all noise from the landfill is predicted to be below the existing ambient at all four residences. Tables 10 through 13 provide the results for Receivers R2 through R5.

Receiver R6 is a recreational vehicle park located on landfill property. The site is approximately 2500 feet from current operations. Noise from landfill operations at the RV park are predicted to be below the existing ambient noise levels. The results of the ODEQ analysis for Receiver R6 are provided in Table 14.

Sites R7 through R9 are located to the east of the landfill, with substantial distance and physical shielding from traffic noise on Highway 18. These are the only locations where the operations of the landfill were predicted to exceed the existing ambient noise levels. At receiver R7, the existing ambient L_{10} was exceeded by 0.2 to 3.7 dBA during landfill operations, and the L_{50} was exceeded twice, once by 1.9 dBA, and once by 0.6 dBA. Landfill noise levels were also predicted to exceed the existing L_{10} ambient at R8 and R9 by levels of less than 3 dBA. None of the noise readings meet, or exceed the 10 dBA ODEQ criteria. Data for Receivers R7 through R9 are provided in Tables 15 through 17.

Table 9: ODEQ Noise Analysis for R1

Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	51.3	47.0	44.3	29.8	No Change	No Change
4:45 AM	52.3	48.6	47.9	37.3	No Change	No Change
5:45 AM	54.0	49.5	49.6	43.3	No Change	No Change
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	51.3	47.0	29.7	26.9	No Change	No Change
4:45 AM	52.3	48.6	31.8	28.7	No Change	No Change
5:45 AM	54.0	49.5	34.1	32.6	No Change	No Change
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	51.3	47.0	36.6	29.1	No Change	No Change
4:45 AM	52.3	48.6	43.6	40.1	No Change	No Change
5:45 AM	54.0	49.5	44.3	40.8	No Change	No Change
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	51.3	47.0	34.8	28.6	No Change	No Change
4:45 AM	52.3	48.6	36.9	33.3	No Change	No Change
5:45 AM	54.0	49.5	42.9	35.5	No Change	No Change

Table 10: ODEQ Noise Analysis for R2

Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.8	54.5	46.5	32.0	No Change	No Change
4:45 AM	59.8	56.1	50.1	39.5	No Change	No Change
5:45 AM	61.5	57.0	51.8	45.5	No Change	No Change
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.8	54.5	31.9	29.1	No Change	No Change
4:45 AM	59.8	56.1	34.0	30.9	No Change	No Change
5:45 AM	61.5	57.0	36.3	34.8	No Change	No Change
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.8	54.5	38.8	31.3	No Change	No Change
4:45 AM	59.8	56.1	45.8	42.3	No Change	No Change
5:45 AM	61.5	57.0	46.5	43.0	No Change	No Change
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.8	54.5	37.0	30.8	No Change	No Change
4:45 AM	59.8	56.1	39.1	35.5	No Change	No Change
5:45 AM	61.5	57.0	45.1	37.7	No Change	No Change

Table 11: ODEQ Noise Analysis for R3

Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.0	53.7	47.3	32.8	No Change	No Change
4:45 AM	59.0	55.3	50.9	40.3	No Change	No Change
5:45 AM	60.7	56.2	52.6	46.3	No Change	No Change
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.0	53.7	32.7	29.9	No Change	No Change
4:45 AM	59.0	55.3	34.8	31.7	No Change	No Change
5:45 AM	60.7	56.2	37.1	35.6	No Change	No Change
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.0	53.7	39.6	32.1	No Change	No Change
4:45 AM	59.0	55.3	46.6	43.1	No Change	No Change
5:45 AM	60.7	56.2	47.3	43.8	No Change	No Change
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	51.3	47.0	34.8	28.6	No Change	No Change
4:45 AM	52.3	48.6	36.9	33.3	No Change	No Change
5:45 AM	54.0	49.5	42.9	35.5	No Change	No Change

Table12: ODEQ Noise Analysis for R4

Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.4	54.1	47.1	32.6	No Change	No Change
4:45 AM	59.4	55.7	50.7	40.1	No Change	No Change
5:45 AM	61.1	56.6	52.4	46.1	No Change	No Change
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.4	54.1	32.5	29.7	No Change	No Change
4:45 AM	59.4	55.7	34.6	31.5	No Change	No Change
5:45 AM	61.1	56.6	36.9	35.4	No Change	No Change
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.4	54.1	39.4	31.9	No Change	No Change
4:45 AM	59.4	55.7	46.4	42.9	No Change	No Change
5:45 AM	61.1	56.6	47.1	43.6	No Change	No Change
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	58.4	54.1	37.6	31.4	No Change	No Change
4:45 AM	59.4	55.7	39.7	36.1	No Change	No Change
5:45 AM	61.1	56.6	45.7	38.3	No Change	No Change

Table 13: ODEQ Noise Analysis for R5

Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	57.9	53.6	45.6	31.1	No Change	No Change
4:45 AM	58.9	55.2	49.2	38.6	No Change	No Change
5:45 AM	60.6	56.1	50.9	44.6	No Change	No Change
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	57.9	53.6	31.0	28.2	No Change	No Change
4:45 AM	58.9	55.2	33.1	30.0	No Change	No Change
5:45 AM	60.6	56.1	35.4	33.9	No Change	No Change
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	57.9	53.6	37.9	30.4	No Change	No Change
4:45 AM	58.9	55.2	44.9	41.4	No Change	No Change
5:45 AM	60.6	56.1	45.6	42.1	No Change	No Change
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	57.9	53.6	36.1	29.9	No Change	No Change
4:45 AM	58.9	55.2	38.2	34.6	No Change	No Change
5:45 AM	60.6	56.1	44.2	36.8	No Change	No Change

Table 14: ODEQ Noise Analysis for R6

Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	50.8	46.5	49.8	39.2	No Change	No Change
4:45 AM	51.8	48.1	51.5	45.2	No Change	No Change
5:45 AM	53.5	49.0	51.5	45.2	No Change	No Change
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	50.8	46.5	33.7	30.6	No Change	No Change
4:45 AM	51.8	48.1	36.0	34.5	No Change	No Change
5:45 AM	53.5	49.0	36.0	34.5	No Change	No Change
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	50.8	46.5	45.5	42.0	No Change	No Change
4:45 AM	51.8	48.1	46.2	42.7	No Change	No Change
5:45 AM	53.5	49.0	46.2	42.7	No Change	No Change
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	50.8	46.5	38.8	35.2	No Change	No Change
4:45 AM	51.8	48.1	44.8	37.4	No Change	No Change
5:45 AM	53.5	49.0	44.8	37.4	No Change	No Change

Table 15: ODEQ Noise Analysis for R7

Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	36.0	32.5	3.1	1.6
4:45 AM	38.6	35.2	39.7	34.6	1.1	No Change
5:45 AM	40.0	36.5	37.7	34.0	No Change	No Change
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	30.6	28.7	No Change	No Change
4:45 AM	38.6	35.2	32.0	28.5	No Change	No Change
5:45 AM	40.0	36.5	37.7	32.7	No Change	No Change
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	39.4	35.6	6.5	4.7
4:45 AM	38.6	35.2	39.6	37.1	1.0	1.9
5:45 AM	40.0	36.5	39.5	37.1	No Change	0.6
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	35.3	32.4	2.4	1.5
4:45 AM	38.6	35.2	42.3	34.1	3.7	No Change
5:45 AM	40.0	36.5	40.2	29.7	0.2	No Change

Table 16: ODEQ Noise Analysis for R8

Friday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	35.2	31.7	2.3	0.8
4:45 AM	38.6	35.2	38.9	33.8	0.3	No Change
5:45 AM	40.0	36.5	36.9	33.2	No Change	No Change
Saturday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	29.8	27.9	No Change	No Change
4:45 AM	38.6	35.2	31.2	27.7	No Change	No Change
5:45 AM	40.0	36.5	36.9	31.9	No Change	No Change
Monday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	38.6	34.8	5.7	3.9
4:45 AM	38.6	35.2	38.8	36.3	0.2	1.1
5:45 AM	40.0	36.5	38.7	36.3	No Change	No Change
Tuesday						
One-Hour Start Time	**Sunday Ambient (dBA)**		**Operational Levels (dBA)**		**Change**	
	L_{10}	**L_{50}**	**L_{10}**	**L_{50}**	**L_{10}**	**L_{50}**
3:45 AM	32.9	30.9	34.5	31.6	1.6	0.7
4:45 AM	38.6	35.2	41.5	33.3	2.9	No Change
5:45 AM	40.0	36.5	39.4	28.9	No Change	No Change

Table 17: ODEQ Noise Analysis for R9

One-Hour Start Time	Sunday Ambient (dBA)		Operational Levels (dBA)		Change	
	L_{10}	L_{50}	L_{10}	L_{50}	L_{10}	L_{50}
Friday						
3:45 AM	32.9	30.9	33.7	30.2	0.8	No Change
4:45 AM	38.6	35.2	37.4	32.3	No Change	No Change
5:45 AM	40.0	36.5	35.4	31.7	No Change	No Change
Saturday						
3:45 AM	32.9	30.9	28.3	26.4	No Change	No Change
4:45 AM	38.6	35.2	29.7	26.2	No Change	No Change
5:45 AM	40.0	36.5	35.4	30.4	No Change	No Change
Monday						
3:45 AM	32.9	30.9	37.1	33.3	4.2	2.4
4:45 AM	38.6	35.2	37.3	34.8	No Change	No Change
5:45 AM	40.0	36.5	37.2	34.8	No Change	No Change
Tuesday						
3:45 AM	32.9	30.9	33.0	30.1	0.1	No Change
4:45 AM	38.6	35.2	40.0	31.8	1.4	No Change
5:45 AM	40.0	36.5	37.9	27.4	No Change	No Change

Conclusion

Noise monitoring was performed over a four day period, including two weekend days, and was used to establish noise levels related to general landfill operations. Pass-by measurements of off-road trucks and other garbage related delivery vehicles were also performed. Sound level measurements taken on Sunday morning, when the site was closed, were used to establish the ambient noise levels at, and around the site. Ambient sound levels measured on Sunday morning are likely lower than early morning ambient sound levels would be during a typical weekday or Saturday due to reduced traffic on Sunday mornings. The measured noise levels were used to predict noise levels at noise sensitive properties near the site and verify compliance with Oregon Department of Environmental Quality (ODEQ) noise criteria. The analysis was performed for nine representative residential properties within ¾ mile of the landfill.

Noise from landfill operations was predicted to be below the existing ambient noise levels for all noise sensitive properties west, south and north of the site due to noise from Highway 18. There are three residences east of the landfill where operational noise levels sometimes exceed existing ambient noise levels, however, the maximum noise level only exceeded the existing ambient by approximately 4 dBA, which is well below the 10 dBA ODEQ criteria. There are no noise sensitive properties that currently meet or exceed the ODEQ criteria.

ATTACHMENT 8

Traffic Impact Study
(Prepared by Lancaster Engineering)

RIVERBEND LANDFILL
ZONE CHANGE
TRAFFIC IMPACT STUDY

YAMHILL COUNTY, OREGON

DATE:
August 30, 2013

PREPARED FOR:
Frank Willmann
Waste Management

PREPARED BY:
William Farley, EI
Todd Mobley, PE, PTOE

REGISTERED PROFESSIONAL ENGINEER
54853
OREGON
JULY 9, 2001
TODD E. MOBLEY
8/30/13
EXPIRES: 12/31/2014

LANCASTER ENGINEERING
321 SW 4th Ave., Suite 400 | Portland, OR 97204 | 503.248.0313 | lancasterengineering.com

TABLE OF CONTENTS

Executive Summary 3

Project Description
- Introduction 4
- Location Description 4
- Traffic Counts 5

Trip Generation & Distribution
- Trip Generation 8
- Trip Distribution 9

Operational Analysis
- Background Traffic 11
- Capacity Analysis 14
- Roadway and Route Impacts 15
- Transporation Planning Rule 15
- Transportation System Plan 16

Safety Analysis
- Crash Data Analysis 17

Conclusions 18

Appendix 19

EXECUTIVE SUMMARY

1. The property adjacent to the Riverbend Landfill, located at 13469 Oregon 18 in McMinnville, Oregon, has been proposed for a change in zoning from Public Works/Safety to Exclusive Farm Use. Following the zone change, Riverbend Landfill is proposing a lateral expansion to the landfill as well as the construction of a green technology facility.

2. Due to the location of the subject property and the limited amount of permitted uses within the Exclusive Farm Use zoning, it is not expected that the property be developed with a more intensive use than what is currently being proposed.

3. The intersection of Oregon Highway 18 at the site access is projected to function well within the Oregon Department of Transportation's performance standards throughout the planning horizon regardless of the additional trips that result from the proposed zone change and subsequent lateral expansion and development of the green technology facility. Accordingly, no mitigation is recommended.

4. The proposed development under the new zoning will not significantly affect existing or planned transportation facilities as defined under Oregon's Transportation Planning Rule (TPR). Accordingly, no mitigation is recommended and the TPR is satisfied.

5. A detailed observation into the crashes occurring at the study intersection shows no excessive crash rates or trends that are indicative of issues that need to be addressed. The site access to Highway 18 already has left and right-turn lanes in place and no safety mitigations are recommended.

PROJECT DESCRIPTION

INTRODUCTION

This traffic study analyzes and addresses the potential traffic impacts of a proposed zone change and lateral expansion of the Riverbend Landfill in Yamhill County, Oregon.

The Riverbend Landfill, located at 13469 Oregon 18 in McMinnville, Oregon, is proposing a lateral expansion to the west as well as the construction of a new green technology facility. To receive approval for this expansion, a zone change from Public Works/Safety to Exclusive Farm Use is required. Detailed information on traffic counts, trip generation calculations, and intersection capacity calculations are included in the technical appendix of this report.

LOCATION DESCRIPTION

The Riverbend Landfill is located approximately two miles southwest of McMinnville, Oregon. The property is bounded by Oregon Highway 18 to the northwest, agricultural land to the north, and the Yamhill River to the east and south.

The landfill operation only has one access to Oregon Highway 18 located at milepost 41.56. There are two other accesses that currently serve other existing uses on the site. The first is a small driveway that serves a single-family home. The second is a driveway near the southern boundary of the site that serves the Mulkey RV Park. None of the activities associated with the operation of the landfill will add traffic to these two additional accesses.

Due to the largely rural location of the site, no major street intersections are present near the subject property that would require analysis of site impacts. Projected traffic impacts during the weekday morning and evening peak hours as well as the Saturday peak were analyzed for the intersection of the landfill access and Oregon Highway 18.

Oregon Highway 18, also designated as Salmon River Highway, is under the jurisdiction of the Oregon Department of Transportation (ODOT) and is classified as a Statewide Highway Route. The highway is on the National Highway System and is designated as a State Freight Route, a Truck Route, as well as an Expressway. It is generally a two-lane roadway with a statutory rural highway speed limit of 55 mph. The facility has wide paved shoulders in the vicinity of the subject property.

The intersection of Oregon Highway 18 at the site access is a three-legged intersection controlled by a STOP sign on the access approach. The southwest bound approach has a through lane and a dedicated left-turn lane, whereas the northbound approach has a through lane and a dedicated right-turn lane. The site access has a shared lane for all turning movements, but is wide enough to accommodate a right and left-turning vehicle simultaneously.

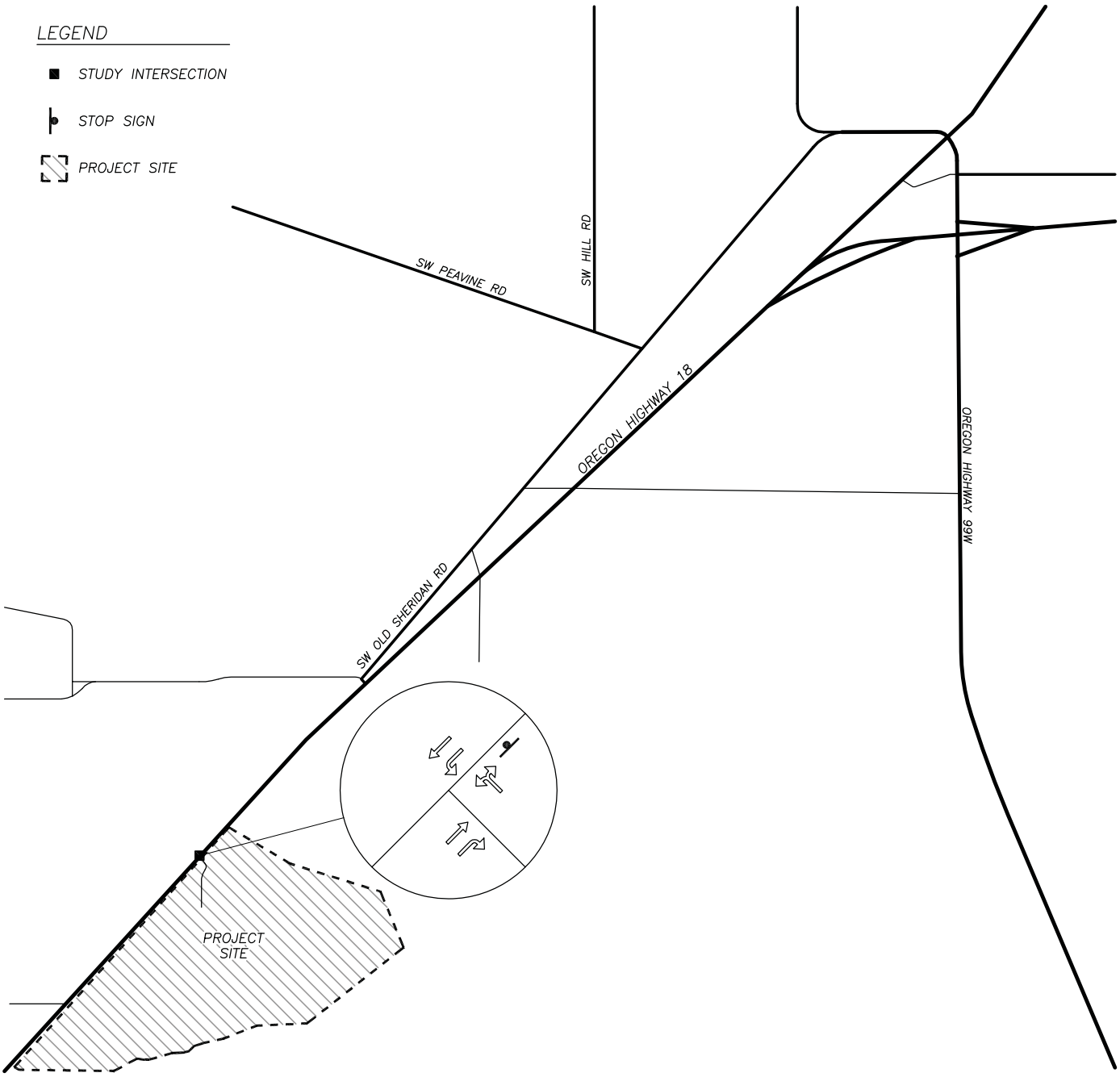
A vicinity map showing the project site, the study area intersection, and the traffic control device is shown in Figure 1 on page six.

TRAFFIC COUNTS

Traffic counts were conducted at the intersection of Oregon Highway 18 and the property access on Thursday, July 11th, 2013, from 5:00 AM to 5:00 PM and on Saturday, July 13th, 2013, from 6:00 AM to 4:00 PM. The times observed corresponded with the operating hours of the Riverbend Landfill. Using these counts, the morning peak hour was found to occur from 7:00 AM to 8:00 AM and the evening peak hour was found to occur from 4:00 PM to 5:00 PM.

Design volumes for ODOT facilities are based on the 30th highest hour conditions, which typically occur during the summer months. Following the procedure given by ODOT's Analysis Procedures Manual, a seasonal adjustment factor was calculated to apply to the counts. ODOT has an Automatic Traffic Recorder (ATR) located at milepost 41.0 along Oregon Highway 18. Using data from this recorder, a seasonal adjustment factor of 1.00 was derived for the weekday traffic count while a seasonal adjustment factor of 1.015 was derived for the Saturday traffic count.

Figure 2 on page seven shows the seasonally adjusted traffic volumes at the study area intersection.

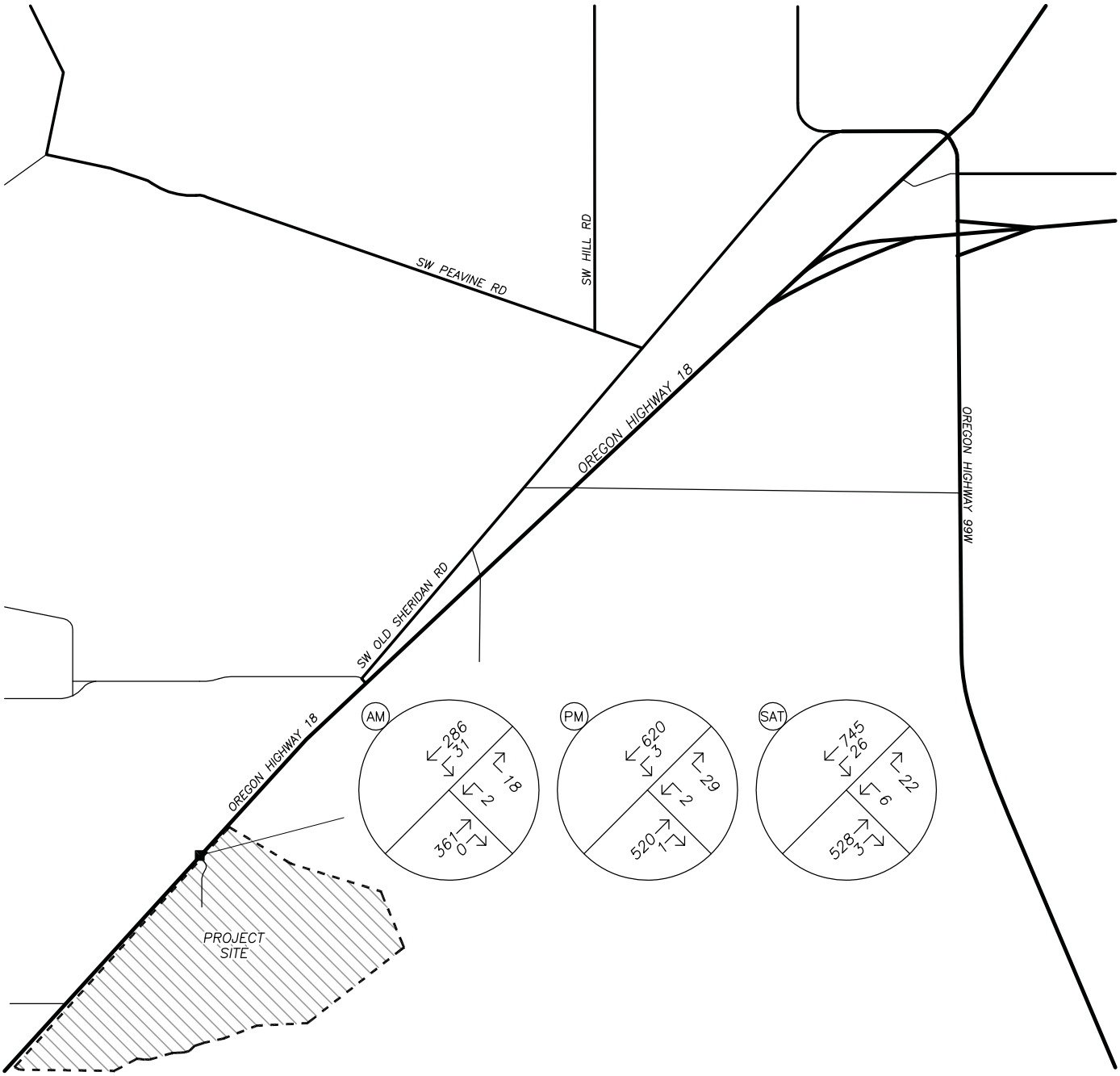


VICINITY MAP

no scale

FIGURE 1

PAGE 6



TRAFFIC VOLUMES
Existing Conditions – Seasonally Adjusted
AM, PM, & Saturday Peak Hours

no scale

FIGURE 2

PAGE 7

TRIP GENERATION & DISTRIBUTION

TRIP GENERATION

The proposed zone change from Public Works/Safety to Exclusive Farm Use affects the 57.5 acre property between the existing location of the Riverbend Landfill and Oregon Highway 18. The property will accommodate the lateral expansion of the landfill directly west of the current location as well as a green technology facility to the southwest.

To observe the effects of the zone change, a reasonable worst-case assumption is made for what development could occupy the property. Due to the location of the subject property and the limited amount of permitted uses within an Exclusive Farm Use district, it is not expected that the property be developed with a more intensive use than what is currently proposed.

The traffic impacts of the landfill and new green technology facility were observed throughout the planning horizon. It should be noted that Waste Management is planning for a flat disposal rate throughout the life of the landfill and is not expecting any increase in traffic to the site. Additional trips beyond this disposal rate would be diverted to other sites. However, to maintain a conservative analysis, annual increases in traffic corresponding with population growth were accounted for in the trip generation calculations.

To account for the increase in traffic using the landfill over the planning horizon, a growth factor was applied to the number of current vehicles using the facility. Since the landfill's trip generation is based on population and the resulting waste stream to the landfill, the growth factor was derived using forecasted traffic volumes along Oregon Highway 18 in front of the site. Due to the landfill only having one access and being the only destination reachable through that access, the growth rate was applied to the traffic counts for vehicles entering and exiting the landfill.

To account for the new green technology facility, information regarding the expected operation of the facility was used to derive a trip generation. The green technology facility will divert a portion of the waste stream and convert that waste into a solid product that can be combusted and used as an alternative energy source. The new facility will be operated by approximately 35 employees split into two shifts per day, seven days a week. The facility will also utilize trucks delivering waste to the landfill to back-haul and transport products from the new facility to the next destination. To maintain a conservative, worst-case analysis, it is assumed that the green technology facility would change shifts during each of the peak hours and that 100 percent of the product produced would be shipped out as new truck loads, with no back-hauling by existing trucks.

As discussed in this report, the existing Mulkey RV Park will be closing. Removal of these trips from Highway 18 will result in a net increase in trips that is slightly lower than what is reported here. A summary of the trip generation calculations for each of the landfill facilities is shown in the tables on the following page. Detailed trip generation calculations are included in the appendix to this report.

Weekday Trip Generation Summary

	Morning Peak Hour			Evening Peak Hour			Weekday
	In	Out	Total	In	Out	Total	Total
Landfill							
Increase w/ Population	9	6	15	1	10	11	172
Green Technology Facility							
Employees	18	17	35	17	18	35	70
Product Shipment	2	1	3	1	1	2	56
Net Trip Increase	29	24	53	19	29	48	298

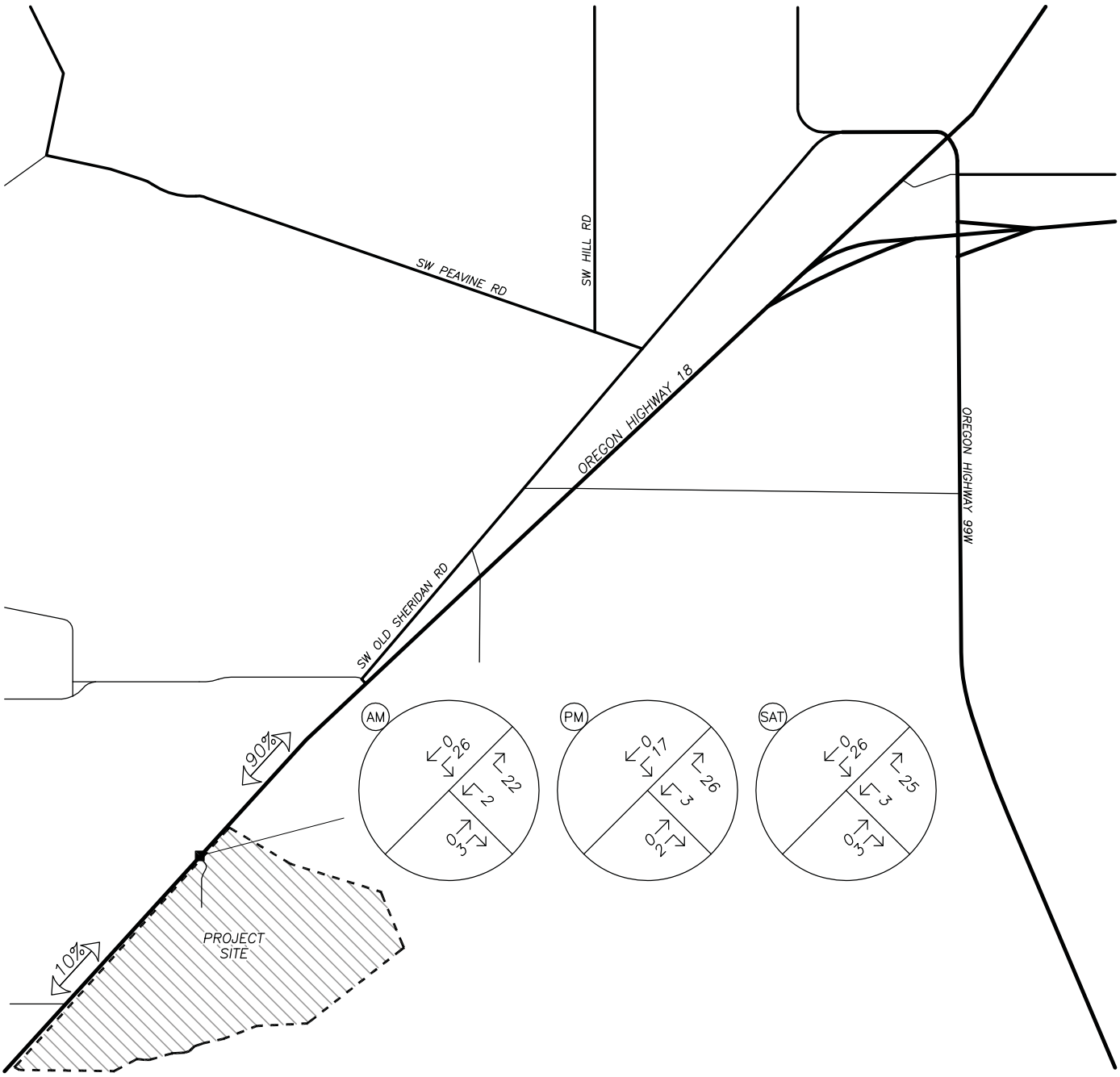
Saturday Trip Generation Summary

	Saturday Peak Hour			Saturday
	In	Out	Total	Total
Landfill				
Increase w/ Population	9	9	18	124
Green Technology Facility				
Employees	18	17	35	70
Product Shipment	2	2	4	56
Net Trip Increase	29	28	57	250

TRIP DISTRIBUTION

The trips generated by the Riverbend Landfill expansion were assumed to be distributed proportionately to the traffic currently entering and exiting the facility. This resulted in approximately a 90-percent distribution of traffic originating and terminating from the northeast of the subject property. Traffic for the green technology facility was assumed to follow a similar distribution with the majority arriving and departing northeast along Oregon Highway 18.

The trip assignment for the projected lateral expansion and construction of the green technology facility is shown in Figure 3 on page 10.



Net Total Increase			
	IN	OUT	TOTAL
AM	29	24	53
PM	19	29	48
SAT	29	28	57

SITE TRIP DISTRIBUTION & ASSIGNMENT
Proposed Development Plan
AM, PM, & Saturday Peak Hours

no scale

FIGURE 3

PAGE 10

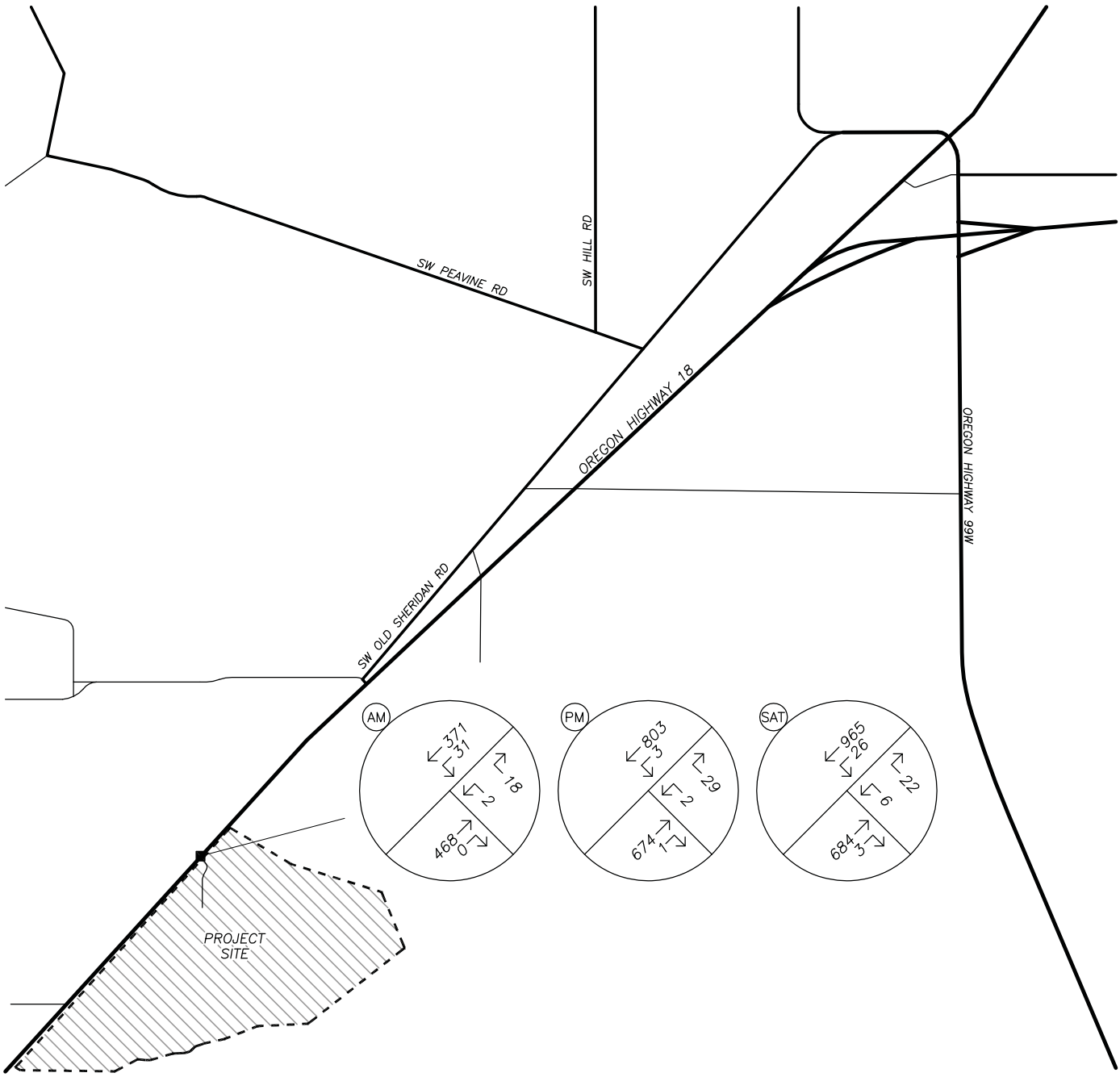
OPERATIONAL ANALYSIS

BACKGROUND TRAFFIC

To provide analysis of the impact of the proposed zone change on the nearby transportation facilities, an estimation of future traffic volumes is required. In order to calculate the future traffic volumes, a growth rate must be applied to existing traffic volumes.

Historical annual average daily traffic (ADT) on Oregon Highway 18 at milepost 41.0 peaked in 2006 with about 14,300 ADT but has decreased over the next years to about 13,100 ADT in 2011. The highway experience a seasonal fluctuation in traffic flow since it is a primary route to the Oregon coast. The peak traffic month is August with traffic volumes 18% higher than the average of all months.

Future traffic volumes were projected in conformance with the requirements established in ODOT's Analysis Procedures Manual. Based on data from ODOT's Future Volumes Table, a growth rate of 1.7 percent per year was derived for Oregon Highway 18 at the location of the ATR. This growth rate was applied to the traffic on Oregon Highway 18 over the 17-year period to observe traffic at the 2030 planning horizon. Figure 4 on page 12 shows the projected year 2030 traffic volumes. Figure 5 on page 13 shows the projected year 2030 traffic volumes plus traffic generated by the landfill's lateral expansion and the construction of the green technology facility.



TRAFFIC VOLUMES
Year 2030 Background Conditions
AM, PM, & Saturday Peak Hours

no scale

FIGURE 4

PAGE 12

TRAFFIC VOLUMES
Year 2030 Background Plus Site Trips
AM, PM, & Saturday Peak Hours

no scale

FIGURE 5

PAGE 13

CAPACITY ANALYSIS

To determine the level of service at the study intersection, a capacity analysis was conducted. Since Oregon Highway 18 is under ODOT jurisdiction, their performance standards based on a volume-to-capacity (v/c) ratio were used for evaluation. The v/c ratio is a measure that compares the traffic volume (demand) against the available capacity of an intersection. According to the Oregon Highway Plan Mobility Standard Guidelines, a v/c ratio of 0.70 or less is required for intersections outside of an Urban Growth Boundary in rural areas.

The study area intersection was analyzed using the unsignalized intersection analysis method in the *HIGHWAY CAPACITY MANUAL*, published by the Transportation Research Board. The analysis was made for the morning, evening, and Saturday peak hours for existing conditions, year 2030 background conditions, and year 2030 background plus site trips from the proposed development.

Currently, the intersection of Oregon Highway 18 at the site access operates at a v/c ratio of 0.04 during the morning peak hour and a v/c ratio of 0.07 during the evening peak hour. During the Saturday mid-day peak period, the intersection presently operates at a v/c ratio of 0.09. Under year 2030 conditions, the intersection is projected to operate at a v/c ratio of 0.05 during the morning peak hour, 0.09 during the evening peak hour, and 0.13 during the Saturday peak hour. With the lateral expansion of the Riverbend Landfill and the construction of the green technology building, the intersection is projected to operate at a v/c ratio of 0.12 during the morning peak hour, 0.19 during the evening peak hour, and 0.25 during the Saturday peak hour. It should be noted that it was assumed all product being shipped from the green technology building would do so on trucks that arrive and depart solely for that purpose, when in reality the facility is expected to ship product on trucks that have already delivered waste to the landfill.

The intersection of Oregon Highway 18 at the site access operates well within ODOT's performance standards throughout the planning horizon. Accordingly, no mitigation is recommended.

The results of the capacity analysis, along with the levels of service, delay, and v/c ratios are shown in the following two tables. Detailed calculations, as well as tables showing the relationships between delay and level of service are included in the appendix to this report.

WEEKDAY CAPACITY ANALYSIS SUMMARY

	AM			PM		
	LOS	Delay (s)	v / c	LOS	Delay (s)	v / c
Oregon Highway 18 at Site Access						
Existing	B	13	0.04	B	13	0.07
2030 Background Conditions	B	15	0.05	C	16	0.09
2030 Background plus Site	C	15	0.12	C	19	0.19

SATURDAY CAPACITY ANALYSIS SUMMARY			
	Saturday		
	LOS	Delay (s)	v / c
Oregon Highway 18 at Site Access			
Existing	C	17	0.09
2030 Background Conditions	C	24	0.13
2030 Background plus Site	D	25	0.25

ROADWAY AND ROUTE IMPACTS

Traffic utilizing the Riverbend Landfill site is pulled from a greater area than just the nearby city of McMinnville or even Yamhill County. Truck traffic transports waste regularly from a Forest Grove transfer site to the Riverbend Landfill by way of Oregon Highway 47. Generally, between 17 and 20 trucks make this round trip per day. This traffic is spread out between the hours of 5:00 AM to 4:00 PM and is not projected to increase with the lateral expansion of the landfill or the construction of the green technology facility.

With the expansion of the Riverbend Landfill facility, the nearby Mulkey RV Park will be closed and the area will be used for operations pertaining to the landfill. The approximately 65-unit recreational vehicle park operates between 40% and 90% of capacity through the typical year. The park will be closed as part of activity on the site following the subject zone change. Based on the occupancy of the park, it currently generates between 5 and 12 AM peak hour trips and between 7 and 16 PM peak hour trips. These trips will be removed from Highway 18 upon closure of the park. Supporting trip generation calculations are included in the appendix to this report.

TRANSPORTATION PLANNING RULE

Oregon's Transportation Planning Rule (TPR) is in place to ensure that the transportation system is capable of supporting possible increases in traffic intensity that could result from changes to adopted plans and land use regulations. The applicable elements of the TPR are each quoted directly in *italics* below, with a response directly following.

660-012-0060

(1) If an amendment to a functional plan, an acknowledged comprehensive plan, or a land use regulation (including a zoning map) would significantly affect an existing or planned transportation facility, then the local government must put in place measures as provided in section (2) of this rule, unless the amendment is allowed under section (3), (9) or (10) of this rule. A plan or land use regulation amendment significantly affects a transportation facility if it would:

(a) Change the functional classification of an existing or planned transportation facility (exclusive of correction of map errors in an adopted plan);

(b) Change standards implementing a functional classification system; or

(c) Result in any of the effects listed in paragraphs (A) through (C) of this subsection based on projected conditions measured at the end of the planning period identified in the adopted TSP. As part of evaluating projected conditions, the amount of traffic projected to be generated within the area of the amendment may be reduced if the amendment includes an enforceable, ongoing requirement that would demonstrably limit traffic generation, including, but not limited to, transportation demand management. This reduction may diminish or completely eliminate the significant effect of the amendment.

(A) Types or levels of travel or access that are inconsistent with the functional classification of an existing or planned transportation facility;

(B) Degrade the performance of an existing or planned transportation facility such that it would not meet the performance standards identified in the TSP or comprehensive plan; or

(C) Degrade the performance of an existing or planned transportation facility that is otherwise projected to not meet the performance standards identified in the TSP or comprehensive plan.

In the case of this report, subsections (A) and (B) are not triggered, since the proposed zone change will not impact or alter the functional classification of any existing or planned facility and the proposal does not include a change to any functional classification standards.

Subsection (C) is also not triggered since the intersection of Oregon Highway 18 at the site access will meet performance standards throughout the planning horizon. The study intersection has sufficient capacity to serve more traffic than is generated under the reasonable worst-case scenario.

Based on the detailed analysis, the proposed zone change will not degrade the performance of any existing or planned transportation facility. Accordingly, the Transportation Planning Rule is satisfied.

TRANSPORTATION SYSTEM PLAN

Yamhill County's 1994 Transportation System Plan (TSP) provides goals, policies, and procedures for the development and improvement of transportation facilities as well as list future planned transportation projects. The TSP makes no specific mention of the Riverbend Landfill or planned transportation improvements that would affect the traffic near the subject property. The change in zoning followed by the expansion of the landfill and construction of a green technology facility is not projected to significantly impact the nearby transportation system's efficiency or safety. Accordingly, the proposed zone change and development is in conformance with Yamhill's TSP.

SAFETY ANALYSIS

CRASH DATA ANALYSIS

Using data obtained from ODOT's Crash Data System, a review was performed for the most recent available five years of crash data (2008 – 2012) for Oregon Highway 18 between milepost 41.00 and 42.00. A crash rate was calculated under the common assumption that traffic counted during the PM peak period represents 10% of the average daily traffic (ADT) at the intersection. Crash rates greater than 1.0 crashes per million entering vehicles (CMEV) are generally indicative of a need for further investigation and possible mitigation.

The one-mile segment of road along Oregon Highway 18 that contains the site access had a total of eight reported crashes during the analysis period. Of these crashes, only one appeared to be related to the intersection in which a vehicle followed too closely and failed to decrease their speed before rear-ending a slowed vehicle. The crash resulted in a possible injury or complaint of pain (*Injury-C*).

Even if all eight crashes are considered, the crash rate would be calculated at 0.37 CMEV, which is not typically indicative of significant crash patterns or design concerns. Accordingly, no safety mitigations are recommended.

CONCLUSIONS

The traffic resulting from the proposed zone change to the property adjacent to the Riverbend Landfill, located at 13469 Oregon 18 in McMinnville, Oregon, from Public Works/Safety to Exclusive Farm Use will not cause any significant impact to the transportation network in the surrounding area.

The expected development of the properties under the proposed zoning will not significantly affect existing or planned transportation facilities as defined under Oregon's Transportation Planning Rule. Accordingly, no mitigation is recommended.

The operational analysis of the intersection of Oregon Highway 18 at the site access shows adequate capacity throughout the planning horizon, regardless of the additional traffic resulting from the zone change and subsequent expansion of the landfill as well as the construction of the green technology facility. No operational mitigations are recommended.

A detailed observation of the crash history at the study intersection shows no trends that are indicative of safety issues that need to be addressed. No safety mitigations are recommended.

Based on the detailed analysis, no mitigations are required or recommended for the zone change from Public Works/Safety to Exclusive Farm Use or the landfill expansion and construction of a green technology facility.

APPENDIX

LEVEL OF SERVICE

Level of service is used to describe the quality of traffic flow. Levels of service A to C are considered good, and rural roads are usually designed for level of service C. Urban streets and signalized intersections are typically designed for level of service D. Level of service E is considered to be the limit of acceptable delay. For unsignalized intersections, level of service E is generally considered acceptable. Here is a more complete description of levels of service:

Level of service A: Very low delay at intersections, with all traffic signal cycles clearing and no vehicles waiting through more than one signal cycle. On highways, low volume and high speeds, with speeds not restricted by other vehicles.

Level of service B: Operating speeds beginning to be affected by other traffic; short traffic delays at intersections. Higher average intersection delay than for level of service A resulting from more vehicles stopping.

Level of service C: Operating speeds and maneuverability closely controlled by other traffic; higher delays at intersections than for level of service B due to a significant number of vehicles stopping. Not all signal cycles clear the waiting vehicles. This is the recommended design standard for rural highways.

Level of service D: Tolerable operating speeds; long traffic delays occur at intersections. The influence of congestion is noticeable. At traffic signals many vehicles stop, and the proportion of vehicles not stopping declines. The number of signal cycle failures, for which vehicles must wait through more than one signal cycle, are noticeable. This is typically the design level for urban signalized intersections.

Level of service E: Restricted speeds, very long traffic delays at traffic signals, and traffic volumes near capacity. Flow is unstable so that any interruption, no matter how minor, will cause queues to form and service to deteriorate to level of service F. Traffic signal cycle failures are frequent occurrences. For unsignalized intersections, level of service E or better is generally considered acceptable.

Level of service F: Extreme delays, resulting in long queues which may interfere with other traffic movements. There may be stoppages of long duration, and speeds may drop to zero. There may be frequent signal cycle failures. Level of service F will typically result when vehicle arrival rates are greater than capacity. It is considered unacceptable by most drivers.

1e

LEVEL OF SERVICE CRITERIA
FOR SIGNALIZED INTERSECTIONS

LEVEL OF SERVICE	CONTROL DELAY PER VEHICLE (Seconds)
A	<10
B	10-20
C	20-35
D	35-55
E	55-80
F	>80

LEVEL OF SERVICE CRITERIA
FOR UNSIGNALIZED INTERSECTIONS

LEVEL OF SERVICE	CONTROL DELAY PER VEHICLE (Seconds)
A	<10
B	10-15
C	15-25
D	25-35
E	35-50
F	>50

All Traffic Data Services, Inc.
15105 SE 17th St. Vancouver, WA. 98683
503-833-2740

File Name : Hwy18&Landfill THUR
Site Code :
Start Date : 7/11/2013
Page No : 1

Groups Printed- Unshifted - Bank 1

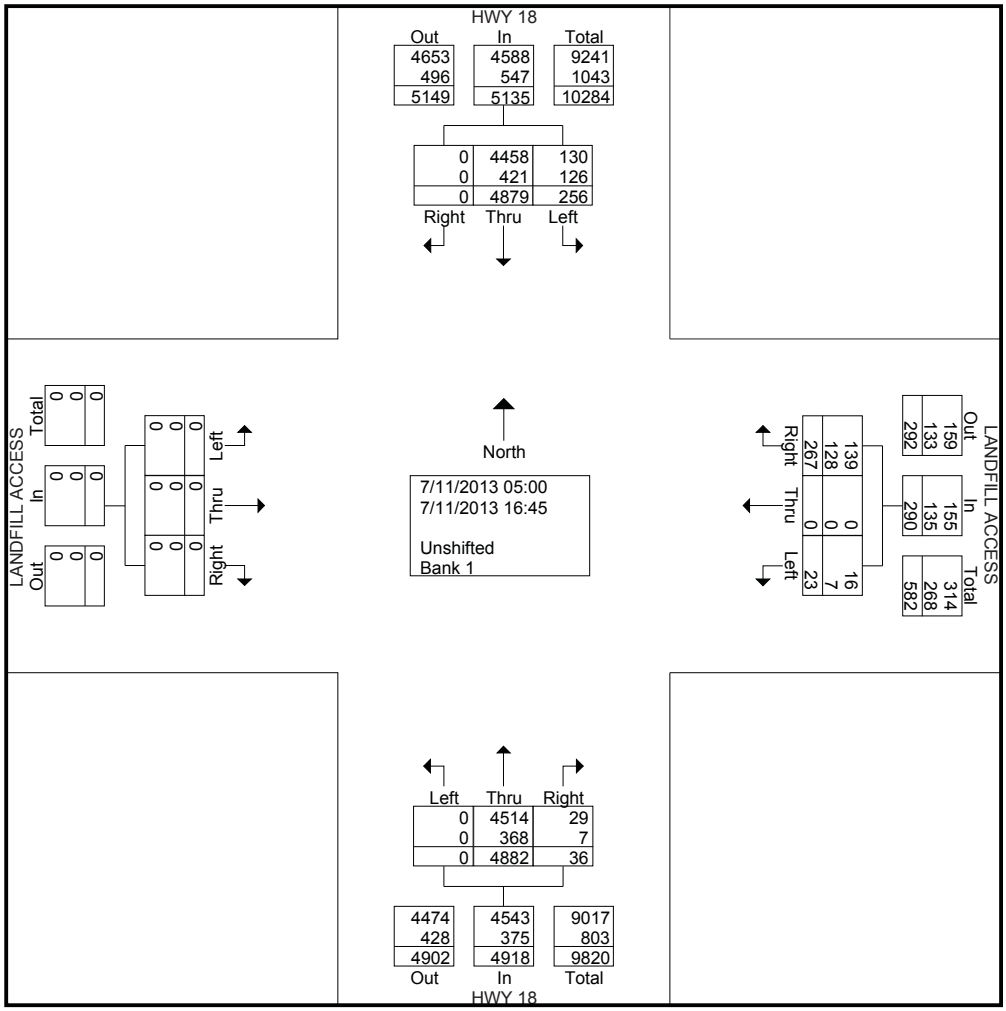
	HWY 18 Southbound					LANDFILL ACCESS Westbound					HWY 18 Northbound					LANDFILL ACCESS Eastbound							
Start Time	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Exclu. Total	Inclu. Total	Int. Total
05:00	3	12	0	0	15	0	0	0	0	0	0	44	0	0	44	0	0	0	0	0	0	59	59
05:15	6	32	0	0	38	0	0	0	0	0	0	61	0	0	61	0	0	0	0	0	0	99	99
05:30	4	47	0	0	51	0	0	0	0	0	0	70	1	0	71	0	0	0	0	0	0	122	122
05:45	8	49	0	0	57	1	0	0	0	1	0	53	0	0	53	0	0	0	0	0	0	111	111
Total	21	140	0	0	161	1	0	0	0	1	0	228	1	0	229	0	0	0	0	0	0	391	391
06:00	7	41	0	0	48	0	0	0	0	0	0	46	0	0	46	0	0	0	0	0	0	94	94
06:15	3	56	0	0	59	0	0	6	0	6	0	63	1	0	64	0	0	0	0	0	0	129	129
06:30	8	63	0	0	71	0	0	3	0	3	0	75	2	0	77	0	0	0	0	0	0	151	151
06:45	8	69	0	0	77	0	0	5	0	5	0	62	0	0	62	0	0	0	0	0	0	144	144
Total	26	229	0	0	255	0	0	14	0	14	0	246	3	0	249	0	0	0	0	0	0	518	518
07:00	5	77	0	0	82	1	0	6	4	7	0	77	0	0	77	0	0	0	0	0	4	166	170
07:15	6	71	0	1	77	0	0	4	0	4	0	95	0	0	95	0	0	0	0	0	1	176	177
07:30	9	75	0	0	84	1	0	2	0	3	0	102	0	0	102	0	0	0	0	0	0	189	189
07:45	11	63	0	0	74	0	0	6	1	6	0	87	0	0	87	0	0	0	0	0	1	167	168
Total	31	286	0	1	317	2	0	18	5	20	0	361	0	0	361	0	0	0	0	0	6	698	704
08:00	6	69	0	0	75	0	0	6	0	6	0	72	1	0	73	0	0	0	0	0	0	154	154
08:15	6	56	0	0	62	0	0	8	0	8	0	88	0	0	88	0	0	0	0	0	0	158	158
08:30	5	73	0	0	78	0	0	5	0	5	0	90	0	0	90	0	0	0	0	0	0	173	173
08:45	2	61	0	0	63	1	0	8	0	9	0	93	1	0	94	0	0	0	0	0	0	166	166
Total	19	259	0	0	278	1	0	27	0	28	0	343	2	0	345	0	0	0	0	0	0	651	651
09:00	5	86	0	0	91	1	0	2	0	3	0	72	1	0	73	0	0	0	0	0	0	167	167
09:15	9	75	0	0	84	1	0	9	2	10	0	105	0	0	105	0	0	0	0	0	2	199	201
09:30	2	80	0	0	82	0	0	5	0	5	0	97	1	0	98	0	0	0	0	0	0	185	185
09:45	6	93	0	0	99	1	0	10	0	11	0	96	1	0	97	0	0	0	0	0	0	207	207
Total	22	334	0	0	356	3	0	26	2	29	0	370	3	0	373	0	0	0	0	0	2	758	760
10:00	9	93	0	0	102	0	0	5	0	5	0	100	1	0	101	0	0	0	0	0	0	208	208
10:15	4	105	0	0	109	2	0	7	0	9	0	102	1	0	103	0	0	0	0	0	0	221	221
10:30	2	119	0	0	121	1	0	4	2	5	0	107	2	0	109	0	0	0	0	0	2	235	237
10:45	3	110	0	0	113	0	0	1	0	1	0	115	1	0	116	0	0	0	0	0	0	230	230
Total	18	427	0	0	445	3	0	17	2	20	0	424	5	0	429	0	0	0	0	0	2	894	896
11:00	4	104	0	0	108	1	0	4	0	5	0	107	1	0	108	0	0	0	0	0	0	221	221
11:15	11	113	0	0	124	1	0	6	0	7	0	115	2	0	117	0	0	0	0	0	0	248	248
11:30	12	141	0	0	153	1	0	8	0	9	0	106	0	0	106	0	0	0	0	0	0	268	268
11:45	4	111	0	0	115	1	0	7	0	8	0	109	1	0	110	0	0	0	0	0	0	233	233
Total	31	469	0	0	500	4	0	25	0	29	0	437	4	0	441	0	0	0	0	0	0	970	970
12:00	6	111	0	0	117	0	0	10	0	10	0	130	1	0	131	0	0	0	0	0	0	258	258
12:15	3	121	0	0	124	0	0	12	0	12	0	135	2	0	137	0	0	0	0	0	0	273	273
12:30	6	112	0	0	118	0	0	8	0	8	0	125	1	0	126	0	0	0	0	0	0	252	252
12:45	5	118	0	0	123	1	0	7	0	8	0	127	0	0	127	0	0	0	0	0	0	258	258
Total	20	462	0	0	482	1	0	37	0	38	0	517	4	0	521	0	0	0	0	0	0	1041	1041
13:00	9	115	0	0	124	0	0	9	0	9	0	100	2	0	102	0	0	0	0	0	0	235	235
13:15	5	141	0	0	146	1	0	5	0	6	0	140	2	0	142	0	0	0	0	0	0	294	294
13:30	9	125	0	0	134	1	0	7	0	8	0	101	1	0	102	0	0	0	0	0	0	244	244
13:45	10	131	0	0	141	1	0	3	0	4	0	111	1	0	112	0	0	0	0	0	0	257	257
Total	33	512	0	0	545	3	0	24	0	27	0	452	6	0	458	0	0	0	0	0	0	1030	1030
14:00	2	134	0	0	136	1	0	8	0	9	0	124	1	0	125	0	0	0	0	0	0	270	270
14:15	6	146	0	0	152	1	0	7	0	8	0	127	0	0	127	0	0	0	0	0	0	287	287
14:30	2	137	0	0	139	0	0	7	0	7	0	128	0	0	128	0	0	0	0	0	0	274	274
14:45	4	128	0	0	132	0	0	5	0	5	0	116	2	0	118	0	0	0	0	0	0	255	255
Total	14	545	0	0	559	2	0	27	0	29	0	495	3	0	498	0	0	0	0	0	0	1086	1086
15:00	4	189	0	0	193	0	0	1	0	1	0	128	2	0	130	0	0	0	0	0	0	324	324
15:15	2	130	0	0	132	0	0	7	0	7	0	106	0	0	106	0	0	0	0	0	0	245	245
15:30	3	140	0	0	143	1	0	6	0	7	0	127	2	0	129	0	0	0	0	0	0	279	279
15:45	9	137	0	0	146	0	0	9	0	9	0	128	0	0	128	0	0	0	0	0	0	283	283
Total	18	596	0	0	614	1	0	23	0	24	0	489	4	0	493	0	0	0	0	0	0	1131	1131
16:00	1	135	0	0	136	0	0	7	0	7	0	116	1	0	117	0	0	0	0	0	0	260	260

All Traffic Data Services, Inc.
15105 SE 17th St. Vancouver, WA. 98683
503-833-2740

File Name : Hwy18&Landfill THUR
Site Code :
Start Date : 7/11/2013
Page No : 2

Groups Printed- Unshifted - Bank 1

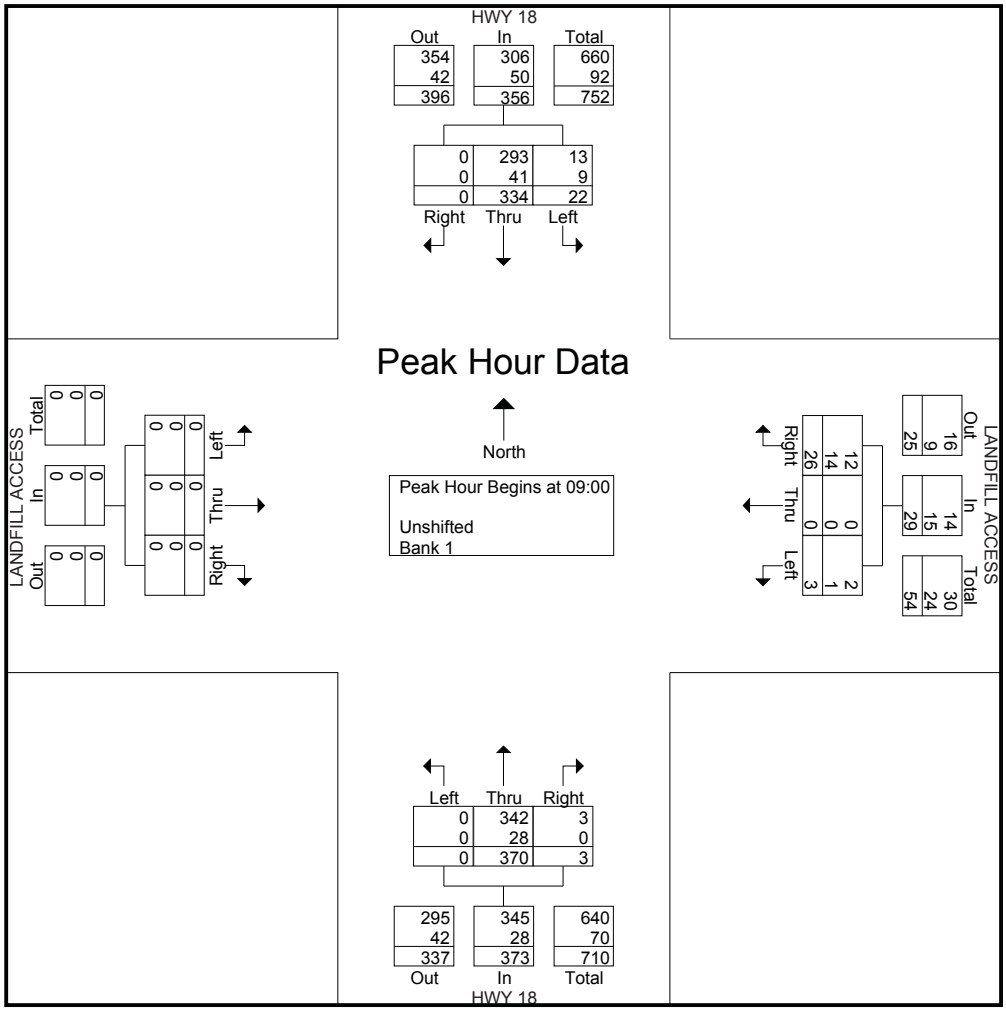
	HWY 18 Southbound					LANDFILL ACCESS Westbound					HWY 18 Northbound					LANDFILL ACCESS Eastbound							
Start Time	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Exclu. Total	Inclu. Total	Int. Total
16:15	2	160	0	0	162	2	0	4	0	6	0	139	0	0	139	0	0	0	0	0	0	307	307
16:30	0	152	0	0	152	0	0	6	0	6	0	133	0	0	133	0	0	0	0	0	0	291	291
16:45	0	173	0	0	173	0	0	12	0	12	0	132	0	0	132	0	0	0	0	0	0	317	317
Total	3	620	0	0	623	2	0	29	0	31	0	520	1	0	521	0	0	0	0	0	0	1175	1175
Grand Total	256	4879	0	1	5135	23	0	267	9	290	0	4882	36	0	4918	0	0	0	0	0	10	10343	10353
Apprch %	5	95	0			7.9	0	92.1			0	99.3	0.7			0	0	0					
Total %	2.5	47.2	0		49.6	0.2	0	2.6		2.8	0	47.2	0.3		47.5	0	0	0		0	0.1	99.9	
Unshifted	130	4458	0		4589	16	0	139		164	0	4514	29		4543	0	0	0		0	0	0	9296
% Unshifted	50.8	91.4	0	100	89.3	69.6	0	52.1	100	54.8	0	92.5	80.6	0	92.4	0	0	0	0	0	0	0	89.8
Bank 1	126	421	0		547	7	0	128		135	0	368	7		375	0	0	0		0	0	0	1057
% Bank 1	49.2	8.6	0	0	10.7	30.4	0	47.9	0	45.2	0	7.5	19.4	0	7.6	0	0	0	0	0	0	0	10.2



All Traffic Data Services, Inc.
15105 SE 17th St. Vancouver, WA. 98683
503-833-2740

File Name : Hwy18&Landfill THUR
Site Code :
Start Date : 7/11/2013
Page No : 3

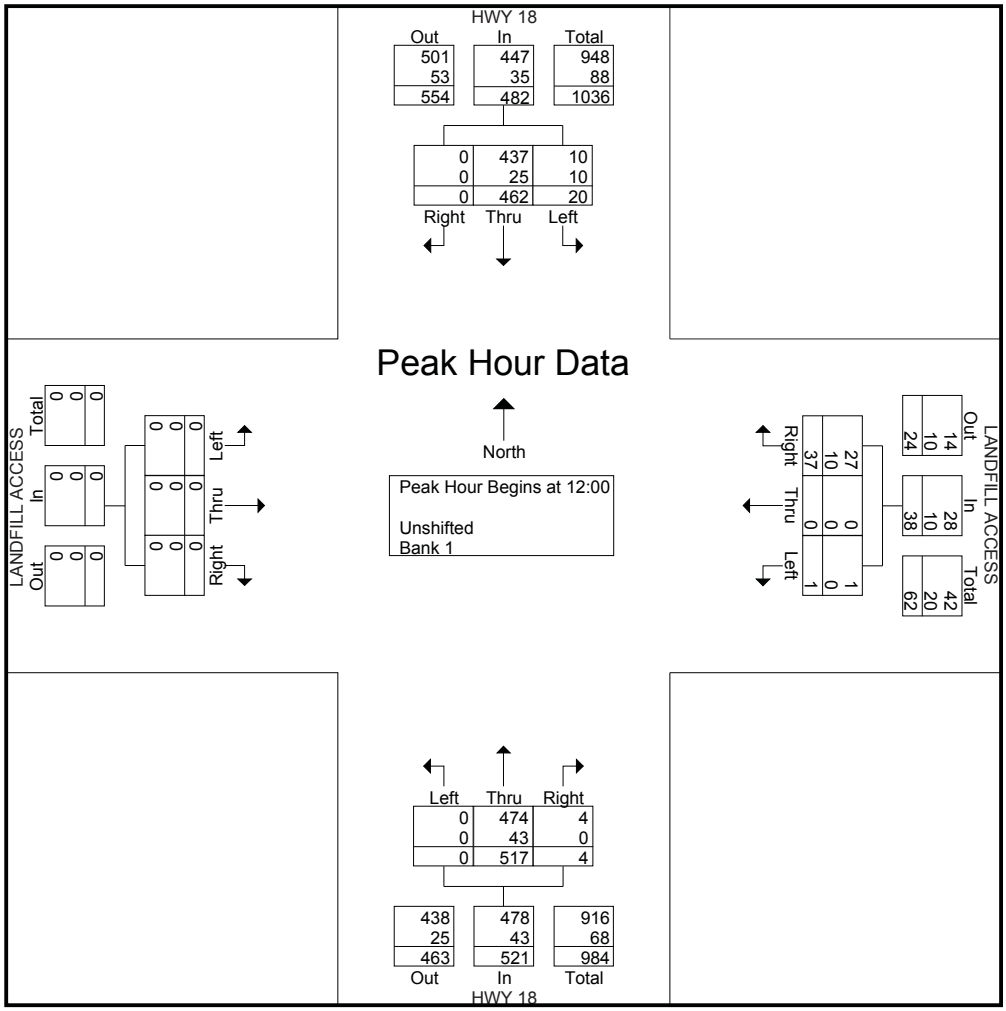
	HWY 18 Southbound				LANDFILL ACCESS Westbound				HWY 18 Northbound				LANDFILL ACCESS Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 05:00 to 09:45 - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 09:00																	
09:00	5	86	0	91	**1**	0	2	3	0	72	**1**	73	0	0	0	0	167
09:15	**9**	75	0	84	1	0	9	10	0	**105**	0	**105**	0	0	0	0	199
09:30	2	80	0	82	0	0	5	5	0	97	1	98	0	0	0	0	185
09:45	6	**93**	0	**99**	1	0	**10**	**11**	0	96	1	97	0	0	0	0	**207**
Total Volume	22	334	0	356	3	0	26	29	0	370	3	373	0	0	0	0	758
% App. Total	6.2	93.8	0		10.3	0	89.7		0	99.2	0.8		0	0	0		
PHF	.611	.898	.000	.899	.750	.000	.650	.659	.000	.881	.750	.888	.000	.000	.000	.000	.915
Unshifted	13	293	0	306	2	0	12	14	0	342	3	345	0	0	0	0	665
% Unshifted	59.1	87.7	0	86.0	66.7	0	46.2	48.3	0	92.4	100	92.5	0	0	0	0	87.7
Bank 1	9	41	0	50	1	0	14	15	0	28	0	28	0	0	0	0	93
% Bank 1	40.9	12.3	0	14.0	33.3	0	53.8	51.7	0	7.6	0	7.5	0	0	0	0	12.3



All Traffic Data Services, Inc.
15105 SE 17th St. Vancouver, WA. 98683
503-833-2740

File Name : Hwy18&Landfill THUR
Site Code :
Start Date : 7/11/2013
Page No : 4

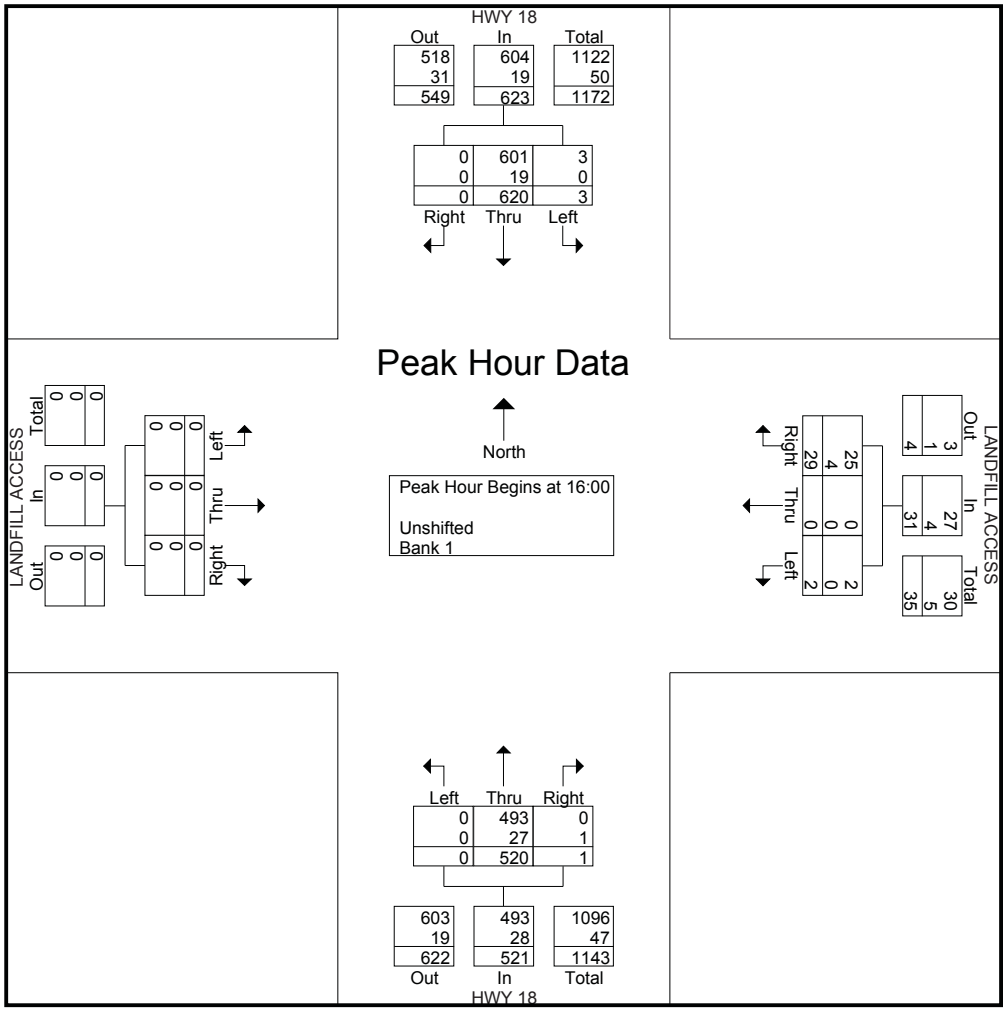
	HWY 18 Southbound				LANDFILL ACCESS Westbound				HWY 18 Northbound				LANDFILL ACCESS Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 10:00 to 13:45 - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 12:00																	
12:00	**6**	111	0	117	0	0	10	10	0	130	1	131	0	0	0	0	258
12:15	3	**121**	0	**124**	0	0	**12**	**12**	0	**135**	**2**	**137**	0	0	0	0	**273**
12:30	6	112	0	118	0	0	8	8	0	125	1	126	0	0	0	0	252
12:45	5	118	0	123	**1**	0	7	8	0	127	0	127	0	0	0	0	258
Total Volume	20	462	0	482	1	0	37	38	0	517	4	521	0	0	0	0	1041
% App. Total	4.1	95.9	0		2.6	0	97.4		0	99.2	0.8		0	0	0		
PHF	.833	.955	.000	.972	.250	.000	.771	.792	.000	.957	.500	.951	.000	.000	.000	.000	.953
Unshifted	10	437	0	447	1	0	27	28	0	474	4	478	0	0	0	0	953
% Unshifted	50.0	94.6	0	92.7	100	0	73.0	73.7	0	91.7	100	91.7	0	0	0	0	91.5
Bank 1	10	25	0	35	0	0	10	10	0	43	0	43	0	0	0	0	88
% Bank 1	50.0	5.4	0	7.3	0	0	27.0	26.3	0	8.3	0	8.3	0	0	0	0	8.5



All Traffic Data Services, Inc.
15105 SE 17th St. Vancouver, WA. 98683
503-833-2740

File Name : Hwy18&Landfill THUR
Site Code :
Start Date : 7/11/2013
Page No : 5

	HWY 18 Southbound				LANDFILL ACCESS Westbound				HWY 18 Northbound				LANDFILL ACCESS Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 14:00 to 16:45 - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 16:00																	
16:00	1	135	0	136	0	0	7	7	0	116	**1**	117	0	0	0	0	260
16:15	**2**	160	0	162	**2**	0	4	6	0	**139**	0	**139**	0	0	0	0	307
16:30	0	152	0	152	0	0	6	6	0	133	0	133	0	0	0	0	291
16:45	0	**173**	0	**173**	0	0	**12**	**12**	0	132	0	132	0	0	0	0	**317**
Total Volume	3	620	0	623	2	0	29	31	0	520	1	521	0	0	0	0	1175
% App. Total	0.5	99.5	0		6.5	0	93.5		0	99.8	0.2		0	0	0		
PHF	.375	.896	.000	.900	.250	.000	.604	.646	.000	.935	.250	.937	.000	.000	.000	.000	.927
Unshifted	3	601	0	604	2	0	25	27	0	493	0	493	0	0	0	0	1124
% Unshifted	100	96.9	0	97.0	100	0	86.2	87.1	0	94.8	0	94.6	0	0	0	0	95.7
Bank 1	0	19	0	19	0	0	4	4	0	27	1	28	0	0	0	0	51
% Bank 1	0	3.1	0	3.0	0	0	13.8	12.9	0	5.2	100	5.4	0	0	0	0	4.3



All Traffic Data Services, Inc.
15105 SE 17th St. Vancouver, WA. 98683
503-833-2740

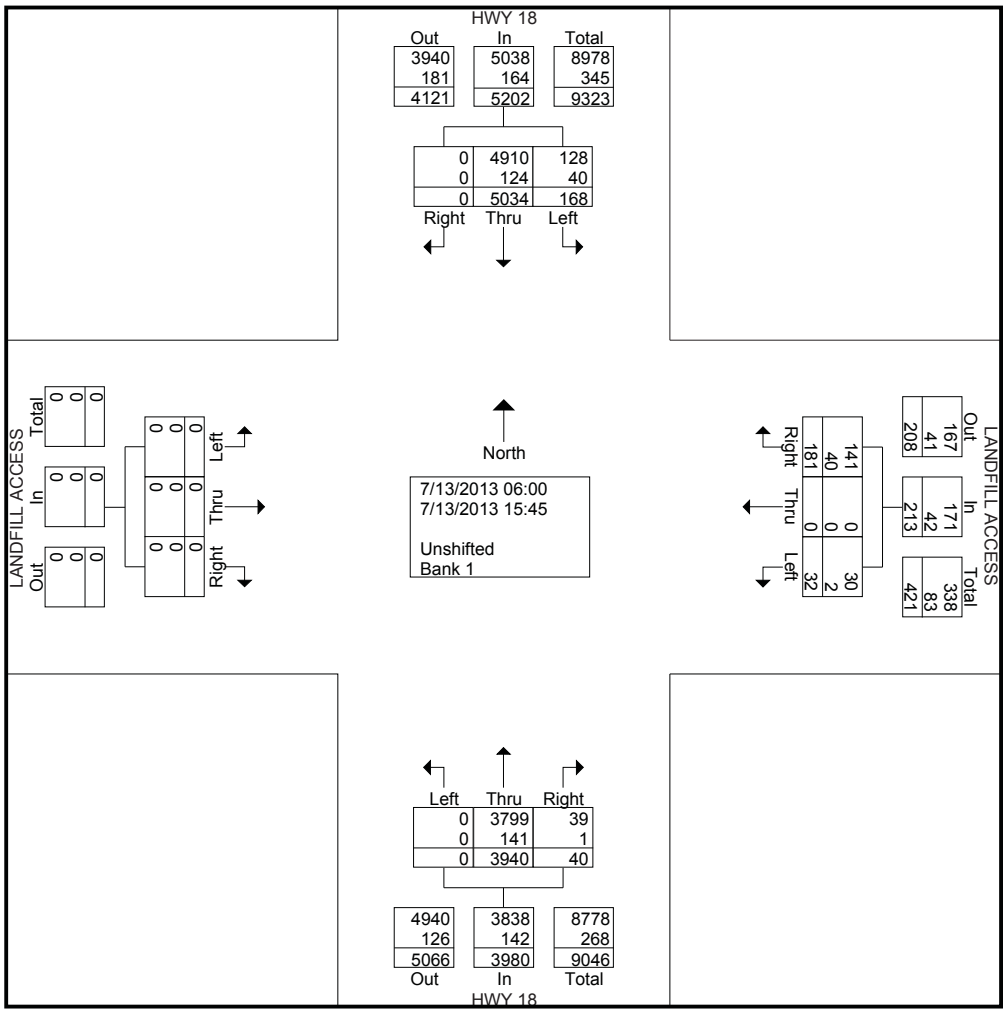
File Name : Hwy18&Landfill SAT
Site Code :
Start Date : 7/13/2013
Page No : 1

Groups Printed- Unshifted - Bank 1

	HWY 18 Southbound					LANDFILL ACCESS Westbound					HWY 18 Northbound					LANDFILL ACCESS Eastbound							
Start Time	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Exclu. Total	Inclu. Total	Int. Total
06:00	1	38	0	0	39	0	0	1	0	1	0	21	0	0	21	0	0	0	0	0	0	61	61
06:15	6	27	0	0	33	1	0	0	0	1	0	25	1	0	26	0	0	0	0	0	0	60	60
06:30	2	30	0	0	32	1	0	0	0	1	0	42	0	0	42	0	0	0	0	0	0	75	75
06:45	11	37	0	0	48	0	0	0	0	0	0	48	0	0	48	0	0	0	0	0	0	96	96
Total	20	132	0	0	152	2	0	1	0	3	0	136	1	0	137	0	0	0	0	0	0	292	292
07:00	8	31	0	0	39	0	0	1	0	1	0	53	0	0	53	0	0	0	0	0	0	93	93
07:15	3	46	0	0	49	1	0	6	0	7	0	40	1	0	41	0	0	0	0	0	0	97	97
07:30	4	58	0	0	62	1	0	7	0	8	0	61	1	0	62	0	0	0	0	0	0	132	132
07:45	4	61	0	0	65	0	0	6	0	6	0	56	0	0	56	0	0	0	0	0	0	127	127
Total	19	196	0	0	215	2	0	20	0	22	0	210	2	0	212	0	0	0	0	0	0	449	449
08:00	3	55	0	0	58	0	0	3	0	3	0	61	1	0	62	0	0	0	0	0	0	123	123
08:15	2	74	0	0	76	0	0	4	0	4	0	64	1	0	65	0	0	0	0	0	0	145	145
08:30	3	79	0	0	82	1	0	4	0	5	0	89	0	0	89	0	0	0	0	0	0	176	176
08:45	4	101	0	0	105	0	0	2	0	2	0	91	0	0	91	0	0	0	0	0	0	198	198
Total	12	309	0	0	321	1	0	13	0	14	0	305	2	0	307	0	0	0	0	0	0	642	642
09:00	7	101	0	0	108	2	0	8	0	10	0	89	0	0	89	0	0	0	0	0	0	207	207
09:15	1	73	0	0	74	0	0	4	0	4	0	74	4	0	78	0	0	0	0	0	0	156	156
09:30	6	134	0	0	140	1	0	5	0	6	0	103	3	0	106	0	0	0	0	0	0	252	252
09:45	5	99	0	0	104	2	0	3	0	5	0	93	2	0	95	0	0	0	0	0	0	204	204
Total	19	407	0	0	426	5	0	20	0	25	0	359	9	0	368	0	0	0	0	0	0	819	819
10:00	4	136	0	0	140	2	0	10	0	12	0	90	0	0	90	0	0	0	0	0	0	242	242
10:15	6	162	0	0	168	1	0	6	0	7	0	119	2	0	121	0	0	0	0	0	0	296	296
10:30	4	172	0	0	176	3	0	5	0	8	0	115	1	0	116	0	0	0	0	0	0	300	300
10:45	7	161	0	0	168	0	0	3	0	3	0	111	0	0	111	0	0	0	0	0	0	282	282
Total	21	631	0	0	652	6	0	24	0	30	0	435	3	0	438	0	0	0	0	0	0	1120	1120
11:00	2	145	0	0	147	1	0	10	0	11	0	122	5	0	127	0	0	0	0	0	0	285	285
11:15	6	183	0	0	189	3	0	4	0	7	0	141	1	0	142	0	0	0	0	0	0	338	338
11:30	7	165	0	0	172	1	0	5	0	6	0	132	2	0	134	0	0	0	0	0	0	312	312
11:45	5	214	0	0	219	1	0	7	0	8	0	127	0	0	127	0	0	0	0	0	0	354	354
Total	20	707	0	0	727	6	0	26	0	32	0	522	8	0	530	0	0	0	0	0	0	1289	1289
12:00	8	172	0	0	180	1	0	6	0	7	0	120	0	0	120	0	0	0	0	0	0	307	307
12:15	6	154	0	0	160	0	0	5	0	5	0	123	1	0	124	0	0	0	0	0	0	289	289
12:30	4	190	0	0	194	1	0	7	0	8	0	121	1	0	122	0	0	0	0	0	0	324	324
12:45	5	154	0	0	159	0	0	8	0	8	0	141	0	0	141	0	0	0	0	0	0	308	308
Total	23	670	0	0	693	2	0	26	0	28	0	505	2	0	507	0	0	0	0	0	0	1228	1228
13:00	4	191	0	0	195	0	0	5	0	5	0	125	4	0	129	0	0	0	0	0	0	329	329
13:15	3	173	0	0	176	0	0	6	0	6	0	130	2	0	132	0	0	0	0	0	0	314	314
13:30	5	158	0	0	163	2	0	4	0	6	0	121	1	0	122	0	0	0	0	0	0	291	291
13:45	3	154	0	0	157	1	0	7	0	8	0	134	4	0	138	0	0	0	0	0	0	303	303
Total	15	676	0	0	691	3	0	22	0	25	0	510	11	0	521	0	0	0	0	0	0	1237	1237
14:00	3	176	0	0	179	0	0	4	0	4	0	117	0	0	117	0	0	0	0	0	0	300	300
14:15	4	181	0	0	185	3	0	4	0	7	0	90	0	0	90	0	0	0	0	0	0	282	282
14:30	6	142	0	0	148	1	0	4	0	5	0	83	2	0	85	0	0	0	0	0	0	238	238
14:45	3	152	0	0	155	1	0	6	0	7	0	143	0	0	143	0	0	0	0	0	0	305	305
Total	16	651	0	0	667	5	0	18	0	23	0	433	2	0	435	0	0	0	0	0	0	1125	1125
15:00	0	167	0	0	167	0	0	2	0	2	0	115	0	1	115	0	0	0	0	0	1	284	285
15:15	0	163	0	0	163	0	0	2	0	2	0	144	0	0	144	0	0	0	0	0	0	309	309
15:30	1	157	0	0	158	0	0	2	0	2	0	131	0	0	131	0	0	0	0	0	0	291	291
15:45	2	168	0	0	170	0	0	5	0	5	0	135	0	0	135	0	0	0	0	0	0	310	310
Total	3	655	0	0	658	0	0	11	0	11	0	525	0	1	525	0	0	0	0	0	1	1194	1195
Grand Total	168	5034	0	0	5202	32	0	181	0	213	0	3940	40	1	3980	0	0	0	0	0	1	9395	9396
Apprch %	3.2	96.8	0			15	0	85			0	99	1			0	0	0					
Total %	1.8	53.6	0		55.4	0.3	0	1.9		2.3	0	41.9	0.4		42.4	0	0	0		0	0	100	
Unshifted	128	4910	0		5038	30	0	141		171	0	3799	39		3839	0	0	0		0	0	0	9048
% Unshifted	76.2	97.5	0	0	96.8	93.8	0	77.9	0	80.3	0	96.4	97.5	100	96.4	0	0	0	0	0	0	0	96.3
Bank 1	40	124	0		164	2	0	40		42	0	141	1		142	0	0	0		0	0	0	348
% Bank 1	23.8	2.5	0	0	3.2	6.2	0	22.1	0	19.7	0	3.6	2.5	0	3.6	0	0	0	0	0	0	0	3.7

All Traffic Data Services, Inc.
15105 SE 17th St. Vancouver, WA. 98683
503-833-2740

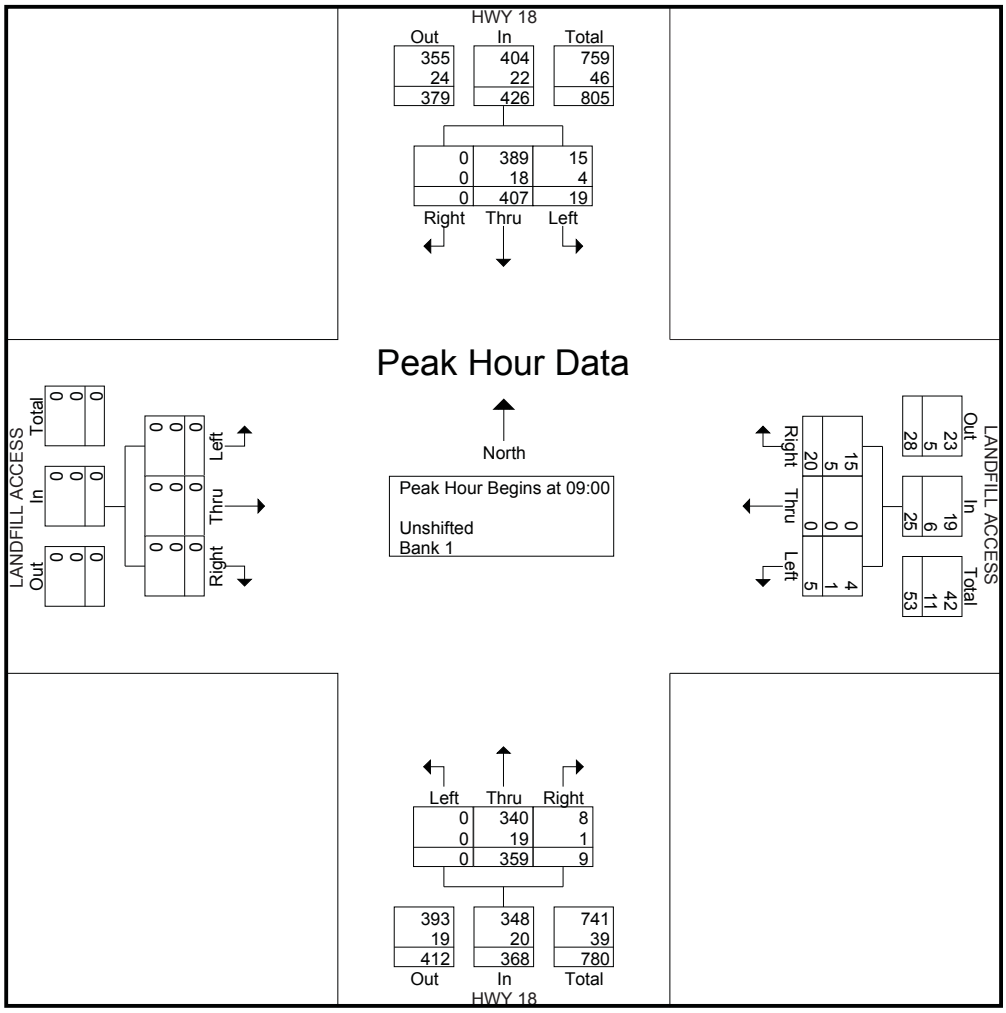
File Name : Hwy18&Landfill SAT
Site Code :
Start Date : 7/13/2013
Page No : 2



All Traffic Data Services, Inc.
15105 SE 17th St. Vancouver, WA. 98683
503-833-2740

File Name : Hwy18&Landfill SAT
Site Code :
Start Date : 7/13/2013
Page No : 3

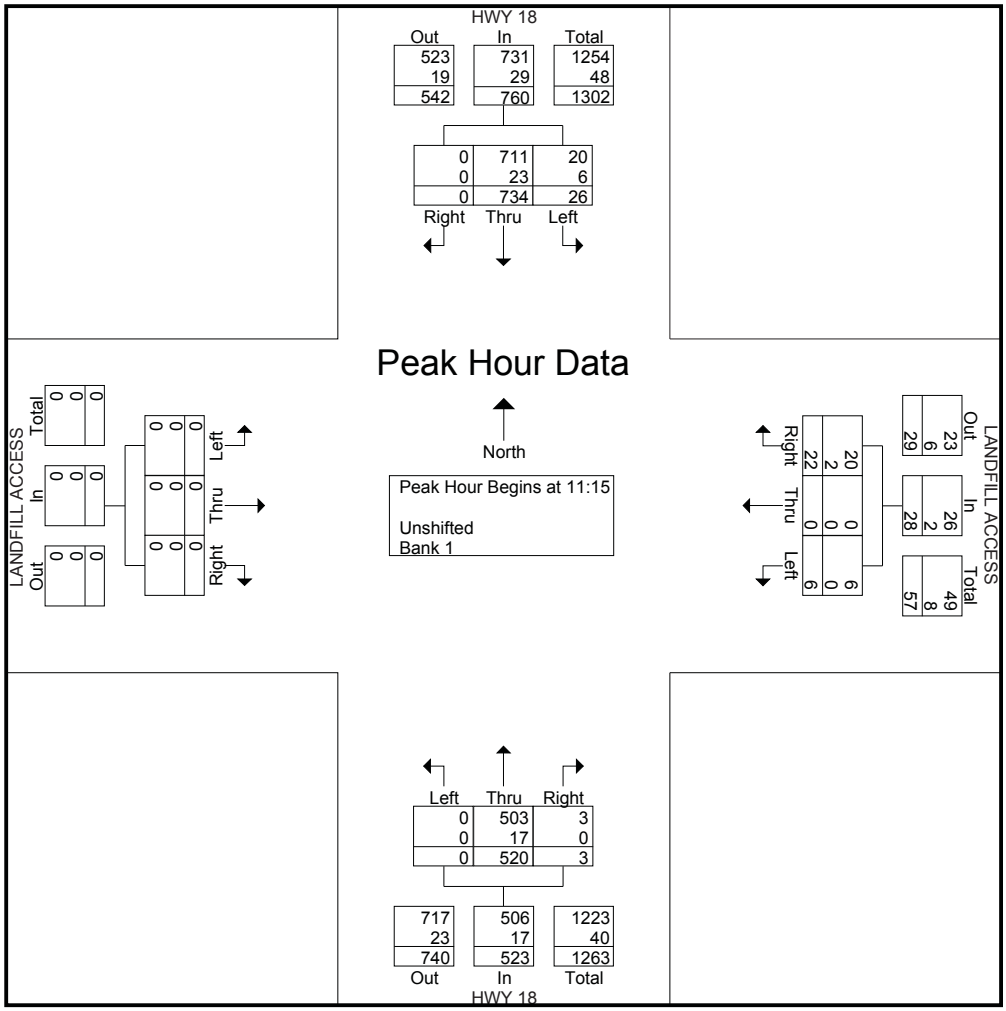
	HWY 18 Southbound				LANDFILL ACCESS Westbound				HWY 18 Northbound				LANDFILL ACCESS Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 to 09:45 - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 09:00																	
09:00	**7**	101	0	108	**2**	0	**8**	**10**	0	89	0	89	0	0	0	0	207
09:15	1	73	0	74	0	0	4	4	0	74	**4**	78	0	0	0	0	156
09:30	6	**134**	0	**140**	1	0	5	6	0	**103**	3	**106**	0	0	0	0	**252**
09:45	5	99	0	104	2	0	3	5	0	93	2	95	0	0	0	0	204
Total Volume	19	407	0	426	5	0	20	25	0	359	9	368	0	0	0	0	819
% App. Total	4.5	95.5	0		20	0	80		0	97.6	2.4		0	0	0		
PHF	.679	.759	.000	.761	.625	.000	.625	.625	.000	.871	.563	.868	.000	.000	.000	.000	.813
Unshifted	15	389	0	404	4	0	15	19	0	340	8	348	0	0	0	0	771
% Unshifted	78.9	95.6	0	94.8	80.0	0	75.0	76.0	0	94.7	88.9	94.6	0	0	0	0	94.1
Bank 1	4	18	0	22	1	0	5	6	0	19	1	20	0	0	0	0	48
% Bank 1	21.1	4.4	0	5.2	20.0	0	25.0	24.0	0	5.3	11.1	5.4	0	0	0	0	5.9



All Traffic Data Services, Inc.
15105 SE 17th St. Vancouver, WA. 98683
503-833-2740

File Name : Hwy18&Landfill SAT
Site Code :
Start Date : 7/13/2013
Page No : 4

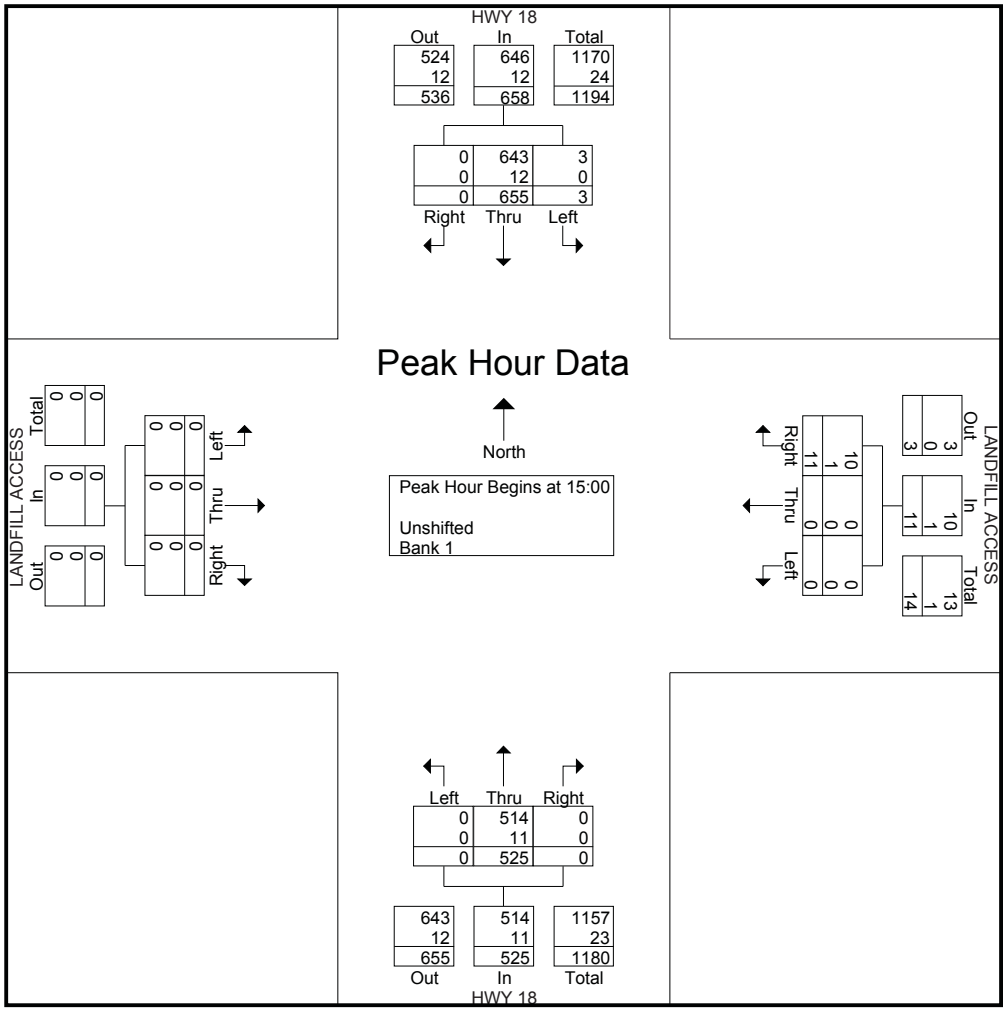
	HWY 18 Southbound				LANDFILL ACCESS Westbound				HWY 18 Northbound				LANDFILL ACCESS Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 10:00 to 13:45 - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 11:15																	
11:15	6	183	0	189	**3**	0	4	7	0	**141**	1	**142**	0	0	0	0	338
11:30	7	165	0	172	1	0	5	6	0	132	**2**	134	0	0	0	0	312
11:45	5	**214**	0	**219**	1	0	**7**	**8**	0	127	0	127	0	0	0	0	**354**
12:00	**8**	172	0	180	1	0	6	7	0	120	0	120	0	0	0	0	307
Total Volume	26	734	0	760	6	0	22	28	0	520	3	523	0	0	0	0	1311
% App. Total	3.4	96.6	0		21.4	0	78.6		0	99.4	0.6		0	0	0		
PHF	.813	.857	.000	.868	.500	.000	.786	.875	.000	.922	.375	.921	.000	.000	.000	.000	.926
Unshifted	20	711	0	731	6	0	20	26	0	503	3	506	0	0	0	0	1263
% Unshifted	76.9	96.9	0	96.2	100	0	90.9	92.9	0	96.7	100	96.7	0	0	0	0	96.3
Bank 1	6	23	0	29	0	0	2	2	0	17	0	17	0	0	0	0	48
% Bank 1	23.1	3.1	0	3.8	0	0	9.1	7.1	0	3.3	0	3.3	0	0	0	0	3.7



All Traffic Data Services, Inc.
15105 SE 17th St. Vancouver, WA. 98683
503-833-2740

File Name : Hwy18&Landfill SAT
Site Code :
Start Date : 7/13/2013
Page No : 5

	HWY 18 Southbound				LANDFILL ACCESS Westbound				HWY 18 Northbound				LANDFILL ACCESS Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 14:00 to 15:45 - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 15:00																	
15:00	0	167	0	167	0	0	2	2	0	115	0	115	0	0	0	0	284
15:15	0	163	0	163	0	0	2	2	0	**144**	0	**144**	0	0	0	0	309
15:30	1	157	0	158	0	0	2	2	0	131	0	131	0	0	0	0	291
15:45	**2**	**168**	0	**170**	0	0	**5**	**5**	0	135	0	135	0	0	0	0	**310**
Total Volume	3	655	0	658	0	0	11	11	0	525	0	525	0	0	0	0	1194
% App. Total	0.5	99.5	0		0	0	100		0	100	0		0	0	0		
PHF	.375	.975	.000	.968	.000	.000	.550	.550	.000	.911	.000	.911	.000	.000	.000	.000	.963
Unshifted	3	643	0	646	0	0	10	10	0	514	0	514	0	0	0	0	1170
% Unshifted	100	98.2	0	98.2	0	0	90.9	90.9	0	97.9	0	97.9	0	0	0	0	98.0
Bank 1	0	12	0	12	0	0	1	1	0	11	0	11	0	0	0	0	24
% Bank 1	0	1.8	0	1.8	0	0	9.1	9.1	0	2.1	0	2.1	0	0	0	0	2.0

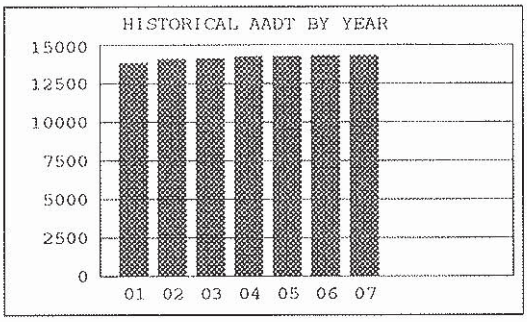


Location: OR18 MP 41.00, SALMON RIVER HIGHWAY, NO. 39
3.36 miles south of Pacific Hwy West (OR99W)

Recorder: SALMON RIVER, 36-006
Installed: July, 2000

HISTORICAL TRAFFIC DATA

Year	Average Daily Traffic	Percent of ADT: Max Day	Max Hour	10TH Hour	20TH Hour	30TH Hour
2001	13844	137	11.4	10.4	10.2	10.0
2002	14083	135	10.7	10.3	10.1	10.0
2003	14113	134	10.9	10.3	10.1	9.9
2004	14237	141	10.8	10.3	10.1	10.0
2005	14230	135	10.6	10.0	9.9	9.7
2006	14298	***	****	****	****	****
2007	14283	137	10.7	10.2	9.9	9.8



2007 TRAFFIC DATA

	Average Weekday Traffic	Percent of ADT	Average Daily Traffic	Percent of ADT
January	11362	80	11931	84
February	12910	90	13675	96
March	13837	97	14471	101
April	13566	95	14320	100
May	13610	95	14454	101
June	14399	101	15016	105
July	15648	110	16357	115
August	15543	109	16458	115
September	14687	103	15418	108
October	13596	95	14242	100
November	12447	87	13010	91
December	11771	82	12040	84

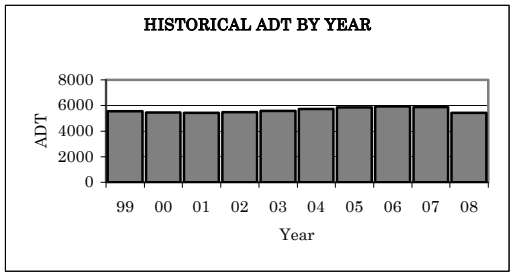
Classification Breakdown	Percent of ADT
Passenger Cars	60.5
Other 2 axle 4 tire vehicles	29.1
Single Unit 2 axle 6 tire	2.3
Single Unit 3 axle	1.8
Single Unit 4 axle or more	0.2
Single Trailer Truck 4 axle or less	0.4
Single Trailer Truck 5 axle	2.4
Single Trailer Truck 6 axle or more	1.3
Dbl-Trailer Truck 5 axle or less	0.0
Dbl-Trailer Truck 6 axle	0.1
Dbl-Trailer Truck 7 axle or more	0.6
Triple Trailer Trucks	0.0
Buses	0.6
Motorcycles & Scooters	0.8

Location: OR99W; MP 47.15; PACIFIC HIGHWAY WEST NO. 91; 0.37 mile north of Yamhill-Polk County Line

Site Name: Amity (36-005)
Installed: September, 1956

HISTORICAL TRAFFIC DATA

Year	Average Daily Traffic	Max Day	Max Hour	10TH Hour	20TH Hour	30TH Hour
		Percent of AADT				
1999	5566	***	***	***	***	***
2000	5451	140	12.1	11.2	11.0	10.9
2001	5425	131	13.1	11.2	10.7	10.5
2002	5483	137	14.1	12.1	11.3	11.1
2003	5571	140	13.2	11.5	11.0	10.9
2004	5731	132	13.3	11.4	11.1	10.9
2005	5858	***	***	***	***	***
2006	5940	137	13.2	11.5	11.1	10.7
2007	5874	132	13.2	11.3	10.9	10.7
2008	5433	131	12.9	11.8	11.2	11.0



2008 TRAFFIC DATA

	Average Weekday Traffic	Percent of AADT	Average Daily Traffic	Percent of AADT
January	5000	92	4900	90
February	5700	105	5500	101
March	5900	109	5600	103
April	5725	105	5634	104
May	5770	106	5712	105
June	5786	106	5642	104
July	5963	110	5631	104
August	5989	110	5759	106
September	5749	106	5753	106
October	5818	107	5726	105
November	5505	101	5393	99
December	4139	76	3946	73

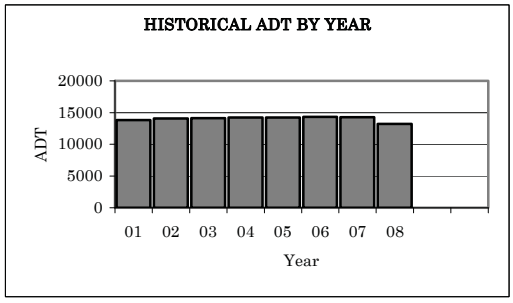
Classification Breakdown	Percent of AADT
Motorcyles	1.0
Passenger cars	58.3
Light Trucks	29.5
Buses	0.3
Single unit trucks (2 axles)	2.6
Single unit trucks (3 axles)	2.2
Single unit trucks (4 or more axles)	0.0
Single trailer trucks (4 or less axles)	0.7
Single trailer trucks (5 axles)	4.8
Single trailer trucks (6 or more axles)	0.3
Multi trailer trucks (5 or less axles)	0.0
Multi trailer trucks (6 axles)	0.0
Multi trailer trucks (7 or more axles)	0.4

Location: OR18; MP 41.00; SALMON RIVER HIGHWAY NO. 39; 3.36 miles south of Pacific Highway West No. 91 (OR99W)

Site Name: Salmon River (36-006)
Installed: July, 2000

HISTORICAL TRAFFIC DATA

Year	Average Daily Traffic	Max Day	Max Hour	10TH Hour	20TH Hour	30TH Hour
		Percent of AADT				
2001	13844	137	11.4	10.4	10.2	10.0
2002	14083	135	10.7	10.3	10.1	10.0
2003	14113	134	10.9	10.3	10.1	9.9
2004	14237	141	10.8	10.3	10.1	10.0
2005	14230	135	10.6	10.0	9.9	9.7
2006	14298	***	***	***	***	***
2007	14283	137	10.7	10.2	9.9	9.8
2008	13234	143	11.8	10.5	10.3	10.1



2008 TRAFFIC DATA

	Average Weekday Traffic	Percent of AADT	Average Daily Traffic	Percent of AADT
January	11423	86	11712	88
February	12590	95	13298	100
March	12900	97	13340	101
April	12691	96	13344	101
May	13144	99	14046	106
June	13199	100	13981	106
July	14213	107	14789	112
August	14413	109	15298	116
September	13520	102	14203	107
October	12732	96	13341	101
November	12093	91	12509	95
December	9314	70	8952	68

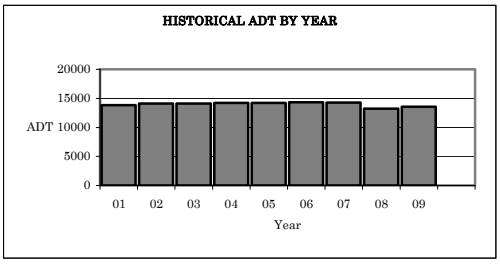
Classification Breakdown	Percent of AADT
Motorcyles	0.8
Passenger cars	60.5
Light Trucks	29.1
Buses	0.6
Single unit trucks (2 axles)	2.3
Single unit trucks (3 axles)	1.8
Single unit trucks (4 or more axles)	0.2
Single trailer trucks (4 or less axles)	0.4
Single trailer trucks (5 axles)	2.4
Single trailer trucks (6 or more axles)	1.3
Multi trailer trucks (5 or less axles)	0.0
Multi trailer trucks (6 axles)	0.1
Multi trailer trucks (7 or more axles)	0.6

Location: OR18; MP 41.00; SALMON RIVER HIGHWAY NO. 39; 3.36 miles south of Pacific Highway West No. 91 (OR99W)

Site Name: Salmon River (36-006)
Installed: July, 2000

HISTORICAL TRAFFIC DATA

Year	Average Daily Traffic	Max Day	Max Hour	Percent of ADT 10TH Hour	20TH Hour	30TH Hour
2001	13844	137	11.4	10.4	10.2	10.0
2002	14083	135	10.7	10.3	10.1	10.0
2003	14113	134	10.9	10.3	10.1	9.9
2004	14237	141	10.8	10.3	10.1	10.0
2005	14230	135	10.6	10.0	9.9	9.7
2006	14298	***	***	***	***	***
2007	14283	137	10.7	10.2	9.9	9.8
2008	13234	143	11.8	10.5	10.3	10.1
2009	13550	136	11.2	10.5	10.2	10.1



2009 TRAFFIC DATA

	Average Weekday Traffic	Percent of ADT	Average Daily Traffic	Percent of ADT
January	11482	85	11842	87
February	12161	90	12917	95
March	12630	93	13290	98
April	12759	94	13580	100
May	13034	96	14054	104
June	13603	100	14348	106
July	14952	110	15605	115
August	14781	109	15562	115
September	13715	101	14496	107
October	12697	94	13241	98
November	12034	89	12257	90
December	11592	86	11407	84

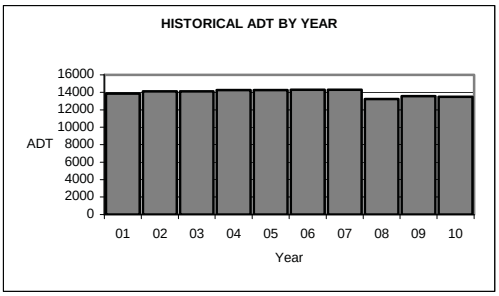
Classification Breakdown	Percent of ADT
Motorcyles	0.04
Passenger cars	76.73
Light Trucks	17.22
Buses	0.56
Single unit trucks (2 axles)	1.20
Single unit trucks (3 axles)	0.83
Single unit trucks (4 or more axles)	0.01
Single trailer trucks (4 or less axles)	0.39
Single trailer trucks (5 axles)	2.23
Single trailer trucks (6 or more axles)	0.48
Multi trailer trucks (5 or less axles)	0.01
Multi trailer trucks (6 axles)	0.01
Multi trailer trucks (7 or more axles)	0.29

Location: OR18; MP 41.00; SALMON RIVER HIGHWAY NO. 39; 3.36 miles south of Pacific Highway West No. 91 (OR99W)

Site Name: Salmon River (36-006)
Installed: July, 2000

HISTORICAL TRAFFIC DATA

Year	Average Daily Traffic	Max Day	Max Hour	10TH Hour	20TH Hour	30TH Hour
		Percent of ADT				
2001	13844	137	11.4	10.4	10.2	10.0
2002	14083	135	10.7	10.3	10.1	10.0
2003	14113	134	10.9	10.3	10.1	9.9
2004	14237	141	10.8	10.3	10.1	10.0
2005	14230	135	10.6	10.0	9.9	9.7
2006	14298	***	***	***	***	***
2007	14283	137	10.7	10.2	9.9	9.8
2008	13234	143	11.8	10.5	10.3	10.1
2009	13550	136	11.2	10.5	10.2	10.1
2010	13487	141	11.4	10.8	10.4	10.3



2010 TRAFFIC DATA

	Average Weekday Traffic	Percent of ADT	Average Daily Traffic	Percent of ADT
January	11348	84	11690	87
February	12127	90	13160	98
March	12820	95	13676	101
April	12377	92	13183	98
May	12725	94	13796	102
June	13421	100	14297	106
July	14749	109	15502	115
August	14626	108	15677	116
September	13336	99	14224	105
October	12585	93	13234	98
November	11421	85	11893	88
December	11514	85	11515	85

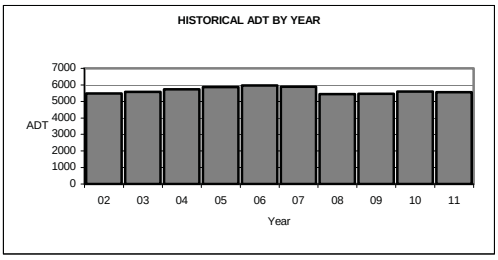
Classification Breakdown	Percent of ADT
Motorcyles	0.04
Passenger cars	76.73
Light Trucks	17.22
Buses	0.56
Single unit trucks (2 axles)	1.20
Single unit trucks (3 axles)	0.83
Single unit trucks (4 or more axles)	0.01
Single trailer trucks (4 or less axles)	0.39
Single trailer trucks (5 axles)	2.23
Single trailer trucks (6 or more axles)	0.48
Multi trailer trucks (5 or less axles)	0.01
Multi trailer trucks (6 axles)	0.01
Multi trailer trucks (7 or more axles)	0.29

Location: OR99W; MP 47.45; PACIFIC HIGHWAY WEST NO. 91; 0.07 mile north of Yamhill-Polk County Line

Site Name: Amity (36-005)
Installed: September, 1956

HISTORICAL TRAFFIC DATA

Year	ADT	Max Day	Max Hour	Percent of ADT 10TH Hour	20TH Hour	30TH Hour
2002	5483	137	14.1	12.1	11.3	11.1
2003	5571	140	13.2	11.5	11.0	10.9
2004	5731	132	13.3	11.4	11.1	10.9
2005	5858	***	***	***	***	***
2006	5957	137	13.2	11.5	11.1	10.7
2007	5874	132	13.2	11.3	10.9	10.7
2008	5433	131	12.9	11.8	11.2	11.0
2009	5452	132	14.5	11.8	11.3	11.0
2010	5594	135	14.7	11.8	11.2	11.0
2011	5553	135	14.5	11.8	11.3	11.1



2011 TRAFFIC DATA

	Average Weekday Traffic	Percent of ADT	Average Daily Traffic	Percent of ADT
January	5305	96	5024	90
February	5329	96	5179	93
March	5502	99	5347	96
April	5763	104	5647	102
May	5742	103	5672	102
June	5943	107	5888	106
July	5848	105	5702	103
August	6127	110	5919	107
September	5866	106	5871	106
October	5920	107	5838	105
November	5757	104	5590	101
December	5173	93	4958	89

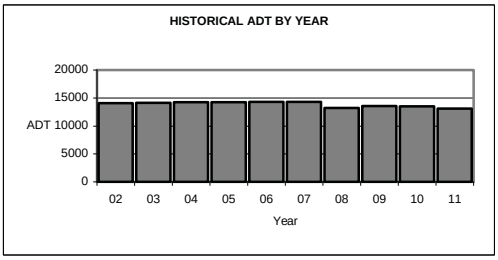
Classification Breakdown	Percent of ADT
Motorcycles	0.67
Passenger cars	60.93
Light Trucks	31.34
Buses	0.29
Single unit trucks (2 axles)	2.81
Single unit trucks (3 axles)	0.74
Single unit trucks (4 or more axles)	0.10
Single trailer trucks (4 or less axles)	0.36
Single trailer trucks (5 axles)	1.38
Single trailer trucks (6 or more axles)	0.89
Multi trailer trucks (5 or less axles)	0.02
Multi trailer trucks (6 axles)	0.01
Multi trailer trucks (7 or more axles)	0.46

Location: OR18; MP 41.00; SALMON RIVER HIGHWAY NO. 39; 3.36 miles south of Pacific Highway West No. 91 (OR99W)

Site Name: Salmon River (36-006)
Installed: July, 2000

HISTORICAL TRAFFIC DATA

Year	ADT	Max Day	Max Hour	Percent of ADT 10TH Hour	20TH Hour	30TH Hour
2002	14083	135	10.7	10.3	10.1	10.0
2003	14113	134	10.9	10.3	10.1	9.9
2004	14237	141	10.8	10.3	10.1	10.0
2005	14230	135	10.6	10.0	9.9	9.7
2006	14298	***	***	***	***	***
2007	14283	137	10.7	10.2	9.9	9.8
2008	13234	143	11.8	10.5	10.3	10.1
2009	13550	136	11.2	10.5	10.2	10.1
2010	13487	141	11.4	10.8	10.4	10.3
2011	13097	138	11.8	10.9	10.7	10.5



2011 TRAFFIC DATA

	Average Weekday Traffic	Percent of ADT	Average Daily Traffic	Percent of ADT
January	11157	85	11650	89
February	11508	88	12194	93
March	12118	93	12727	97
April	12014	92	12780	98
May	12423	95	13290	101
June	12814	98	13747	105
July	14105	108	14931	114
August	14262	109	15415	118
September	13300	102	14354	110
October	12266	94	12893	98
November	11352	87	11749	90
December	11222	86	11435	87

Classification Breakdown	Percent of ADT
Motorcycles	0.04
Passenger cars	76.73
Light Trucks	17.23
Buses	0.56
Single unit trucks (2 axles)	1.20
Single unit trucks (3 axles)	0.83
Single unit trucks (4 or more axles)	0.01
Single trailer trucks (4 or less axles)	0.39
Single trailer trucks (5 axles)	2.23
Single trailer trucks (6 or more axles)	0.48
Multi trailer trucks (5 or less axles)	0.01
Multi trailer trucks (6 axles)	0.00
Multi trailer trucks (7 or more axles)	0.29

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	*Will Farley*	Intersection	
Agency/Co.	*Lancaster Engineering*	Jurisdiction	*ODOT*
Date Performed	*8/5/2013*	Analysis Year	*2013*
Analysis Time Period			

Project Description *Riverbend Landfill*

East/West Street: *Oregon Highway 18* North/South Street: *Access*

Intersection Orientation: *East-West* Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)		*361*	*0*	*31*	*286*	
Peak-Hour Factor, PHF	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*
Hourly Flow Rate, HFR (veh/h)	*0*	*392*	*0*	*33*	*310*	*0*
Percent Heavy Vehicles	*0*	--	--	*19*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*1*	*1*	*0*
Configuration		*T*	*R*	*L*	*T*	
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*2*		*18*			
Peak-Hour Factor, PHF	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*
Hourly Flow Rate, HFR (veh/h)	*2*	*0*	*19*	*0*	*0*	*0*
Percent Heavy Vehicles	*75*	*0*	*75*	*0*	*0*	*0*
Percent Grade (%)		*0*			*0*	
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*0*	*0*	*0*	*0*	*0*
Configuration		*LR*				

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration		*L*		*LR*				
v (veh/h)		*33*		*21*				
C (m) (veh/h)		*1080*		*481*				
v/c		*0.03*		*0.04*				
95% queue length		*0.09*		*0.14*				
Control Delay (s/veh)		*8.4*		*12.8*				
LOS		*A*		*B*				
Approach Delay (s/veh)	--	--	*12.8*					
Approach LOS	--	--	*B*					

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 8/20/2013 10:48 AM

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	*Will Farley*	Intersection	
Agency/Co.	*Lancaster Engineering*	Jurisdiction	*ODOT*
Date Performed	*8/5/2013*	Analysis Year	*2013*
Analysis Time Period	*Existing PM Peak Hour*		

Project Description *Riverbend Landfill*

East/West Street: *Oregon Highway 18* North/South Street: *Access*

Intersection Orientation: *East-West* Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)		*520*	*1*	*3*	*620*	
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*0*	*559*	*1*	*3*	*666*	*0*
Percent Heavy Vehicles	*0*	--	--	*3*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*1*	*1*	*0*
Configuration		*T*	*R*	*L*	*T*	
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*2*		*29*			
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*2*	*0*	*31*	*0*	*0*	*0*
Percent Heavy Vehicles	*13*	*0*	*13*	*0*	*0*	*0*
Percent Grade (%)		*0*			*0*	
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*0*	*0*	*0*	*0*	*0*
Configuration		*LR*				

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration		*L*		*LR*				
v (veh/h)		*3*		*33*				
C (m) (veh/h)		*1006*		*459*				
v/c		*0.00*		*0.07*				
95% queue length		*0.01*		*0.23*				
Control Delay (s/veh)		*8.6*		*13.4*				
LOS		*A*		*B*				
Approach Delay (s/veh)	--	--	*13.4*					
Approach LOS	--	--	*B*					

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 8/20/2013 10:49 AM

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	*Will Farley*	Intersection	
Agency/Co.	*Lancaster Engineering*	Jurisdiction	*ODOT*
Date Performed	*8/5/2013*	Analysis Year	*2013*
Analysis Time Period	*Existing Saturday Peak Hour*		

Project Description *Riverbend Landfill*

East/West Street: *Oregon Highway 18* North/South Street: *Access*

Intersection Orientation: *East-West* Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)		*520*	*3*	*26*	*734*	
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*0*	*559*	*3*	*27*	*789*	*0*
Percent Heavy Vehicles	*0*	--	--	*4*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*1*	*1*	*0*
Configuration		*T*	*R*	*L*	*T*	
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*6*		*22*			
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*6*	*0*	*23*	*0*	*0*	*0*
Percent Heavy Vehicles	*7*	*0*	*7*	*0*	*0*	*0*
Percent Grade (%)		*0*			*0*	
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*0*	*0*	*0*	*0*	*0*
Configuration		*LR*				

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration		*L*		*LR*				
v (veh/h)		*27*		*29*				
C (m) (veh/h)		*999*		*340*				
v/c		*0.03*		*0.09*				
95% queue length		*0.08*		*0.28*				
Control Delay (s/veh)		*8.7*		*16.6*				
LOS		*A*		*C*				
Approach Delay (s/veh)	--	--	*16.6*					
Approach LOS	--	--	*C*					

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 8/20/2013 10:52 AM

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	*Will Farley*	Intersection	
Agency/Co.	*Lancaster Engineering*	Jurisdiction	*ODOT*
Date Performed		Analysis Year	*2030*
Analysis Time Period	*Background AM Peak Hour*		

Project Description *Riverbend Landfill*

East/West Street: *Oregon Highway 18* | North/South Street: *Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)		468	0	31	371	
Peak-Hour Factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Hourly Flow Rate, HFR (veh/h)	0	508	0	33	403	0
Percent Heavy Vehicles	0	--	--	19	--	--
Median Type	Undivided					
RT Channelized			0			0
Lanes	0	1	1	1	1	0
Configuration		T	R	L	T	
Upstream Signal		0			0	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	2		18			
Peak-Hour Factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Hourly Flow Rate, HFR (veh/h)	2	0	19	0	0	0
Percent Heavy Vehicles	75	0	75	0	0	0
Percent Grade (%)		0			0	
Flared Approach		N			N	
Storage		0			0	
RT Channelized			0			0
Lanes	0	0	0	0	0	0
Configuration		LR				

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration		L		LR				
v (veh/h)		33		21				
C (m) (veh/h)		975		398				
v/c		0.03		0.05				
95% queue length		0.11		0.17				
Control Delay (s/veh)		8.8		14.5				
LOS		A		B				
Approach Delay (s/veh)	--	--	14.5					
Approach LOS	--	--	B					

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 8/20/2013 10:47 AM

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	*Will Farley*	Intersection	
Agency/Co.	*Lancaster Engineering*	Jurisdiction	*ODOT*
Date Performed	*8/15/2013*	Analysis Year	*2030*
Analysis Time Period	*Background PM Peak Hour*		

Project Description *Riverbend Landfill*

East/West Street: *Oregon Highway 18* North/South Street: *Access*

Intersection Orientation: *East-West* Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)		*674*	*1*	*3*	*803*	
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*0*	*724*	*1*	*3*	*863*	*0*
Percent Heavy Vehicles	*0*	--	--	*3*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*1*	*1*	*0*
Configuration		*T*	*R*	*L*	*T*	
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*2*		*29*			
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*2*	*0*	*31*	*0*	*0*	*0*
Percent Heavy Vehicles	*13*	*0*	*13*	*0*	*0*	*0*
Percent Grade (%)		*0*			*0*	
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*0*	*0*	*0*	*0*	*0*
Configuration		*LR*				

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration		*L*		*LR*				
v (veh/h)		*3*		*33*				
C (m) (veh/h)		*873*		*351*				
v/c		*0.00*		*0.09*				
95% queue length		*0.01*		*0.31*				
Control Delay (s/veh)		*9.1*		*16.3*				
LOS		*A*		*C*				
Approach Delay (s/veh)	--	--	*16.3*					
Approach LOS	--	--	*C*					

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 8/20/2013 10:55 AM

TWO-WAY STOP CONTROL SUMMARY

General Information

Analyst	*Will Farley*
Agency/Co.	*Lancaster Engineering*
Date Performed	*8/15/2013*
Analysis Time Period	*Background Saturday Peak Hour*

Site Information

Intersection	
Jurisdiction	*ODOT*
Analysis Year	*2030*

Project Description *Riverbend Landfill*

East/West Street: *Oregon Highway 18* | North/South Street: *Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)		*684*	*3*	*26*	*965*	
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*0*	*735*	*3*	*27*	*1037*	*0*
Percent Heavy Vehicles	*0*	--	--	*4*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*1*	*1*	*0*
Configuration		*T*	*R*	*L*	*T*	
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*6*		*22*			
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*6*	*0*	*23*	*0*	*0*	*0*
Percent Heavy Vehicles	*7*	*0*	*7*	*0*	*0*	*0*
Percent Grade (%)	*0*			*0*		
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*0*	*0*	*0*	*0*	*0*
Configuration		*LR*				

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration		*L*		*LR*				
v (veh/h)		*27*		*29*				
C (m) (veh/h)		*859*		*220*				
v/c		*0.03*		*0.13*				
95% queue length		*0.10*		*0.45*				
Control Delay (s/veh)		*9.3*		*23.8*				
LOS		*A*		*C*				
Approach Delay (s/veh)	--	--	*23.8*					
Approach LOS	--	--	*C*					

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 8/20/2013 10:53 AM

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	*Will Farley*	Intersection	
Agency/Co.	*Lancaster Engineering*	Jurisdiction	*ODOT*
Date Performed	*8/15/2013*	Analysis Year	*2030*
Analysis Time Period	*Site AM Peak Hour*		

Project Description *Riverbend Landfill*

East/West Street: *Oregon Highway 18* North/South Street: *Access*

Intersection Orientation: *East-West* Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)		*468*	*3*	*57*	*371*	
Peak-Hour Factor, PHF	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*
Hourly Flow Rate, HFR (veh/h)	*0*	*508*	*3*	*61*	*403*	*0*
Percent Heavy Vehicles	*0*	--	--	*19*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*1*	*1*	*0*
Configuration		*T*	*R*	*L*	*T*	
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*4*		*40*			
Peak-Hour Factor, PHF	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*
Hourly Flow Rate, HFR (veh/h)	*4*	*0*	*43*	*0*	*0*	*0*
Percent Heavy Vehicles	*75*	*0*	*75*	*0*	*0*	*0*
Percent Grade (%)		*0*			*0*	
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*0*	*0*	*0*	*0*	*0*
Configuration		*LR*				

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration		*L*		*LR*				
v (veh/h)		*61*		*47*				
C (m) (veh/h)		*973*		*394*				
v/c		*0.06*		*0.12*				
95% queue length		*0.20*		*0.40*				
Control Delay (s/veh)		*8.9*		*15.4*				
LOS		*A*		*C*				
Approach Delay (s/veh)	--	--	*15.4*					
Approach LOS	--	--	*C*					

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 8/20/2013 10:47 AM

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	*Will Farley*	Intersection	
Agency/Co.	*Lancaster Engineering*	Jurisdiction	*ODOT*
Date Performed	*8/15/2013*	Analysis Year	*2030*
Analysis Time Period	*Site PM Peak Hour*		

Project Description *Riverbend Landfill*

East/West Street: *Oregon Highway 18* North/South Street: *Access*

Intersection Orientation: *East-West* Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)		*674*	*3*	*20*	*803*	
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*0*	*724*	*3*	*21*	*863*	*0*
Percent Heavy Vehicles	*0*	--	--	*3*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*1*	*1*	*0*
Configuration		*T*	*R*	*L*	*T*	
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*5*		*55*			
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*5*	*0*	*59*	*0*	*0*	*0*
Percent Heavy Vehicles	*13*	*0*	*13*	*0*	*0*	*0*
Percent Grade (%)		*0*			*0*	
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*0*	*0*	*0*	*0*	*0*
Configuration		*LR*				

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration		*L*		*LR*				
v (veh/h)		*21*		*64*				
C (m) (veh/h)		*872*		*331*				
v/c		*0.02*		*0.19*				
95% queue length		*0.07*		*0.70*				
Control Delay (s/veh)		*9.2*		*18.5*				
LOS		*A*		*C*				
Approach Delay (s/veh)	--	--	*18.5*					
Approach LOS	--	--	*C*					

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 8/20/2013 10:56 AM

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	*Will Farley*	Intersection	
Agency/Co.	*Lancaster Engineering*	Jurisdiction	*ODOT*
Date Performed	*8/15/2013*	Analysis Year	*2030*
Analysis Time Period	*Site Saturday Peak Hour*		

Project Description *Riverbend Landfill*

East/West Street: *Oregon Highway 18* North/South Street: *Access*

Intersection Orientation: *East-West* Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)		*684*	*6*	*52*	*965*	
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*0*	*735*	*6*	*55*	*1037*	*0*
Percent Heavy Vehicles	*0*	--	--	*4*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*1*	*1*	*0*
Configuration		*T*	*R*	*L*	*T*	
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*9*		*47*			
Peak-Hour Factor, PHF	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*	*0.93*
Hourly Flow Rate, HFR (veh/h)	*9*	*0*	*50*	*0*	*0*	*0*
Percent Heavy Vehicles	*7*	*0*	*7*	*0*	*0*	*0*
Percent Grade (%)		*0*			*0*	
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*0*	*0*	*0*	*0*	*0*
Configuration		*LR*				

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration		*L*		*LR*				
v (veh/h)		*55*		*59*				
C (m) (veh/h)		*857*		*238*				
v/c		*0.06*		*0.25*				
95% queue length		*0.21*		*0.95*				
Control Delay (s/veh)		*9.5*		*25.0*				
LOS		*A*		*D*				
Approach Delay (s/veh)	--	--	*25.0*					
Approach LOS	--	--	*D*					

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 8/20/2013 10:54 AM

Total crash records: 8

SER# / INVEST	S P E D / A L C S	R G H L	S W O K	DATE / DAY / TIME	COUNTY / CITY / URBAN AREA	RD# FC / COMPNT / MLG TYP / MILEPNT	CONN# / FIRST STREET / SECOND STREET	RD CHAR / DIRECT / LOCTN	INT-TYPE / (MEDIAN) / LEGS / (#LANES)	INT-REL / TRAF- / CONTL	OFFRD / RNDBT / DRVWY	WTHR / SURF / LIGHT	CRASH / COLL / SVRTY	V#	SPCL USE / TRLR QTY / OWNER / TYPE	MOVE / FROM / TO	PRTC / P# TYPE	INJ / SVRTY	A G E	S X	LICNS / RES	PED LOC	ERROR	ACT	EVENT	CAUSE
01020	Y	N	N	N 11/22/2010	YAMHILL	1	02	STRGHT		N	Y	SLT	FIX OBJ	01	NONE 0	STRGHT									043,010,124	01
COUNTY				MO		MN	0	UN	(NONE)	NONE	N	ICE	FIX		PRVTE	W -E							000	043,010,124	00
				4P		41.00		01			N	DUSK	PDO		PSNGR CAR		01 DRVR	NONE	52	F	OR-Y	047	017		01
									(02)												OR<25				
00521	N	Y	Y	N 07/21/2009	YAMHILL	1	02	STRGHT		N	N	CLR	S-1STOP	01	NONE 1	STRGHT										07
STATE				TU		MN	0	UN	(NONE)	UNKNOWN	N	DRY	REAR		PRVTE	W -E							000		00
				2P		41.00		03			N	DAY	INJ		PSNGR CAR		01 DRVR	NONE	63	M	OR-Y	026	000		07
									(02)												OR<25				
														02	NONE 0	STOP										
															PRVTE	W -E							011		00
															PSNGR CAR		01 DRVR	INJC	63	M	OR-Y	000	000		00
																					OR<25				
														03	NONE 0	STOP										
															PRVTE	W -E							011		00
															PSNGR CAR		01 DRVR	INJC	55	M	OR-Y	000	000		00
																					OR<25				
00757	N	N	N	09/18/2011	YAMHILL	1	02	STRGHT		N	N	RAIN	S-1STOP	01	NONE 0	STRGHT										07
NONE				SU		MN	0	UN	(NONE)	UNKNOWN	N	WET	REAR		PRVTE	W -E							000		00
				12P		41.00		03			N	DAY	PDO		PSNGR CAR		01 DRVR	NONE	16	F	OR-Y	026	000		07
									(02)												OR<25				
														02	NONE 0	STOP										
															PRVTE	W -E							011		00
															PSNGR CAR		01 DRVR	NONE	18	M	OR-Y	000	000		00
																					OR<25				
01172	Y	N	N	N N 12/17/2012	YAMHILL	1	02	STRGHT		N	Y	RAIN	FIX OBJ	01	NONE 0	STRGHT									124,079,053	01
STATE				MO		MN	0	UN	(NONE)	NONE	N	WET	FIX		PRVTE	W -E							000	124,079,053	00
				1A		41.00		06			N	DARK	PDO		PSNGR CAR		01 DRVR	NONE	62	F	OR-Y	047,080,081	017		01
									(02)												OR<25				
00681	N	N	N	N N 08/23/2010	YAMHILL	1	02	STRGHT		N	N	CLR	S-1STOP	01	NONE 0	STRGHT										07
STATE				MO		MN	0	UN	(NONE)	NONE	N	DRY	REAR		PRVTE	W -E							000		00
				5P		41.00		08			N	DAY	INJ		PSNGR CAR		01 DRVR	NONE	41	F	OR-Y	026	000		07
									(02)												OR<25				
														01	NONE 0	STRGHT										
															PRVTE	W -E							000		00
															PSNGR CAR		02 PSNG	NO<5	04	M		000	000		00
														02	NONE 0	STOP										
															PRVTE	W -E							011		00
															PSNGR CAR		01 DRVR	INJC	25	M	OR-Y	000	000		00
																					OR<25				
														02	NONE 0	STOP										
															PRVTE	W -E							011		00
															PSNGR CAR		02 PSNG	INJC	27	F		000	000		00
00378	N	N	N	04/01/2008	YAMHILL	1	02	STRGHT		N	N	CLR	S-STRGHT	01	NONE 0	STRGHT										07
NONE				TU		MN	0	UN	(NONE)	UNKNOWN	N	DRY	REAR		PRVTE	W -E							000		00
				4P		41.54		03			N	DAY	INJ		PSNGR CAR		01 DRVR	NONE	34	F	OR-Y	042	000		07
									(02)												OR<25				
														02	NONE 0	STRGHT										

Disclaimer: The information contained in this report is compiled from individual driver and police crash reports submitted to the Oregon Department of Transportation as required in ORS 811.720. The Crash Analysis and Reporting Unit is committed to providing the highest quality crash data to customers. However, because submittal of crash report forms is the responsibility of the individual driver, the Crash Analysis and Reporting Unit can not guarantee that all qualifying crashes are represented nor can assurances be made that all details pertaining to a single crash are accurate. Note: Legislative changes to DMV's vehicle crash reporting requirement, effective 01/01/2004, may affect injury/property damage only crashes being eligible for inclusion in the Statewide Crash Data File.

Total crash records: 8

SER# INVEST	S P E D	A L C	U G S	C S L	O H K	W R W	DATE DAY TIME	COUNTY CITY URBAN AREA	RD# FC COMPNT MLG TYP MILEPNT	CONN# FIRST STREET SECOND STREET	RD CHAR DIRECT LOCTN	INT-TYPE (MEDIAN) LEGS (#LANES)	INT-REL TRAF- CONTL	OFFRD RNDBT DRVWY	WTHR SURF LIGHT	CRASH COLL SVRTY	V#	SPCL USE TRLR QTY OWNER TYPE	MOVE FROM TO	P#	PRTC TYPE	INJ SVRTY	A G E	S E X	LICNS RES	PED LOC	ERROR	ACT	EVENT	CAUSE
																		PRVTE	W -E								006		00
																		PSNGR CAR		01	DRVR	INJC	35	F	OR-Y		000	000		00
																									OR<25					
00351	N	N	N	N	N		05/09/2009	YAMHILL	1 02		STRGHT		N	Y	CLR	FIX OBJ	01	NONE 0	STRGHT										037	16
STATE							SA		MN 0		UN	(NONE)	UNKNOWN	N	DRY	FIX		PRVTE	E -W									000	037	00
							4P		41.73		06			N	DAY	INJ		PSNGR CAR		01	DRVR	INJC	19	M	OR-Y		081	025		16
												(02)													OR<25					
00857	N	N	N	N	N		10/22/2011	YAMHILL	1 02		STRGHT		N	N	CLD	S-1TURN	01	NONE 0	U-TURN											08
STATE							SA		MN 0		UN	(NONE)	UNKNOWN	N	DRY	TURN		PRVTE	E -E									000		00
							5P		42.00		03			N	DAY	INJ		PSNGR CAR		01	DRVR	INJB	23	F	OR-Y		008	000		08
												(02)													OR<25					
																	01	NONE 0	U-TURN											
																		PRVTE	E -E									000		00
																		PSNGR CAR		02	PSNG	NO<5	01	F			000	000		00
																	02	NONE 0	STRGHT											
																		PRVTE	E -W									000		00
																		PSNGR CAR		01	DRVR	NONE	62	F	OR-Y		000	000		00
																									OR<25					

Disclaimer: The information contained in this report is compiled from individual driver and police crash reports submitted to the Oregon Department of Transportation as required in ORS 811.720. The Crash Analysis and Reporting Unit is committed to providing the highest quality crash data to customers. However, because submittal of crash report forms is the responsibility of the individual driver, the Crash Analysis and Reporting Unit can not guarantee that all qualifying crashes are represented nor can assurances be made that all details pertaining to a single crash are accurate. Note: Legislative changes to DMV's vehicle crash reporting requirement, effective 01/01/2004, may affect personal property damage only crashes being eligible for inclusion in the Statewide Crash Data File.

ATTACHMENT 9

Evaluation of Historical Groundwater Elevations Memorandum (Prepared by SCS Engineers)

Environmental Consultants
and Contractors

14945 SW Sequoia Parkway
Suite 180
Portland, OR 97224

(503) 639-9201
FAX (503) 684-6948
www.scsengineers.com

SCS ENGINEERS

MEMORANDUM

DATE: April 23, 2015

TO: Hari Sharma and Fabrizio Settepani, Geosyntec Consultants

Cc: Tim Watson, Riverbend Landfill Company
Frank Willmann, Waste Management
Paul Burns, Waste Management
Mark Verwiel, Waste Management

FROM: David Lamadrid, R.G., and Louis Caruso, SCS Engineers

REGISTERED OREGON DAVID LAMADRID G1905 GEOLOGIST
Expires 1/31/16

SUBJECT: **Evaluation of Historical Groundwater Elevations in the Proposed Module 11 Expansion Area, Riverbend Landfill, McMinnville, Oregon (SCS No. 04215015.00)**

This memorandum, prepared by SCS Engineers (SCS) at the request of Riverbend Landfill Company (RLC), presents and evaluates available historical groundwater elevation data and interpreted groundwater potentiometric surface contours in the proposed Module 11 expansion area at Riverbend Landfill (RL) in McMinnville, Oregon. SCS understands that this information will be used to support the design of base grade elevations for the proposed Module 11 landfill cell(s). As such, this memorandum focuses on identifying historical high groundwater elevations in the proposed Module 11 expansion area using available historical data.

Monitoring wells and piezometers located within or adjacent to the proposed Module 11 expansion area, along with the historical range of available groundwater elevation data for each well, are listed below and shown in Figure 1.

- Existing monitoring well pairs MW-1A/MW-1B and MW-10A/MW-10B, and former piezometer pair P-04A/P-04B (decommissioned in June 2013), each with historical groundwater elevation monitoring data dating back to 1993.
- Existing monitoring well pairs MW-18A/MW-18B and MW-20A/MW-20B with historical groundwater elevation monitoring data dating back to 2000.
- Existing piezometers P-05A and P-06A with historical groundwater elevation monitoring data dating back to 2006.
- Existing piezometer GT-10-1 with historical groundwater elevation monitoring data dating back to 2010.

The "A" designated wells/piezometers and GT-10-1 are screened in the shallow (upper) silt-clay water-bearing zone (WBZ), and the "B" designated wells are screened in the deep (lower) sand-gravel WBZ, except for monitoring well pair MW-1A/MW-1B for which the designations are reversed from this nomenclature.

Information used to support this evaluation included historical depth-to-groundwater and groundwater elevation data presented in Table 1, and groundwater elevation hydrographs provided in Attachment 1, for the above-mentioned wells and piezometers. The hydrographs identify historical high groundwater elevations for each well and piezometer during the well-specific monitoring period, and include precipitation data.

The determination of high groundwater elevations only considered groundwater elevation data for the shallow WBZ because (1) this WBZ is relevant with respect to the base grade designs for the proposed Module 11 landfill cell(s), and (2) groundwater elevations in shallow WBZ wells are typically shallower than those in the associated deep WBZ wells.

Based on the data presented in Table 1 and the hydrographs, the following are noteworthy findings related to groundwater elevations in the shallow WBZ in the proposed Module 11 expansion area:

- Historical high groundwater elevations ranged from 127.25 feet above mean sea level (amsl [local datum]) at well MW-20A (in April 2011) near the southeast corner of proposed Module 11, to 150.27 feet amsl at well MW-1B (in December 1994) near the northern corner of proposed Module 11.

- The historical high groundwater elevations correspond to depth-to-groundwater measurements that were typically less than 5 feet below ground surface (bgs).

- The hydrographs show that groundwater elevations exhibit typical seasonal fluctuations (see hydrographs in Attachment 1). The magnitudes of the fluctuations, however, do not appear to directly correspond to annual precipitation (i.e., in most cases high annual precipitation does not result in higher groundwater elevations in the complete subset of wells in the Module 11 area). This is due in part to the frequency that groundwater elevation data are collected (i.e., quarterly prior to 2003 and semiannually since 2003).

- Historical interpretations of groundwater elevations indicate that groundwater within the shallow WBZ consistently flows southeasterly across the proposed Module 11 area.

- Groundwater elevations in shallow WBZ wells/piezometers are typically higher than those in the associated deep WBZ wells/piezometers (see hydrographs in Attachment 1).

Groundwater flow and hydraulic gradients representative of high groundwater conditions in the proposed Module 11 expansion area were evaluated based on review of (1) the groundwater elevation data presented in this memorandum, and (2) previous interpretations of shallow WBZ groundwater potentiometric surface contours presented in annual environmental monitoring reports submitted to the Oregon Department of Environmental Quality (DEQ) since 2000. It should be noted that groundwater elevation data collected after 1999 were used for this evaluation because interpretation of groundwater flow in the shallow WBZ across the proposed Module 11 area was greatly improved in 2000 when monitoring wells MW-18A and MW-20A were installed. The interpretations were further enhanced with the installation of piezometers P-05A and P-06A in 2006 and GT-10-1 in 2010.

Based on review of the post-1999 groundwater elevation data, representative high groundwater conditions were identified for the following monitoring periods:

- **February 2002:** The hydrograph for monitoring well MW-18A shows that the historical high groundwater elevation for this well occurred in February 2002. The February 2002 groundwater elevation measured in well MW-20A was nearly equivalent (within 0.17 feet) to the historical high groundwater elevation for this well. The precipitation amounts in late 2001 and early 2002 were generally about average based on precipitation data provided in this memorandum.

- **April 2011:** The full set of existing monitoring wells and piezometers within or adjacent to the proposed Module 11 expansion area was in place by 2010 (including piezometer GT-10-1 that was installed in September 2010). This set of wells and piezometers allows further improvement in the interpretation of groundwater flow. The hydrographs for MW-20A and P-06A show that historical high groundwater elevations occurred in these wells in April 2011. The precipitation amounts in late 2010 and early 2011 were generally above average based on precipitation data provided in this memorandum.

- **April 2014:** The hydrographs for piezometers P-05A and GT-10-1 show that the historical high groundwater elevations for these piezometers occurred in April 2014. The precipitation amounts in late 2013 and early 2014 were generally about average.

Groundwater potentiometric surface (i.e., elevation) contours for the shallow (silt-clay) WBZ based on groundwater elevation data collected in April 2014, April 2011, and February 2002 are shown in Figures 1, 2, and 3, respectively. The interpretative groundwater elevation contours for each monitoring period show that shallow groundwater beneath the proposed Module 11 expansion area flowed southeasterly, consistent with other historical interpretations for this area. The hydraulic gradient for each monitoring period was about 0.011 feet/feet (as measured between upgradient well MW-10A and downgradient well MW-20A).

Figure 4 presents groundwater elevation hydrographs for shallow WBZ wells and piezometers, along with the April 2011 interpretative groundwater elevation contours in the proposed Module 11 area. The hydrographs also denote ground surface elevations to illustrate the depth to groundwater below ground surface. In some cases the groundwater level was at ground surface during the wet season (e.g., as measured in GT-10-1 and MW-20A). The unusually high groundwater conditions in piezometers GT-10-1 and P-05A and monitoring well MW-20A are likely due to surface water ponding in the in the proposed Module 11 area (and in some cases near these monitoring points based on direct observations during groundwater monitoring events). It should be noted that extensive surface water ponding was believed to be responsible, in part, for changes in MW-20A water quality based on results of a 2006 water-quality assessment performed for the north poplar tree farm area (i.e., proposed Module 11 area) (Shaw Environmental, Inc., 2006[1]). The assessment indicated buried drain tiles in the north field were

[1] Shaw Environmental, Inc., 2006, Water-Quality Assessment of the North Poplar Tree Farm, Riverbend Landfill, McMinnville, Oregon, prepared for Riverbend Landfill, Inc., by Shaw Environmental, Inc., Portland, Oregon, December 27.

channelizing stormwater runoff toward MW-20A resulting in surface water ponding in the area of this monitoring well.

Attachment: Table 1: Proposed Module 11 Area Groundwater Elevations
Figure 1: Shallow Water-Bearing Zone Groundwater Elevation Contours (April 28, 2014)
Figure 2: Shallow Water-Bearing Zone Groundwater Elevation Contours (April 12, 2011)
Figure 3: Shallow Water-Bearing Zone Groundwater Elevation Contours (February 7, 2002)
Figure 4: Shallow Water-Bearing Zone Groundwater Elevation Hydrographs and April 2011 Groundwater Elevation Contours
Attachment 1: Groundwater Elevation Hydrographs

Table

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-01A (Deep)	11-Feb-93	155.30	20.72	134.58
MW-01A (Deep)	12-May-93	155.30	22.37	132.93
MW-01A (Deep)	12-Jul-93	155.30	26.49	128.81
MW-01A (Deep)	10-Aug-93	155.30	28.08	127.22
MW-01A (Deep)	14-Sep-93	155.30	28.39	126.91
MW-01A (Deep)	12-Oct-93	155.30	29.33	125.97
MW-01A (Deep)	4-Dec-93	155.30	28.97	126.33
MW-01A (Deep)	5-Jan-94	155.30	22.76	132.54
MW-01A (Deep)	22-Feb-94	155.30	20.92	134.38
MW-01A (Deep)	25-Mar-94	155.30	21.83	133.47
MW-01A (Deep)	26-Apr-94	155.30	22.25	133.05
MW-01A (Deep)	26-May-94	155.30	31.57	123.73
MW-01A (Deep)	1-Jul-94	155.30	29.88	125.42
MW-01A (Deep)	2-Aug-94	155.30	33.00	122.30
MW-01A (Deep)	2-Sep-94	155.30	33.27	122.03
MW-01A (Deep)	13-Oct-94	155.30	30.12	125.18
MW-01A (Deep)	11-Nov-94	155.30	28.38	126.92
MW-01A (Deep)	21-Dec-94	155.30	23.22	132.08
MW-01A (Deep)	20-Jan-95	155.30	21.85	133.45
MW-01A (Deep)	23-Feb-95	155.30	21.49	133.81
MW-01A (Deep)	28-Mar-95	155.30	21.79	133.51
MW-01A (Deep)	14-Apr-95	155.30	23.00	132.30
MW-01A (Deep)	18-May-95	155.30	20.12	135.18
MW-01A (Deep)	20-Jun-95	155.30	26.24	129.06
MW-01A (Deep)	26-Jul-95	155.30	27.54	127.76
MW-01A (Deep)	22-Aug-95	155.30	32.40	122.90
MW-01A (Deep)	11-Sep-95	155.30	28.53	126.77
MW-01A (Deep)	24-Oct-95	155.30	27.29	128.01
MW-01A (Deep)	20-Dec-95	155.30	21.64	133.66
MW-01A (Deep)	11-Jan-96	155.30	22.19	133.11
MW-01A (Deep)	16-Feb-96	155.30	21.39	133.91
MW-01A (Deep)	30-Mar-96	155.30	22.58	132.72
MW-01A (Deep)	9-Apr-96	155.30	27.30	128.00
MW-01A (Deep)	28-May-96	155.30	26.72	128.58
MW-01A (Deep)	28-Jun-96	155.30	30.90	124.40
MW-01A (Deep)	30-Jul-96	155.30	33.72	121.58
MW-01A (Deep)	29-Aug-96	155.30	31.58	123.72
MW-01A (Deep)	30-Sep-96	155.30	32.63	122.67
MW-01A (Deep)	31-Oct-96	155.30	32.20	123.10
MW-01A (Deep)	12-Dec-96	155.30	23.20	132.10
MW-01A (Deep)	22-Jan-97	155.30	21.23	134.07
MW-01A (Deep)	31-Mar-97	155.30	23.33	131.97
MW-01A (Deep)	19-May-97	155.30	32.13	123.17
MW-01A (Deep)	9-Sep-97	155.30	28.95	126.35
MW-01A (Deep)	18-Dec-97	155.30	21.79	133.51
MW-01A (Deep)	17-Mar-98	155.30	25.42	129.88
MW-01A (Deep)	8-Jun-98	155.30	30.90	124.40
MW-01A (Deep)	18-Aug-98	155.30	32.21	123.09
MW-01A (Deep)	5-Nov-98	155.30	26.93	128.37

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-01A (Deep)	22-Mar-99	155.30	21.93	133.37
MW-01A (Deep)	7-Sep-99	155.30	31.58	123.72
MW-01A (Deep)	9-Dec-99	155.30	NR	---
MW-01A (Deep)	7-Feb-00	155.30	20.38	134.92
MW-01A (Deep)	29-May-00	155.30	29.43	125.87
MW-01A (Deep)	21-Aug-00	155.30	33.01	122.29
MW-01A (Deep)	6-Nov-00	155.30	27.14	128.16
MW-01A (Deep)	29-Jan-01	155.30	23.97	131.33
MW-01A (Deep)	23-Apr-01	155.30	23.59	131.71
MW-01A (Deep)	27-Aug-01	155.30	28.95	126.35
MW-01A (Deep)	5-Nov-01	155.30	29.45	125.85
MW-01A (Deep)	7-Feb-02	155.30	21.81	133.49
MW-01A (Deep)	8-Apr-02	155.30	25.93	129.37
MW-01A (Deep)	22-Jul-02	155.30	30.21	125.09
MW-01A (Deep)	7-Oct-02	155.30	30.21	125.09
MW-01A (Deep)	24-Feb-03	155.30	24.89	130.41
MW-01A (Deep)	12-May-03	155.30	27.77	127.53
MW-01A (Deep)	18-Aug-03	155.30	42.78	112.52
MW-01A (Deep)	17-Nov-03	155.30	32.69	122.61
MW-01A (Deep)	19-Apr-04	155.30	29.88	125.42
MW-01A (Deep)	8-Nov-04	155.30	29.16	126.14
MW-01A (Deep)	23-May-05	155.30	28.77	126.53
MW-01A (Deep)	24-Oct-05	155.30	29.76	125.54
MW-01A (Deep)	8-May-06	155.30	33.75	121.55
MW-01A (Deep)	16-Oct-06	155.30	32.05	123.25
MW-01A (Deep)	7-May-07	155.30	28.31	126.99
MW-01A (Deep)	5-Nov-07	155.30	30.35	124.95
MW-01A (Deep)	19-May-08	155.30	46.09	109.21
MW-01A (Deep)	10-Nov-08	155.30	40.69	114.61
MW-01A (Deep)	4-May-09	155.30	24.81	130.49
MW-01A (Deep)	16-Nov-09	155.30	28.06	127.24
MW-01A (Deep)	19-Apr-10	155.30	31.96	123.34
MW-01A (Deep)	4-Oct-10	155.30	34.29	121.01
MW-01A (Deep)	12-Apr-11	155.30	24.57	130.73
MW-01A (Deep)	1-Nov-11	155.30	29.60	125.70
MW-01A (Deep)	30-Apr-12	155.30	23.35	131.95
MW-01A (Deep)	12-Nov-12	155.30	40.50	114.80
MW-01A (Deep)	8-Apr-13	155.30	22.65	132.65
MW-01A (Deep)	18-Nov-13	155.30	25.57	129.73
MW-01A (Deep)	28-Apr-14	155.30	23.28	132.02
MW-01A (Deep)	17-Nov-14	155.30	38.92	116.38
MW-01B (Shallow)	11-Feb-93	155.00	7.02	147.98
MW-01B (Shallow)	12-May-93	155.00	7.12	147.88
MW-01B (Shallow)	12-Jul-93	155.00	11.63	143.37
MW-01B (Shallow)	10-Aug-93	155.00	12.56	142.44
MW-01B (Shallow)	14-Sep-93	155.00	14.30	140.70
MW-01B (Shallow)	12-Oct-93	155.00	14.52	140.48
MW-01B (Shallow)	4-Dec-93	155.00	9.43	145.57
MW-01B (Shallow)	5-Jan-94	155.00	4.74	150.26

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-01B (Shallow)	22-Feb-94	155.00	6.14	148.86
MW-01B (Shallow)	25-Mar-94	155.00	5.85	149.15
MW-01B (Shallow)	26-Apr-94	155.00	8.54	146.46
MW-01B (Shallow)	26-May-94	155.00	10.90	144.10
MW-01B (Shallow)	1-Jul-94	155.00	13.78	141.22
MW-01B (Shallow)	2-Aug-94	155.00	14.64	140.36
MW-01B (Shallow)	2-Sep-94	155.00	15.67	139.33
MW-01B (Shallow)	13-Oct-94	155.00	17.17	137.83
MW-01B (Shallow)	11-Nov-94	155.00	17.77	137.23
MW-01B (Shallow)	21-Dec-94	155.00	4.73	150.27
MW-01B (Shallow)	20-Jan-95	155.00	5.16	149.84
MW-01B (Shallow)	23-Feb-95	155.00	5.70	149.30
MW-01B (Shallow)	28-Mar-95	155.00	6.44	148.56
MW-01B (Shallow)	14-Apr-95	155.00	6.42	148.58
MW-01B (Shallow)	18-May-95	155.00	9.07	145.93
MW-01B (Shallow)	20-Jun-95	155.00	9.72	145.28
MW-01B (Shallow)	26-Jul-95	155.00	11.75	143.25
MW-01B (Shallow)	22-Aug-95	155.00	13.13	141.87
MW-01B (Shallow)	11-Sep-95	155.00	16.10	138.90
MW-01B (Shallow)	24-Oct-95	155.00	13.83	141.17
MW-01B (Shallow)	22-Nov-95	155.00	6.97	148.03
MW-01B (Shallow)	20-Dec-95	155.00	5.16	149.84
MW-01B (Shallow)	11-Jan-96	155.00	5.22	149.78
MW-01B (Shallow)	16-Feb-96	155.00	6.22	148.78
MW-01B (Shallow)	30-Mar-96	155.00	8.00	147.00
MW-01B (Shallow)	9-Apr-96	155.00	8.49	146.51
MW-01B (Shallow)	28-May-96	155.00	6.85	148.15
MW-01B (Shallow)	28-Jun-96	155.00	9.83	145.17
MW-01B (Shallow)	30-Jul-96	155.00	12.51	142.49
MW-01B (Shallow)	29-Aug-96	155.00	12.18	142.82
MW-01B (Shallow)	30-Sep-96	155.00	11.02	143.98
MW-01B (Shallow)	31-Oct-96	155.00	7.04	147.96
MW-01B (Shallow)	12-Dec-96	155.00	5.31	149.69
MW-01B (Shallow)	22-Jan-97	155.00	5.01	149.99
MW-01B (Shallow)	31-Mar-97	155.00	6.73	148.27
MW-01B (Shallow)	19-May-97	155.00	9.16	145.84
MW-01B (Shallow)	9-Sep-97	155.00	11.53	143.47
MW-01B (Shallow)	18-Dec-97	155.00	4.96	150.04
MW-01B (Shallow)	17-Mar-98	155.00	5.98	149.02
MW-01B (Shallow)	8-Jun-98	155.00	8.10	146.90
MW-01B (Shallow)	18-Aug-98	155.00	10.71	144.29
MW-01B (Shallow)	5-Nov-98	155.00	11.97	143.03
MW-01B (Shallow)	22-Mar-99	155.00	5.13	149.87
MW-01B (Shallow)	7-Sep-99	155.00	14.43	140.57
MW-01B (Shallow)	9-Dec-99	155.00	NR	---
MW-01B (Shallow)	7-Feb-00	155.00	6.00	149.00
MW-01B (Shallow)	29-May-00	155.00	8.50	146.50
MW-01B (Shallow)	21-Aug-00	155.00	NR	---
MW-01B (Shallow)	6-Nov-00	155.00	NR	---

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-01B (Shallow)	29-Jan-01	155.00	9.09	145.91
MW-01B (Shallow)	23-Apr-01	155.00	8.61	146.39
MW-01B (Shallow)	27-Aug-01	155.00	NR	---
MW-01B (Shallow)	5-Nov-01	155.00	NR	---
MW-01B (Shallow)	7-Feb-02	155.00	5.08	149.92
MW-01B (Shallow)	8-Apr-02	155.00	7.43	147.57
MW-01B (Shallow)	22-Jul-02	155.00	NR	---
MW-01B (Shallow)	7-Oct-02	155.00	NR	---
MW-01B (Shallow)	24-Feb-03	155.00	5.75	149.25
MW-01B (Shallow)	12-May-03	155.00	7.33	147.67
MW-01B (Shallow)	18-Aug-03	155.00	NR	---
MW-01B (Shallow)	17-Nov-03	155.00	20.62	134.38
MW-01B (Shallow)	19-Apr-04	155.00	7.54	147.46
MW-01B (Shallow)	8-Nov-04	155.00	17.53	137.47
MW-01B (Shallow)	23-May-05	155.00	7.57	147.43
MW-01B (Shallow)	24-Oct-05	155.00	22.25	132.75
MW-01B (Shallow)	8-May-06	155.00	9.24	145.76
MW-01B (Shallow)	16-Oct-06	155.00	23.22	131.78
MW-01B (Shallow)	7-May-07	155.00	8.10	146.90
MW-01B (Shallow)	5-Nov-07	155.00	19.03	135.97
MW-01B (Shallow)	19-May-08	155.00	8.49	146.51
MW-01B (Shallow)	10-Nov-08	155.00	17.43	137.57
MW-01B (Shallow)	4-May-09	155.00	6.90	148.10
MW-01B (Shallow)	16-Nov-09	155.00	9.70	145.30
MW-01B (Shallow)	19-Apr-10	155.00	6.55	148.45
MW-01B (Shallow)	5-Oct-10	155.00	18.01	136.99
MW-01B (Shallow)	12-Apr-11	155.00	5.16	149.84
MW-01B (Shallow)	1-Nov-11	155.00	13.34	141.66
MW-01B (Shallow)	30-Apr-12	155.00	7.09	147.91
MW-01B (Shallow)	12-Nov-12	155.00	10.14	144.86
MW-01B (Shallow)	8-Apr-13	155.00	6.54	148.46
MW-01B (Shallow)	18-Nov-13	155.00	9.81	145.19
MW-01B (Shallow)	28-Apr-14	155.00	5.51	149.49
MW-01B (Shallow)	17-Nov-14	155.00	7.70	147.30
MW-10A (Shallow)	4-Dec-93	153.21	16.35	136.86
MW-10A (Shallow)	5-Jan-94	153.21	4.08	149.13
MW-10A (Shallow)	22-Feb-94	153.21	3.96	149.25
MW-10A (Shallow)	25-Mar-94	153.21	4.62	148.59
MW-10A (Shallow)	26-Apr-94	153.21	6.22	146.99
MW-10A (Shallow)	26-May-94	153.21	8.31	144.90
MW-10A (Shallow)	1-Jul-94	153.21	15.49	137.72
MW-10A (Shallow)	2-Aug-94	153.21	19.44	133.77
MW-10A (Shallow)	2-Sep-94	153.21	20.72	132.49
MW-10A (Shallow)	13-Oct-94	153.21	21.71	131.50
MW-10A (Shallow)	11-Nov-94	153.21	14.42	138.79
MW-10A (Shallow)	21-Dec-94	153.21	4.82	148.39
MW-10A (Shallow)	20-Jan-95	153.21	4.65	148.56
MW-10A (Shallow)	23-Feb-95	153.21	4.88	148.33
MW-10A (Shallow)	28-Mar-95	153.21	5.41	147.80

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-10A (Shallow)	14-Apr-95	153.21	5.60	147.61
MW-10A (Shallow)	18-May-95	153.21	8.05	145.16
MW-10A (Shallow)	20-Jun-95	153.21	9.54	143.67
MW-10A (Shallow)	26-Jul-95	153.21	14.69	138.52
MW-10A (Shallow)	22-Aug-95	153.21	17.20	136.01
MW-10A (Shallow)	11-Sep-95	153.21	18.32	134.89
MW-10A (Shallow)	24-Oct-95	153.21	17.85	135.36
MW-10A (Shallow)	22-Nov-95	153.21	7.00	146.21
MW-10A (Shallow)	20-Dec-95	153.21	4.39	148.82
MW-10A (Shallow)	11-Jan-96	153.21	4.46	148.75
MW-10A (Shallow)	16-Feb-96	153.21	5.16	148.05
MW-10A (Shallow)	30-Mar-96	153.21	6.24	146.97
MW-10A (Shallow)	9-Apr-96	153.21	6.49	146.72
MW-10A (Shallow)	28-May-96	153.21	5.66	147.55
MW-10A (Shallow)	28-Jun-96	153.21	9.63	143.58
MW-10A (Shallow)	30-Jul-96	153.21	15.73	137.48
MW-10A (Shallow)	29-Aug-96	153.21	18.35	134.86
MW-10A (Shallow)	30-Sep-96	153.21	10.01	143.20
MW-10A (Shallow)	31-Oct-96	153.21	17.97	135.24
MW-10A (Shallow)	12-Dec-96	153.21	4.56	148.65
MW-10A (Shallow)	22-Jan-97	153.21	4.55	148.66
MW-10A (Shallow)	31-Mar-97	153.21	5.67	147.54
MW-10A (Shallow)	19-May-97	153.21	6.74	146.47
MW-10A (Shallow)	9-Sep-97	153.21	15.49	137.72
MW-10A (Shallow)	18-Dec-97	153.21	3.93	149.28
MW-10A (Shallow)	17-Mar-98	153.21	5.00	148.21
MW-10A (Shallow)	8-Jun-98	153.21	6.20	147.01
MW-10A (Shallow)	18-Aug-98	153.21	11.35	141.86
MW-10A (Shallow)	5-Nov-98	153.21	14.03	139.18
MW-10A (Shallow)	22-Mar-99	153.21	5.29	147.92
MW-10A (Shallow)	7-Sep-99	153.21	18.22	134.99
MW-10A (Shallow)	9-Dec-99	153.21	NR	---
MW-10A (Shallow)	7-Feb-00	153.21	5.00	148.21
MW-10A (Shallow)	29-May-00	153.21	6.70	146.51
MW-10A (Shallow)	21-Aug-00	153.21	17.19	136.02
MW-10A (Shallow)	6-Nov-00	153.21	19.82	133.39
MW-10A (Shallow)	29-Jan-01	153.21	8.34	144.87
MW-10A (Shallow)	23-Apr-01	153.21	7.26	145.95
MW-10A (Shallow)	27-Aug-01	153.21	13.70	139.51
MW-10A (Shallow)	5-Nov-01	153.21	19.78	133.43
MW-10A (Shallow)	7-Feb-02	153.21	4.62	148.59
MW-10A (Shallow)	8-Apr-02	153.21	5.98	147.23
MW-10A (Shallow)	22-Jul-02	153.21	15.39	137.82
MW-10A (Shallow)	7-Oct-02	153.21	21.01	132.20
MW-10A (Shallow)	24-Feb-03	153.21	5.00	148.21
MW-10A (Shallow)	12-May-03	153.21	6.02	147.19
MW-10A (Shallow)	18-Aug-03	153.21	18.81	134.40
MW-10A (Shallow)	17-Nov-03	153.21	27.01	126.20
MW-10A (Shallow)	19-Apr-04	153.21	5.97	147.24

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-10A (Shallow)	8-Nov-04	153.21	19.61	133.60
MW-10A (Shallow)	23-May-05	153.21	5.70	147.51
MW-10A (Shallow)	24-Oct-05	153.21	20.74	132.47
MW-10A (Shallow)	8-May-06	153.21	7.44	145.77
MW-10A (Shallow)	16-Oct-06	153.21	22.55	130.66
MW-10A (Shallow)	7-May-07	153.21	6.21	147.00
MW-10A (Shallow)	5-Nov-07	153.21	20.39	132.82
MW-10A (Shallow)	19-May-08	153.21	7.15	146.06
MW-10A (Shallow)	10-Nov-08	153.21	19.75	133.46
MW-10A (Shallow)	4-May-09	153.21	5.51	147.70
MW-10A (Shallow)	16-Nov-09	153.21	12.95	140.26
MW-10A (Shallow)	19-Apr-10	153.21	4.81	148.40
MW-10A (Shallow)	4-Oct-10	153.21	19.05	134.16
MW-10A (Shallow)	12-Apr-11	153.21	3.94	149.27
MW-10A (Shallow)	1-Nov-11	153.21	19.07	134.14
MW-10A (Shallow)	30-Apr-12	153.21	4.84	148.37
MW-10A (Shallow)	12-Nov-12	153.21	17.95	135.26
MW-10A (Shallow)	8-Apr-13	153.21	4.65	148.56
MW-10A (Shallow)	18-Nov-13	153.21	17.96	135.25
MW-10A (Shallow)	28-Apr-14	153.21	4.38	148.83
MW-10A (Shallow)	17-Nov-14	153.21	14.95	138.26
MW-10B (Deep)	4-Dec-93	152.87	23.61	129.26
MW-10B (Deep)	5-Jan-94	152.87	18.59	134.28
MW-10B (Deep)	22-Feb-94	152.87	12.53	140.34
MW-10B (Deep)	25-Mar-94	152.87	6.55	146.32
MW-10B (Deep)	26-Apr-94	152.87	17.44	135.43
MW-10B (Deep)	26-May-94	152.87	20.31	132.56
MW-10B (Deep)	1-Jul-94	152.87	21.99	130.88
MW-10B (Deep)	2-Aug-94	152.87	25.65	127.22
MW-10B (Deep)	2-Sep-94	152.87	25.20	127.67
MW-10B (Deep)	13-Oct-94	152.87	25.83	127.04
MW-10B (Deep)	11-Nov-94	152.87	22.60	130.27
MW-10B (Deep)	21-Dec-94	152.87	18.13	134.74
MW-10B (Deep)	20-Jan-95	152.87	17.11	135.76
MW-10B (Deep)	23-Feb-95	152.87	16.71	136.16
MW-10B (Deep)	28-Mar-95	152.87	17.06	135.81
MW-10B (Deep)	14-Apr-95	152.87	17.44	135.43
MW-10B (Deep)	18-May-95	152.87	18.64	134.23
MW-10B (Deep)	20-Jun-95	152.87	19.00	133.87
MW-10B (Deep)	26-Jul-95	152.87	22.52	130.35
MW-10B (Deep)	22-Aug-95	152.87	23.88	128.99
MW-10B (Deep)	11-Sep-95	152.87	23.74	129.13
MW-10B (Deep)	24-Oct-95	152.87	23.23	129.64
MW-10B (Deep)	22-Nov-95	152.87	20.78	132.09
MW-10B (Deep)	20-Dec-95	152.87	16.44	136.43
MW-10B (Deep)	11-Jan-96	152.87	16.25	136.62
MW-10B (Deep)	16-Feb-96	152.87	15.57	137.30
MW-10B (Deep)	30-Mar-96	152.87	17.07	135.80
MW-10B (Deep)	9-Apr-96	152.87	19.30	133.57

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-10B (Deep)	28-May-96	152.87	17.15	135.72
MW-10B (Deep)	28-Jun-96	152.87	19.86	133.01
MW-10B (Deep)	30-Jul-96	152.87	22.85	130.02
MW-10B (Deep)	29-Aug-96	152.87	24.53	128.34
MW-10B (Deep)	30-Sep-96	152.87	22.39	130.48
MW-10B (Deep)	31-Oct-96	152.87	23.31	129.56
MW-10B (Deep)	12-Dec-96	152.87	16.38	136.49
MW-10B (Deep)	22-Jan-97	152.87	16.15	136.72
MW-10B (Deep)	31-Mar-97	152.87	16.17	136.70
MW-10B (Deep)	19-May-97	152.87	19.86	133.01
MW-10B (Deep)	9-Sep-97	152.87	22.91	129.96
MW-10B (Deep)	18-Dec-97	152.87	16.94	135.93
MW-10B (Deep)	17-Mar-98	152.87	15.75	137.12
MW-10B (Deep)	8-Jun-98	152.87	19.47	133.40
MW-10B (Deep)	18-Aug-98	152.87	22.70	130.17
MW-10B (Deep)	5-Nov-98	152.87	22.89	129.98
MW-10B (Deep)	22-Mar-99	152.87	14.86	138.01
MW-10B (Deep)	7-Sep-99	152.87	25.29	127.58
MW-10B (Deep)	9-Dec-99	152.87	19.41	133.46
MW-10B (Deep)	7-Feb-00	152.87	15.87	137.00
MW-10B (Deep)	29-May-00	152.87	19.08	133.79
MW-10B (Deep)	21-Aug-00	152.87	24.45	128.42
MW-10B (Deep)	6-Nov-00	152.87	23.13	129.74
MW-10B (Deep)	29-Jan-01	152.87	18.78	134.09
MW-10B (Deep)	23-Apr-01	152.87	18.50	134.37
MW-10B (Deep)	27-Aug-01	152.87	23.88	128.99
MW-10B (Deep)	5-Nov-01	152.87	25.06	127.81
MW-10B (Deep)	7-Feb-02	152.87	16.15	136.72
MW-10B (Deep)	8-Apr-02	152.87	18.32	134.55
MW-10B (Deep)	22-Jul-02	152.87	26.14	126.73
MW-10B (Deep)	7-Oct-02	152.87	26.75	126.12
MW-10B (Deep)	24-Feb-03	152.87	17.52	135.35
MW-10B (Deep)	12-May-03	152.87	19.45	133.42
MW-10B (Deep)	18-Aug-03	152.87	29.72	123.15
MW-10B (Deep)	17-Nov-03	152.87	22.86	130.01
MW-10B (Deep)	19-Apr-04	152.87	21.34	131.53
MW-10B (Deep)	8-Nov-04	152.87	24.13	128.74
MW-10B (Deep)	23-May-05	152.87	20.86	132.01
MW-10B (Deep)	24-Oct-05	152.87	26.07	126.80
MW-10B (Deep)	8-May-06	152.87	24.46	128.41
MW-10B (Deep)	16-Oct-06	152.87	26.44	126.43
MW-10B (Deep)	7-May-07	152.87	19.64	133.23
MW-10B (Deep)	5-Nov-07	152.87	24.89	127.98
MW-10B (Deep)	19-May-08	152.87	30.87	122.00
MW-10B (Deep)	10-Nov-08	152.87	34.44	118.43
MW-10B (Deep)	4-May-09	152.87	19.43	133.44
MW-10B (Deep)	16-Nov-09	152.87	23.95	128.92
MW-10B (Deep)	19-Apr-10	152.87	20.14	132.73
MW-10B (Deep)	4-Oct-10	152.87	24.70	128.17

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-10B (Deep)	12-Apr-11	152.87	16.88	135.99
MW-10B (Deep)	1-Nov-11	152.87	25.77	127.10
MW-10B (Deep)	30-Apr-12	152.87	17.50	135.37
MW-10B (Deep)	12-Nov-12	152.87	27.25	125.62
MW-10B (Deep)	8-Apr-13	152.87	17.57	135.30
MW-10B (Deep)	18-Nov-13	152.87	21.99	130.88
MW-10B (Deep)	28-Apr-14	152.87	17.71	135.16
MW-10B (Deep)	17-Nov-14	152.87	30.34	122.53
MW-18A (Shallow)	6-Nov-00	148.77	17.05	131.72
MW-18A (Shallow)	29-Jan-01	148.77	12.87	135.90
MW-18A (Shallow)	23-Apr-01	148.77	13.59	135.18
MW-18A (Shallow)	27-Aug-01	148.77	18.59	130.18
MW-18A (Shallow)	5-Nov-01	148.77	17.73	131.04
MW-18A (Shallow)	7-Feb-02	148.77	7.01	141.76
MW-18A (Shallow)	8-Apr-02	148.77	12.13	136.64
MW-18A (Shallow)	22-Jul-02	148.77	17.12	131.65
MW-18A (Shallow)	7-Oct-02	148.77	21.25	127.52
MW-18A (Shallow)	24-Feb-03	148.77	8.80	139.97
MW-18A (Shallow)	12-May-03	148.77	12.54	136.23
MW-18A (Shallow)	18-Aug-03	148.77	19.52	129.25
MW-18A (Shallow)	17-Nov-03	148.77	17.31	131.46
MW-18A (Shallow)	19-Apr-04	148.77	12.56	136.21
MW-18A (Shallow)	8-Nov-04	148.77	16.15	132.62
MW-18A (Shallow)	23-May-05	148.77	12.93	135.84
MW-18A (Shallow)	24-Oct-05	148.77	19.29	129.48
MW-18A (Shallow)	8-May-06	148.77	13.75	135.02
MW-18A (Shallow)	16-Oct-06	148.77	21.40	127.37
MW-18A (Shallow)	7-May-07	148.77	13.00	135.77
MW-18A (Shallow)	5-Nov-07	148.77	17.58	131.19
MW-18A (Shallow)	19-May-08	148.77	13.86	134.91
MW-18A (Shallow)	10-Nov-08	148.77	17.20	131.57
MW-18A (Shallow)	4-May-09	148.77	12.18	136.59
MW-18A (Shallow)	16-Nov-09	148.77	12.16	136.61
MW-18A (Shallow)	19-Apr-10	148.77	10.27	138.50
MW-18A (Shallow)	4-Oct-10	148.77	18.76	130.01
MW-18A (Shallow)	12-Apr-11	148.77	7.24	141.53
MW-18A (Shallow)	1-Nov-11	148.77	18.95	129.82
MW-18A (Shallow)	30-Apr-12	148.77	11.41	137.36
MW-18A (Shallow)	12-Nov-12	148.77	13.61	135.16
MW-18A (Shallow)	8-Apr-13	148.77	8.31	140.46
MW-18A (Shallow)	18-Nov-13	148.77	15.00	133.77
MW-18A (Shallow)	28-Apr-14	148.77	7.55	141.22
MW-18A (Shallow)	17-Nov-14	148.77	14.62	134.15
MW-18B (Deep)	6-Nov-00	148.57	20.67	127.90
MW-18B (Deep)	29-Jan-01	148.57	16.01	132.56
MW-18B (Deep)	23-Apr-01	148.57	15.91	132.66
MW-18B (Deep)	27-Aug-01	148.57	21.37	127.20
MW-18B (Deep)	5-Nov-01	148.57	22.13	126.44

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-18B (Deep)	7-Feb-02	148.57	13.15	135.42
MW-18B (Deep)	8-Apr-02	148.57	14.33	134.24
MW-18B (Deep)	22-Jul-02	148.57	24.26	124.31
MW-18B (Deep)	7-Oct-02	148.57	24.75	123.82
MW-18B (Deep)	24-Feb-03	148.57	14.29	134.28
MW-18B (Deep)	12-May-03	148.57	16.19	132.38
MW-18B (Deep)	18-Aug-03	148.57	24.93	123.64
MW-18B (Deep)	17-Nov-03	148.57	23.42	125.15
MW-18B (Deep)	19-Apr-04	148.57	16.86	131.71
MW-18B (Deep)	8-Nov-04	148.57	21.12	127.45
MW-18B (Deep)	23-May-05	148.57	19.10	129.47
MW-18B (Deep)	24-Oct-05	148.57	23.03	125.54
MW-18B (Deep)	8-May-06	148.57	17.99	130.58
MW-18B (Deep)	16-Oct-06	148.57	23.53	125.04
MW-18B (Deep)	7-May-07	148.57	15.95	132.62
MW-18B (Deep)	5-Nov-07	148.57	21.15	127.42
MW-18B (Deep)	19-May-08	148.57	25.31	123.26
MW-18B (Deep)	10-Nov-08	148.57	30.83	117.74
MW-18B (Deep)	4-May-09	148.57	15.83	132.74
MW-18B (Deep)	16-Nov-09	148.57	20.50	128.07
MW-18B (Deep)	19-Apr-10	148.57	14.47	134.10
MW-18B (Deep)	4-Oct-10	148.57	21.15	127.42
MW-18B (Deep)	12-Apr-11	148.57	13.30	135.27
MW-18B (Deep)	1-Nov-11	148.57	22.48	126.09
MW-18B (Deep)	30-Apr-12	148.57	13.75	134.82
MW-18B (Deep)	12-Nov-12	148.57	22.20	126.37
MW-18B (Deep)	8-Apr-13	148.57	14.40	134.17
MW-18B (Deep)	18-Nov-13	148.57	18.67	129.90
MW-18B (Deep)	28-Apr-14	148.57	14.27	134.30
MW-18B (Deep)	17-Nov-14	148.57	21.77	126.80
MW-20A (Shallow)	6-Nov-00	129.92	7.00	122.92
MW-20A (Shallow)	29-Jan-01	129.92	3.85	126.07
MW-20A (Shallow)	23-Apr-01	129.92	3.93	125.99
MW-20A (Shallow)	27-Aug-01	129.92	4.93	124.99
MW-20A (Shallow)	5-Nov-01	129.92	6.18	123.74
MW-20A (Shallow)	7-Feb-02	129.92	2.84	127.08
MW-20A (Shallow)	8-Apr-02	129.92	3.31	126.61
MW-20A (Shallow)	22-Jul-02	129.92	6.53	123.39
MW-20A (Shallow)	7-Oct-02	129.92	9.71	120.21
MW-20A (Shallow)	24-Feb-03	129.92	3.54	126.38
MW-20A (Shallow)	12-May-03	129.92	3.66	126.26
MW-20A (Shallow)	18-Aug-03	129.92	8.75	121.17
MW-20A (Shallow)	17-Nov-03	129.92	8.86	121.06
MW-20A (Shallow)	19-Apr-04	129.92	4.38	125.54
MW-20A (Shallow)	8-Nov-04	129.92	6.67	123.25
MW-20A (Shallow)	23-May-05	129.92	4.04	125.88
MW-20A (Shallow)	24-Oct-05	129.92	6.73	123.19
MW-20A (Shallow)	8-May-06	129.92	4.59	125.33
MW-20A (Shallow)	16-Oct-06	129.92	9.14	120.78

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-20A (Shallow)	7-May-07	129.92	4.49	125.43
MW-20A (Shallow)	5-Nov-07	129.92	5.19	124.73
MW-20A (Shallow)	19-May-08	129.92	4.99	124.93
MW-20A (Shallow)	10-Nov-08	129.92	5.67	124.25
MW-20A (Shallow)	4-May-09	129.92	3.47	126.45
MW-20A (Shallow)	16-Nov-09	129.92	3.88	126.04
MW-20A (Shallow)	19-Apr-10	129.92	3.25	126.67
MW-20A (Shallow)	4-Oct-10	129.92	6.44	123.48
MW-20A (Shallow)	12-Apr-11	129.92	2.67	127.25
MW-20A (Shallow)	1-Nov-11	129.92	6.40	123.52
MW-20A (Shallow)	30-Apr-12	129.92	3.09	126.83
MW-20A (Shallow)	12-Nov-12	129.92	5.85	124.07
MW-20A (Shallow)	8-Apr-13	129.92	3.27	126.65
MW-20A (Shallow)	18-Nov-13	129.92	6.11	123.81
MW-20A (Shallow)	28-Apr-14	129.92	3.11	126.81
MW-20A (Shallow)	17-Nov-14	129.92	5.35	124.57
MW-20B (Deep)	6-Nov-00	129.72	8.80	120.92
MW-20B (Deep)	29-Jan-01	129.72	5.26	124.46
MW-20B (Deep)	23-Apr-01	129.72	5.44	124.28
MW-20B (Deep)	27-Aug-01	129.72	8.93	120.79
MW-20B (Deep)	5-Nov-01	129.72	9.45	120.27
MW-20B (Deep)	7-Feb-02	129.72	1.62	128.10
MW-20B (Deep)	8-Apr-02	129.72	2.96	126.76
MW-20B (Deep)	22-Jul-02	129.72	9.49	120.23
MW-20B (Deep)	7-Oct-02	129.72	11.19	118.53
MW-20B (Deep)	24-Feb-03	129.72	2.78	126.94
MW-20B (Deep)	12-May-03	129.72	4.20	125.52
MW-20B (Deep)	18-Aug-03	129.72	12.08	117.64
MW-20B (Deep)	17-Nov-03	129.72	11.01	118.71
MW-20B (Deep)	19-Apr-04	129.72	5.57	124.15
MW-20B (Deep)	8-Nov-04	129.72	8.59	121.13
MW-20B (Deep)	23-May-05	129.72	4.55	125.17
MW-20B (Deep)	24-Oct-05	129.72	9.60	120.12
MW-20B (Deep)	8-May-06	129.72	6.10	123.62
MW-20B (Deep)	16-Oct-06	129.72	10.73	118.99
MW-20B (Deep)	7-May-07	129.72	4.75	124.97
MW-20B (Deep)	5-Nov-07	129.72	8.54	121.18
MW-20B (Deep)	19-May-08	129.72	9.24	120.48
MW-20B (Deep)	10-Nov-08	129.72	13.09	116.63
MW-20B (Deep)	4-May-09	129.72	4.44	125.28
MW-20B (Deep)	16-Nov-09	129.72	20.74	108.98
MW-20B (Deep)	19-Apr-10	129.72	3.07	126.65
MW-20B (Deep)	4-Oct-10	129.72	8.45	121.27
MW-20B (Deep)	12-Apr-11	129.72	1.71	128.01
MW-20B (Deep)	1-Nov-11	129.72	8.99	120.73
MW-20B (Deep)	30-Apr-12	129.72	2.55	127.17
MW-20B (Deep)	12-Nov-12	129.72	9.53	120.19
MW-20B (Deep)	8-Apr-13	129.72	3.22	126.50
MW-20B (Deep)	18-Nov-13	129.72	6.57	123.15

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
MW-20B (Deep)	28-Apr-14	129.72	2.77	126.95
MW-20B (Deep)	17-Nov-14	129.72	9.44	120.28
P-04A (Shallow)	4-Dec-93	141.15	16.67	124.48
P-04A (Shallow)	5-Jan-94	141.15	15.13	126.02
P-04A (Shallow)	22-Feb-94	141.15	15.33	125.82
P-04A (Shallow)	25-Mar-94	141.15	15.42	125.73
P-04A (Shallow)	26-Apr-94	141.15	16.22	124.93
P-04A (Shallow)	26-May-94	141.15	17.23	123.92
P-04A (Shallow)	1-Jul-94	141.15	18.07	123.08
P-04A (Shallow)	2-Aug-94	141.15	19.26	121.89
P-04A (Shallow)	2-Sep-94	141.15	19.67	121.48
P-04A (Shallow)	11-Nov-94	141.15	13.18	127.97
P-04A (Shallow)	21-Dec-94	141.15	12.79	128.36
P-04A (Shallow)	20-Jan-95	141.15	12.11	129.04
P-04A (Shallow)	23-Feb-95	141.15	13.64	127.51
P-04A (Shallow)	28-Mar-95	141.15	13.93	127.22
P-04A (Shallow)	14-Apr-95	141.15	13.91	127.24
P-04A (Shallow)	18-May-95	141.15	15.18	125.97
P-04A (Shallow)	20-Jun-95	141.15	15.23	125.92
P-04A (Shallow)	26-Jul-95	141.15	16.92	124.23
P-04A (Shallow)	22-Aug-95	141.15	17.87	123.28
P-04A (Shallow)	11-Sep-95	141.15	18.35	122.80
P-04A (Shallow)	24-Oct-95	141.15	15.37	125.78
P-04A (Shallow)	22-Nov-95	141.15	14.39	126.76
P-04A (Shallow)	20-Dec-95	141.15	13.01	128.14
P-04A (Shallow)	11-Jan-96	141.15	13.44	127.71
P-04A (Shallow)	16-Feb-96	141.15	13.33	127.82
P-04A (Shallow)	30-Mar-96	141.15	15.18	125.97
P-04A (Shallow)	9-Apr-96	141.15	14.88	126.27
P-04A (Shallow)	28-May-96	141.15	14.50	126.65
P-04A (Shallow)	28-Jun-96	141.15	16.62	124.53
P-04A (Shallow)	30-Jul-96	141.15	17.65	123.50
P-04A (Shallow)	29-Aug-96	141.15	18.34	122.81
P-04A (Shallow)	30-Sep-96	141.15	17.18	123.97
P-04A (Shallow)	31-Oct-96	141.15	17.33	123.82
P-04A (Shallow)	12-Dec-96	141.15	13.57	127.58
P-04A (Shallow)	22-Jan-97	141.15	13.61	127.54
P-04A (Shallow)	31-Mar-97	141.15	14.32	126.83
P-04A (Shallow)	19-May-97	141.15	15.54	125.61
P-04A (Shallow)	9-Sep-97	141.15	17.21	123.94
P-04A (Shallow)	18-Dec-97	141.15	13.12	128.03
P-04A (Shallow)	17-Mar-98	141.15	13.35	127.80
P-04A (Shallow)	8-Jun-98	141.15	15.03	126.12
P-04A (Shallow)	18-Aug-98	141.15	NR	---
P-04A (Shallow)	5-Nov-98	141.15	15.82	125.33
P-04A (Shallow)	22-Mar-99	141.15	13.73	127.42
P-04A (Shallow)	7-Sep-99	141.15	19.37	121.78
P-04A (Shallow)	9-Dec-99	141.15	11.49	129.66
P-04A (Shallow)	7-Feb-00	141.15	13.51	127.64

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
P-04A (Shallow)	29-May-00	141.15	14.78	126.37
P-04A (Shallow)	21-Aug-00	141.15	17.53	123.62
P-04A (Shallow)	6-Nov-00	141.15	15.83	125.32
P-04A (Shallow)	29-Jan-01	141.15	14.55	126.60
P-04A (Shallow)	23-Apr-01	141.15	15.44	125.71
P-04A (Shallow)	27-Aug-01	141.15	17.42	123.73
P-04A (Shallow)	5-Nov-01	141.15	15.30	125.85
P-04A (Shallow)	7-Feb-02	141.15	12.82	128.33
P-04A (Shallow)	8-Apr-02	141.15	15.07	126.08
P-04A (Shallow)	22-Jul-02	141.15	17.27	123.88
P-04A (Shallow)	7-Oct-02	141.15	18.00	123.15
P-04A (Shallow)	24-Feb-03	141.15	12.72	128.43
P-04A (Shallow)	12-May-03	141.15	14.25	126.90
P-04A (Shallow)	18-Aug-03	141.15	17.87	123.28
P-04A (Shallow)	17-Nov-03	141.15	16.00	125.15
P-04A (Shallow)	19-Apr-04	141.15	13.86	127.29
P-04A (Shallow)	8-Nov-04	141.15	13.91	127.24
P-04A (Shallow)	23-May-05	141.15	14.24	126.91
P-04A (Shallow)	24-Oct-05	141.15	21.10	120.05
P-04A (Shallow)	8-May-06	141.15	15.85	125.30
P-04A (Shallow)	16-Oct-06	141.15	19.06	122.09
P-04A (Shallow)	7-May-07	141.15	14.85	126.30
P-04A (Shallow)	5-Nov-07	141.15	16.01	125.14
P-04A (Shallow)	19-May-08	141.15	15.90	125.25
P-04A (Shallow)	10-Nov-08	141.15	14.47	126.68
P-04A (Shallow)	4-May-09	141.15	12.79	128.36
P-04A (Shallow)	16-Nov-09	141.15	13.27	127.88
P-04A (Shallow)	19-Apr-10	141.15	13.52	127.63
P-04A (Shallow)	4-Oct-10	141.15	16.89	124.26
P-04A (Shallow)	12-Apr-11	141.15	14.32	126.83
P-04A (Shallow)	1-Nov-11	141.15	16.91	124.24
P-04A (Shallow)	30-Apr-12	141.15	14.56	126.59
P-04A (Shallow)	12-Nov-12	141.15	14.05	127.10
P-04A (Shallow)	8-Apr-13	141.15	12.65	128.50
P-04A (Shallow)	Decommissioned on June 25, 2013			
P-04B (Deep)	4-Dec-93	141.65	21.63	120.02
P-04B (Deep)	5-Jan-94	141.65	16.98	124.67
P-04B (Deep)	22-Feb-94	141.65	16.37	125.28
P-04B (Deep)	25-Mar-94	141.65	15.45	126.20
P-04B (Deep)	26-Apr-94	141.65	16.74	124.91
P-04B (Deep)	26-May-94	141.65	19.02	122.63
P-04B (Deep)	1-Jul-94	141.65	21.32	120.33
P-04B (Deep)	2-Aug-94	141.65	23.73	117.92
P-04B (Deep)	2-Sep-94	141.65	23.51	118.14
P-04B (Deep)	13-Oct-94	141.65	13.59	128.06
P-04B (Deep)	11-Nov-94	141.65	19.99	121.66
P-04B (Deep)	21-Dec-94	141.65	15.46	126.19
P-04B (Deep)	20-Jan-95	141.65	13.50	128.15
P-04B (Deep)	23-Feb-95	141.65	13.80	127.85

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
P-04B (Deep)	28-Mar-95	141.65	14.64	127.01
P-04B (Deep)	14-Apr-95	141.65	15.84	125.81
P-04B (Deep)	18-May-95	141.65	17.63	124.02
P-04B (Deep)	20-Jun-95	141.65	19.01	122.64
P-04B (Deep)	26-Jul-95	141.65	21.58	120.07
P-04B (Deep)	22-Aug-95	141.65	21.95	119.70
P-04B (Deep)	11-Sep-95	141.65	22.00	119.65
P-04B (Deep)	24-Oct-95	141.65	21.39	120.26
P-04B (Deep)	22-Nov-95	141.65	18.80	122.85
P-04B (Deep)	20-Dec-95	141.65	13.61	128.04
P-04B (Deep)	11-Jan-96	141.65	14.52	127.13
P-04B (Deep)	16-Feb-96	141.65	12.95	128.70
P-04B (Deep)	30-Mar-96	141.65	16.00	125.65
P-04B (Deep)	9-Apr-96	141.65	16.90	124.75
P-04B (Deep)	28-May-96	141.65	16.09	125.56
P-04B (Deep)	28-Jun-96	141.65	18.62	123.03
P-04B (Deep)	30-Jul-96	141.65	21.09	120.56
P-04B (Deep)	29-Aug-96	141.65	21.95	119.70
P-04B (Deep)	30-Sep-96	141.65	21.39	120.26
P-04B (Deep)	31-Oct-96	141.65	21.47	120.18
P-04B (Deep)	12-Dec-96	141.65	14.63	127.02
P-04B (Deep)	22-Jan-97	141.65	13.75	127.90
P-04B (Deep)	31-Mar-97	141.65	14.60	127.05
P-04B (Deep)	19-May-97	141.65	17.48	124.17
P-04B (Deep)	9-Sep-97	141.65	20.97	120.68
P-04B (Deep)	18-Dec-97	141.65	15.42	126.23
P-04B (Deep)	17-Mar-98	141.65	14.17	127.48
P-04B (Deep)	8-Jun-98	141.65	16.95	124.70
P-04B (Deep)	18-Aug-98	141.65	21.02	120.63
P-04B (Deep)	5-Nov-98	141.65	20.61	121.04
P-04B (Deep)	22-Mar-99	141.65	13.27	128.38
P-04B (Deep)	7-Sep-99	141.65	22.32	119.33
P-04B (Deep)	9-Dec-99	141.65	16.01	125.64
P-04B (Deep)	7-Feb-00	141.65	13.86	127.79
P-04B (Deep)	29-May-00	141.65	17.16	124.49
P-04B (Deep)	21-Aug-00	141.65	22.25	119.40
P-04B (Deep)	6-Nov-00	141.65	21.21	120.44
P-04B (Deep)	29-Jan-01	141.65	17.77	123.88
P-04B (Deep)	23-Apr-01	141.65	17.80	123.85
P-04B (Deep)	27-Aug-01	141.65	21.37	120.28
P-04B (Deep)	5-Nov-01	141.65	21.85	119.80
P-04B (Deep)	7-Feb-02	141.65	13.97	127.68
P-04B (Deep)	8-Apr-02	141.65	15.38	126.27
P-04B (Deep)	22-Jul-02	141.65	21.75	119.90
P-04B (Deep)	7-Oct-02	141.65	23.45	118.20
P-04B (Deep)	24-Feb-03	141.65	15.19	126.46
P-04B (Deep)	12-May-03	141.65	16.63	125.02
P-04B (Deep)	18-Aug-03	141.65	24.37	117.28
P-04B (Deep)	17-Nov-03	141.65	23.34	118.31

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
P-04B (Deep)	19-Apr-04	141.65	18.02	123.63
P-04B (Deep)	8-Nov-04	141.65	21.02	120.63
P-04B (Deep)	23-May-05	141.65	17.29	124.36
P-04B (Deep)	24-Oct-05	141.65	22.00	119.65
P-04B (Deep)	8-May-06	141.65	18.69	122.96
P-04B (Deep)	16-Oct-06	141.65	23.09	118.56
P-04B (Deep)	7-May-07	141.65	17.29	124.36
P-04B (Deep)	5-Nov-07	141.65	20.48	121.17
P-04B (Deep)	19-May-08	141.65	21.60	120.05
P-04B (Deep)	10-Nov-08	141.65	25.34	116.31
P-04B (Deep)	4-May-09	141.65	16.94	124.71
P-04B (Deep)	16-Nov-09	141.65	20.26	121.39
P-04B (Deep)	19-Apr-10	141.65	15.51	126.14
P-04B (Deep)	4-Oct-10	141.65	20.85	120.80
P-04B (Deep)	12-Apr-11	141.65	14.20	127.45
P-04B (Deep)	1-Nov-11	141.65	21.41	120.24
P-04B (Deep)	30-Apr-12	141.65	15.02	126.63
P-04B (Deep)	12-Nov-12	141.65	22.05	119.60
P-04B (Deep)	8-Apr-13	141.65	15.85	125.80
P-04B (Deep)	Decommissioned on June 25, 2013			
P-05A	8-May-06	140.70	7.83	132.87
P-05A	16-Oct-06	140.70	16.20	124.50
P-05A	7-May-07	140.70	6.61	134.09
P-05A	5-Nov-07	140.70	12.01	128.69
P-05A	19-May-08	140.70	7.57	133.13
P-05A	10-Nov-08	140.70	8.04	132.66
P-05A	4-May-09	140.70	5.29	135.41
P-05A	16-Nov-09	140.70	4.41	136.29
P-05A	19-Apr-10	140.70	4.27	136.43
P-05A	4-Oct-10	140.70	14.29	126.41
P-05A	12-Apr-11	140.70	3.61	137.09
P-05A	1-Nov-11	140.70	13.91	126.79
P-05A	30-Apr-12	140.70	4.20	136.50
P-05A	12-Nov-12	140.70	15.54	125.16
P-05A	8-Apr-13	140.74	3.67	137.07
P-05A	18-Nov-13	140.74	18.11	122.63
P-05A	28-Apr-14	140.74	3.49	137.25
P-05A	17-Nov-14	140.74	15.28	125.46
P-06A	8-May-06	131.60	5.83	125.77
P-06A	16-Oct-06	131.60	11.12	120.48
P-06A	7-May-07	131.60	5.59	126.01
P-06A	5-Nov-07	131.60	7.86	123.74
P-06A	19-May-08	131.60	6.13	125.47
P-06A	10-Nov-08	131.60	9.56	122.04
P-06A	4-May-09	131.60	4.51	127.09
P-06A	16-Nov-09	131.60	8.91	122.69
P-06A	19-Apr-10	131.60	4.08	127.52

Table 1
Proposed Module 11 Area Groundwater Elevations
Riverbend Landfill

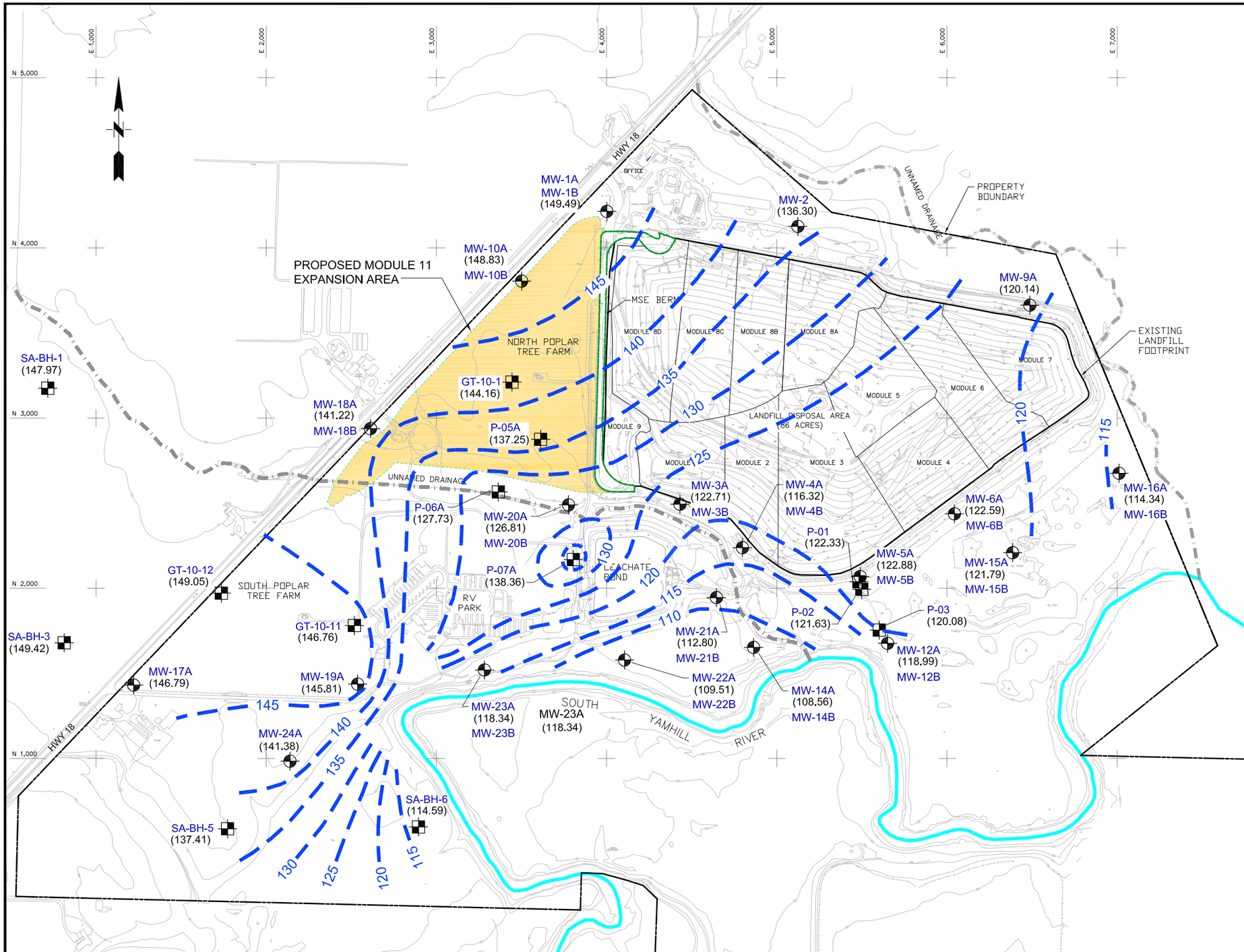
Monitoring Location	Measure Date	Reference Elevation [a] (ft.)	Depth to Water (ft.)	Ground Water Elevation (ft.)
P-06A	4-Oct-10	131.60	8.62	122.98
P-06A	12-Apr-11	131.60	3.61	127.99
P-06A	1-Nov-11	131.60	9.52	122.08
P-06A	30-Apr-12	131.60	4.15	127.45
P-06A	12-Nov-12	131.60	8.03	123.57
P-06A	8-Apr-13	131.58	4.09	127.49
P-06A	18-Nov-13	131.58	5.95	125.63
P-06A	28-Apr-14	131.58	3.85	127.73
P-06A	17-Nov-14	131.58	5.87	125.71
GT10-1	4-Oct-10	145.56	15.46	130.10
GT10-1	12-Apr-11	145.56	1.55	144.01
GT10-1	1-Nov-11	145.56	15.85	129.71
GT10-1	30-Apr-12	145.56	2.02	143.54
GT10-1	12-Nov-12	145.56	18.45	127.11
GT10-1	8-Apr-13	145.56	1.76	143.80
GT10-1	18-Nov-13	145.56	17.32	128.24
GT10-1	28-Apr-14	145.56	1.40	144.16
GT10-1	17-Nov-14	145.56	14.51	131.05

NOTE:

NR = no reading; --- = null value.

[a] All site monitoring wells and piezometers were resurveyed in July 2013. All reference elevations remained the same except for P-05A, P-06A, and P-07A.

Figures



LEGEND:

- Topographic Contours (Surveyed)
- Topographic Contours (USGS)
- Property Boundary
- Flow Line - Yamhill River
- Flow Line - Tributary Stream
- Proposed Expansion Area
- Mechanically Stabilized Earthen (MSE) Berm

EXISTING MONITORING LOCATIONS

- MW-19A — Groundwater Monitoring Well
- P-05A — Piezometer
- (120.14) — Shallow Water - Bearing Zone Well Groundwater Elevation in Feet Above Mean Sea Level on April 28, 2014
- 145 — Potentiometric Surface Contours for Shallow Water - Bearing Zone (Feet Above Mean Sea Level)

SOURCE:

1) Existing contours based on aerial topography provided by Miller Creek Aerial Mapping, date of photograph March 22, 2014. Contours are based on NAVD 88.

2) Horizontal Datum: Assumed
Iron pipe at scale house = N4000.000 E4000.000
Iron pipe at maintenance building = N2825.685 E4000.000

NOTES:

1) Monitoring wells and piezometers with "A" designation are screened in the shallow (Silt-Clay) water-bearing zone, and monitoring wells and piezometers with "B" designation are screened in the deeper (Sand-Gravel) water-bearing zone.

2) Piezometers with "GT" and "SA-BH" designations are screened in the shallow (Silt-Clay) water-bearing zone.

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

WASTE MANAGEMENT

0 600 1200
SCALE IN FEET

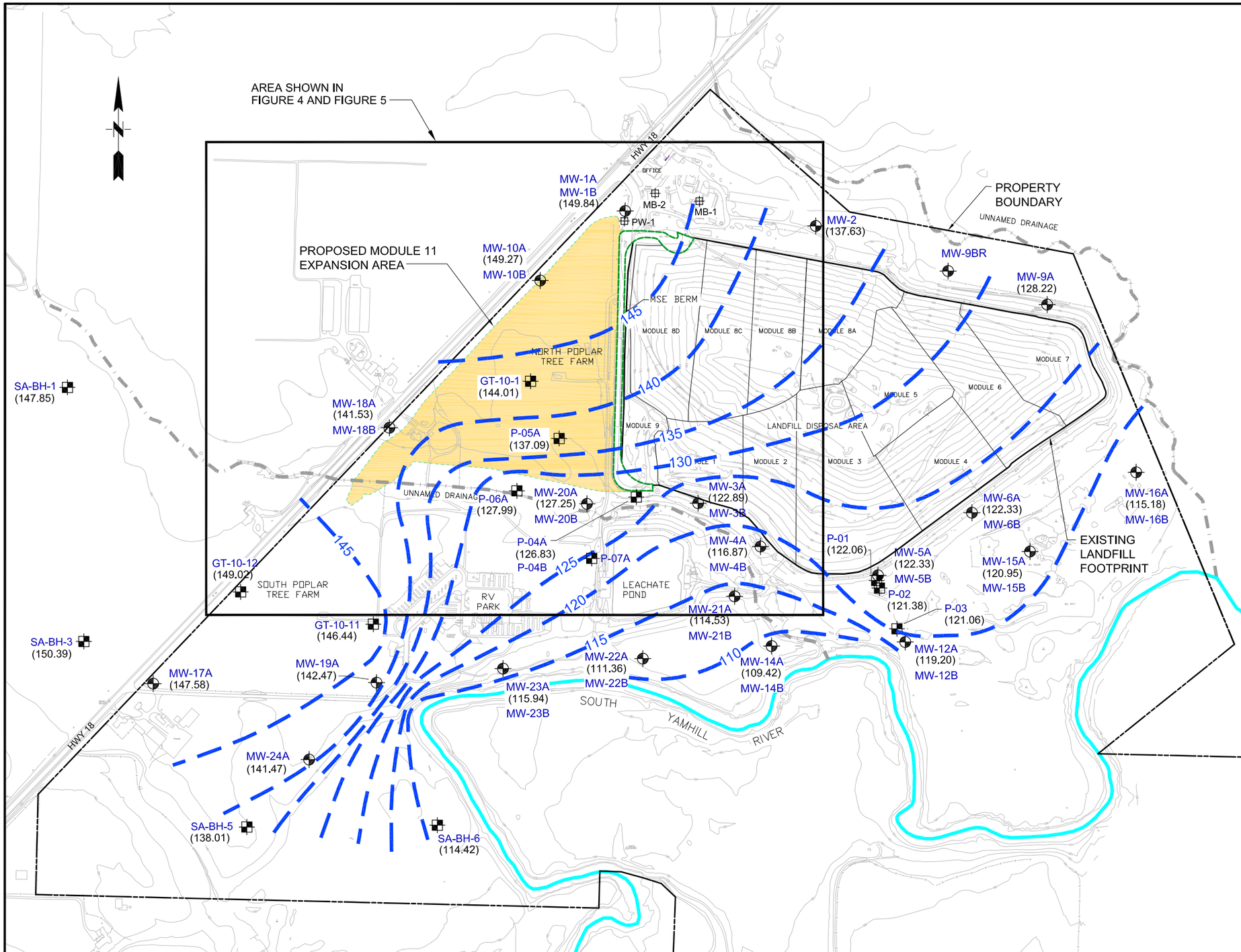
PROJECT NO. 04215015.00	DES BY D.L.
SCALE AS SHOWN	CHK BY L.C.
CAD FILE FIGURE 1	APP BY L.C.

SHALLOW WATER - BEARING ZONE
POTENTIOMETRIC SURFACE CONTOURS
(APRIL 28, 2014)

RIVERBEND LANDFILL
McMINNVILLE, OREGON

DATE APRIL 2015

FIGURE 1



LEGEND:

- Topographic Contours (Surveyed)
- Topographic Contours (USGS)
- Property Boundary
- Flow Line - Yamhill River
- Flow Line - Unnamed Drainage
- Proposed Expansion Area
- Mechanically Stabilized Earthen (MSE) Berm

EXISTING MONITORING LOCATIONS

- MW-19A — Groundwater Monitoring Well
- P-05A — Piezometer
- MB-2 — On-Site Water Well
- (149.27) — Shallow Water - Bearing Zone Well Groundwater Elevation in Feet Above Mean Sea Level on April 12, 2011
- 145 — Potentiometric Surface Contours for Shallow Water - Bearing Zone (Feet Above Mean Sea Level)

SOURCE:

1) Topographic base map prepared by Miller Creek Aerial Mapping, using photogrammetric survey methods, date of photograph March 22, 2014. Contours are based on NAVD 88.

NOTES:

1) Monitoring wells and piezometers with "A" designation are screened in the shallow (Silt-Clay) water-bearing zone, and monitoring wells and piezometers with "B" designation are screened in the deeper (Sand-Gravel) water-bearing zone.

2) Piezometers with "GT" and "SA-BH" designations are screened in the shallow (Silt-Clay) water-bearing zone.

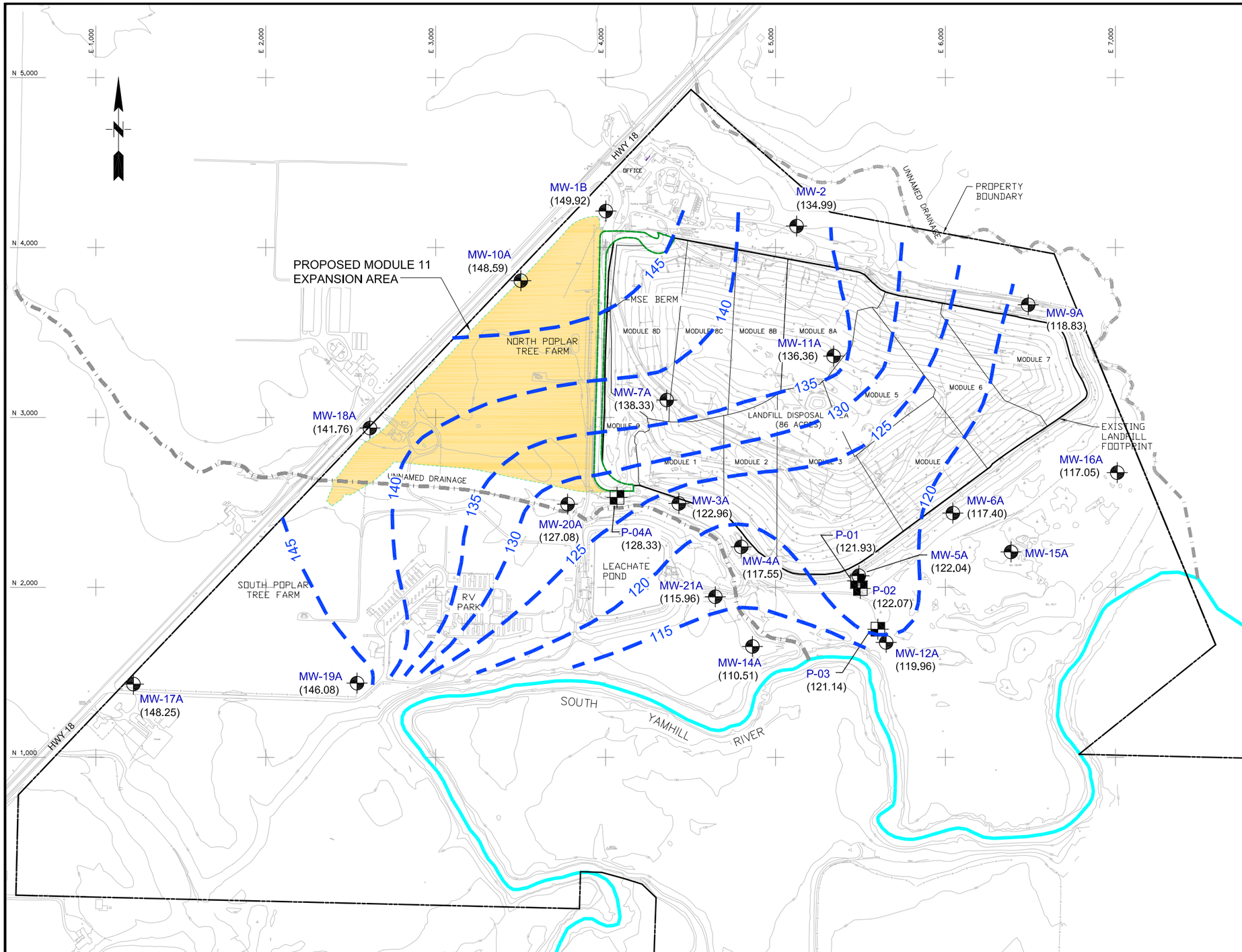
3) This figure shows the groundwater monitoring network as it existed in April 2011.

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

WASTE MANAGEMENT

0 600 1200
SCALE IN FEET

PROJECT NO. 04215015.00	DES BY D.L.	SHALLOW WATER - BEARING ZONE POTENTIOMETRIC SURFACE CONTOURS (APRIL 12, 2011) RIVERBEND LANDFILL McMINNVILLE, OREGON	DATE APRIL 2015
SCALE AS SHOWN	CHK BY L.C.		FIGURE 2
CAD FILE FIGURE 2	APP BY L.C.		



LEGEND:

- Topographic Contours (Surveyed)
- Topographic Contours (USGS)
- Property Boundary
- Flow Line - Yamhill River
- Flow Line - Tributary Stream
- Proposed Expansion Area
- Mechanically Stabilized Earthen (MSE) Berm

EXISTING MONITORING LOCATIONS

- MW-9A — Groundwater Monitoring Well
- P-02 — Piezometer
- (149.92) — Shallow Water - Bearing Zone Well Groundwater Elevation in Feet Above Mean Sea Level on February 7, 2002
- 145 — Potentiometric Surface Contours for Shallow Water - Bearing Zone (Feet Above Mean Sea Level)

SOURCE:

1) Topographic base map prepared by Miller Creek Aerial Mapping, using photogrammetric survey methods, date of photograph March 22, 2014. Contours are based on NAVD 88.

2) This figure shows the groundwater monitoring network as it existed in February 2002.

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

WASTE MANAGEMENT

0 600 1200
SCALE IN FEET

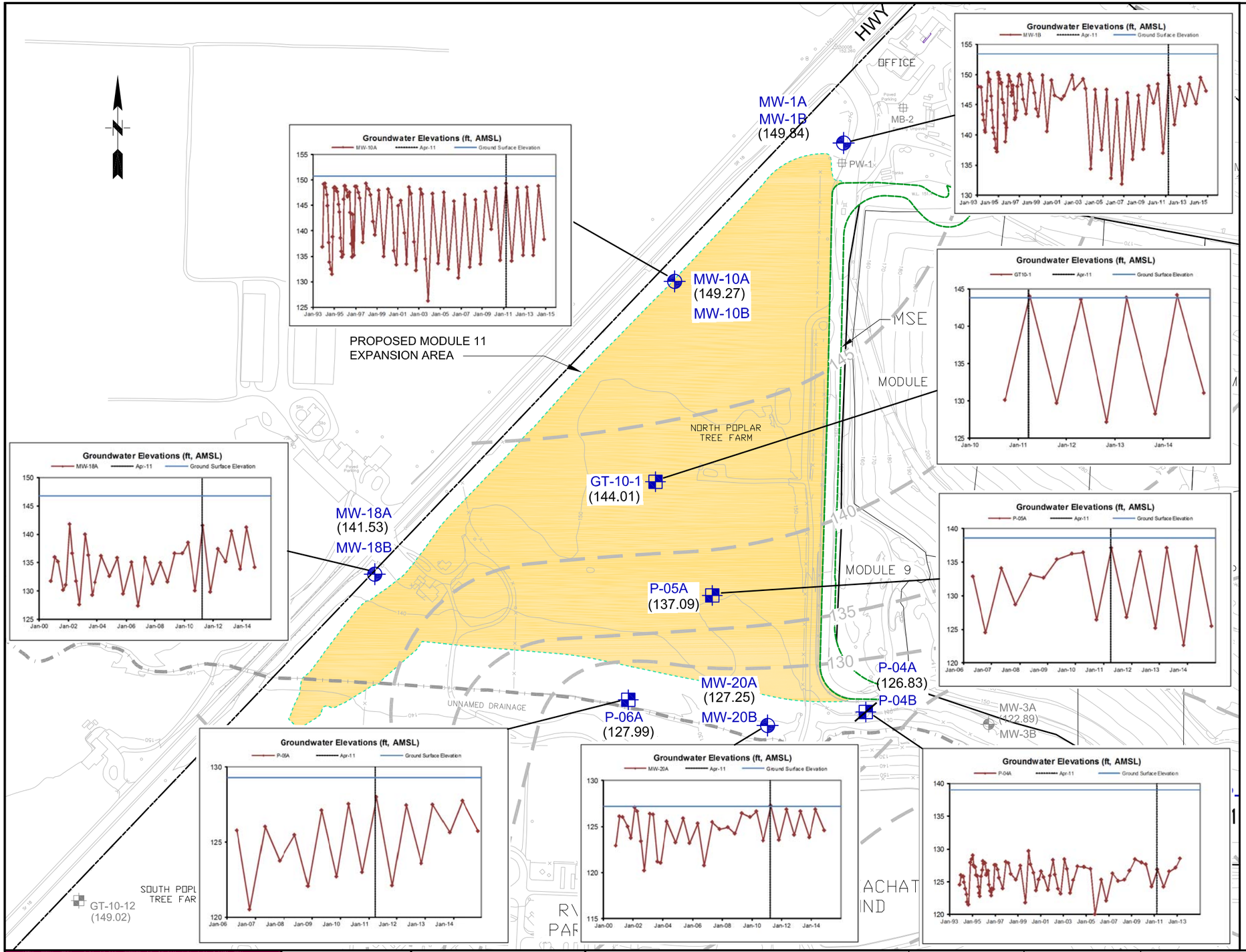
PROJECT NO. 04215015.00	DES BY D.L.
SCALE AS SHOWN	CHK BY L.C.
CAD FILE FIGURE 3	APP BY L.C.

SHALLOW WATER - BEARING ZONE POTENTIOMETRIC SURFACE CONTOURS (FEBRUARY 7, 2002)

RIVERBEND LANDFILL
McMINNVILLE, OREGON

DATE APRIL 2015

FIGURE 3



LEGEND:

- Topographic Contours (Surveyed)
- Topographic Contours (USGS)
- Property Boundary
- Flow Line - Yamhill River
- Flow Line - Unnamed Drainage
- Proposed Expansion Area
- Mechanically Stabilized Earthen (MSE) Berm

EXISTING MONITORING LOCATIONS

- MW-20A — Groundwater Monitoring Well
- P-05A — Piezometer
- MB-2 — On-Site Water Well
- P-04A — Decommissioned (Former) Piezometer
- (149.27) — Shallow Water - Bearing Zone Well Groundwater Elevation in Feet Above Mean Sea Level on April 12, 2011
- 145 — Potentiometric Surface Contours for Shallow Water - Bearing Zone on April 12, 2011 (Feet Above Mean Sea Level)

SOURCE:

1) Topographic base map prepared by Miller Creek Aerial Mapping, using photogrammetric survey methods, date of photograph March 22, 2014. Contours are based on NAVD 88.

NOTES:

1) Monitoring wells and piezometers with "A" designation are screened in the shallow (Silt-Clay) water-bearing zone, and monitoring wells and piezometers with "B" designation are screened in the deeper (Sand-Gravel) water-bearing zone.

2) Piezometers with "GT" and "SA-BH" designations are screened in the shallow (Silt-Clay) water-bearing zone. .

SCS ENGINEERS
Environmental Consultants and Contractors
14945 SW Sequoia Parkway, Suite 180
Portland, Oregon 97224
(503) 639-9201 FAX: (503) 684-6948

WASTE MANAGEMENT

0 300 600
SCALE IN FEET

PROJECT NO.	DES BY	DATE
04215015.00	D.L.	APRIL 2015
SCALE: AS SHOWN	CHK BY: L.C.	FIGURE: 4
CAD FILE: FIGURE 4	APP BY: L.C.	

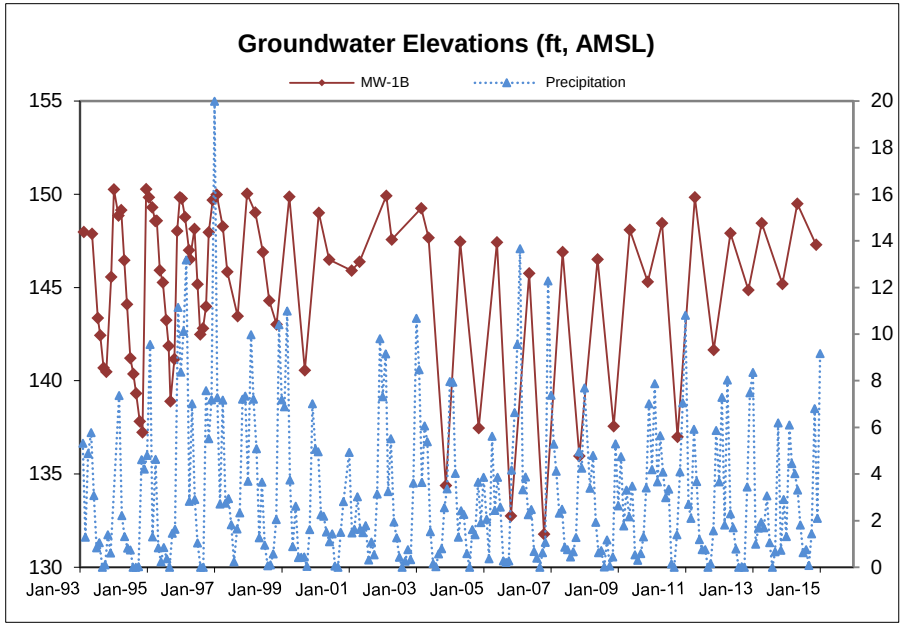
SHALLOW WATER - BEARING ZONE
GROUNDWATER ELEVATION HYDROGRAPHS

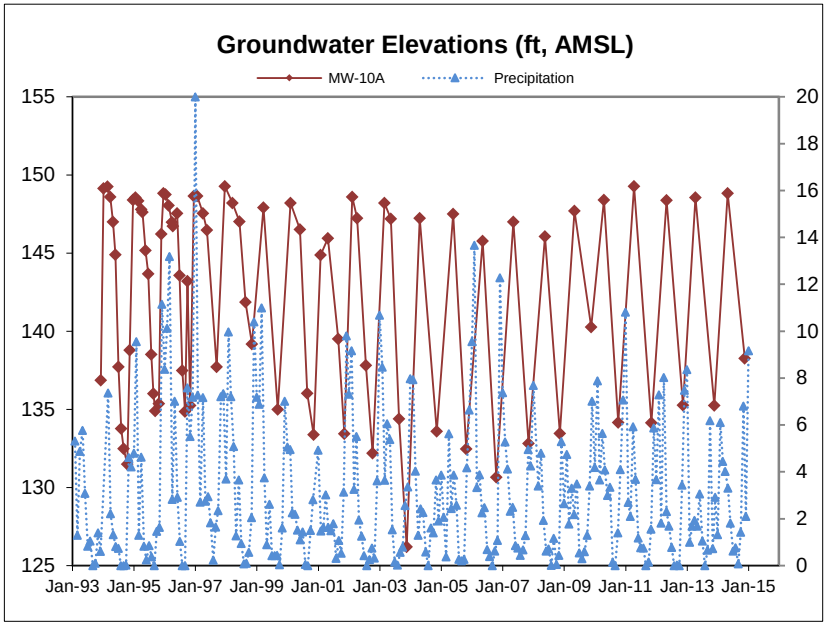
RIVERBEND LANDFILL
McMINNVILLE, OREGON

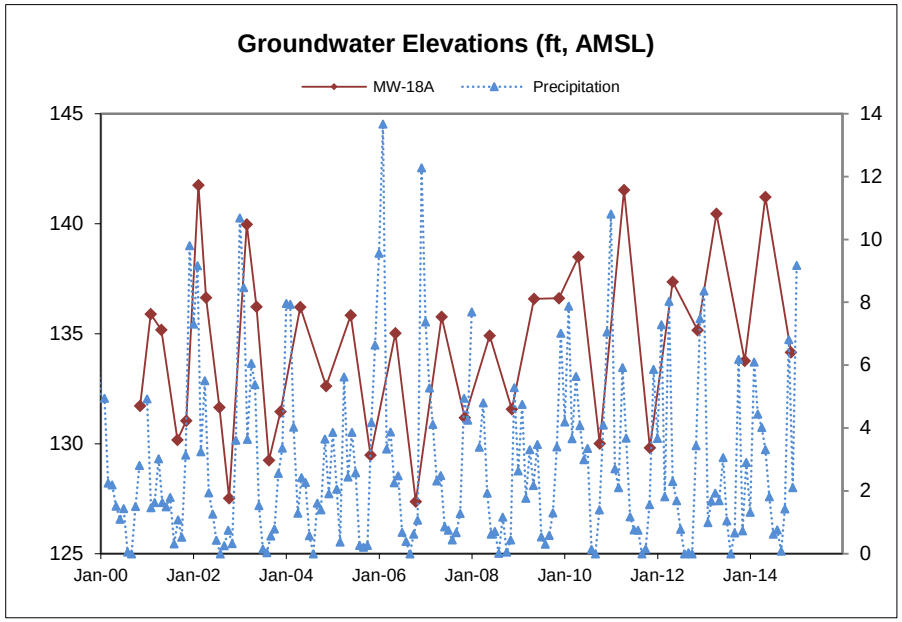
Attachment 1

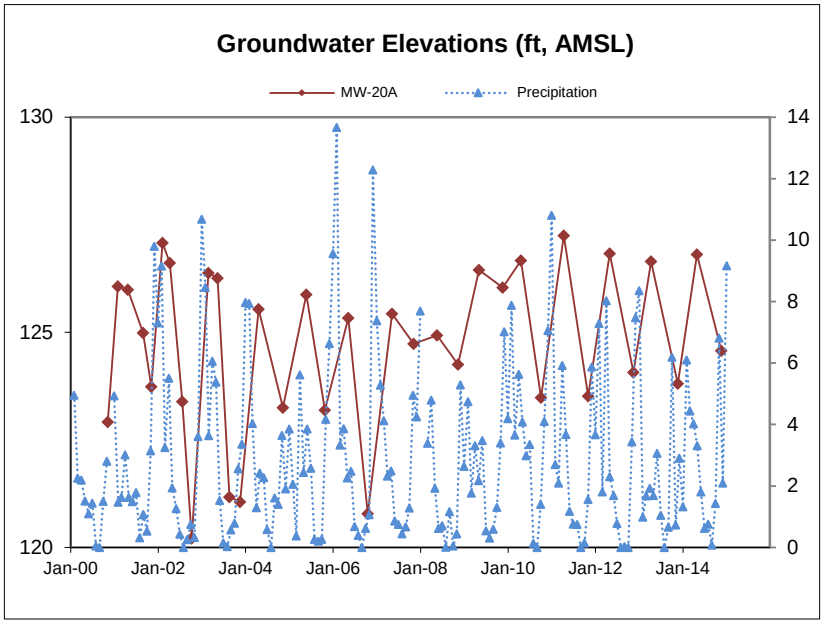
Groundwater Elevation Hydrographs

Attachment 1
Proposed Module 11 Area Groundwater Elevation Hydrographs With Precipitation
Riverbend Landfill



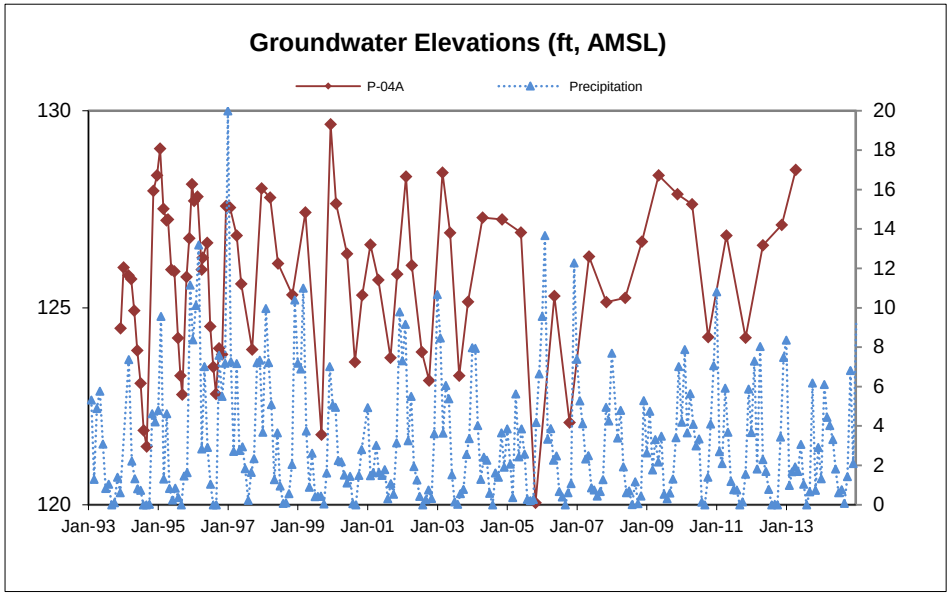


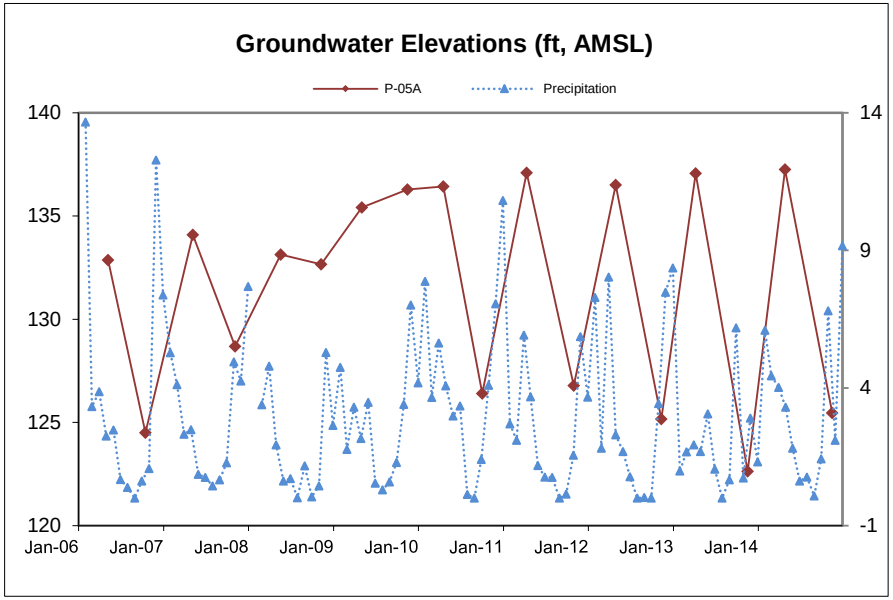


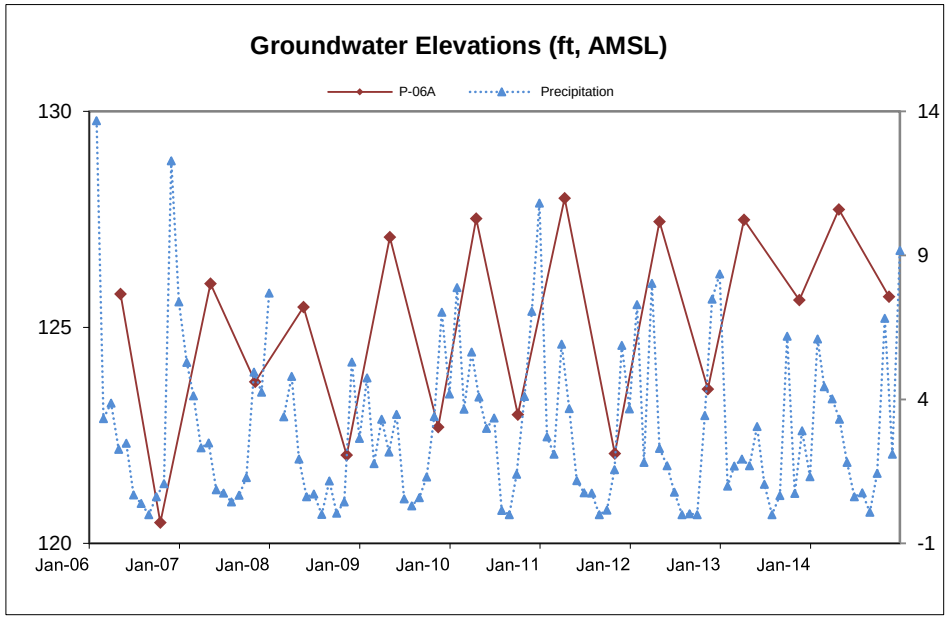


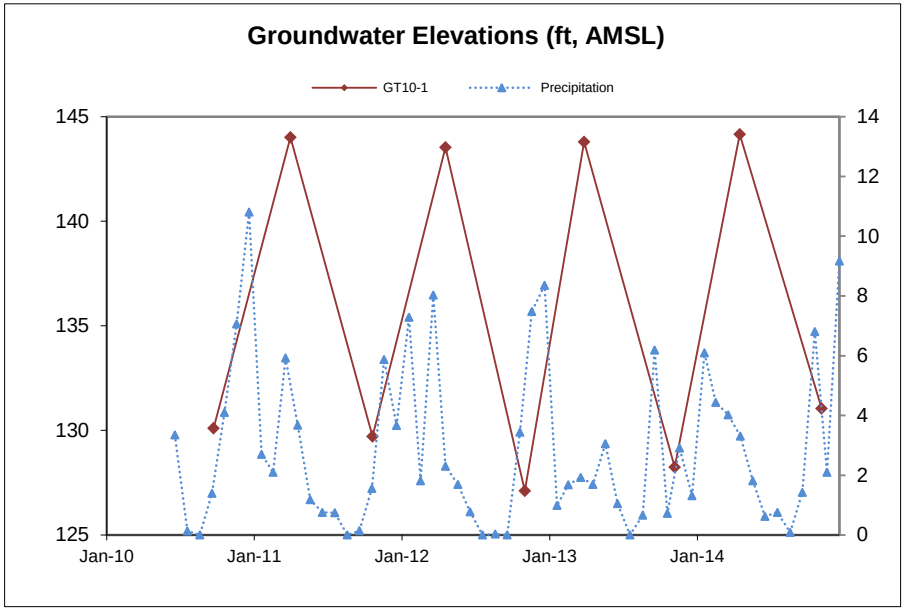
Notes:
Left axis, groundwater elevation in feet above mean sea level (local datum). Right axis, precipitation in inches.

Attachment 1
Proposed Module 11 Area Groundwater Elevation Hydrographs With Precipitation
Riverbend Landfill



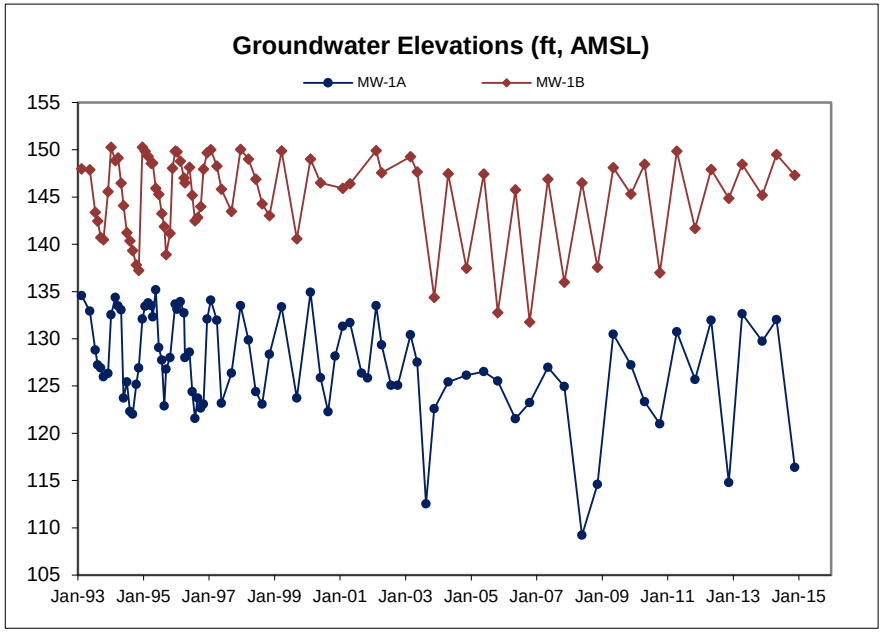


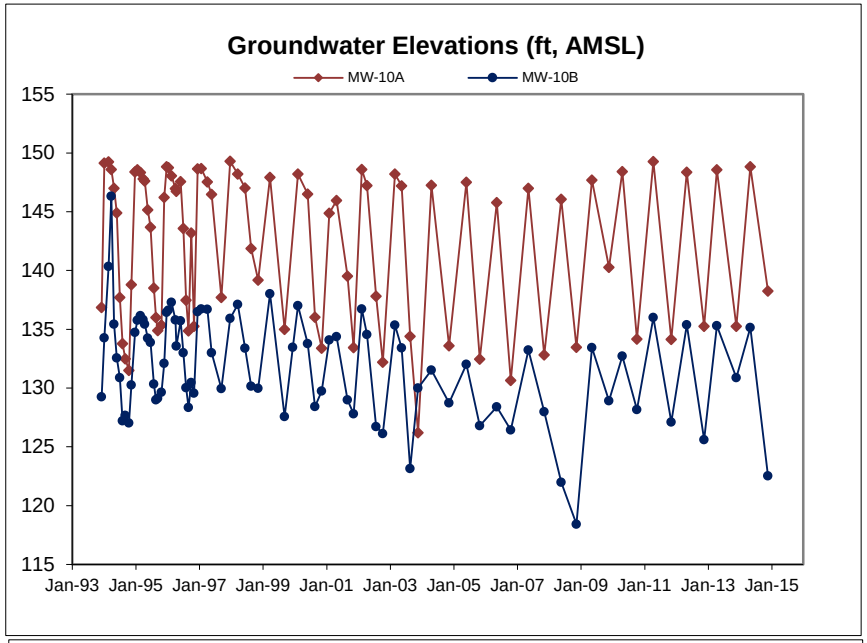


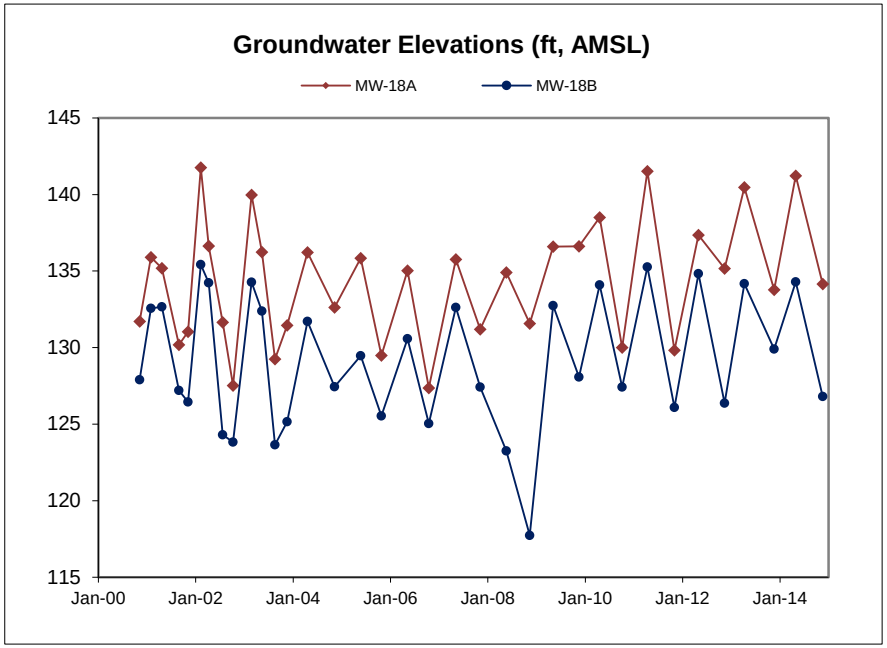


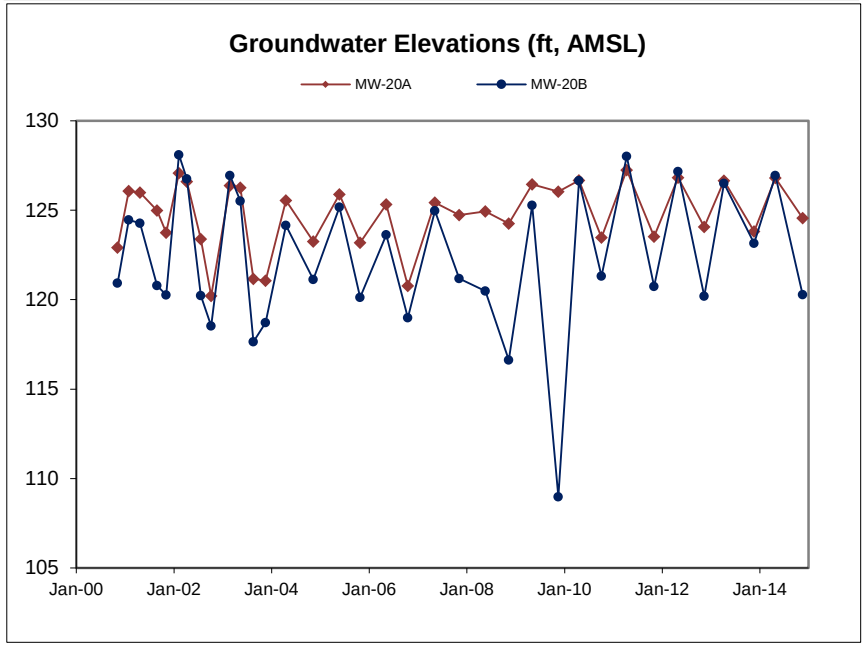
Notes:
Left axis, groundwater elevation in feet above mean sea level (local datum). Right axis, precipitation in inches.

Attachment 1
Proposed Module 11 Area Groundwater Elevation Hydrographs (Shallow and Deep Zones)
Riverbend Landfill



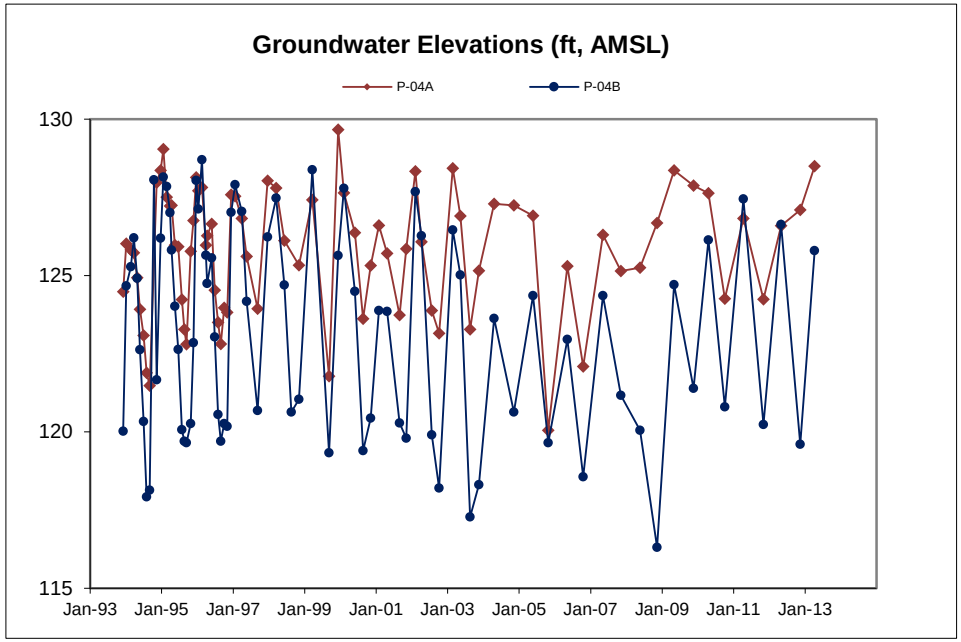






Notes: Groundwater elevation in feet above mean sea level (local datum) (ft, AMSL).

Attachment 1
Proposed Module 11 Area Groundwater Elevation Hydrographs (Shallow and Deep Zones)
Riverbend Landfill



Notes: Groundwater elevation in feet above mean sea level (local datum) (ft, AMSL).