David A. Weber
President and CEO
NW Natural Gas Storage, LLC
Tel: 503-220-2405
Fax: 503-721-2490
Toll Free: 1.800.422.4012
e-mail: daw@nwnatural.com

NW Natural
220 NW 2ND AVENUE
PORTLAND, OR 97209
TEL 503.226.4211
www.nwnatural.com

November 13, 2015

Mr. Maxwell Woods
Oregon Department of Energy
625 Marion Street, N.E.
Salem, OR 97310-3742

RE: Revised Request for Amendment No. 11

Dear Max:

Enclosed for filing is an original and 1 copy of NW Natural's revised Request for Amendment No. 11 to the Mist Underground Natural Gas Storage Site Certificate.

If you have any questions, or require further information, please contact me at (503) 220-2405.

Sincerely,

David A. Weber

Enclosures

cc: MardiLyn Saathoff
Margaret Kirkpatrick
David Anderson
Keith White
Grant Yoshihara
C. Alex Miller
Greg Hazelton
Bill Edmonds
Todd Thomas
Clayton Roth
Mike Hayward
Sue Jordan

I. AFFIDAVIT OF AUTHENTICITY

I, David A. Weber, being sworn, state that:

I am President and CEO for Northwest Natural Gas Storage and am authorized to act on behalf of NW Natural.

NW Natural is submitting this revised Request to Amend the Mist Underground Natural Gas Storage Site Certificate.

To my best knowledge and belief, the information in this Request to Amend the Site Certificate is true and accurate.

Dated: November 13, 2015

NORTHWEST NATURAL GAS COMPANY

BY: _____

David A. Weber
President and CEO
Northwest Natural Gas Storage

State of Oregon)
)
County of Multnomah)
)

On this 11th day of November, 2015, before me, the undersigned, a notary public in and for said state, personally appeared David A. Weber, known or identified to me to be an authorized representative of Northwest Natural Gas Company dba NW Natural, that executed this Affidavit of Authenticity ("Affidavit") or the person who executed this Affidavit on behalf of NW Natural, and acknowledged to me that NW Natural executed the same.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal on the day and year in this certificate first above written.

Notary Public for the State of Oregon
Residing at: Portland, Oregon
My Commission expires: 10/18/2016

OFFICIAL SEAL
DONNA K CERUTI
NOTARY PUBLIC - OREGON
COMMISSION NO. 471310
MY COMMISSION EXPIRES OCTOBER 18, 2016

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REQUEST FOR AMENDMENT NO. 11
TO THE MIST UNDERGROUND
NATURAL GAS STORAGE SITE CERTIFICATE

Project Description and OAR Division 27 Compliance

North Mist Expansion Project

November 2015

NW Natural

Northwest Natural Gas

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I. INTRODUCTION

Pursuant to Oregon Administrative Rule (OAR) 345-027-0050 and the Energy Facility Siting Council's (EFSC) Declaratory Order issued in April 2013, Northwest Natural (NWN) proposes to amend the Mist Underground Natural Gas Storage Site Certificate (Site Certificate) for its underground natural gas storage facility in Columbia County, Oregon through the North Mist Expansion Project (the Project). In this Request for Amendment No. 11 (Request), NWN seeks to expand the EFSC-certificated facility boundary to include the proposed Adams storage reservoir, as well as the Newton, Medicine, Crater, and Stegosaur future storage areas (currently production reservoirs). In this Request, NWN proposes to develop only the Adams reservoir as a new underground storage area, to install injection and withdrawal (I/W) transmission pipelines to connect the underground storage reservoir in the Adams storage area to a new compressor facility, North Mist Compressor Station (NMCS), located approximately 2.2 miles northwest of Miller Station (approximately 5 miles by road), and to construct an approximately 13-mile, up to 24-inch high-pressure natural gas transmission pipeline between the new compressor station and Portland General Electric's (PGE) Port Westward Industrial Park (PWIP). Any conversion of the Newton, Medicine, Crater, and Stegosaur future storage areas to storage facilities, along with the development of EFSC-jurisdictional surface facilities, I/W pipelines, and any other jurisdictional related and supporting facilities, will require a future amendment to the Site Certificate.

A. Location of Existing Energy Facility

The existing Mist Site consists of the Bruer/Flora area and the Calvin Creek area. Bruer/Flora and Miller Station are located north of the Nehalem River in rural Columbia County, in parts of Sections 2, 3, 4, 10, and 11 of Township 6 North, Range 5 West, Willamette Meridian, Oregon. The Calvin Creek area, south of the Nehalem River, was added to the facility in 1997 in Amendment No. 4. It is 2.5 miles south of Miller Station in parts of Sections 21, 22, 23, 26, and 27. Twin 16-inch pipelines cross the Nehalem River and connect the Calvin Creek area with Miller Station (**Figure A-1)**.

B. Location of Area Proposed to Be Added to Site Boundary

Storage Expansion Area: The area to be added to the facility boundary, including the NMCS, the Adams storage area, future expansion areas, and the well sites, is located north of the Nehalem River in rural Columbia County, in parts of Sections 3 and 4 of Township 6 North, Range 5 West, and parts of Sections 28, 27, 32, 33, 34, and 35 of Township 7 North, Range 5 West, Willamette Meridian, Oregon (**Figure A-1)**.

Proposed Transmission Pipeline: The proposed natural gas transmission pipeline traverses a north, northeast track from the NMCS to the PGE PWIP, in parts of Section 3 of Township 6 North, Range 5 West; parts of Sections 34, 27, 22, 15, 14, 11, 12, and 1 of Township 7 North, Range 5 West; in parts

of Section 6 and 7 of Township 7 North, Range 4 West; and in parts of Sections 31, 32, 29, 28, 21, 22, 15, and 16 of Township 8 North, Range 4 West, Willamette Meridian, Oregon, crossing the Clatskanie River prior to terminating at the PWIP (**Figure A-2)**.[1]

II. EFSC JURISDICTION

When the EFSC approved the underground natural gas storage facility at the Mist Site in 1981, its jurisdiction included both the surface and underground components of the facility. In 1993, the siting law was amended such that EFSC now has jurisdiction only over the "surface facility related to an underground gas storage reservoir that, at design injection or withdrawal rates, will receive or deliver more than 50 million cubic feet of natural or synthetic gas per day, or require more than 4,000 horsepower of natural gas compression to operate" (ORS 469.300(11)(a)(I)). The surface facility at Mist exceeds this 50-million-cubic-feet threshold and is therefore subject to EFSC jurisdiction. Subsurface elements (other than pipelines) are within the exclusive jurisdiction of the Department of Geology and Mineral Industries (DOGAMI).

The Project is an "energy facility" subject to EFSC jurisdiction because it has the capacity to receive or deliver up to 120 million cubic feet of natural gas per day. While it is a related and supporting facility, if the proposed transmission pipeline were proposed as a stand-alone facility, it would be subject to EFSC jurisdiction. This is because the pipeline is up to 24 inches in diameter and its aggregate length is approximately 13 miles (greater than the 16-inch minimum diameter and five-mile minimum length for jurisdictional purposes; (ORS 469.300(11)(a)(E)(ii)). In this instance, EFSC's jurisdiction over the Project is based on the Project's expansion of an existing jurisdictional facility (ORS 469.320(1); OAR 345-021-0000(1); OAR 345-027-0050).

On March 13, 1998, EFSC approved a request to replace the amendment provisions in the Site Certificate with a requirement that future Site Certificate amendments be governed by the "duly adopted rules of the Energy Facility Siting Council for the amendment of site certificates." Accordingly, this Request is set forth pursuant to the requirements of OAR 345-027-0060.[2]

---

[1] Parts of Section 14, Township 6 North, Range 5 West and part of Section 1 Township 8 North, Range 5 West include temporary storage areas that will not be considered part of the final Site Boundary (**Figure A-2**).

[2] Although this Request is not organized in accordance with OAR 345-021-0010, the information contained herein addresses all provisions of the rule as required by OAR 345-021-0010(1). Key resource reports and regulatory analyses are appended hereto, identified by exhibit lettering corresponding with the OAR chapter 345, division 21 provisions, including evidence supporting the compliance narratives in this Request.

III. CERTIFICATE HOLDER INFORMATION (OAR 345-027-0060(1)(a); OAR 345-021-0010)

A. Name and Mailing Address of the Certificate Holder

Northwest Natural Gas Company

220 NW Second Avenue

Portland, Oregon 97209

B. Name and Mailing Address of the Individuals Responsible for Submitting the Request

David Weber

DWeber.nwngs@nwnatural.com

Northwest Natural Gas Company

220 NW Second Avenue

Portland, Oregon 97209

(503) 913-9088

Timothy L. McMahan

Tim.McMahan@Stoel.com

Stoel Rives LLP

900 SW Fifth Avenue, Suite 2600

Portland, Oregon 97204

(503) 294-9517

IV. DESCRIPTION OF THE FACILITY (OAR 345-027-0060(1)(b))

A. Nature of the Facility

NWN is a natural gas utility that delivers energy to more than 700,000 residential, commercial, and industrial customers whose energy needs change significantly on a daily, monthly, and seasonal basis due to changes in space-heating requirements, harvest processing, annual production cycles, and other factors. However, in Oregon gas usage is generally lowest during summer months and peaks during December, January, and February. Underground gas storage provides the most efficient means of balancing relatively constant pipeline gas supplies with widely fluctuating seasonal, daily, and hourly market requirements. Gas is injected into storage during off-peak periods when it is least expensive because market requirements are less than supply availability, and is withdrawn from storage when market demand exceeds available supplies from other sources. Storage reservoirs are usually replenished from April through September, and are typically drawn down between October and March.

Underground reservoir storage requires suitable underground geological conditions in a specific geographic area. These conditions can occur in depleted gas pools (or reservoirs), like the Adams pool, which is the subject of this Request.

An underground storage reservoir, reduced to simplest terms, is little more than a gas production reservoir retrofitted to inject gas back into the ground and withdraw it on a cyclical basis. Some gas

always remains in the reservoir, to maintain operating pressure. This gas is referred to as "cushion gas." Generally, between one-quarter and one-half of the original gas in place in each reservoir (including some that could never have been produced) is used as cushion gas. The remainder of the reservoir's capacity is used to inject and withdraw gas relatively rapidly, to meet market or customer needs. This gas is referred to as "working gas."

The principal differences between a natural gas production field and an underground storage reservoir are operational and legal/jurisdictional. The gas wells in a production field are designed to produce gas at flow rates that permit the efficient drainage of the reservoir over a relatively long period. DOGAMI regulates the spacing of gas wells. Generally, pursuant to DOGAMI's spacing order, no more than one well per quarter section (160 acres) is allowed. Closer well spacing could result in higher development costs with negligible increase in overall gas production. Competing wells could also cause the premature demise of a reservoir, leaving behind gas that is uneconomical to produce.

A different operating concept applies to a storage reservoir. Instead of producing the major portion of the underground gas by careful management of field pressures and auxiliary compression over a period of years, the goal changes to that of performing multiple partial fill- and-drawdown cycles within a year. To rapidly fill and withdraw from a reservoir without harming it, a more closely spaced pattern of wells designed for high rates of injection and withdrawal is used for storage operations. Compressors restore the storage pressure during injections and provide for sustained high delivery rates during withdrawals as the reservoir pressure depletes.

B. Site Selection

Underground storage facilities can be developed only in rare locations where the underground geological conditions are right. The Mist gas field (the Mist Field) is such a place. As configured prior to this Request, the Mist Site, located in rural Columbia County in parts of Sections 2, 3, 4, 10, 11, 21, 22, 23, 26, and 27 of Township 6 North, Range 5 West, Willamette Meridian, Oregon, is located in the Mist Field.

Millions of years ago, the present gas-producing sands in the Mist Field were laid down by a large river delta advancing into the ocean (analogous to the modern Mississippi River delta). The delta subsided and water depths increased, resulting in mud being deposited over the sand. Compaction from the weight of the material consolidated the sand and mud into sandstone and mudstone. Organic material in the rock formed natural gas. Large amounts of natural gas migrated from deeper formations into the sandstone and accumulated in areas where the gas could be trapped and the water displaced from between the sand grains, forming a "bubble" of gas within the sandstone. The mudstone that forms the seal (cap rock) over the sandstone prevents further vertical gas migration. Tectonic forces generated by the collision of the North American Plate with segments of the Pacific Plate created the folds and faults in the sandstone that form the compartments that trap the gas and prevent lateral migration. The fact that gas remains in these reservoirs at high pressure (up to 1,000 pounds per square inch) after millions of years demonstrates the stable nature of these reservoirs. No man-made structures have been so thoroughly tested.

The NMCS site location was selected for two key reasons: (1) the location is above the Adams reservoir, giving NWN the ability to develop the reservoir from an I/W well site immediately adjacent to the compressor station and eliminating the need to install a long-distance pipeline between the I/W wells and the compressor station; and (2) the location is in close proximity to Miller Station, existing roads, and transmission pipeline corridors for the conveyance of natural gas to PGE's PWIP. These locational attributes enable the installation of infrastructure that minimizes impacts to the surrounding commercial forest and agricultural operations, while also establishing the safest locations for ongoing operation and maintenance of the underground gas storage and pipeline facilities.

C. Site Background

By the late 1970s, NWN had anticipated its need for additional natural gas storage capacity in its service territory to serve its customers. NWN believed the area around Mist, in rural Columbia County, Oregon, might be one of the few areas in the state containing sandstone zones of reservoir quality that could be used to store natural gas. These sandstone zones, surrounded by impermeable rock, are referred to as underground "reservoirs." These reservoirs are frequently and incorrectly considered to be large caverns, or holes in the ground. Instead, the sandstone has small spaces (porosity) between sand grains that are in excess of 30 percent of the volume of the rock, and this space can be filled with natural gas. NWN recognized that the Mist area would be an excellent location for storage facilities to serve the region.

Reichhold Energy Company and Diamond Shamrock Exploration Company were exploring the Mist area with the hope that underground reservoirs containing commercial gas deposits would be discovered. NWN formed a subsidiary, Oregon Natural Gas Development Corporation (ONG), to participate with those two companies in exploring the Mist area by drilling exploration wells to depths of several thousand feet below the surface.

From NWN's perspective, simply finding a good underground reservoir, even without commercial gas deposits, would have been satisfactory. The discovery of natural gas at Mist was a bonus.

The Mist Field was discovered in April 1979. Natural gas production was established in December of that year when the first volumes of natural gas were transported via the newly constructed 12-inch North Mist Feeder pipeline to a connection with the NWN pipeline system about 9 miles away, near Clatskanie. Subsequently, additional production was connected by buried gathering pipelines from commercial discoveries in the Mist Field to the natural gas processing equipment located at Miller Station. At Miller Station, the produced natural gas was collected, measured, treated, and odorized before its transmission to NWN pipelines.

Through the 1980s and into the 1990s, gas exploration and production in the Mist Field were carried out by ONG and a variety of industry participants, including Reichhold Energy Company, Diamond Shamrock Exploration Company, ARCO Oil & Gas Company, Nahama & Weagant Energy Company, and Enerfin Resources NW-LP (Enerfin). Gathering pipelines connecting individual production wells to Miller Station were constructed and operated by ONG until December 1995,

and by Enerfin thereafter. During these same periods, ONG and Enerfin also operated the production wells under contract with the wells' various owners.

By the early 1980s, ONG had produced most of the economically recoverable natural gas in the Bruer and Flora pools, two of the first production reservoirs at the Mist Site. In anticipation of that depletion, in 1981 ONG applied for the permits necessary to convert the Bruer and Flora pools into an underground natural gas storage facility. As explained below, the original Site Certificate authorized the Mist Site to utilize the Bruer and Flora pools in the Bruer/Flora storage area. Later amendments expanded the Mist Site to include similarly produced pools in the Calvin Creek storage area, Al's Pool, and the Reichhold Pool. Additional pools (Schlicker and Busch) in and adjacent to the Calvin Creek storage area were added under Amendment No. 9.

D. Existing Site Certificate, Prior Amendments, and Summary Description of Proposed Amended Facility

On September 30, 1981, EFSC issued a site certificate to ONG for an underground natural gas storage facility near Mist, Oregon in Columbia County (the Site Certificate). The Site Certificate has been amended 10 times.

The Site Certificate authorized ONG to construct and operate two naturally existing underground gas reservoirs (the Flora and Bruer pools) and Miller Station with attendant equipment, including, but not limited to: compressors, gathering lines, access roads, existing natural gas wells, monitoring wells, and proposed I/W wells; all located in rural Columbia County in parts of Sections 2, 3, 4, 10, and 11 of Township 6 North, Range 5 West, Willamette Meridian, Oregon (the original Mist Site).

Amendment Nos. 1, 2, and 3: In 1990, ONG assigned the Site Certificate to its parent, NWN. EFSC approved amendments to the Site Certificate in 1987 (Amendment No. 1), 1988 (Amendment No. 2), and 1990 (Amendment No. 3). The amendments modified several terms of the Site Certificate and authorized the construction and replacement of wells.

Amendment No. 4: In 1997, EFSC approved Amendment No. 4. That amendment approved an expansion of the Mist Site that increased the combined total Mist storage peak-day delivery capability from 100 million standard cubic feet per day (MMscfd) to 145 MMscfd. The expansion included: (1) improvements to the Miller Station gas processing facility, including the replacement of two older 550-horsepower compressor units with one larger, more efficient unit; (2) total available compression of 6,650 brake horsepower (BHP); (3) construction of a building for the new compressor and updates to related equipment; (4) natural gas storage in one additional naturally occurring underground pool, Al's Pool, in the Calvin Creek storage area; (5) up to four new sites for I/W wells, including one to four wells at each site; (6) approximately 1 mile of buried 8-inch and 6-inch gathering pipeline; and (7) approximately 2.5 miles of buried twin 16-inch transmission pipelines.

Amendment No. 5: On March 13, 1998, EFSC approved Amendment No. 5, which replaced the amendment provisions in the Site Certificate with a requirement that future Site Certificate amendments be governed by EFSC's amendment rules.

Amendment No. 6: In 1999, EFSC approved Amendment No. 6, increasing the capacity of the Mist storage facility. The gas storage portion of that project included: (1) upgrades to the dehydration and metering systems at Miller Station; (2) natural gas storage in one additional naturally occurring underground pool, the Reichhold Pool, within the existing Site Boundary; (3) up to four new sites for I/W wells, including one to four wells at each site; (4) approximately 6,500 feet of buried gathering pipeline no greater than 12 inches in diameter; and (5) the removal of the 6,650 compressor horsepower limitation then in place for the Miller Station facility. Approval of Amendment No. 6 allowed Miller Station to operate at rates of up to 190 MMscfd without any restriction on the use of the three existing compressor units, which have a total rating of 8,200 BHP.

Amendment No. 7: On May 17, 2001, the Federal Energy Regulatory Commission (FERC) granted NWN a limited jurisdiction blanket certificate under section 284.224 of FERC's regulations. Under that certificate, NWN is authorized to use existing and expanded facilities at the Mist Site to provide FERC jurisdictional bundled firm and interruptible storage and related transportation services in interstate commerce. *See Northwest Natural Gas Company*, 95 FERC ¶ 61,242 (2001). However, FERC's jurisdiction extends only to the interstate services themselves. NWN provides the interstate storage services using existing and expanded facilities at the Mist Site that are not needed to serve its "core" utility customer needs. NWN also has agreements in place with state utility regulators regarding this use. To make increased capacity available to the interstate market, NWN amended its Site Certificate (Amendment No. 7) by increasing the permitted throughput of the Mist Site to 245 MMscfd. Amendment No. 7 was approved on November 17, 2000.

Amendment No. 8: In Amendment No. 8, approved October 26, 2001, EFSC authorized an increase of the permitted daily throughput from 245 MMscfd to 317 MMscfd. As described in the Amendment, this involved the installation of new metering facilities, new interconnect piping to the South Mist and North Mist pipelines, and a new gas-turbine-driven compressor. The new compressor added 7,800 horsepower, bringing the total compression capability to 16,000 horsepower.

Amendment No. 9: In Amendment No. 9, approved December 5, 2003, EFSC authorized an increase of the permitted daily throughput from 317 MMscfd to 515 MMscfd. EFSC also authorized the construction of improvements at Miller Station, including the installation of new dehydration facilities and gas quality and monitoring equipment. EFSC also authorized NWN to develop related and supporting facilities associated with new underground gas storage reservoirs in the Calvin Creek storage area, the Busch and Schlicker pools. Approval of Amendment No. 9 also allowed NWN to terminate the vibration monitoring program created in Amendment No. 1.

Amendment No. 10: In Amendment No. 10, approved May 30, 2008, EFSC approved a Consolidated, Restated, and Amended Site Certificate. In its Request for Amendment No. 10, NWN sought no substantive changes to the Site Certificate other than clarification of conditions where the applicable law had changed since the Site Certificate was initially approved. The approved Consolidated, Restated, and Amended Site Certificate consolidated the original Site Certificate and Amendment Nos. 1-9 to the Site Certificate, updated the Site Certificate to reflect the current statutory and regulatory regime, deleted outdated and superseded conditions, added language

describing the surface facilities related to the underground gas storage reservoir, updated the site maps, and eliminated inconsistencies between the various documents.

Proposed Amendment No. 11: In this Request, and as noted above, NWN proposes to develop only the Adams reservoir as a new underground storage area, to install I/W pipelines to connect the underground storage reservoir in the Adams storage area to a new compressor facility located approximately 2.2 miles northwest of Miller Station (approximately 5 miles by road), and to construct an approximately 13-mile, up to 24-inch high-pressure natural gas transmission pipeline between the new compressor station and PGE's PWIP. Any conversion of the Newton, Medicine, Crater, and Stegosaur production reservoirs into storage facilities, along with the development of EFSC-jurisdictional surface facilities, underground transmission (or I/W) pipelines, and any other jurisdictional related and supporting facilities, will require a future amendment to the Site Certificate.[3]

Council's 2013 Declaratory Order; Matters Decided: In April 2013, NWN filed with EFSC a Petition seeking a Declaratory Order (DO Petition) to guide the next (this) amendment to the Site Certificate. The DO Petition requested EFSC's formal determinations that (1) the transmission pipeline proposed in this Request would be considered a "related or supporting facility" of the Mist Site, and (2) the expansion proposed in this Request would be considered an amendment to the Site Certificate, rather than requiring a new Application for Site Certificate. On June 21, 2013, following public notification and hearing, EFSC concurred with NWN's propositions of law and issued its Final Declaratory Order accordingly. NWN bases this Request on EFSC's Conclusions of Law as set forth in the Final Declaratory Order. The facility as described in this Request is substantially the same as that described in NWN's DO Petition.

V. PROJECT DESCRIPTION (OAR 345-027-0060(1)(c); OAR 345-021-0010(1)(b)(A))

A. Description of Proposed Change and Reason for This Site Certificate Amendment

In accordance with OAR 345-001-0010(55), the new Site Boundary includes the previously site-certificated locations depicted in Figure A-1, along with the following Facility areas and related or supporting facilities:

- The Expansion Area (**Figure A-1**), including the NMCS;
- The North Mist Transmission Pipeline (NMTP) Corridor, including the micrositing corridor areas (**Figure A-2**); and

[3] In addition to the formal amendments, over the years NWN has incrementally changed the Mist Site in accordance with the provisions of OAR 345-027-0050(5). The last two formal requests were submitted in August 2005 and May 2007.

- All temporary laydown and staging areas, including those described below that are remote from the NMTP Corridor (**FigureC-2**).

The term Site Boundary as described in Exhibits C, J, L, P, Q, R, S, T, and X includes only the NMCS, NMTP corridor and all temporary laydown and staging areas for analysis purposes. As described elsewhere in this Request, temporary laydown and staging areas, particularly those that are remote from the NMTP corridor, are considered to be within the Site Boundary only during the construction phase, for purpose of compliance with OAR 345-001-0010(55). However, these locations are privately owned, and should not considered part of the final, new Site Boundary for any other long-term jurisdictional purposes.

As described above, the Mist Site has been in existence since 1981 and has been expanded multiple times.[4] Currently, seven reservoirs have been developed for underground storage service with a combined working gas capacity of 15.9 billion cubic feet and maximum deliverability of 515 MMscfd. Installed compression equipment totals 15,200 BHP.

Five additional producing reservoirs within the Mist Field (not currently included within the Mist Site boundary) have been identified as having the proper characteristics for future development for underground storage service. All five of these reservoirs are in the later stages of primary natural gas production and could be developed for underground storage service to satisfy customer needs, either individually or in various combinations to achieve the desired working gas and deliverability additions.

The existing permitted storage area consists of approximately 2,828 acres. NWN proposes to expand the Site Boundary to accommodate the expansion of facilities described in this Request, with surface facilities needed to serve the Adams reservoir, and to provide for future expansion involving the Newton, Medicine, Crater, and Stegosaur production reservoirs (as future storage areas). The key reasons for the expanded Site Boundary to include all five reservoirs are:

(1) The reservoirs themselves are oddly shaped and in relatively close proximity to each other, causing challenges from both regulatory and management perspectives. Drawing lines between the reservoirs is difficult and not meaningful for overall facility management.

(2) As NWN continues to serve the needs of northwest homes and businesses, it is essential that NWN be able to offer storage services within a defined regulatory boundary of sufficient dimension to accommodate future needs. NWN believes that for EFSC's project management, as well as public notification, it is most logical to identify plans for potential expansion now, establishing the platform for future amendments. In the 2013 Declaratory Order, EFSC reviewed and acknowledged NWN's plan to propose the expanded Site

[4] NWN received its Site Certificate in 1981, but the Mist Site was not built until sometime later, and became operational around 1988.

Boundary to encompass the five reservoirs, seeking regulatory authorization of future underground natural gas storage infrastructure as those needs emerge.

The inclusion of future underground storage reservoirs within an expanded Site Boundary is consistent with EFSC's decision in approving the Calvin Creek expansion. Similar to the previous expansion as part of Site Certificate Amendment Nos. 4 and 6, where the Calvin Creek reservoir was added, nearly doubling the size of the Site Boundary, this proposed expansion of 2,644 acres will nearly double the size again and provide for future development subject to approval of additional Site Certificate amendment requests or changes made pursuant to OAR 345-027-0050(5). The expansion area would be merged into the EFSC-jurisdictional Facility Site Boundary, as a single, unified energy facility. **Figure A-1** depicts the existing approved Site Boundary and the proposed expansion area.

NWN proposes to amend the Site Certificate to expand the Site Boundary to include the Adams reservoir, along with four additional future storage reservoirs. The Project proposed with this Request will develop new underground gas storage capacity through the development of the Adams reservoir, one compressor station facility capable of delivering 120 MMscfd to the PWIP facilities near the Beaver terminus of the Kelso Beaver (KB) pipeline, and a new transmission pipeline with capacity to accommodate current needs and reasonably foreseeable future customer load requirements. This capacity will serve peak and flexible gas supply to meet immediate needs for PGE's electric generation facilities near Clatskanie, Oregon and potentially serve other large industrial, electrical generation, or manufacturing customers that choose to connect along the pipeline corridor or request interstate services through the KB pipeline.[5]

At this time, NWN is only proposing that EFSC and other agencies with jurisdiction issue regulatory authorizations and approvals related to the Adams reservoir portion of the expansion area. Through this Request, NWN provides studies and other information related only to the EFSC-jurisdictional facilities proposed regarding the Adams reservoir. This is because at this time, NWN can only identify facilities needed for the development of the Adams reservoir (other facilities related to development of the other four reservoirs within the expanded Site Boundary are unknown and hypothetical at this time). Should NWN propose future expansions (through Site Certificate amendments and/or the process in OAR 345-027-0050(5)), such expansions will be proposed within the mapped Site Boundary, including the proposed expansion area.

B. NWN's Resource Planning; OPUC Proceedings

Regulatory and tariff issues concerning the proposed expansion have been subject to proceedings before the Oregon Public Utility Commission (OPUC). On March 5, 2015, in Order No. 15-064, OPUC acknowledged NWN's 2014 Integrated Resource Plan (IRP). The IRP, at page 3.7, describes NWN's obligation to serve "core" utility customers as follows:

[5] The KB pipeline is subject to the exclusive jurisdiction of FERC.

> The Company's utility customers currently receive underground storage service at Mist through the Miller Station central control and compressor facility using four depleted production reservoirs (Bruer, Flora, Al's Pool and a portion of Reichhold), collectively referred to as Mist storage. * * * Capacity in excess of core needs is made available for the non-utility storage business and AMA [asset management agreement] activities. As core needs grow, existing storage capacity may be recalled and transferred for use by core utility customers, which NWN refers to as Mist Recall. The IRP models the recallable portion of Mist as an incremental resource.

At present, the Mist Site is fully subscribed and cannot meet PGE's long-term needs or any substantial future customer needs, necessitating expansion. NWN anticipates recalling its interstate service pursuant to those contracts. As stated in NWN's IRP, due to constraints in the Mist Field, to meet core customer needs,

> the main near term resource addition (up until at least 2020) in every scenario that is chosen as the least cost option to meet expected shortfalls is Mist Recall. Mist Recall is the linchpin of the Company's strategy to keep its options open while the prospective interstate pipeline projects play out * * * (IRP at p. 1.10[6]).

At present, pursuant to its interstate service contract with NWN, PGE receives 70,000 dekatherms of natural gas, approximately 68 MMscfd from the Mist Field, to serve the PWIP. This capacity would be subject to recall to serve the NWN core utility service customers.[7] In order to best serve customer needs, including flexible generation to "follow" wind energy generation, PGE has entered into an agreement with NWN pursuant to which NWN will provide "firm," "no notice," on-demand service withdrawal from the Mist Field.

In October 2014, OPUC reviewed NWN's request for approval of its new "no notice" withdrawal storage service and accompanying Rate Schedules 90 and 91. The October 2, 2014 OPUC Staff Report and Findings is attached hereto as **Exhibit B-1.** In its report, OPUC set forth the following rationale for its approval of the "no notice" service and accompanying rate schedules:

> The purpose of this filing is to request approval for new intrastate no-notice withdrawal storage service to be made available under two new rate schedules, the availability of which is dependent upon the customer location relative to such customer's access to certain NWN pipeline facilities. The two rate schedules are: Rate Schedule 90 'Firm Storage Service with No-Notice Withdrawal' and Rate Schedule 91 'Firm Storage Service with No-Notice

[6] The IRP, Chapter 3, describes "supply side" resources in detail. *See* IRP at pp. 3.19-3.23.

[7] The IRP, at page 3.23, explains Mist "recall" as follows: "In addition to the existing Mist storage capacity currently reserved for the core market (*see* **Table 3.3**); the Company has four reservoirs (a portion of Reichhold and all of Schlicker, Busch and Meyer) that also have been developed for storage services. They currently serve the interstate/intrastate storage market, but could be recalled for service to the Company's utility customers as those third party storage agreements expire[.]"

Withdrawal and Direct Connection to South Mist Pipeline.' In summary, these rate schedules would provide NWN an ability to deliver a unique NWN storage service to customers that have agreed to pay all costs associated with the service (including the necessary capital additions). In providing such service, NWN would recover its cost of service, including its authorized cost of capital.

The only customer known at this time is Portland General Electric (PGE). The approval of Schedule 90 by the Public Utility Commission of Oregon (OPUC) is a condition precedent under the terms of a Precedent Agreement between NWN and PGE for service to the Port Westward 2 generating plant. The Precedent Agreement between NWN and PGE documents an agreement that the Schedule 90 Service Agreement with PGE will be for a 30-year initial term, with three unilateral elective 10-year extensions. In the case of PGE, the new Non-Core Mist Storage facilities to be constructed are known as the North Mist expansion. In the interim NWN will provide PGE with no-notice storage service utilizing existing Mist storage capacity and deliverability.

The North Mist expansion proposed to serve PGE will not be shared with, or used by core ratepayers. NWN notes that:

- Revenues are not subject to sharing under Schedule 185 (optimization revenue sharing); and
- The new storage capacity built in order to serve PGE is not subject to recall for core ratepayer use.

NWN's analysis supporting its 2014 Integrated Resource Plan (IRP) shows that an additional build-out of storage capacity at North Mist for core ratepayers is a component of the least cost portfolio in all future scenarios, although the timing of that build-out varies significantly by scenario. The earliest date on which expanded capacity would be needed from North Mist for core ratepayers would be 2020. The expansion proposed for PGE in the North Mist Field will involve only a portion of the available resources. If North Mist's Adams reservoir is built out for PGE under this tariff, sufficient capacity remains in the other reservoirs that can be built out to meet forecast requirements for core ratepayers. The possibility for core ratepayer need in the future for storage capacity at North Mist is a driver for the Schedule 90 Conditions of Approval discussed below and presented in Attachment 1 (OPUC Staff Report at pp. 1-2[8]).

[8] The IRP at page 7.18 states: "An important finding in this IRP is that a North Mist expansion project is part of the portfolio regardless of the future that comes to fruition. This indicates that no matter the future that plays out a North Mist expansion is part of a least cost portfolio." *See also* IRP at p. 7.27 ("A North Mist Expansion is needed within the planning horizon under every scenario, and potentially as soon as 2020 under certain conditions.").

On October 14, 2014, OPUC approved Rate Schedules 90 and 91, pursuant to the OPUC Staff Report and Findings. See **Exhibit B-2** (OPUC Minutes of Public Meeting, October 14, 2014); **Exhibit B-3** (Advice No. 14-7, October 14, 2014).

C. Proposed Reservoir Developments

Amendment No. 11 will respond to the service needs identified in the 2014 IRP, and will allow NWN to provide service in accordance with Rate Schedule 90. As described below, similar to the approach approved by EFSC in Amendment No. 4, and in accordance with OPUC's Rate Schedule 90 approval, Amendment No. 11 will provide a sufficient site expansion area to meet current customer needs, and provide for the ongoing growth and development of the Mist Site to both meet immediate needs and provide the platform for ongoing modifications and expansions as additional customer needs arise. As such, the proposed expansion subject to Amendment No. 11 will increase the combined Mist Site storage peak-day delivery capability to 635 MMscfd. The operations of the expanded capacity will be integrated into the existing facility so that they are maintained, controlled, and monitored on a unified basis.

To serve the purposes of NWN in the ongoing delivery of underground natural gas storage services to its customers, NWN proposes to add to the Mist Site the infrastructure and facilities described below.

The Project will require development of I/W wells sufficient to deliver the 120 MMscfd design flow requirements. The area where the reservoirs are located has been mapped utilizing a three-dimensional seismic survey and other subsurface data from multiple exploratory and production wells drilled in the area. Subsurface development of the reservoirs will be very similar to those storage reservoirs currently in service.

The reservoir will be developed from drill sites located near the reservoirs using high-angle directional (deviated) and/or horizontal I/W wells. These wells are designed for high flow rates without damaging the storage formation or the installed subsurface equipment. Following is a summary of the reservoir proposed for development:

Deliverability: 120 MMscfd Number of I/W wells: 4

The drill sites for the Adams reservoir I/W wells will be adjacent to the compressor station site. NWN will also drill one new observation/monitoring well for the Adams reservoir and recomplete and convert two existing production wells to observation/monitoring wells. These wells will be used to observe water (pressure) movement within the reservoir, and monitor potential underground spill points[9]. These locations are not depicted, as they are subject to the sole jurisdiction of DOGAMI (subsurface) and Columbia County (land use).

[9] "Spill points" for an underground storage reservoir are those areas where a reservoir is most likely to leak from one formation to another if it is filled beyond its capacity. Fill volumes are monitored closely, so this is

(continued . . .)

D. Miller Station Operation and Maintenance Facility; Proposed New Compressor Station

As described in prior Site Certificate amendments, operation and maintenance (O&M) activities for the Mist Field are conducted at the existing Miller Station. As further explained below, the expansion area subject to Amendment No. 11 will also be operated from Miller Station. Hence, no changes to the O&M functions are proposed with this Amendment. Storage of all operation-phase equipment, supplies, fuel, fire protection and control, chemical storage, etc., will continue at Miller Station, with no expansion required at Miller Station. The existing Miller Station compressor facility is at capacity, and expansion would be very difficult and cost-prohibitive. For this reason, one satellite compressor facility (the NMCS) is planned to be developed on an up to 10-acre parcel (approximately 3 acres for the well pad and approximately 7 acres for the compressor station) that will be located as close as is practical to the reservoir. The site plan is attached hereto as **Figure B-1** with a list and description of the equipment proposed for the station presented in **Table 1** below.

Table 1. Compressor Station Equipment

Item	Equipment	Description
1	Waste oil tank	This tank is for the storage of depleted or used waste oil from the engines and compressors at the site. It is a 5-foot, 4-inch diameter by 6-foot long, 1000 gallon tank installed within a dike for secondary containment. The tank will be of carbon steel construction. Pneumatic pumps in the compressor building will convey the waste oil from the compressors to the tank. No lining is anticipated.
2	Oily water tank	This is a tank for the storage of liquids collected at the various separators in the facility: the filter separators, the coalescing filter separators, the fuel gas skid pan, and the compressor suction separator. It is up to a 12-foot diameter by 20-foot tall, 600 bbl tank installed within a dike for secondary containment. The tank will be of carbon steel construction. Natural gas pressure within the vessels will send the oily water to the tank. No lining is anticipated.
3	Produced water storage tank	The produced water storage tank is a 10-foot diameter by 12-foot tall, 200 bbl tank installed within a dike for secondary containment. The tank will be of carbon steel construction. It contains fluids collected from the separators at the well pad. Natural gas pressure within the separators will send the produced water to the tank. No lining is anticipated.
4	Standby generators	There are three 150kw natural gas powered engine-driven electric power generators that provide electrical power allowing compressor station equipment to remain operational when utility power fails.

(. . . continued)

not likely to occur and create a hazard at the surface, but it could lead to loss of the stored natural gas from the storage reservoir.

Table 1. Compressor Station Equipment

Item	Equipment	Description
5	Transformer	This is a non-PCB mineral oil filled electrical power transformer with 1000 kVA capacity for stepping down the power line voltage of 12.47 kV to the required voltage of the station, which is 480V. The transformer will have a pad with an oil containment foundation and a refractory-lined firewall between the same and adjacent structures.
6	Thermal oxidizers	The thermal oxidizers reduce hydrocarbon contaminants from the triethylene glycol regenerator discharge, prior to release to the atmosphere. The oxidizer will be 30-inches diameter and 40-feet tall.
7	Produced water 3-sided shed	The three sided shed over the produced water tank provides weather protection and prevents the accumulation of rainwater in the concrete secondary containment dike area. It will be constructed with steel supports and metal siding. It will be 15-feet long by 15-feet wide with an eave height of 15 feet.
8	4-sided small auxiliary sheds	These sheds will house the gas chromatograph at the compressor station and the Remote Telemetry Unit (RTU) at the well pad; a second shed at the well pad will serve as a utility shed. These are four sided structures with a roof to provide weather protection to the equipment stored inside. They will be constructed with steel supports and metal siding. The sheds will be 8-feet long by 6-feet wide with an eave height of 8 feet.
9	3-sided dehydration shed	This structure provides weather protection for the TEG (triethylene glycol) regenerator unit, i.e., the dehydration unit. It will be constructed with steel supports and metal siding. The dehydration shed will be 45-feet long by 20-feet wide with an eave height of 12 feet. The slab will be designed to contain any spills. Penetrations for conduit and pipe will be designed to ensure no leakage.
10	3-sided liquid storage shed	This shed provides weather protection to the liquid storage vessels and prevents the accumulation of rainwater in the concrete secondary containment dike area. It will be constructed with steel supports and metal siding. It will be 50-feet long by 55-feet wide with an eave height of 15 feet.
11	3-sided standby generator shed	This shed provides weather protection for the standby generators. It will be constructed with steel supports and metal siding. It will be 40-feet long by 15-feet wide with an eave height of 12 feet. The floor slab will be designed to collect oil spills.
12	Air compressor shed	This shed provides weather protection for the air compressor. It will be 30-feet long by 10-feet wide with an eave height of 10 feet.
13	4-sided MCC & control center	This is a building that provides protection from the weather for the Motor Control Center (MCC) and other equipment in the building. It will be constructed with steel supports and metal siding. It will be 30' long by 10' wide with an eave height of 10 feet.

Table 1. Compressor Station Equipment

Item	Equipment	Description
14	4-sided compressor building	This building provides weather protection as well as a crane for maintenance of the engine-driven natural gas compressors. It will also mitigate noise transmitted outside of the building. It will be a pre-engineered metal building designed to meet the seismic design requirements for the area. It will be 100-feet long by 70-feet wide with an eave height of 28 feet. The compressor building floor and slab will be designed to contain a spill from any engine/compressor via sloped floor, sump pit, etc.
15	Injection and withdrawal pipeline	The injection and withdrawal pipeline runs from the gas pipeline to the storage field wells. It is the main pipe used to inject the natural gas from the pipeline into the wells and withdraw the gas from the wells and put it back into the pipeline. The main pipe through the station is 16-inch diameter and then it splits off into four 8-inch diameter pipes that lead to the four wells. The pipelines are carbon steel, with portions of the pipe buried and portions aboveground.
16	Air receivers	The air receivers store compressed air at 150 psig, which is used to start the engine-driven natural gas compressors. They also store air which is used for the operation of the air-power valve actuators. There are two receivers with a capacity of 180 cubic feet.
17	TEG System (Triethylene Glycol)	The TEG system is used to remove water vapor entrained in the natural gas when withdrawn from the gas storage field. The system consists of a dehydration (dehy) tower that transfers the moisture in the gas to the TEG fluid. The TEG regenerator then vaporizes the water removing it from the TEG fluid in order to recycle the TEG back to the tower. The TEG regenerator effluent stream is principally water vapor but some TEG and entrained natural gas components are carried over in it. The effluent stream is sent to the thermal oxidizer (TOx unit) where the TOx unit combusts most of the hydrocarbons in the TEG regenerator effluent stream prior to discharging this stream to atmosphere.
18	Compressors	Two Ariel - JGK-4 natural gas compressors are driven by Caterpillar G3606, 1775 HP engines. The compressors are of single stage design but can be operated in series or parallel. When needed they are used to compress the natural gas from the pipeline to be stored in the gas storage reservoir via the storage wells. They are also used to compress the gas being removed from the wells and sent to the pipeline. The compressor suction pressure ranges from 300-700 psig with the discharge pressure ranging from 400-1050 psig. The flow rate per compressor is between 10-60 MMSCFD (million standard cubic feet per day) at design conditions.

Operations of the storage facility will be integrated such that they will be monitored and remotely controlled by trained operators at Miller Station, approximately 5 miles away by road. The new NMCS will be constructed so as to not need staffing 24 hours per day during routine operations. The compressor station site will be constructed on a hardened, rocked surface, and will be enclosed by security fencing, with yard lighting installed for security purposes. The NMCS will include a dedicated building for the compressors and a modular building that will contain the motor control center and small on-site auxiliary control room. Surveillance and intrusion detection systems will be in place to monitor the security of the remote facility, and fire detection and suppression systems will be installed within the compressor station as needed. NWN will maintain fire extinguishers, fire prevention and suppression equipment, and emergency shutdown and station venting systems to address fire considerations. In addition to Miller Station's 24-hour-per-day monitoring, NWN Gas Control, located in Portland, Oregon, will continue to provide additional monitoring of the newly integrated facilities on a 24-hour basis.

Communication and electric utility services for NMCS will be provided from Miller Station through approximately 4 miles of underground conduit. Of these 4 miles, approximately 1.5 miles are preexisting conduit as shown in **Figure B-2**. All conduits will be installed within existing roads or rights-of-way (ROWs), avoiding any timber removal. NWN proposes underground electrical distribution and communication lines and associated telemetry equipment as elements of Amendment No. 11, in order to fully integrate the new compressor station into the storage facility, tied directly to Miller Station. NWN will install a 3.5-inch conduit for power, a 3-inch conduit for fiber optic cable, and a 3-inch conduit as a spare resource for any future needs. NWN will install an approximately 80-foot-tall lattice communication tower at NMCS. The communication tower will be freestanding, without guy wire supports, and will not require FAA lights. It will be at a height similar to the surrounding tree cover. Additionally, some of the existing logging roads will likely be improved to provide sufficient access to the compressor station facility. The construction access route is depicted in **Figure B-3**.

The new NMCS will serve only the Adams reservoir, having the capability not only to compress the gas for injection into and withdrawal from the reservoir, but also to measure and control the gas flow and dehydrate the gas as needed during withdrawal. The proposed compressor facility will have total installed compression of approximately 3,600 BHP, provided by two gas-fueled compressors.

Pursuant to OAR 345-021-0010(b)(A)(vii), the NMCS's compressor equipment will include the following attributes:

- <u>Estimated daily injection and withdrawal rates:</u>

  Injection: Variable – 10 to 56 MMscfd

  Withdrawal: Variable – 10 to 120 MMscfd

- <u>Horsepower compression required to operate at design injection or withdrawal rates:</u> Variable – zero to 3,550 horsepower

- Operating pressure range: 250 to 1100 pounds per square inch
- Fuel type of compressors: Natural gas

The proposal takes advantage of the existing Miller Station's capabilities as a central "hub" to operate and serve the additional storage reservoir in a unified fashion, consistent with the Mist Site's prior permits and EFSC approvals. The Consolidated Site Certificate approved by Amendment No. 10 provides a platform for this process, as anticipated by the Oregon Department of Energy (ODOE) and NWN in 2008.

E. Proposed Injection/Withdrawal Pipelines

The new reservoir will have one underground I/W transmission pipeline to connect the four I/W wells to the compressor station. This I/W transmission pipeline is designed to operate at pressures sufficient for the injection of gas into the reservoir at the maximum design injection pressure as well as withdrawal flow-rate conditions. The I/W pipeline is 16 inches in diameter. NWN plans to connect the four 8-inch well pipelines, one from each of the four I/W wellheads, to the two dehydration contact towers, and then to the 16-inch I/W pipeline. At the compressor station, the I/W pipeline will feed the compressor station process piping. NWN designed the Project such that the well pad is adjacent to the compressor station. Consequently, the I/W pipeline resides wholly within the well pad and compressor station footprints, thereby minimizing I/W line locations and eliminating the need for additional site disturbance and permanent ROWs in the areas above the I/W pipeline. The I/W pipeline is buried below ground and will have a minimum depth of cover of 5 feet. This design increases efficiency and reduces emissions. *See* **Figure B-1**.

F. Proposed Transmission Pipeline; Right-of-Way Description (OAR 345-021-0010(b)(E))

The existing Mist Site is connected to NWN's gas transmission network in Oregon by three separate pipelines: the 12-inch North Mist Feeder, the 16-inch South Mist Feeder, and the 24-inch South Mist Pipeline Extension. During periods of peak withdrawal, these pipelines operate at full capacity to deliver up to 515 MMscfd of storage gas from the Mist Site to the marketplace. Thus, the existing transmission pipeline system does not have the capacity to meet the natural gas transmission needs associated with this proposed North Mist Site expansion.

Due to these capacity limitations, NWN proposes to build a new natural gas transmission pipeline, the NMTP, up to 24 inches in diameter, that will provide sufficient capacity for the Project as well as additional capacity for the future. The NMTP will not be physically connected to the existing Mist reservoirs or pipelines. NWN proposes to expand the EFSC-jurisdictional Site Boundary to include the NMTP corridor. See **Figure A-2**. The NMTP corridor is depicted on a series of photo panels, **Figure C-2.1 – C-2.34**.

The NMTP will traverse generally north from the storage facility, paralleling the original 12-inch North Mist Feeder pipeline where it is practical to do so, then extending to the northeast past the terminus of that pipeline for an additional approximately 6 miles to the PGE PWIP and pipeline network at the Beaver end of the KB pipeline, just south of the Columbia River. The NMTP will be

installed with a minimum safety separation distance of 10 feet from any existing pipelines. See **Figure B-4**. Minimum pipeline cover will be 5 feet. The total NMTP distance will be approximately 13 miles.

Approximately 7.4 miles of the NMTP will be located on commercial forest lands, most of them located in or adjacent to existing pipeline and road ROWs. Approximately 4.7 miles of the NMTP will be located on agricultural lands and will be installed principally by horizontal directional drilling (HDD) methods. See **Figure C-2.22 through C-2.34.** The pipeline easements will authorize placement of the NMTP within a ROW approximately 40 feet wide, and will restrict certain uses of the property that could damage the pipeline. Landowners will be compensated for losses associated with such restrictions. See **Exhibit K** and **Attachment K-1: Agricultural Impact Mitigation Plan (AIMP)**.

In order to minimize impacts to natural resources and agricultural lands, a significant portion of the NMTP (slightly more than one-third of the overall length) will be installed utilizing HDD methods. NWN proposes a total of seven bore pads within the agricultural area. As the NMTP emerges from the agricultural area, near the Columbia River, the eighth and final bore pad location is proposed within the PGE PWIP property. From the bore pad, the pipeline will split in two directions: one 12- to 24-inch pipeline will be routed due east to the KB/Beaver metering area, and a second 12-inch pipeline will be routed due north, down an existing road serving PGE's generation facilities, paralleling an existing 12-inch pipeline, then turning east as it moves toward PGE's Port Westward 1 and 2 generating plants, tying into the existing NWN pipeline that currently serves these plants. The NMTP corridor location is shown on **Figures C-2.20 – C-2.34**, along with all bore pad locations, laydown areas, and construction areas, and described in detail in **Exhibit K**.

NWN will acquire easements from landowners along the NMTP route. Construction ROWs will require easements up to 80 feet in width, with permanent ROWs of approximately 40 feet.[10] To avoid areas where slope stability is a concern, NWN has conducted a geotechnical review of the route. Based on the study results, NWN will, as needed, implement engineering and construction methods and practices, in order to avoid or mitigate geotechnical hazards. See **Exhibit H**. Similarly, NWN has conducted a cultural and environmental review in accordance with existing regulations and industry practices to ensure that there will be no significant adverse impacts to any cultural or environmental resources. NWN is working closely with all relevant regulatory and permitting agencies at this time, and will continue doing so during construction to satisfy all applicable regulatory and permitting requirements.

[10] NWN proposes a "study corridor" for Council approval, with dimensions in accordance with applicable Council rules. The corridor will be of sufficient dimension to enable NWN to determine final pipeline locations to best minimize natural resource, cultural, and agricultural impacts, while also meeting engineering feasibility, construction, and safety considerations. See **Exhibit K** and the attached AIMP for discussion regarding micro-siting and NWN's proposed protocols to implement this strategy to minimize and avoid impacts.

NWN has conducted on-site natural resource and geologic surveys within a 200-foot study corridor, and proposes a 200-foot-wide micro-siting corridor permitting approach for installation of the NMTP. This approach allows flexibility in the final locations and orientation of facility components, and minimizes or avoids impacts to wildlife, habitat, and other resources. Micro-siting also provides flexibility in reaching final easement agreements with landowners and minimizes ground disturbance. NWN can optimize the final layout while assessing possible impacts using a worst-case scenario, thus demonstrating to the regulatory agencies that the facility will meet applicable regulatory standards.

The NMTP will cross Highway 30, a railroad line, the Beaver Diking District, and the Clatskanie River via HDD. Before construction, NWN will coordinate with the Oregon Department of Transportation (ODOT) to obtain a permit to occupy or perform operations upon a state highway. NWN will provide documentation of written correspondence with ODOT staff to ODOE. The pipeline will not require any additional public ROW. See **Exhibit K**; **Figures C-2.20 – C-2.25**.

G. Proposed Transmission Pipeline; Corridor Selection Assessment (OAR 345-021-0010(b)(D))

Pursuant to OAR 345-021-0010(1)(b)(D), because the Project includes, as a related or supporting facility, a pipeline that, by itself, is an energy facility under the definition in ORS 469.300, a "corridor selection assessment" is required. NWN may select any corridor for analysis, may select only one corridor, and may select more than one corridor. In compliance with OAR 345-021-0010(1)(b)(D), NWN is required to discuss the reasons for selecting the corridor(s), based upon evaluation of the following factors:

(i) Least disturbance to streams, rivers and wetlands during construction.

(ii) Least percentage of the total length of the pipeline or transmission line that would be located within areas of Habitat Category 1, as described by the Oregon Department of Fish and Wildlife.

(iii) Greatest percentage of the total length of the pipeline or transmission line that would be located within or adjacent to public roads [as defined in ORS 368.001] and existing pipeline or transmission line rights-of-way.

(iv) Least percentage of the total length of the pipeline or transmission line that would be located within lands that require zone changes, variances or exceptions.

(v) Least percentage of the total length of the pipeline or transmission line that would be located in a protected area as described in OAR 345-022-0040.

(vi) Least disturbance to areas where historical, cultural or archaeological resources are likely to exist.

(vii) Greatest percentage of the total length of the pipeline or transmission line that would be located to avoid seismic, geological, and soils hazards.

(viii) Least percentage of the total length of the pipeline or transmission line that would be located within lands zoned for exclusive farm use.

The NMTP is a related or supporting facility. NWN has proposed a single pipeline corridor that minimizes or avoids impacts to wildlife, habitat, and other sensitive resources. The proposed pipeline corridor is shown in **Figure B-2**.

NWN selected the proposed route after a 6-year process in which NWN undertook rigorous efforts to develop the shortest, safest possible route, with the least possible impacts on natural resources. NWN has determined that no other route would better meet NWN's own criteria for successful siting, and at the same time satisfy EFSC's standards.

NWN's fundamental objectives have been to maximize the use of safe locations along existing pipeline corridors and roadways while minimizing impacts to agricultural practices, streams, wetlands, and dike infrastructure by use of HDD drilling; safely navigating difficult and varied topography; and locating the route through land for which NWN has negotiated or is in the process of negotiating long-term ROW commitments and easements.

There is no reasonable alternative to the construction of the NMTP. From the new NMCS through the forestry properties, NWN has primarily routed the pipeline along existing roads and pipeline corridors. As the pipeline corridor reaches the agricultural area near the Columbia River, installation will be primarily undertaken through HDD methods in order to minimize and avoid disturbance to agricultural lands, wetlands, streams, and rivers. NWN proposes all HDD bore pads in locations chosen to avoid and minimize sensitive agricultural practices, wetlands, riparian areas, dikes, and other sensitive natural resource areas.

The requirements of OAR 345-021-0010(1)(b)(D) do not constitute an EFSC standard. They are applicable to a new Application for Site Certificate, and should be considered as informational, within the context of other applicable EFSC standards. Arguably, the rule does not apply to Site Certificate amendments. Most importantly, the requirements in the rule must be read in concert with the analysis in **Exhibit K**, specifically the requirements of ORS 215.275. **Exhibit K** contains a milepost-to-milepost analysis of the entire corridor, from the compressor station to the PGE PWIP, documenting NWN's efforts to propose a route that minimizes impacts to natural resources and agricultural practices. That analysis provides essential information documenting NWN's compliance with ORS 215.275, and how that compliance integrates with successful efforts to avoid and minimize impacts to sensitive habitat, and to propose a safe pipeline.

In summary, the route proposed for the NMTP from the NMCS to the PGE PWIP best meets NWN's needs and at the same time satisfies Council standards. NWN has determined that no alternative routes would achieve the same result.

(i) Least disturbance to streams, rivers and wetlands during construction.

Response: The NMTP will minimize disturbance to streams, rivers, and wetlands during facility construction, as evidenced by the description provided in **Exhibit J**. Pipeline crossings of streams and wetlands will be placed outside of wetlands and stream channels to the maximum extent

possible, with drilling and construction methods intended to avoid and minimize impacts. Before construction, NWN will complete a Joint Permit Application (JPA) and obtain the necessary permits from the U.S. Army Corps of Engineers and Oregon Department of State Lands. A draft of the JPA is appended to **Exhibit J**.

*(ii) Least percentage of the total length of the pipeline * * * that would be located within areas of Habitat Category 1, as described by the Oregon Department of Fish and Wildlife.*

Response: The NMTP will avoid all Category 1 habitat, as evidenced by the description provided in **Exhibit P**.

*(iii) Greatest percentage of the total length of the pipeline * * * that would be located within or adjacent to public roads [as defined in ORS 368.001] and existing pipeline * * * rights-of-way.*

Response: The NMTP will maximize proximity to private logging roads, public roads, and locations along existing pipeline ROWs. **Figures C-2.1 – C-2.34** show the proposed pipeline corridor.

*(iv) Least percentage of the total length of the pipeline * * * that would be located within lands that require zone changes, variances or exceptions.*

Response: The NMTP will avoid lands that require zone changes, variances, or exceptions. See **Exhibit K**.

*(v) Least percentage of the total length of the pipeline * * * that would be located in a protected area as described in OAR 345-022-0040.*

Response: The NMTP will avoid all protected areas described in OAR 345-022-0040, as evidenced by the description provided in **Exhibit L**.

(vi) Least disturbance to areas where historical, cultural or archaeological resources are likely to exist.

Response: The NMTP will avoid areas where historical, cultural, or archaeological resources are likely to exist, as evidenced by the description provided in **Exhibit S**.

*(vii) Greatest percentage of the total length of the pipeline * * * that would be located to avoid seismic, geological and soils hazards.*

Response: The NMTP will avoid seismic, geological, and soils hazards, as evidenced by the description provided in **Exhibit H**. Pipeline construction, including the HDD installations, will not adversely affect slope stability or cause long-term erosion impacts.

*(viii) Least percentage of the total length of the pipeline * * * that would be located within lands zoned for exclusive farm use.*

Response: Locations within exclusive farm use lands are unavoidable. The portion of the NMTP installed through HDD methods will be located entirely within lands zoned for exclusive farm use, as evidenced by the description provided in **Exhibit K**. No other route would avoid exclusive farm

use zoning or provide a shorter or more direct route to PGE's PWIP. Moreover, as described in **Exhibit K**, the NMTP corridor is the most reasonably direct route available that also minimizes agricultural impacts.

H. Construction Laydown, Storage, and Staging Areas

During construction, NWN will use four temporary storage and staging areas to store supplies and equipment (three of these already exist; the fourth will be temporarily located on the Kynsi property), as described in **Exhibit K**. The storage and staging areas are shown in **Figures C-2.1, C-2.18, C-2.21, and C-2.34**. From the NMCS to the PGE PWIP, the first storage area will be at the Bark and Haul yard located slightly west of the intersection of Highway 47 and Highway 202, with 1.63 acres situated on previously disturbed land used for product storage and hauling. The Bark and Haul location is remote from the Project. **Figure C-2.1.** The second area, located at NMTP milepost 6.25, is proposed at the Weyerhaeuser log-sorting yard in an approximately 200-by-200-foot, previously disturbed area adjacent to the construction corridor. **Figure C-2.18.** The third location is a pasture area, owned by the Kynsi family, and is also remote from the Project (i.e., not along the NMTP corridor). **Figure C-2.21.** This location's dimension is approximately 510 by 680 feet. The fourth storage and final staging area is within the PGE PWIP, at the established helipad area, and has dimensions of 420 by 355 feet. **Figure C-2.34.** Each of these locations is described in detail in **Exhibit K**.

Additionally, NWN proposes numerous workspace areas along the NMTP corridor. Each of these locations is depicted in the **Figure C-2** map set. Each is proposed immediately adjacent to the construction corridor. See **Exhibit K**.

I. Access Roads

Access to the facility during construction will be provided by interstate and state highways, a combination of existing private forestry and farm roads, and county roads. No new roads will be constructed for facility access (see **Exhibit U** for transportation routes). Any upgrades or improvements to existing roads will be done according to Columbia County ordinances and through approval of the Columbia County public works department. Improved roads will include a gravel, all-weather surfaced roadbed. Compliance with county ordinances regarding road improvement construction is addressed in **Exhibit K**.

Typical existing timber operation roads are generally 20 to 60 feet in width. Existing agricultural access roads are generally 12 to 50 feet in width. Proposed improvements may include widening some existing roads to provide access for construction vehicles along the pipeline corridor roads during construction, with all construction occurring within the 80-foot construction corridor. It is possible that timber operators will improve some roads for pending, planned, and ongoing timber operations prior to NWN's construction. During construction, some roads may need an additional shoulder for turnaround areas for larger vehicles. These areas will be restored upon completion of construction. For purposes of estimating impacts, NWN assumes that up to ten hammerhead turnaround areas may be needed, each with a turning radius of up to 150 feet. These locations are

not known and are not mapped at this time, nor are other areas of potential minor widening known at this time. They will all be constructed within the 200-foot study corridor, and will be fully restored after completion of construction.

J. NMTP Summary Pipeline Construction Description (OAR 345-021-0010(b))

Pipeline construction methods and associated mitigation are described in detail in **Exhibit K** and the AIMP appended to **Exhibit K**, as well as **Exhibit J**; the JPA appended to **Exhibit J**; and the construction evaluation and requirements set forth in **Exhibit H**. The description provided below is a summary. A more detailed description related to specific natural resources can be found throughout the applicable exhibits.

The Standard pipeline construction includes survey and staking of the ROW, clearing and grading, trenching, pipe stringing and bending, welding and coating pipe, lowering in pipe and backfilling, hydrostatic testing, ROW cleanup, and restoration. See **Figure B-5**. NWN will use a standard 80-foot wide construction ROW to install the pipeline. In wetland situations, where feasible, the construction ROW will be narrowed to 50 feet or less in width to reduce impacts (See **Exhibit J**). The total excavation and fill will be 24,394.50 and 24,394.50 cubic yards, respectively (See **Exhibit J**, JPA, Tables 6-2 and 6-4). There are no permanent impacts to wetlands and waterways. Temporary and permanent disturbance areas and quantities are provided in **Exhibit C**.

Pre-Construction

Prior to any construction activities, survey crews will stake the outside limits of the construction ROW, the centerline of the pipeline trench, and temporary workspace areas with color-coded flagging. Sensitive areas to be avoided may be marked using specific flagging tape or construction fencing to maintain separation from construction activities, and wetland boundaries will be clearly indicated using easily identifiable temporary signage.

Clearing and Grading

Vegetation will be cleared and the construction corridor graded, as needed, to provide safe and efficient operation of construction equipment. In forested areas, timber will be cut and cleared from the ROW using standard logging techniques, in accordance with landowner requirements. The landowner will most likely clear forested areas based on planation rotation. Within wetland and agricultural areas, space will be provided for temporary storage of spoil material and segregated topsoil. The width of the construction corridor will be restricted to avoid undue surface disturbance to adjacent resources. Temporary workspaces will all be within the boundaries of the studied corridor, and will be clearly staked or flagged. Temporary erosion control devices will be installed at the end of clearing activities.

When grading is required, trees, brush, and shrubs within the construction corridor will be cut or scraped at or near the ground level. Low brush will be scraped up and stored with the topsoil. Timber and larger brush will be stored adjacent to the ROW and placed on the ROW during final clean-up or removed from the ROW. Slash will be spread back across the ROW, chipped and spread on the ROW, or removed from the ROW, subject to landowner approval and applicable law. All

clearing activities will utilize existing access roads and ROWs permitted for the Project. The Project does not include construction of additional access roads.

The construction area will be graded to create a suitable work surface for construction vehicles. The terrain along the Project varies from relatively flat on lands north of Highway 30 to steep with significant side slopes on lands south of Highway 30.

Trenching

Excavation of the pipeline trench will follow clearing and grading of the ROW. The majority of the excavation will be accomplished using machinery such as ditching machines, backhoes, or trackhoes. The depth of the trench will vary according to site-specific conditions; however, the trench will be excavated to a sufficient depth to provide the minimum depth of cover required by the Pipeline and Hazardous Materials Safety Administration, within the U.S. Department of Transportation. The depth of cover will be at least 30 or 36 inches, depending on the consolidated rock conditions, between the top of the pipe and the final land surface after backfilling. See **Figure B-6**.

Lowering and Backfilling

Once pipe sections have been welded, the pipeline will be lowered into the trench. Side boom tractors will be used to lift the pipe, position it over the trench, and lower it into place. The pipeline and trench will be inspected to verify that minimum cover is provided, that the trench is free of rock or debris, that external pipe coating is not damaged, and that the pipe is properly fitted and installed into the trench. Trench dewatering may be necessary at certain times during the lowering-in process. Any trench dewatering will be accomplished in a manner designed to prevent heavily silt-laden water from flowing into wetlands or water bodies.

After the pipe is lowered into the trench, the pipeline will be padded and the trench will be backfilled. Backfill material generally consists of the material excavated from the trench. Padding or other protective coating will be used to prevent damage to the pipe coating. This padding will typically consist of subsoil removed from the trench that has been screened to remove larger rocks. Alternatively, other suitable material (e.g., soil or sand) may be imported to the site from other areas along the ROW. Topsoil will not be used for padding. Previously excavated materials will be pushed back into the trench using bladed equipment or backhoes.

Hydrostatic Testing

The pipeline will be hydrostatically tested before being placed into service to verify its integrity and to ensure its ability to operate at the maximum allowable operating pressure. Water for hydrostatic testing will be obtained from local sources with valid water rights. Topography and the availability of test water will determine the length of each test segment. Pipeline test segments will be capped and filled with water, then pressurized in accordance with ODOT regulations (49 CFR part 192). Any leaks detected will be repaired and that section of pipeline re-tested.

Upon completion of the test, the water may be pumped to the next segment for testing, or discharged. The test water will ultimately be discharged in accordance with the National Pollutant

Discharge Elimination System (NPDES) hydrostatic discharge permit requirements (See **Exhibit J**, JPA, Attachment G). Only clean pipe will be tested, and no chemicals will be added. Once a pipe segment has been successfully tested and dried, the test cap and manifold will be removed and that section of the pipe will be connected to the remainder of the tested pipeline.

Clean-Up and Restoration

After backfilling is complete, disturbed areas will be final graded and erosion control measures will be implemented. During final cleanup and initial restoration, drainage ditches, culverts, and other structures that may have been temporarily removed or damaged during construction will be permanently repaired, returned to their pre-construction condition, or replaced. In addition, final cleanup typically will involve a series of steps, including off-site waste disposal and equipment removal. Stream banks will be stabilized, and permanent erosion control devices will be installed. The ROW will be mulched, seeded, and revegetated.

All areas disturbed by construction will be restored and revegetated, as described in **Exhibit J**, JPA, Attachment H: Restoration and Rehabilitation Site Plan for Temporary Impacts, and **Exhibit K**. The ROW will be regraded and topographic contours and drainage patterns returned to as close to pre-construction conditions as possible. In forested lands, NWN will reseed across the construction ROW and permanent easement, and the landowner will be allowed to replant up to five feet on either side of the pipeline centerline.

Road and Railroad Crossings

Construction of the NMTP across major paved highways, railroads, paved roads, and unpaved roads where traffic cannot be interrupted will be accomplished by boring under the roadbed, via HDD. Smaller unpaved roads and drives will be crossed by open trenching and then restored to pre-construction or better condition. NWN will also repair road damage caused by construction of the pipeline. The pipeline will be buried to the depth required by applicable road crossing permits/approvals and will be designed to withstand anticipated external loadings. Railroad crossings will be installed using HDD in accordance with the requirements of the railroad.

Access to the Construction ROW

Typical pipeline construction equipment includes pipe trucks, flat-bed trucks, mowers, bulldozers, graders, front-end loaders, backhoes, bending machines, side-booms, welding machines, padding machines, winch trucks, water trucks, dump trucks, pickup trucks, and other miscellaneous equipment. See **Figure B-5.** Equipment involved in pipeline construction will be moved onto the ROW using approved access roads, and will then generally proceed down the ROW performing their job tasks. Part of the construction ROW will include a travel lane for construction equipment and related project vehicles, accommodated within the standard 80-foot-wide construction ROW. When access is no longer required, the travel lane will be removed and the ROW restored. NWN will place mats over any wetlands which could not be avoided along the travel lane. Typical construction drawings are presented in **Exhibit J**, JPA, Attachment C-1.

Waterbody and Wetland Crossings

The proposed pipeline corridor crosses both streams and wetlands. There are a number of different construction methods that could potentially be used for any given crossing. Presented below is a brief description of the available construction methods and a description of their potential applicability to the Project. Several features are common to all of the construction methodologies. Typical construction drawings are presented in **Exhibit J**, JPA, Attachment C-1.

Trenching

Installation of a pipeline crossing by trenching can be accomplished either in the wet or in the dry, with preference being given to the dry approach as a means of enhancing protection of aquatic resources. Dry trenching occurs by definition when the crossing is installed during a time when there is no flow or inundation present. Dry trenching can be accomplished when flows or inundation are present at crossings through the use of structures that temporarily create a dry area within which the work is completed.

Wet Trench Method

The wet trench method is proposed for crossing wetlands only. Potential constraints to installing the pipeline by wet trenching across a wetland are inadequate equipment access and insufficient upland staging areas to place spoils and temporary detention facilities. In the wet trench method the trench is excavated with a backhoe through shallow standing water and/or saturated soils. The backhoe will work either from the adjacent upland area or from construction mats placed on the surface of the wetland area. The work area in the wetland will be limited to 80 feet or less in width and the only part of the equipment that will come directly into contact with the aquatic environment will be the bucket of the backhoe.

The excavation will be accomplished in two passes in order to segregate the topsoil from the underlying materials. The excavated material will be placed in holding areas outside of the wetland area. Filtering media will be used to clean the water, which will then be allowed to flow out of the holding area and eventually return to the wetland. Pre-constructed segments of pipe of sufficient length to span the wetland will then be positioned above and lowered into the trench by equipment operating from either the adjacent upland area or construction mats placed on the surface of the wetland area.

If other portions of the pipeline have already been installed adjacent to the crossing point, the crossing line will be tied into those portions. If the adjacent portions of the pipeline have not yet been installed, the ends of the crossing will be fitted with temporary caps to prevent water or debris from entering the pipe. This will allow the trench to be filled immediately and the crossing to be tied into the remainder of the pipeline at a later time without further disturbance to the wetland.

Pipe burial depth will be verified, the stockpiled materials will be placed back into the trench in the reverse order of their removal, and the disturbed area over the trench will be replanted with vegetation salvaged during the trenching activities. In these situations, sediments will not be carried away and impacts will be confined to the construction corridor.

The wet trench method is proposed for wetlands since the use of diversion barriers is not necessary or helpful due to very low flow velocity and volume. Because the flow velocity is low or non-existent, sediments disturbed during the construction phase are expected to settle quickly and not result in elevated downstream sediment levels. Impacts from the wet trench method can be minimized by carefully selecting the crossing location to avoid unstable slopes and trees in the wetland buffer, using erosion and sediment controls during and after construction, and replanting vegetation after construction. The wet trench method will be used for all trenched crossings of wetlands, except those that are dry during construction.

Dry Stream Trench Method

The dry stream trench method is proposed for watercourses where the stream is dry at the time of construction. It consists of constructing the pipeline through a dry stream channel in the absence of surface water. The dry stream trench method can be used in any situation where the surface features will support normal cross-country pipeline construction. Construction in the stream will typically be completed within 8 hours.

This crossing method utilizes standard cross-country construction techniques with the following exceptions:

- Provisions will be made for handling water coming down the channel if a rainstorm occurs during construction.
- The width of the construction corridor through the streams will be limited to 80 feet or less.

Potential impacts from the dry stream trench method include leaving sediments where they can be suspended by later stream flows, streambed erosion and stream bank instability, loss of riparian vegetation, and risk of spill from scour and pipeline damage. Impacts from the dry trench method can be minimized by carefully selecting the crossing location to avoid unstable stream banks and trees in the riparian zone, using erosion and sediment controls during and after construction, stabilizing stream banks after construction, and burying the pipeline at sufficient depth to prevent scour from damaging the pipe.

The dry stream trench method will only be used for dry stream channels. All trenched crossings where water is present will use the following method.

<u>Waterbody Crossing Methods</u>

Over/Under Existing Culverts

The fill over and under existing culverts may be suitable for crossing streams or wetlands without impacts to the aquatic ecosystem. The fill must be deep enough to allow installation of the pipe while maintaining adequate clearance from the culvert and adequate cover over the pipeline. The pipeline may be buried in either the roadbed or the fog line (shoulder) of the road. This method will be used when crossing stream culverts that meet the requirements listed above.

Horizontal Directional Drilling (HDD)

HDD is a method of installing a pipeline underground by drilling a slightly over-sized hole at a very shallow angle under surface features and pulling a pre-assembled string of pipe through that hole. Pipe used for HDD will have an additional 40-nun Lily 20/40 Lockguard protective coating. This method requires the preparation of an entrance (*i.e.*, drill) site and an exit site. The process includes the drilling of a pilot hole using a drill bit and an injection of bentonite slurry under pressure to remove the cuttings and hold the hole open. After the pilot hole is completed, a reamer and bentonite slurry combination is used to enlarge the hole and then the pipe is pulled through.

The entrance site requires an area that is approximately 150 feet to 200 feet long and 200 feet wide on level ground with an all-weather road access. A hardstand is constructed on this site with fill, wooden mats, or steel plates. The exit site requires a rectangular area approximately 150 feet to 200 feet long and 150 feet to 200 feet wide, and the construction of a dry, flat hardstand similar to the entrance site. Similar access is also required, and a bentonite pit is constructed to collect the bentonite slurry discharged from the drill hole. Typical HDD rig side workspace areas and bore pad design are depicted on **Figure B-7**. These sites must be located at least 75 feet from the edge of the stream or wetland to achieve minimum adequate cover at the boundary of the aquatic feature. They must also be located at least 50 feet from the base of electric transmission towers and must provide for standard safety clearances between equipment and conductors to be maintained during construction.

The pipeline corridor or other clear area of similar width must extend in a straight line beyond the exit site for a distance slightly greater than the length of the bore. This area is needed to assemble and test the pipe string that will be installed. For the horizontal directional bore method, the maximum depth is about 100 feet in loose soils, 200 feet in consolidated soils, and 250 feet in soft rock. The minimum horizontal distance is approximately 500 feet and the maximum horizontal distance is 5,000 feet. Some types of substrate are unsuitable for HDD, such as hard fractured rock or soft peat soils. A typical HDD construction segment is depicted in **Figure B-8**.

Potential impacts from HDD are the loss of upland vegetation and slight potential for bentonite spills. Impacts from HDD can be minimized by analysis of the substrate prior to design, revegetation of cleared staging areas, and not staging in sensitive areas.

Because HDD methodology impacts large areas during the construction of entrance and exit sites and staging the pipe, it is not practical for crossing small streams and wetlands. The areas impacted by the entrance and exit areas of the directional bore are often in forested land or wetlands and impact 20,000 to 40,000 square feet of land as opposed to the 3,000 to 4,200 square feet of riparian habitat impacted by trenching. Another problem with many of the crossings is the minimum distance of 1,200 feet required in a straight line. Steep hills or bends in the pipeline corridor often make HDD impractical. Steep terrain or the unwillingness of landowners to allow construction at the entrance, exit, or staging sites can also prevent the use of HDD methodology.

There will be eight HDD crossings. HDD will be utilized to cross Highway 30 and railroad tracks, Clatskanie River and levees, Beaver Slough and levees, Larson Slough and levees, Lewis Road,

Poplar Tree Farms, Collins Road, Hermo Road, blueberry fields, and a mint farm (*see* **Exhibit J**, JPA, Attachment C-2 for site specific drawings).

Inadvertent Return Response Plan

NWN has prepared an Inadvertent Return Response Plan for locations where the HDD and boring construction methods will be utilized (*see* **Exhibit J**, JPA, Attachment F). The HDD pipeline construction method will use bentonite as a drilling fluid, and to fill in the area around the installed pipeline. In case of an accidental release of bentonite, either through a vent in the soil profile or at the installation point, the release point will be fully encircled with siltation fencing and the bentonite will be allowed to vent and flow into the enclosed area. When the enclosure becomes near full, a vacuum truck or pump will remove the bentonite. The siltation fencing will remain in place during the boring, back reaming, pipe pulling procedures and after completion to ensure the vent has sealed. The enclosure will only be removed after all evidence of the release has ceased.

Fill material will consist of gravel, silt, clay, sand, loam, rock, and crushed rock, depending on the construction site and job to be accomplished. No material will be excavated from waters of the state for use as fill material. Excavated material will be properly disposed of at upland disposal sites, and no excavated material will be disposed of in waters of the state.

K. Construction Schedule (OAR 345-021-0010(1)(b)(F))

For the purpose of this Request, "work on the site" means any work within a site or corridor, other than surveying, exploration, or other activities to define or characterize the site or corridor, that NWN anticipates or has performed as of the time of submitting this Request. Facility construction is anticipated to begin in 2017. The completion of commissioning and start of commercial operation is targeted for October 2018. Additional engineering and geotechnical investigations may occur prior to issuance of the Site Certificate Amendment. No other construction work is anticipated to begin prior to issuance of the Amendment. The estimated cost of the pre-construction work is less than $250,000 (ORS 469.300(6); OAR 345-001-0010(12)).

VI. AMENDMENT REQUIRED UNDER OAR 345-027-0050(1); SITE CERTIFICATE CHANGES LISTED PURSUANT TO OAR 345-027-0060(1)(d); REQUEST FOR EXTENDED REVIEW UNDER OAR 345-027-0070(2)(a)

OAR 345-027-0050(1) requires a certificate holder to submit a request to amend its site certificate to design, construct, or operate a facility in a manner different from the description in the site certificate, if the proposed change:

(a) Could result in a significant adverse impact that the Council has not addressed in an earlier order and the impact affects a resource protected by Council standards;

(b) Could impair the certificate holder's ability to comply with a site certificate condition; or

(c) Could require a new condition or a change to a condition in the site certificate.

The changes NWN proposes require a Site Certificate amendment under subsections (a) through (c). Pursuant to OAR 345-027-0060(1)(c) and (d), NWN's proposed changes to the Site Certificate

and operational conditions are attached as **Exhibits B-4 and B-5**. NWN requests "extended review" as required by OAR 345-027-0070(2)(a).

VII. DIVISION 22 STANDARDS (OAR 345-027-0060(1)(e), (f))

A. Organizational Expertise (OAR 345-022-0010)

Under this standard, EFSC determines whether the applicant has the organizational, managerial, and technical expertise to construct and operate the facility. To conclude that the applicant has the necessary expertise, EFSC must find that the applicant "has demonstrated the ability to design, construct and operate the proposed facility in compliance with site certificate conditions and in a manner that protects public health and safety and has demonstrated the ability to restore the site to a useful, non-hazardous condition."

Discussion

1. NWN's Underground Storage and Pipeline Experience

NWN is more than 150 years old, and its core business is the local distribution of natural gas. Around 1980, NWN began developing the natural gas fields in the Mist area for the reinjection and storage of natural gas. Since 1988, NWN has operated its underground natural gas storage operation at Mist under the Site Certificate. NWN also has a site certificate authorizing it to build and operate the South Mist Feeder pipeline, which brings natural gas to and from the storage facility.

The storage facility allows NWN to (1) store natural gas that it purchases from the interstate pipeline and withdraw that gas when it is needed, and (2) store gas owned by others. Company personnel who have been managing the existing storage operation will continue to operate the expanded facility. Many of the individuals now working for NWN who are involved in the design and construction for the Mist Site have been with the underground storage project at Mist since its inception, as described below.

There are no third-party permits or ISO programs associated with the Project. OAR 345-022-0010(2)-(4).

2. Technical Expertise Available to NWN

NWN has assembled an experienced team of professional, technical, and administrative personnel to manage all phases of the Project. Following is a brief description of several key members of the Project team:

Charlie Stinson, CS Energy Ventures. Mr. Stinson is an Oregon-registered petroleum engineer who has been continuously involved in the Mist development since 1979. He has 35 years of broad experience in the permitting, development, and operation of natural gas pipelines and underground storage facilities in both Oregon and California. His project experience includes the Mist Gas Storage Facility, the Gill Ranch Storage Facility, the South Mist Feeder Loop and Pipeline Extension, addition

of the Calvin Creek reservoir to the Mist Site, expansion and modification of Miller Station at Mist, and the South Mist Pipeline Extension.

Todd Thomas, Storage Project Manager. Mr. Thomas is a certified project manager professional and has a degree in geology. Previously he served for 16 years as a drilling superintendent and field operations engineer. Mr. Thomas was a member of the reservoir development teams for both the Bruer/Flora project and the Calvin Creek project. He has supervised the drilling of all the storage wells in the Mist Field. Mr. Thomas managed the on-site construction activity for the South Mist Feeder expansion completed in 1999 and the Miller Station work in 2000 and 2001. Mr. Thomas is responsible for the overall management of the Project.

Jack Meyer, Reservoir Development. Mr. Meyer is an Oregon-registered geologist with more than 27 years of geological and geophysical mapping and interpretation experience. Mr. Meyer has worked on the Mist project for both exploration purposes and underground storage development at the Bruer and Flora pools continuously for the past 22 years.

James Fairchild, Fairchild & Associates. Mr. Fairchild is a registered Professional Engineer in the state of Texas and has B.S. and M.S. degrees in Mechanical Engineering. Since 1971, Mr. Fairchild has performed gas storage studies on many of the gas storage fields currently operating in the United States. Mr. Fairchild has performed screening studies to assess the technical feasibility of establishing new gas storage reservoirs in California, Texas, Louisiana, Mississippi, Alabama, Colorado, Pennsylvania, New York, and Florida. As a consultant, he has worked with NWN since 1982 and has been a part of the development of the Bruer/Flora storage reservoirs and the Calvin Creek storage expansions. Mr. Fairchild has performed several Inventory Verification studies on NWN's underground gas storage fields. In 2009, Mr. Fairchild consulted with NWN on the gas storage reservoir design study for Gill Ranch in California. Reservoir modeling was part of this design study.

Clayton Roth, Reservoir Engineer. Mr. Roth is a registered and licensed Professional Engineer in Petroleum Engineering and is also a registered and licensed Professional Geologist. He has over 35 years of experience in underground natural gas storage, exploration, and production operations. He is responsible for all of NWN's reservoir engineering. At Mist, he has directed reservoir management and development operations since the start of underground storage operations in 1988 and 1989 and has developed seven reservoirs for underground gas storage. At Gill Ranch, he was involved in the selection and development of the storage field and continues to direct all reservoir engineering activities for the three underground storage reservoirs. Mr. Roth has conducted economic evaluations of oil and gas properties, developed prospects, analyzed well and reservoir performance, and directed natural gas drilling and production operations in Oregon, California, Wyoming, Colorado, New Mexico, and Texas.

James Thum, President and Consulting Geophysicist, Ferry Canyon Consulting, Inc. Mr. Thum has over 30 years' experience in U.S. and international onshore and offshore exploration and development projects, including geothermal, coal bed methane, and underground gas storage operations. He began his career in 1983 as an exploration geophysicist with Tenneco Oil E&P in Houston, Texas and has worked for British Petroleum, Anadarko Petroleum, and Equitable

Resources since that time. Mr. Thum began consulting for NWN in 2007, prior to founding Ferry Canyon Consulting the following year. Under his direction, Ferry Canyon Consulting provides integrated geological and geophysical mapping services to the petroleum and energy industry, including design and management of seismic field operations, data processing and geophysical modeling, well planning, design, and drilling operations.

Roger Haley, Principal Engineer. Mr. Haley has a B.S. in Chemical Engineering from Oregon State University and is a registered Professional Engineer in Chemical Engineering in the state of Oregon. Mr. Haley has worked for NWN in engineering and operations for 23 years. For the past 20 years, Mr. Haley has been involved at all levels on numerous projects at all four of NWN's gas storage facilities, as well as many natural gas pipeline projects. Mr. Haley was also the Newport LNG plant Supervisor and Engineer from 2000 to 2005. Mr. Haley's expertise is with surface facilities and processes after the wellhead flange.

Ability to Complete Habitat Mitigation. NWN has the ability to successfully complete the proposed mitigation as stated in the Mitigation Plan provided as part of the RFA. NWN has the financial capability as stated in Exhibit M as well as past experience with similar projects. In 1999, NWN amended the South Mist Feeder Site Certificate and constructed a 24-inch diameter, 30-mile pipeline as part of the company's first leg of what is now known as the South Mist Pipeline Extension (SMPE). In its 1999 Final Order, EFSC imposed a host of conditions requiring avoidance, minimization and mitigation of fish and wildlife habitat, including a fish and wildlife habitat mitigation plan. See pages 28 - 35. As EFSC/ODOE records will corroborate, NWN successfully complied with all of the conditions imposed on the South Mist Feeder Amendment, including all mitigation plan requirements. In March, 2003, EFSC issued its Site Certificate authorizing construction and operation of the SMPE. NWN completed construction of the SMPE in 2004. As EFSC records show, the SMPE Site Certificate included 62 conditions imposed to ensure compliance with the Council's Fish and Wildlife Habitat Standard. These conditions addressed avoidance, minimization and mitigation measures related to a 24-inch diameter, 62-mile pipeline constructed through a diverse array of habitats. Please reference the SMPE Site Certificate, pages 20 - 29. The Department of Energy, in consultation with ODFW, conducted continuous monitoring and inspections to ensure compliance. EFSC records will demonstrate NWN's success in complying with all conditions related to this complex project. In addition to fish and wildlife mitigation measures, NWN complied with a host of mitigation measures developed in collaboration with ODOE, the Department of Agriculture and others, imposed through the SMPE Agricultural Impact Mitigation Plan (AIMP). For this North Mist Request for Amendment No. 11, NWN volunteers to mitigate agricultural impacts in compliance with an AIMP, which is materially consistent to the SMPE AIMP. EFSC records will demonstrate NWN's successful implementation of the SMPE AIMP.

Conclusion

In its Order approving Amendment No. 9, EFSC stated:

> Amendment 9 would authorize the installation and operation of equipment that is practically identical to facilities and equipment installed under amendments 4,6, and 8.

NWN's prior experience constructing and operating the Mist Storage Facility, its development of the Calvin Creek area in 1997, the South Mist Feeder extension in 1999, and the new compressor in 2001 provide reasonable assurance that NWN can successfully construct, operate and retire the upgrades requested in amendment 9. No new conditions are required.

In approving Amendment No. 9, EFSC recognized that based on NWN's prior experience constructing and operating the Mist storage facility, and the successful completion of the Calvin Creek expansion in 1997, the South Mist Feeder extension in 1999, and the new compressor in 2001, NWN demonstrated its ability to successfully construct, operate, and retire the facility. Additionally, in the March 13, 2003 Final Order for the South Mist Pipeline Extension, EFSC confirmed NWN's organizational expertise to construct and operate that facility. NWN has completed the construction of all EFSC-certificated facilities and operates its facilities in full compliance with all EFSC conditions. Added to that is the successful expansion of facilities authorized in Amendment No. 9. Amendment No. 11 does not request approval for a new type of facility but rather for the expansion of facilities that are already in operation. The NWN personnel who have been managing the existing facility will continue to operate the expanded facility. Given this prior experience and the expertise of key personnel, NWN has demonstrated that it has a reasonable probability of successful construction and operation of the Project.

B. Structural Standard (OAR 345-022-0020)

Under the structural standard, EFSC must find:

(a) The applicant, through appropriate site-specific study, has adequately characterized the site as to the Maximum Considered Earthquake Ground Motion as shown for the site in the 2009 International Building Code and maximum probable ground motion, taking into account ground failure and amplification for the site specific soil profile under the maximum credible and maximum probable seismic events; and

(b) The applicant can design, engineer, and construct the facility to avoid dangers to human safety presented by seismic hazards affecting the site that are expected to result from maximum probable ground motion events. As used in this rule 'seismic hazard' includes ground shaking, ground failure, landslide, liquefaction, lateral spreading, tsunami inundation, fault displacement, and subsidence;

(c) The applicant, through appropriate site-specific study, has adequately characterized the potential geological and soils hazards of the site and its vicinity that could, in the absence of a seismic event, adversely affect, or be aggravated by, the construction and operation of the proposed facility; and

(d) The applicant can design, engineer and construct the facility to avoid dangers to human safety presented by the hazards identified in subsection (c).

Discussion

NWN retained GeoEngineers to complete site-specific geotechnical work for the Project, including a subsurface exploration program for the proposed compressor station and HDD alignments, and site reconnaissance of proposed pipeline and utility conduit routes, HDD alignments and facility locations, laboratory testing, and geotechnical analysis. This report includes the information required by OAR 345-021-0010(1)(h), and is attached as **Exhibit H**.

1. Geologic Setting

The Project is located within mountainous terrain of the Oregon Coast Range, and a relatively flat valley associated with the Columbia River. In Oregon, the Coast Range is a belt of moderately high mountains, extending along a north-south axis between the Columbia River and the Klamath Mountains. The core of this anticlinal structural chain is underlain by early Tertiary-aged pillow basalts, lavas, and basalt breccias that were erupted underwater as oceanic islands. The flanks of the Coast Range are composed of marine sedimentary rocks that accumulated around the underwater oceanic islands. The volcanic and sedimentary rocks were later accreted onto the western edge of the North American continent by the subduction of the Juan de Fuca tectonic plate. During and after this accretion, the Columbia River cut through the Oregon and Washington Coast Range forming a river valley and associated broad alluvial plain that forms the northern border of the Oregon Coast Range.

Because of the presence of natural gas in economic quantities, Columbia County has been subject to several generations of geologic research. Geologic mapping has been aided by the large number of wells drilled and geophysical surveys conducted in support of natural gas exploration. A detailed description of the geologic structure and site geology is presented in **Exhibit H**.

2. Contributing Earthquake Sources

Seismic hazard deaggregations were performed for the 4,975-year, 2,475-year and 475-year hazard levels for rock outcrop condition (i.e. Vs30 = 760 m/s) using the 2008 USGS Probabilistic Seismic Hazard Model (PSHM) at the compressor station site, pipeline MP 6.1 and milepost 12.1. Figures H-24 through H 32 show the deaggregations obtained from the USGS. The 475-year motion corresponds to a 10 percent probability of exceedance (PE) in 50 years. The 2,475-year motion has a 2 percent PE in 50 years, and the 4,975-year motion has a 1 percent PE in 50 years. Deaggregations were also performed for the 2,475-year hazard level at half-mile increments along the full 12.5-mile-long alignment to evaluate changes in fault influence and ground motion in support of the liquefaction triggering analyses described in a subsequent section of this exhibit.

The 2014 USGS probabilistic seismic hazard mapping, which maps the expected 475-year and 2,475 year peak ground acceleration (PGA) throughout the United States, was reviewed for a comparison to the 2008 model. As explained later in this section, the 2014 mapping provides similar probabilistic PGA results as the 2008 model. Because the 2008 model can be utilized to provide probabilistic results for a specific site by latitude and longitude rather than a general area like the

2014 hazard mapping, the evaluation below was performed utilizing the 2008 probabilistic seismic hazard model.

The seismic deaggregation results show that the dominant seismic hazard sources for the 475-year, 2,475 year and 4,975-year earthquake levels are the magnitude (M)8.0 to M9.0 Cascadia Subduction Zone (CSZ) interface events, M6.8 to M6.9 deep intraplate earthquakes, and M6.0 to M6.2 crustal earthquakes from background seismicity that is associated with gridded crustal fault sources of non-discrete origin. In general, fault distances for CSZ and deep intraplate fault sources identified by the PSHM were closest to the compressor station site and became more distant as the analysis moved northward along the pipeline alignment to PGE's PWIP property near the Columbia River. The distance to gridded crustal sources remains essentially constant across the alignment for each hazard level, as would be expected for a deliberately distributed seismic source. The calculated distance of gridded crustal sources is placed closer to the site as the hazard level increases.

In addition to fault hazards returned by the seismic deaggregation results, eleven crustal faults capable of generating strong ground motion were identified by the USGS Quaternary Fault and Fold Database within 50 miles of the compressor station site and pipeline alignment. Many of these faults are considered within the PSHM. A summary of Quaternary faults within 50 miles of the compressor station site and pipeline alignment is provided in Table H-6 and shown with respect to the site in Figure H-24. Fault source parameters were obtained from the documentation for the 2008 Update of the United States Seismic Maps.

3. Site Seismic Hazards

The following sections address the potential for seismic hazards to affect the site.

Ground Shaking. Ground shaking for the 475-year, 2,475-year, and 4,975-year hazard level was assessed at the compressor station site and at the approximate midpoint and end of the pipeline alignment (MP 6.1 and MP 12.1, respectively) using the PSHM for rock outcrop conditions. To characterize ground motion amplification effects along the pipeline alignment, a site class was assigned in accordance with methods outlined in Chapter 20 of ASCE 7-10 (with March 2013 errata) based on boring log data and geologic interpretation. The USGS Seismic Design Maps application (USGS 2014) was then used to collect mapped acceleration parameters along the length of the alignment at half-mile intervals.

Modern buried pipes with welded joints have low vulnerability to ground shaking without permanent ground deformation. A detailed study of the Southern California Gas Company's transmission and distribution system found that there are no reported cases of damage to steel pipelines with arc-welded joints due to ground shaking. A study commissioned by the USGS reports that "…pipelines can readily accommodate wave propagation moving the pipe tangential to its alignment." Ballantyne also states that historically, steel pipelines with high quality arc welded joints perform very well in ground shaking environment, whereas pipelines with joints using oxy-acetylene welds can have failure rates nearly 100 times greater than those with electric arc welded joints. Based on this information, and the fact that all modern natural gas pipelines utilize arc-

welded butt joints, there is a low risk of ground shaking in the absence of other deformation adversely affecting the pipeline.

Fault Rupture. The Gales Creek Fault Zone is the closest fault structure to the site that has been mapped by the USGS Quaternary Fault and Fold Database. The closest expression of the Gales Creek Fault Zone is located approximately 18.7 miles south of the site. In addition, the lack of small earthquakes in the recent historical record in the immediate vicinity of the site also indicates a low probability of a future earthquake large enough to cause ground rupture. During site reconnaissance, surface evidence of fault rupture (recent faulting related escarpments, weathered fault related escarpments) at the compressor station site or along the proposed pipeline or utility conduit alignments was not identified. Nor were lineaments identified in the LiDAR hillshade model, vegetation patterns or soil contrasts in aerial photographs that may indicate previously identified faults at the compressor station site or crossing the pipeline and utility conduit alignments. Therefore, fault rupture is not considered a credible hazard at the compressor station site, or along the pipeline and utility conduit alignments.

Seismically Induced Landslides. Earthquake forces can cause slope failures and movement of sloping ground. Existing landslides are most susceptible to seismic slope failure, but very steep slopes and jointed rock outcrops are also vulnerable. The pipeline was routed to avoid very steep slopes (greater than 70 percent) and existing landslides to the extent practical. However, the proposed compressor station is situated on a landform that is interpreted as a landslide deposit (based on subsurface materials observed in borings completed at the site), and the proposed pipeline crosses two ancient landslides. Otherwise, the proposed pipeline follows adjacent to existing gravel roads where adjacent slopes are generally gentle to moderate, or traverses cross country along gentle to moderate slopes predominately along or near ridge tops. In the absence of landslide reactivation (discussed below), there is a relatively low risk of seismically induced landsliding affecting the proposed compressor station, pipeline and utility conduit.

There is a risk that the existing landslides could be reactivated during a seismic event. Seismically reactivated landslides present a low to moderate risk to the pipeline and compressor station site, depending on the location of the earthquake and the magnitude of landslide movement. However, if existing landslides are reactivated during a seismic event, and the landslides damage the pipeline or compressor station, there is a low risk to public safety because the known landslides that are in close proximity are located in unpopulated areas.

Liquefaction and Liquefaction-Induced Hazards. Liquefaction is not typically associated with mountainous terrain where static groundwater is located tens to hundreds of feet below the surface; rather it is associated with thick deposits of saturated, loose to medium dense granular alluvium, typically in low-lying alluvial plains with high groundwater conditions. The preliminary geotechnical work at the compressor station site, which is located in the mountainous terrain at an elevation of 1,285 feet MSL, found an isolated pocket of loose granular soils with relatively high moisture contents. The loose granular soil is interpreted to be derived from a landslide deposit, rather than alluvial deposition. Although relatively loose granular soils with relatively high moistures contents were observed, the loose granular soils are laterally discontinuous, and

groundwater is likely located tens to hundreds of feet below the site. Therefore, there is no liquefaction hazard at the compressor site and as a result, detailed liquefaction analyses were not conducted for the compressor station site.

The utility conduit and pipeline alignments south of Highway 30 are located in the mountainous terrain that is not associated with liquefaction. Therefore, a detailed analysis of liquefaction hazard was focused along the 4.7 miles of the alignment that crosses the Columbia River floodplain, from the Highway 30 crossing near MP 7.5 to the pipeline termination near MP 12.2.

Topography along this part of the alignment is very flat. Aside from the roads that cross the low-lying lands and the dikes that contain the meandering streams and sloughs (which often are the same), the majority of the alignment has ground surface elevation 0 feet. There are some stretches of the alignment with topographic contours more than a mile apart.

The CSZ Interplate seismic source controls the seismic hazard along the alignment; all of the liquefaction triggering and lateral spreading computations use Mw=9.01. Ground-surface PGAs for the liquefaction triggering computations were obtained from the USGS probabilistic seismic hazard application at coordinates spaced ½-mile along the 12 mile-long alignment. The seismic hazard profile plotted to the right (for the low-lying segment of the pipeline north of Highway 30) shows the estimated ground surface PGA relative to pipeline milepost. The PGA used in the 18 liquefaction triggering analyses was evaluated by interpolating off of the line for each boring location.

Liquefaction Potential. The potential for liquefaction under MCE ground shaking was evaluated for each of the 18 logged soil profiles which are presented in detail in **Exhibit H**. The borings encountered highly variable alluvium ranging from silty sands to highly plastic clays, along the pipeline alignment within the Columbia River valley north of Highway 30.

Three separate methods were used at each soil profile, for a total of 54 liquefaction-triggering computations. Generally, the methods gave results within 5 percent of each other; differences were not significant enough to lead to disparate conclusions. Overall, the analyses indicate that:

1. Loose to medium dense sandy and silty-sandy alluvial soil layers are susceptible to liquefaction during MCE ground shaking. Even the sand deposit 40 to 70 feet deep in boring B-18, with uncorrected N of about 20 blows/foot (meaning a medium dense sand), has a safety factor of about 0.25 because the ground shaking has PGA>0.4 g and the M9 shaking has such long duration.
2. Fine-grained deposits are prevalent and generally have high plasticity. Aside from isolated zones of thick fine-grained deposits, and a hard material more than 170 feet deep in boring B-10, plasticity indices are 12 or higher. The elastic silt soils and other fine-grained soils are not susceptible to liquefaction.
3. The medium-dense to dense sands encountered deeper than 100 feet in B-10, B-11, and B-20 are not liquefiable according to the two methods that have regression coefficients capable of considering such depths.

Liquefaction Settlement. Volumetric strain of 1.5 percent to 2 percent is expected to occur in liquefied soils that had initial (corrected) penetration resistance of 10 to 20 blows per foot. This strain manifests as settlement of the ground surface after excess pore water pressures drain and liquefied sands reconsolidate. Different amounts of volumetric strain or different sand layer thicknesses, therefore, can cause differential settlement under the pipeline.

Differential settlement of the ground under the pipeline can cause bending stresses in the pipe wall. For the most part, the HDD alignments are deep and the liquefiable sandy layers are above the pipeline. For the short segments where the pipeline is shallow, such as locations in between HDD installations, the alignment crosses from beneath to above some of the discontinuous layers of potentially liquefiable alluvium, creating the potential for differential settlement along the pipe.

Differential settlement considers both settlement magnitude and the pipeline segment length over which that settlement occurs. The analyses computed settlement magnitudes using the logged soil profiles and the volumetric strain correlations in Tokimatsu & Seed. Distances from non-settling points to the maximum settlement locations were evaluated using interpreted cross sections.

The maximum vertical differential settlement of 12 inches is expected to occur along a 700-foot-long segment between Station 434+00 and Station 441+00. The deflection angle for this settlement would be only about 0.08°, which is not the most severe on the alignment. Rather, the most severe differential settlement is expected to occur as HDD-4 rises through about 50 feet of potentially liquefiable sand between Stations 510+00 and 514+00. This segment may experience as much as 9 inches of differential vertical settlement over a run of 400 feet. The deflection angle caused by falling 9 inches in 400 feet is about 0.1° and the radius of curvature for that deflection is approximately 106,700 feet.

The typical HDD design radius for curves in 24-inch pipe is about 2,400 feet. The most severe liquefaction settlement appears capable of imposing a radius of curvature about 1/44th as tight as a normal design curve. This deflection is effectively in the same category as construction layout tolerances. On this basis, it was concluded that the most severe differential settlement caused by the maximum credible earthquake, while sufficient to cause noticeable ground-surface settlement, is not abrupt enough to cause measurable effect on the planned pipeline. Differential settlement of liquefied soils is not a credible hazard to the pipeline.

Lateral Spreading. The potential lateral spread magnitude was computed for two cases: (a) the gently sloping ground where pipeline segments will be installed in shallow trenches, and (b) for the ground between shallow pipeline and free faces created by the stream and river channels. The likely lateral ground displacement for both cases was computed using the regression equations developed by Youd and others which, though dated, remain the preferred lateral spread regression relationship.

For the gently sloping case, the maximum lateral spread hazard is located along the trenched segment between MP 8.8 and MP 9.1 (pipeline Stations 462+50 to 478+00), the connecting segment between HDD-3 and HDD-4. Thirty-five feet of liquefiable medium-grained sand is estimated to

underlie the pipeline at this segment based on the conditions logged in boring B-13. The computations predict 6.3 feet of lateral spread.

Assuming that the deep parts of HDD-3 and HDD-4 anchor the pipe so that the lateral spread pulls the straight pipeline into an arc, the radius of curvature on a 1,500-foot-long segment that moves laterally a maximum of 6.3 feet is about 44,600 feet. Assuming a certain amount of unavoidable irregularity creates localized areas that curve twice as sharply, the lateral spreading curvature radius for gently sloping ground is about 10 times longer than a typical design radius in 24-inch pipe. Lateral spreading in the gently sloping parts of the low-lying alignment has negligible potential to cause inelastic strain in the pipe and essentially no potential to cause pipeline rupture.

The analyses indicate that the greatest lateral spread hazard occurs where the shallow parts of the pipeline are closest to the river channel. For the critical case, lateral spreading could affect the shallow segment at the end of HDD-3. Spreading would be toward Beaver Slough, generally transverse to the pipeline, with the ends restrained by the deep part of HDD-3 down-station and the long trenched section up-station. The arc length would be approximately 300 feet, and the height from the original alignment (which makes a chord on the arc) is 2.7 feet for an arc length of 4,200 feet. The lateral spread magnitude is not sufficient to yield the pipe (meaning to cause permanent deformation) and has negligible potential to cause pipeline rupture.

Cyclic Strain Softening. The fine-grained layers of alluvium along the low-lying alignment segment (north of Highway 30) are likely to soften significantly during the MCE earthquake. The pipeline is insensitive to cyclic soil softening, though, because there are no loads capable of causing large displacements in the softened ground around the pipeline.

There is no topographic relief, no building foundations, and no other source of initial shear stress along the pipeline alignment north of Highway 30. Where the ground does have slopes, such as at the flood control berms, the pipeline is installed 70 to 110 feet deep. Because there is no driving force, cyclic strain softening will not cause ground displacement. Cyclic strain softening is not a credible hazard to the pipeline.

Tsunami Inundation. The northern portion of the project, north of Highway 30, is located approximately 40 miles from the mouth of the Columbia River and is outside the tsunami inundation mapping for the state of Oregon. A "Workshop on Tsunami Hydrodynamics in a Large River" and associated paper (Yeh, et al., 2012) examined the tsunami penetration into the Columbia River. Yeh et al.'s study found that tsunami inundation would result in a wave height between 0 and 1 meters at the site, and that the wave would be completely contained within existing channels of the Columbia River. A model developed during the workshop and presented in Yeh et al.'s 2012 paper showed that no tsunami inundation would occur along the portion of the pipeline alignment within the Columbia River flood plain north of Highway 30. Based on the aforementioned mapping and research, tsunami inundation is not considered to be a seismic hazard at this site. Evidence that the site was impacted by past tsunamis was not identified during site reconnaissance conducted for the project.

Coseismic Subsidence. Discussions of subsidence associated with M9.0 CSZ events are typically limited to areas in close proximity to the coastline in the Northwest. Coseismic Subsidence Map for Simulated Magnitude 9 Cascadia Earthquake: Clatsop County, Oregon (Madin and Burns, 2013) and associated geographic information system (GIS) data depicting modeled coseismic subsidence developed as part the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes were reviewed to provide a qualitative assessment of the potential for subsidence at the site, particularly along the northern portion of the pipeline alignment located within the flood plain of the Columbia River.

Mapping of subsidence presented by Burns and Madin includes a stretch of the Columbia River that begins at the northwestern tip of the Clatsop Spit and reaches east to the community of Brownsmead, Oregon approximately 24-miles inland. However, GIS data included with the report reaching approximately 15 miles east beyond the Clatsop County map's published boundary suggests that maximum subsidence across the entire pipeline alignment may range between zero and 1 foot. While the GIS data reviewed falls outside of Burns and Madin's published coseismic subsidence mapping, it could be inferred that a relatively small amount of subsidence associated with a M9.0 CSZ event may impact surface elevations as far east as the project site.

Seismically Induced Seiche Potential. Seismically induced seiche is a phenomena whereby an oscillation of a body of water in an enclosed or semi-enclosed basin creates a sudden rise in water height. The rise in water height can have a duration of a few minutes to several hours and a change in water height of a few centimeters to a few meters, depending on basin size, and in the case of earthquakes, the duration of shaking. Seiche can be caused by changes in atmospheric pressure, aided by winds, tidal currents and earthquakes. For the purposes of this discussion, seiche is only considered as a result of earthquake shaking. Seiche in the project area could occur within the Columbia River near the northern end of the project, and within the Clatskanie River, Beaver Slough, Beaver Dredge and Larson Slough. Research has indicated that seismic seiche may occur on water bodies with a wide range in depth, width and rate of flow, and is more dependent on geologic and seismic factors than on hydrodynamic factors. For example, seismic seiche distribution appears to be controlled by variations of thickness of low rigidity sediments, seismic wave period, major tectonic features such as thrust faults, basins, arches and domes. McGarr and Vorhis report that the greatest distribution of seiche in the United States related to the March 1964 Alaska earthquake was in the states bordering the Gulf of Mexico. The proposed pipeline alignment north of Highway 30 is located in an area with relatively thick accumulations of low rigidity sediments, and is not located in an enclosed or semi-enclosed basin. As such, although seiche may occur within water bodies adjacent to the pipeline alignment, the seiche would be relatively minor and would present a low risk to the buried pipeline.

The seismic data and hazards discussed above are presented in detail in **Exhibit H**.

4. Assessment of Soil Related Hazards

Exhibit H includes an assessment of soil-related hazards, including landslides, erosion, flooding, and groundwater.

Erosion. Erosion can be caused by air or water. Wind erosion is not a significant concern because of the fine-grained surface soils, tree cover along and adjacent to much of the NMTP and utility conduit alignments, planned post-construction revegetation of the pipeline corridors, and the subgrade protection measures that will be implemented to provide equipment access.

The soils at the Project area are susceptible to water erosion as indicated in the soil assessment section of **Exhibit H**. However, where the NMTP alignment follows the existing roadways, water erosion will be minimal because of existing surface water drainage systems and crushed rock road surfacing.

Flooding and Groundwater. The northern half of the NMTP alignment, north of Highway 30, will be located in the Columbia River flood plain. However, this area is protected from flooding of the Columbia River by a dike system. Moreover, the proposed development within the Columbia River flood plain is limited to a buried pipeline, most of which is installed by HDD methods at depths exceeding 40 feet below ground surface. As such, there is a low risk of flooding from the Columbia River adversely affecting the Project.

Groundwater levels are near the ground surface within the flood plain regions of the Project site. HDD methods will be used for pipeline installation in most of the flood plain region. However, there are three relatively short, open trench segments within the Columbia River flood plain where groundwater may be a temporary construction consideration. Dewatering may be necessary to install the NMTP in the open trench segments within the flood plain depending on the time of year construction is completed and the precipitation conditions at the time of construction. However, groundwater does not present a long-term hazard to the NMTP within the Columbia River flood plain, provided the open trench pipeline segments are designed with buoyancy control.

Landslide and Slope Stability. GeoEngineers completed a desktop study to identify landslide hazards at the Project site by reviewing the state landslide inventory database (SLIDO) and by interpreting historical aerial photographs and LiDAR-generated hillshade digital elevation models. In addition, they completed a site reconnaissance of the Project area focusing on landslides identified in the desktop study and observing conditions along the NMTP and utility conduit alignments. The proposed NMTP and utility conduit corridors were generally routed to avoid existing landslides and/or unstable slopes to the extent practical.

The compilation landslide mapping by DOGAMI (SLIDO) shows numerous landslides within the Project area, as shown in **Exhibit H**. Most of these landslides are not in close proximity to the NMTP alignment, so they are unlikely to affect the proposed Project. However, the NMTP alignment crosses one landslide and is within 1,500 feet of several others. **Exhibit H** summarizes the assessment of these landslides along with additional landslides mapped by GeoEngineers in the Project area.

The NMTP generally follows existing roads, or relatively gently sloping cross-country terrain. However, some portions of the NMTP and utility corridor alignments traverse slopes that are in excess of 65 percent, as shown in **Exhibit H**. Where the NMTP and utility conduit routes follow existing roads that are located on steep side slopes, the NMTP will generally be installed using only

the workspace provided for by the road surface. However, there may be localized areas where excavation into steep slopes may be required for temporary construction workspace. These areas have not been delineated at this time. Cutting and/or filling for construction of ROW workspace on slopes in excess of 50 percent could create localized slope instability and should be evaluated on a site-specific basis prior to construction.

5. Seismic Hazard Mitigation

NW Natural will design, engineer and construct the compressor station in accordance with the Oregon Structural Specialty Code (OSSC), which uses the 2012 IBC, with current amendments by the state of Oregon and local agencies. Pertinent design codes as they relate to geology, seismicity, and near-surface soil, are contained in IBC Section 1613, with slight modifications by the current amendments of the state of Oregon and local agencies. The project will be designed to meet these minimum standards

The liquefaction and lateral spreading analyses conducted for the project, as discussed above, indicate that the estimated liquefaction and lateral spreading displacements will not result in rupture or overstress conditions of the pipeline and thus will not threaten public safety. Therefore, no specific mitigation for these hazards is required.

There is a risk that existing landslides could be reactivated during a seismic event. However, if existing landslides are reactivated during a seismic event, and the landslides damage the pipeline, there is a very low risk to public safety because the known landslides are located in unpopulated areas. Pipeline pressures are monitored and valves on each side of the pipeline will be remotely shut off in the event of a sudden loss of gas pressure, which will also mitigate risk related to the seismic reactivation of a landslide. Lastly, NW Natural's landslide hazards risk and monitoring plan presented in Section H.9.3.2 below provides actions to be taken in the case of a seismic event, which further help reduce risk to the public.

6. Non-Seismic Hazard Mitigation

NW Natural proposes to design, engineer and construct the compressor station, utility conduit and pipeline to avoid dangers to human safety related to non-seismic hazards in many ways, including:

- The proposed pipeline has been routed to avoid very steep slopes and active landslides.
- The proposed pipeline will be installed between 52 and 93 feet below the lowest points of waterways to mitigate potential environmental disturbance, and reduce the risk of groundwater flooding related hazards affecting the pipeline to the extent practical.
- The proposed pipeline north of Highway 30 will be installed almost entirely using HDD installation methods. Utilizing this construction method not only reduces environmental impacts, it mitigates potential hazards due to groundwater, flooding, stream channel migration, avulsion and dike breach to the extent practical.

- Site-specific geotechnical evaluations will be conducted for the compressor station site and for proposed grading along the utility conduit and pipeline alignments. These evaluations will be completed to reduce the risk of slope stability and foundation settlement adversely affecting the proposed facilities.

The paragraphs below provide discussion and recommended or anticipated mitigation measures for non-seismic hazards identified in this study.

Erosion. Where the proposed pipeline and utility conduit follows existing gravel roads, erosion is expected to be minimal and no special mitigation will be required. In overland segments, the pipeline and the utility conduit corridors will be protected from erosion during and after construction using current erosion control best management practices (BMPs). BMPs will also be used during and after construction of the proposed compressor station. A detailed erosion and sediment control plan will be completed to fulfill requirements of the National Pollutant Discharge Elimination System (NPDES) Permit 1200-C. Erosion control measures that may be employed during construction include:

- Installing sediment fence or other approved BMPs at downslope side of excavations and disturbed areas.
- Straw mulching within disturbed cross country segments of the corridor and locations adjacent to the road that have been affected during construction.
- Planting designated seed mixes within disturbed cross country segments of the corridor at affected areas adjacent to the road.

Exposed soil areas that are affected by the construction will be seeded after construction when there is adequate soil moisture. They will be reseeded in the spring if a healthy cover crop does not grow. The sediment fences will remain in place until the affected areas are well vegetated.

Whenever feasible, overland corridors will be constructed with waterbars so that surface drainage continues to natural drainage patterns, with minimal diversions through ditches and culverts. Regular maintenance of drainage facilities will ensure continued proper operation.

Flooding and Groundwater. Groundwater might be a concern in entry and exit pits for HDD installations and the trenched section of the pipeline within the Columbia River valley. Localized areas will be dewatered if necessary and the effluent will be treated, if necessary, and discharged on site through filter bags or other similar water discharge structures.

High groundwater conditions and flooding could result in positive buoyancy conditions (floating) of the pipeline within open trench segments within the flood plain north of Highway 30. In addition, if a dike breach should occur, wide spread flooding and high velocity waters from multiple dike breach locations is possible. Positive buoyancy conditions will be mitigated within the open trench segments of the pipeline north of Highway 30 by utilizing concrete coated pipe or concrete pipe weights that will counteract buoyancy conditions that may result from flooding or high groundwater.

Where the pipeline crosses streams north of Highway 30 (Clatskanie River, Beaver Slough and Larson Slough), it will be installed using HDD installation methods and will be between approximately 50 and 90 feet beneath the waterways. The HDD entry and exit points, where the HDD installed pipeline will be relatively shallow, will be a minimum of 225 feet away from dikes adjacent to the waterways, and in most cases much further. This setback from the dike system, coupled with the deeply installed pipeline, mitigates most of the risk associated with potential scour that could result from high velocity water flow if a dike breach were to occur. However, because of the limitations in HDD lengths, there will be short sections of pipeline between HDD installations that will be installed in a shallow open trench. These shallow open trench areas are located in a rural, relatively unpopulated area with the nearest residence more than 800 feet away. For these reasons, there is a low risk of scour due to dike breach presenting a hazard to public safety and therefore no additional mitigation is required.

No mitigation is deemed necessary for the southern half of the pipeline alignment or at all other proposed construction since these will be located in upland areas and ridge tops.

Landslides. Three ancient, inactive landslides were identified along the proposed pipeline alignment. These landslides are the SLIDO mapped landslide Marshland 13 along the proposed pipeline route between MP 1.45 and MP 1.75, Landslide 3-048-029 identified along the proposed pipeline alignment from MP 2.85 to 3.25 and from approximate MP 3.57 to 3.82, and Landslide 3-050-029-A located approximately 100 feet west of the pipeline alignment near MP 4.3. As previously discussed, these landslides pose a low risk to the pipeline. However, if these landslides were to re-activate in the future and affect the pipeline, there is a low risk to public safety because there are no structures, public facilities, or paved arterial roadways within several miles of the location where the pipeline crosses the landslides. Mitigation for potential risk will include monitoring this landslide in accordance with NW Natural's existing monitoring schedule for a low risk landslide, which is discussed in **Exhibit H**. Because of the low risk to the pipeline and public safety, no other evaluation or mitigation of these landslides will be conducted.

Two recently active landslides were identified along the proposed utility conduit alignment (Landslides 3 042-031-A and 3-042-030-A along the utility conduit alignment, Figure H-9). To reduce the risk of the landslide scarps retrogressing and adversely affecting the proposed utility conduit, NW Natural has reduced the risk by moving the utility conduit location towards the inboard edge of the road away from the landslide scarps and so that the conduit will be buried in weathered bedrock. Additional mitigation will include monitoring the landslides in accordance with NW Natural's Landslide Risk Ranking and Monitoring Schedule, which is described in **Exhibit H**. Because the utility conduit does not house flammable gas or liquid, there is a no risk to public safety if the landslide scarps were to retrogress and adversely affect the utility conduit. Because of the low risk to public safety if these landslides were to retrogress and involve the utility conduit, no further mitigation is required to protect public safety. However, NW Natural intends to further investigate these two landslides to evaluate risk to the adjacent logging road and utility conduit and to road stabilization options to discuss with the landowner.

Landslide Marshfield 1841 is located within approximately 100 feet of the proposed utility conduit alignment. This landslide presents a low risk to the utility conduit alignment. Mitigation of the risk will include monitoring the landslides in accordance with NW Natural's Landslide Risk Ranking and Monitoring Schedule, which is described in **Exhibit H**. Because the utility conduit does not house flammable gas or liquid, there is a no risk to public safety if the landslide scarps were to retrogress and adversely affect the utility conduit. Because of the low risk to public safety if these landslides were to retrogress and involve the utility conduit, no further mitigation is required to protect public safety.

The proposed compressor station site is situated on landslide deposits derived from a rapidly moving shallow landslide that initiated upslope of the compressor station site (3-043-031-B). The Evaluation presented in this Exhibit suggests that the landslide deposits at the compressor station site have remained stable since deposition. Additional evaluation of the landslide will be conducted as part of future work as described in **Exhibit H**. The additional investigation will be completed to more accurately define the limits of the landslide and to provide geotechnical engineering recommendations for grading of the compressor station site and placement of foundations associated with structures. To mitigate the risk posed by the mapped landslide, this landslide will be included in NW Natural's landslide management system database and be monitored annually in accordance with the criteria for low risk landslides, as discussed in **Exhibit H**.

Landslides could be reactivated due to extensive grading on the landslide, logging, precipitation and during or after a seismic event. There is a low to moderate risk that the landslides identified in this study would be reactivated by these processes. However, if the landslides were to be reactivated, there is a low risk to public safety because the known landslides are located in unpopulated areas. NW Natural maintains a landslide-monitoring program into which each of the landslides identified below will be placed. NW Natural has mitigated the risk of the reactivation of landslides adversely affecting the pipeline by routing the pipeline to avoid active landslides, and monitoring inactive landslides crossed by or in the near vicinity of the proposed pipeline at least once yearly (unless otherwise specified by the monitoring program) and after rain events or seismic events that exceed specified thresholds.

Although the logging roads followed by the proposed pipeline and the utility conduit alignment are well maintained and appear to be in good condition, smaller road slumps predominately along fills might occur along existing roads that the pipeline/utility conduit routes will follow. In order to reduce the potential for the pipeline to be affected by road related fill slumps, the pipeline and the utility conduit will be installed within the inside (bar ditch) edge of the roads where possible.

NW Natural's Landslide Hazard Monitoring Program. NW Natural developed a landslide risk ranking and monitoring schedule program for landslides that may affect their pipelines, and manages those landslides in a management system database. In general, the program classifies landslide risk to NW Natural's pipelines into categories of high, moderate and low, and then establishes a monitoring schedule for landslides placed into those categories. This monitoring program is completed in addition to quarterly monitoring of all NW Natural's transmission

pipelines that are required by various utility commissions. NW Natural's landslide risk and monitoring schedule is presented in **Exhibit H**.

Conclusion

The evidence presented in **Exhibit H** demonstrates that NWN can design, engineer, and construct Project improvements to avoid dangers to human safety.

C. Soil Protection (OAR 345-022-0022)

Under this standard, EFSC must find that the design, construction, and operation of the facility, taking into account mitigation, are not likely to result in a significant adverse impact to soils.

Discussion

NWN engaged GeoEngineers to prepare a soil evaluation. This report is attached as **Exhibit I**.

1. Potential Adverse Impacts to Soil

Construction. Construction activities can introduce the potential for increased erosion due to soil disturbance, loss of vegetation, compaction, and changes to surface drainage patterns. Erosion can be caused by increasing exposure to wind or water. Wind erosion is influenced by the wind intensity, vegetative cover, soil texture, soil moisture, grain size of unprotected soil surface, topography, and frequency of soil disturbance. Wind erosion is not a significant concern in the Project area because of the cohesive surface soils, the moisture content of the soil in the northern region of the alignment, the tree cover along and adjacent to the southern region of the alignment, and the erosion control measures that will be implemented to mitigate erosion potential. Water erosion is a function primarily of oil type, vegetative cover, precipitation, and slope inclination. If left unmitigated, erosion from rainfall will be a hazard during construction.

The runoff potential and water erosion hazard for the identified soils at the site range from slight to high, with higher erosion potentials associated with steeper slopes. The NRCS reports that the site vicinity receives approximately 50 to 70 inches of rainfall per year. The erosion potential and available precipitation, therefore, make site soils sensitive to water erosion during much of the year, particularly where slopes are steep.

The proposed construction will disturb soil where grading and excavations will be required for preparation of the NMCS site and NMTP installation. Specifically, the proposed construction areas include an 80-foot-wide easement along the pipeline and utility conduit alignments where they are not located along existing gravel roads, an approximately 40-foot-wide easement (or the width of the gravel road) where the NMTP and utility conduits are located within gravel roads, and the approximately 10-acre NMCS site. A number of temporary workspace, staging, and storage areas are proposed along the 200-foot pipeline study corridor, with three other locations outside of the corridor, as depicted in the erosion control plans included in **Appendix A** of **Exhibit I**. In addition, temporary workspaces and pipe stringing areas during HDD construction will also disturb soil. The temporary entry and exit workspaces and pipe stringing areas for HDD installation will range from approximately 0.6 to 1.11 acres each. Construction of the NMTP in roadway areas will primarily

involve trenching, associated stock piling of excavation spoils, placing pipe, and backfilling the trenches. Vegetation removal will occur along overland pipeline segments and at the proposed NMCS. If not mitigated, the disturbed construction areas can modify drainage patterns by capturing, concentrating, and rerouting surface water runoff. Such modifications can lead to increased erosion.

Operations. Operations activities will be limited to those areas directly related to the Project. Other parts of the Project area will not be affected.

During operations, the NMTP and utility conduit will have a 40-foot-wide easement in overland segments where vegetation will be managed and maintained to provide access for monitoring. Where the NMTP and utility corridor follow existing gravel roads, no vegetation removal will occur. Existing gravel roads will be used to access major components of the Project. NWN does not anticipate that significant soil disturbance or erosion will result from typical operations. The NMCS site will be covered with gravel and/or pavement that will have a low susceptibility to wind and water erosion.

The North Mist Compressor Station site totals 7 acres with 2 acres finish graded for the facilities and roadways and the remaining 5 acres cleared and rough graded as needed to be utilized as a construction laydown area. The graded areas will reasonably match the existing elevations such that drainage in the laydown area will then match the existing flow patterns.

The well pad occupies additional area separate from the compressor station. The combined area is comprised of two separate operational graded benches. The compressor facility occupies 2.10 acres at nominal elevation 1295 and the well heads occupy 2.41 acres at nominal elevation 1269.

The storm drainage will be designed based on the 25-year storm. The storm drainage system will consist of earth ditches and culverts passing beneath the looped access roadway. The finished surfaces will be stabilized with permeable crushed rock and the roadways will be surfaced with aggregate base. The benches will be drained by sheet flow (minimum 2% slope) to earth ditches adjacent the roadways and there will be ditches at the toe of cuts and the top of fills. Drainage from the compressor facility bench will be directed to the southwest corner with discharge west to the natural westerly drainage way. The well head bench will also drain to the southwest corner with discharge southwesterly to the southwesterly drainage way.

There will be no land application of liquid wastes, and no hazardous liquid materials will be produced during operations.

2. Mitigation of Potential Adverse Impacts

Potential adverse impacts to soil from construction and operations of the NMTP, utility conduit and NMCS should be mitigated by adhering to appropriate erosion and sediment control BMPs during construction and operations. Specific mitigation measures are discussed in **Exhibit I**.

Conclusion

The evidence presented in **Exhibit I** demonstrates that construction and operation of the Project will not cause significant adverse impacts to soils.

D. Land Use (OAR 345-022-0030)

Under this standard, EFSC must find that the Project complies with the statewide planning goals adopted by the Land Conservation and Development Commission. An applicant may demonstrate compliance either by securing necessary local approvals or by obtaining a Council determination that the facility can meet all applicable land use criteria. NWN has elected to address this standard by obtaining a land use determination from EFSC for the components of the Project under Council jurisdiction.

Discussion

Exhibit K demonstrates the Project's compliance with the applicable substantive criteria from Columbia County's acknowledged land use regulations, the Columbia County Zoning Ordinance, and the Columbia County Comprehensive Plan. The substantive criteria contained in these documents have been reviewed by Oregon's Land Conservation and Development Commission to ensure consistency with the statewide planning goals. The applicable code and plan fully implement Oregon's land use laws; therefore, the Project is reviewed under the applicable local standards. There are no statutes or administrative rules that are directly applicable to the Project. Because the current versions of the applicable code and plan fully implement Oregon's land use statutes, statewide planning goals, and administrative rules that are potentially applicable to the Project, and the Project complies with the applicable substantive criteria from these codes and plans, the Project also complies with the statewide planning goals and no exception is required. Therefore, EFSC may find that the Project complies with the statewide planning goals under OAR 345-022-0030(2)(b)(A) and the land use standard set forth at OAR 345-022-0030.

Conclusion

Based on the information provided in **Exhibit K**, there is sufficient evidence upon which EFSC may find that the design, construction, and operation of the Project are consistent with EFSC's land use standard.

E. Protected Areas (OAR 345-022-0040)

This standard prohibits the siting of an energy facility in any of the protected areas listed in the rule. The standard permits the siting of a facility outside the listed protected areas, provided that, taking into account mitigation, the design, construction, and operation of the facility are not likely to result in significant adverse impacts to any of the protected areas. OAR 345-022-0040(1).

Discussion

NWN retained Tetra Tech, Inc. (Tetra Tech) to conduct an analysis of the Project's impacts on protected areas, as required to meet the submittal requirements of OAR 345-021-0010(1)(l)(A)-(C).

The protected-areas analysis area encompasses portions of four Oregon counties (Columbia, Clatsop, Tillamook, and Washington), as well as portions of four Washington counties (Cowlitz,

Wahkiakum, Pacific, and Lewis). A discussion of and map sets depicting the Project Site Boundary, analysis area, locations of inventoried protected areas, and impact assessments are presented in **Exhibit L** of this Request.

As discussed in **Exhibit L**, the Project will have no direct impacts to any protected area. Most protected areas will experience no indirect impacts from the Project, as they are too far away for Project noise to be audible; construction traffic will not be routed near them; views of the Project will be blocked by terrain and/or vegetation; and there will be no water or wastewater impacts. The only protected area that is likely to experience any construction noise impact is portions of the Julia Butler Hansen Refuge (JBHR) nearest the Project area, specifically the Wallace Island, Crims Island, and Anunde Island units. However, the JBHR is not considered a noise-sensitive receptor, and Project noise would not conflict with the management goals and objectives of the JBHR. Up to seven protected areas may have partial views of the Project area, primarily of the pipeline ROW through the timber lands south of Highway 30; of these, three may have a view of the NMCS. However, the long viewing distances, existing vegetative screening, and context of the Project, in addition to the lack of management direction applicable to preservation of scenic qualities, render the visual impacts of the Project negligible for all protected areas.

Conclusion

Based on the information provided in **Exhibit L**, there is sufficient evidence upon which EFSC may find that the design, construction, and operation of the Project are consistent with EFSC's protected areas standard.

F. Retirement and Financial Assurance (OAR 345-022-0050)

Under this standard, EFSC must find that:

(1) The site, taking into account mitigation, can be restored adequately to a useful, non-hazardous condition following permanent cessation of construction or operation of the facility.

(2) The applicant has a reasonable likelihood of obtaining a bond or letter of credit in a form and amount satisfactory to the Council to restore the site to a useful, non-hazardous condition.

The retirement and financial assurance standard relies on evidence of compliance as set forth in OAR 345-021-0010(1)(w), along with information regarding the applicant's financial capability pursuant to OAR 345-021-0010(1)(m). NWN's financial capability is addressed below, but is essentially resolved pursuant to prior EFSC approvals. Evidence is supplied to address the following information requirements set forth in OAR 345-021-0010(1)(w):

(A) The estimated useful life of the proposed facility.

(B) Specific actions and tasks to restore the site to a useful, non-hazardous condition.

(C) An estimate, in current dollars, of the total and unit costs of restoring the site to a useful, non-hazardous condition.

(D) A discussion and justification of the methods and assumptions used to estimate site restoration costs.

(E) For facilities that might produce site contamination by hazardous materials, a proposed monitoring plan, such as periodic environmental site assessment and reporting, or an explanation why a monitoring plan is unnecessary.

Discussion

The estimated facility life is indefinite because it is not anticipated that the natural underground reservoirs will lose their storage capacity, and the process equipment will be replaced as needed. The original Mist storage facility has been fully operational since 1988. The integrity of the formation and capacity of the reservoirs have not changed in nearly 27 years of operation. However, if retirement is necessary, the site can be restored to a useful non-hazardous condition.

The storage facility is composed of (1) the gas processing facilities (compressor station), (2) the I/W pipelines (described as "gathering lines" in prior amendments and in the Consolidated Site Certificate), (3) the 24-inch high-pressure transmission pipeline, and (4) the I/W wells. NWN also proposes extending electrical and other services to the NMCS via conduit. Retirement would be conducted in accordance with the nature of the equipment and structures. The retirement process for these facilities would be the same as for those described in Amendment Nos. 4 and 9, with the standards and consideration of offsetting scrap and salvage values approved by EFSC. The proposed plan for this Amendment is based on the retirement plan approved by EFSC in Amendment No. 9.

1. Gas Processing Facility

The gas processing facility at the NMCS will be located on an eight-acre site and will contain the I/W line manifold. A chain-link fence will surround the site. The NMCS will include the installation of the building(s) to house process equipment such as compressors, a gas dehydration system, control systems, and safety equipment. The I/W line manifold consists of a series of aboveground pipes and valves.

Upon decommission, the process equipment would be removed and sold as used equipment or scrap. Any hazardous materials stored in the buildings or located within the process equipment would be removed and disposed of following the applicable state and federal hazardous materials statutes and rules. The building(s) would be disassembled, and the steel siding and frames would be sold as scrap metal. The concrete slabs would be broken up, and the concrete would be recycled or disposed of at an appropriate landfill. The I/W line manifold and the aboveground portion of the I/W pipelines would be removed and sold as scrap metal. The fence would be removed and sold as scrap metal. At the NMCS, in collaboration with local landowners and commercial timber operators, NWN would remove sufficient gravel and structural fill and replace it with topsoil to a sufficient depth to enable growth of commercial timber. Any structural fill would be offered to surrounding landowners, sold, and reused. The grade would be left as is. It is also assumed that all buried piping would be purged, then cut and capped below grade and left in place.

2. Injection/Withdrawal Pipeline; Conduit

The proposed new I/W pipelines will extend a short distance underground from the NMCS to the new wellheads (situated immediately adjacent to the NMCS). Upon decommission, the below ground portion of the I/W pipelines would be left in place because removing the pipelines would cause unnecessary disruption to the environment. Before abandoning the pipelines, NWN would inspect them and would remove any hazardous materials in the I/W pipelines. The aboveground portions of the pipelines would be removed and sold as scrap metal. If necessary, NWN would remove structural fill, restore topsoil, and revegetate the well pad to enable growth of commercial timber. NWN would comply with any local permits concerning restoration of the well pad area. The conduit, which will provide power and other services to the NMCS, would be retired in place, with no need for any additional restoration work.

3. High-Pressure Transmission Pipeline

The NMTP will extend underground from the processing facilities at the NMCS to the existing PGE PWIP. Upon decommission, the pipeline would be left in place because removing the pipeline would cause unnecessary disruption to the environment. Before abandoning the pipeline, NWN would inspect it and remove any hazardous materials in the pipeline. The aboveground portions of the pipeline would be removed and sold as scrap metal. Because NWN would retire the transmission pipeline in place, revegetation of the pipeline corridor would not be necessary. At any areas where NWN may remove below ground pipeline infrastructure, NWN would revegetate the ROW to encourage habitat redevelopment.

4. Injection/Withdrawal and Monitoring Wells

The I/W and monitoring wells are composed of an aboveground portion, the wellhead, and a below ground portion, the encased well. With approval of this Project, and with the addition of four new I/W wells and one monitoring well, there will be a total of 44 wells in the Mist storage field. An I/W wellhead is typically installed through a concrete base; a monitoring wellhead is installed through a gravel base. Upon decommission, the wellhead would be removed and the well would be plugged in compliance with DOGAMI regulations. The wellhead would be sold as scrap metal. The concrete base would be broken up, and the concrete would be recycled or disposed of at an appropriate landfill. The well would be capped at least four feet below ground level as required by DOGAMI. If necessary, NWN would revegetate the wellhead area to prevent erosion and encourage native habitat redevelopment and would otherwise reclaim the well site in accordance with DOGAMI regulations. Because the wells are subject to the sole jurisdiction of DOGAMI, with Columbia County responsible for local land use compliance, the retirement and any associated costs would be within the County's and DOGAMI's purview.

5. Cost of Restoration

The costs of restoration are nearly all associated with the new NMCS. The cost of restoration of the NMCS is equal to the removal and disposal cost of all structures and foundations and the cost to remove any structural fill and replace with suitable soils for timber use.

The demolition and disposal cost will consist of the labor costs of disassembling the aboveground equipment and the disposal costs for the foundations.

The abandonment of the I/W wells will consist of labor, equipment, and materials to plug the wells in accordance with DOGAMI regulations. As noted above, abandonment and restoration of the well pad are subject to County jurisdiction.

NWN estimates the cost of restoration attributable to Amendment No. 11 to be approximately $3,030,000 in 2015 dollars. These estimates are based on information provided by licensed engineers at Willbros Co. **(Exhibit M-1)**, detailed below:

Removal & Disposal Costs

Decommission gas processing facility	$1,300,000
Remove steel/buildings/piping	$500,000
Remove foundations	$200,000
Remove EI&C	$300,000
Decommission I/W wells	$200,000
Cut and cap pipeline at each end	$40,000
Clean and nitrogen-purge pipeline	$35,000
Cut and plug pipeline in five-mile increments	$80,000
Replace structural fill with topsoil	$375,000
Total Removal	**$3,030,000**

6. Bond or Letter of Credit

Attached is evidence that NWN has a reasonable likelihood of obtaining the proposed bond, security, or other financial instrument in the amount identified above before beginning construction of the Project. **Exhibit M-2** includes a copy of NWN's annual report for 2014. The report shows net operating revenue of $754 million in 2014. **Exhibit M-3** includes a copy of the bond issued to NWN from SafeCo Insurance Company of America for Amendment No. 9. NWN will either update this existing bond or obtain an additional bond in a substantially similar format to cover the retirement costs associated with Amendment No. 11. **Exhibit M-4** is an opinion from NWN's General Counsel in conformance with OAR 345-021-0010(1)(m)(A). As the Site Certificate

holder, NWN can and will comply with all conditions of approval related to the financial assurance standard.

Conclusion

The costs to restore the portions of the gas storage and pipeline facilities proposed in this Request are partially offset by the salvage values. There is a reasonable likelihood that NWN can obtain a bond or letter of credit in a form and amount satisfactory to EFSC to restore the site to a useful, non-hazardous condition. The conditions set forth in the Consolidated Site Certificate, pp. 11-12, are sufficient to ensure compliance with EFSC's retirement and financial assurance standard.

G. Fish and Wildlife Habitat (OAR 345-022-0060)

Under this standard, EFSC must find that the design, construction, and operation of the Project, taking into account mitigation, are consistent with the fish and wildlife habitat mitigation goals and standards of OAR 635-415-0025 in effect as of September 1, 2000.

Discussion

NWN retained Tetra Tech to conduct a site-specific analysis of the Project's impacts on fish and wildlife habitat as required to meet the submittal requirements of OAR 635-415-0025. In accordance with OAR 345-001-0010(59)(c), the analysis area for fish and wildlife habitat and species consists of the Site Boundary and the area within one-half mile from the Site Boundary. Ground surveys were performed within the Site Boundary, and desktop analysis was used to understand the area within one-half mile from the Site Boundary. The Site Boundary is defined in the Project Description (Section V) of this Request. The Oregon Department of Fish and Wildlife (ODFW) confirmed the sufficiency of this survey approach. **Exhibit P-1**.

Biological and Botanical Surveys. Biological and botanical surveys were conducted within the Site Boundary in support of this document and **Exhibit P** as required under OAR 345-021-0010(1)(p)(A). Biological and botanical surveys included an initial desktop-level review followed by field surveys.

Information Review. Preparation for the general biological and botanical surveys included a review of available information on the occurrence and habitat requirements of special status species (e.g., federal or state listed species, state sensitive species, or U.S. Fish and Wildlife Service (USFWS) species of concern) and special habitats that could occur within the analysis area.

General Biological and Habitat Categorization Surveys. General biological and habitat categorization surveys consisted of intuitive controlled transects while mapping and categorizing habitat, along with a generalized, simultaneous search for all special status plant and animal species within the Site Boundary. Special status species targeted during general surveys included federal and state endangered, threatened, proposed, and candidate species; species of concern; birds of conservation concern; sensitive-critical species; and sensitive-vulnerable species.

General surveys typically occurred during the months of April through July to coincide with the period of highest biological activity of neotropical migrant and breeding birds, flowering plants, and

other taxa. Survey teams included a botanist and a wildlife biologist so that a specialist was focused on surveying for each taxon. Surveyors recorded the Global Positioning System location of special status animal and plant species (or recognizable signs) and recorded information on the number of individuals and habitat characteristics on field datasheets.

Habitat Categorization. Within the Site Boundary, habitats were categorized based on field survey results. Outside of the Site Boundary, areas within the fish and wildlife habitat analysis area were categorized based on desktop analysis. The complete fish and wildlife habitat categorization study of the North Mist Expansion Project is presented in **Exhibit P** of this Request.

Conclusion

As part of the Project siting process, habitats within the fish and wildlife habitat analysis area were identified and categorized pursuant to OAR 635-415-0025. Based on survey results, no Category 1 habitat was identified and Project facilities were adjusted to avoid all impacts to Category 2 habitats. For other habitat categories, habitat impacts will be mitigated consistent with OAR 635-415-0025.

Therefore, based on the information provided, there is sufficient evidence upon which EFSC may find that the design, construction, and operation of the Project, taking into account the proposed mitigation measures, are consistent with the fish and wildlife mitigation goals and standards of OAR 635-415-0025. Accordingly, NWN demonstrates compliance with OAR 345-022-0060. Documentation supporting these conclusions is presented in **Exhibit P** of this Request.

H. Threatened and Endangered Species (OAR 345-022-0070)

Under this standard, EFSC must find, with respect to plants that the Oregon Department of Agriculture has listed as threatened or endangered, that the design, construction, and operation of the facility, taking into account mitigation, are consistent with the protection and conservation programs adopted pursuant to ORS 564.105(3). If no conservation program applies, EFSC must determine that the facility is not likely to cause a significant reduction in the likelihood of survival or recovery of the species. With respect to wildlife species that the Oregon Fish and Wildlife Commission has listed as threatened or endangered, EFSC must find that the design, construction, and operation of the proposed facility, taking into account mitigation, are not likely to cause a significant reduction in the likelihood of survival or recovery of the species.

Discussion

In compliance with OAR 345-021-0010(1)(q)(A), NWN retained Tetra Tech to identify all threatened and endangered species listed under ORS 496.172(2) (state threatened and endangered wildlife species), ORS 564.105(2) (state threatened and endangered plant species), and 16 USC § 1533 that may be affected by the Project. Federal and state candidate species and species proposed for listing were also identified due to their potential to become listed during the amendment process.

1. Desktop Review

Tetra Tech used a variety of sources to identify state and federal threatened, endangered, candidate, and proposed species that may be affected by the Project. Data collection has been ongoing since 2013, with updates to account for changes to species status and changes to the Project. Initial and ongoing desktop-level review has included database inquiry letters to the USFWS in 2013, ODFW in 2013, and Oregon Biodiversity Information Center (ORBIC) in 2013.

In order to identify listed, candidate, and proposed species with the potential to occur within the analysis area, Tetra Tech requested known occurrence locations from ORBIC from within Columbia County, the county within which the Project analysis area is contained, and the neighboring counties of Clatsop, Tillamook, and Washington. Occurrence locations outside of the analysis area were requested in order to ensure all species with the potential to occur within the analysis area were included in this analysis, not just species that are known to occur within the analysis area. Field survey data was considered a more accurate indicator of species presence and habitat than the ORBIC data, and was substituted as it became available.

The ODFW (2013, 2014a), Oregon Department of Agriculture, ORBIC, USFWS, National Oceanic and Atmospheric Administration, and National Marine Fisheries Service websites were queried for additional literature on listed species. The StreamNet and ODFW databases were searched for listed fish species within five miles of the analysis area. Finally, a number of botanical resources were reviewed to identify proposed, candidate, threatened, and endangered plant species that could occur near the analysis area. The results of these inquiry letters and the literature review were used to generate a list of state and federal listed and candidate species with the potential to occur in the analysis area.

Once a preliminary species list was developed through the initial desktop review described above, a Geographic Information Systems habitat analysis was conducted in order to evaluate the quality of habitat for federal and state threatened, endangered, and candidate species in the analysis area. This information was gathered in order to initially guide species-specific and general field survey efforts and inform preliminary desktop siting. Data sources analyzed included aerial photography, National Wetland Inventory (NWI), U.S. Geological Survey National Hydrography Dataset (NHD), Natural Resources Conservation Service soils, and the Northwest Regional Gap Analysis Project data.

Based on the review of existing data, 15 species listed as threatened, endangered, or candidate were identified as having the potential to occur within the analysis area. These included one mammal, three fish, and 11 vascular plant species. No species proposed for listing were identified as having the potential to occur within the analysis area.

Several species initially considered for inclusion were excluded, as they are not known or expected to occur within the analysis area. Species excluded because they are very unlikely to occur within the analysis area due to lack of suitable habitat include the red tree vole (*Arborimus longicaudus*), northern spotted owl (*Strix occidentalis caurina*), marbled murrelet (*Brachyramphus marmoratus*), and streaked horned lark (*Eremophila alpestris strigata*). Species considered because their range

includes Columbia County but excluded because the Project is outside the current range of the species include Lower Columbia Chinook salmon (*Oncorhynchus tshawytscha*), Snake River Chinook salmon, Upper Willamette River Chinook salmon, Snake River sockeye salmon (*O. nerka*), Snake River Basin steelhead trout (*O. mykiss*), Upper Columbia River steelhead trout, Middle Columbia River steelhead trout, Upper Willamette River steelhead trout, Lower Columbia River steelhead trout, Oregon Coast coho salmon (*O. kisutch*), bull trout (*Salvelinus confluentus*), and green sturgeon (*Acipenser medirostris*, southern distinct population segment).

2. Field Surveys

Tetra Tech conducted two primary field survey efforts to evaluate the potential presence of state or federal listed or candidate species: a general biological and habitat categorization (habitat categorization) survey, and a botanical survey. Species-specific surveys were not conducted for fish or Columbian white-tailed deer. Initial criteria used to determine whether to conduct species-specific field surveys included the likelihood of a species occurring in the analysis area, the feasibility of conducting species-specific field surveys, and the level of conclusiveness provided by field survey results, and thus the effectiveness of conducting field surveys. Species-specific surveys were not conducted for fish, as these surveys cannot prove absence, as described below. Typical approaches to deer surveys (*i.e.,* pellet surveys or spot-light surveys) would not reliably discriminate between the listed Columbian white-tailed deer and non-listed black-tailed deer.

Supplemental field surveys may also be conducted to respond to potential changes in the Site Boundary. Additional survey information will be reported to ODOE and ODFW prior to construction.

General Biological and Habitat Categorization Survey. Tetra Tech conducted habitat categorization surveys in 2013 and 2014. Surveyors used an intuitive controlled transect methodology to characterize habitat throughout the analysis area, and during these efforts detections of proposed, candidate, threatened, or endangered wildlife species were recorded.

***Botanical Survey*.** Tetra Tech conducted field surveys for listed and candidate plant species in 2013 and 2014. Surveyors used an intuitive controlled transect methodology to locate plants. Surveys were conducted within the analysis area in suitable habitat, and when an area with high potential for target plants was encountered, 100 percent of that area was surveyed for listed plants. Field surveys were conducted during the appropriate time of year to capture target species during blooming or fruiting.

The study identified 15 federal and state listed and candidate species with the potential to occur within the analysis area, which are listed in **Exhibit Q**.

3. Avoidance and Minimization

This section provides a description of measures proposed to avoid and minimize adverse effects to species listed in **Exhibit Q** and their critical habitat. Only species for which potential adverse impacts are anticipated are included.

a. Wildlife: Columbian White-Tailed Deer

Avoidance. Given the mobility of this species and its broad use of habitats within its range, avoidance of areas that could be used by the species is not possible. Placement of the pipeline below grade will avoid obstruction of movement of deer once construction is complete.

Minimization. Within the range of the Columbian white-tailed deer, a combination of pipeline routing and planned use of HDD is being used to avoid impacts to riparian vegetation areas that provide cover, diverse foraging opportunities, and refuge from disturbance. As described in detail in **Exhibit Q**, BMPs will be used within the range of the Columbian white-tailed deer to minimize impacts to the species during construction, operation, and maintenance.

Potential adverse effects that could occur as a result of Project construction, operation, and maintenance include disturbance, temporary habitat removal and modification, and direct mortality of individuals. The Columbian white-tailed deer is assumed to be most sensitive to these impacts during the fawning season (June 1 to July 31). To minimize these potential impacts, NWN will largely avoid construction activities within the range of the Columbian white-tailed deer during the fawning season, but may begin boring on the flood plain in mid-July.

Through avoidance and minimization measures, NWN will avoid population-level impacts to this species. Impacts to riparian vegetation will be avoided through the use of HDD to avoid impacts to streams and adjacent riparian areas. In addition, NWN has committed to BMPs designed to minimize the likelihood of disturbance and direct take. These BMPs include temporal and seasonal construction restrictions implemented to the extent practicable, construction speed limits, and specialized trench excavation. As a result of these avoidance and minimization efforts, the Project is not likely to cause a significant reduction in the likelihood of survival or recovery of this species.

Conducting construction, operation, and maintenance activities during daylight hours outside of dawn and dusk, to the extent practicable, will further reduce the risk of collision and minimize the risk of disturbance, although boring may occur throughout the 24-hour period.

b. Fish

The Lower Columbia River Chinook salmon, Lower Columbia River coho salmon, and Columbia River chum salmon could each experience adverse impacts as a result of the Project. The range of each of these species intersects with the Project at the same location. Thus, avoidance and minimization measures are treated for the species as a group.

Avoidance. NWN used NWI and NHD data as well as Project wetlands and waters survey results to adjust the pipeline corridor to avoid impacts to wetlands and waters to the extent practicable. As a result, a single stream crossing within the range of listed fish species is identified at the Clatskanie River.

Minimization. NWN proposes to use HDD to avoid impacts to the listed fish-bearing stream at the Clatskanie River stream crossing. Impacts from inadvertent release of non-toxic drilling lubricant would be avoided through implementation of BMPs described in **Exhibit Q**.

Based on desktop analysis, three federally listed threatened fish species were assumed to have the potential to occur within the analysis area: the Lower Columbia River DPS of coho salmon, the Lower Columbia River DPS of Chinook salmon, and the Columbia River chum salmon. The Lower Columbia River coho salmon is state-listed as endangered, and the other two are state sensitive species. All three species occur at a single Project stream crossing and thus have the potential to be affected by the Project. However, as a result of the avoidance, minimization, and mitigation measures described above, potential impacts are not expected.

Through avoidance and minimization measures, NWN will avoid population-level impacts to the Lower Columbia River Chinook salmon, Lower Columbia River coho salmon, and Columbia River chum salmon. Impacts to streams and adjacent riparian vegetation will be avoided through the use of HDD. Risks to fish from the inadvertent release of the non-toxic bentonite slurry used in HDD will be managed through appropriate BMPs. As a result of these avoidance and minimization efforts, the Project is not likely to cause a significant reduction in the likelihood of survival or recovery of this species.

c. Plants: Tall Bugbane

Avoidance. The locations of tall bugbane within the analysis area were identified during Project surveys. Boring technology will be used to avoid impacts to identified plant locations.

Minimization. Eleven plant species that are federally or state-listed or are candidates or proposed for federal or state listing were found to have the potential to occur within the analysis area based on desktop analysis. Only one of these, tall bugbane (state candidate species) was found to occur within the analysis area during Project surveys.

A single population of tall bugbane consisting of approximately 70 plants was observed during Project surveys. Individuals were observed in two groups, the first consisting of approximately 65 plants within a 100-square-foot area, and the second consisting of approximately five plants within a seven-square-foot area. The two groups were approximately 128 feet apart, and separated by a road and a perennial stream. Impacts to this species would be avoided by identifying and avoiding plants through the use of HDD technology.

Therefore, based on the information provided, there is sufficient evidence upon which EFSC may find that the design, construction, and operation of the Project, taking into account the proposed mitigation measures, are consistent with the standards of OAR 345-022-0070. Accordingly, NWN demonstrates compliance with OAR 345-022-0060. Documentation supporting these conclusions is presented in **Exhibit Q** of this Request.

The complete threatened and endangered species study of the North Mist Expansion Project is presented in **Exhibit Q** of this Request.

Conclusion

The Project has the potential to have adverse effects and impacts to the species listed in **Exhibit Q**. The mitigation measures implemented on this Project for the specific species or groups of species

found within the analysis area are listed above. For those listed in **Exhibit Q** but not found within the analysis area, it is assumed that their absence mitigates any adverse effects and impacts.

I. Scenic Resources (OAR 345-022-0080)

Under this standard, EFSC must determine that "the design, construction and operation of the facility, taking into account mitigation, are not likely to result in significant adverse impact to scenic resources and values identified as significant or important in local land use plans, tribal management plans and federal land management plans for any lands located within the analysis area." OAR 345-022-0080(1).

Discussion

NWN retained Tetra Tech to inventory scenic resources identified as significant or important in local, tribal, and federal land use plans within the analysis area, as required to demonstrate compliance with the approval standard in OAR 345-022-0080. The analysis area includes parts of two counties in Oregon (Columbia and Clatsop) and two counties in Washington (Cowlitz and Wahkiakum). The analysis area contains two cities (Clatskanie, Oregon and Longview, Washington) and one town (Cathlamet, Washington). There are many rural communities within the analysis area (*e.g.*, Mist, Mayger, and Westport); however, these are unincorporated areas that are managed under county land use plans. There are no tribal lands located within the analysis area. Federal lands within the analysis area are limited to land administered by USFWS at JBHR; there are no other federal lands.

The applicable land use plans and an assessment of whether each plan identifies significant or important scenic resources within the analysis area are described in **Exhibit R** of this Request.

Conclusion

NWN has adopted a number of measures to avoid, reduce, or otherwise mitigate potential impacts of the Project on scenic resources. The primary visual impact avoidance measure is to construct the Project underground. While this does require the clearing of an ROW, trenching, and other land disturbance, the Project has been sited such that it is far from most scenic resources and will not be highly visible. During construction, dust generation will be limited by the implementation of BMPs as described in **Exhibit O** of this Request. Following construction, the ROW will be revegetated, reducing (and eventually eliminating) visual evidence of the pipeline corridor. Where the pipeline crosses rivers or sloughs in the flood plain, HDD will be used to avoid removal of riparian vegetation, eliminating visual impacts for boaters.

Because no significant visual impacts are anticipated, no further mitigation measures are proposed. Monitoring for visual impacts is not proposed. Visual impacts typically do not change over time, and monitoring for visual impact is therefore not required. Documentation supporting these conclusions is presented in **Exhibit R** of this Request.

J. Historic, Cultural, and Archaeological Resources (OAR 345-022-0090)

Under this standard, EFSC must find that the construction and operation of the Project, taking into account mitigation, are not likely to result in significant adverse impacts to:

(a) Historic, cultural or archaeological resources that have been listed on, or would likely be listed on the National Register of Historic Places;

(b) For a facility on private land, archaeological objects, as defined in ORS 358.905(1)(a), or archaeological sites, as defined in ORS 358.905(1)(c); and

(c) For a facility on public land, archaeological sites, as defined in ORS 358.905(1)(c).

Discussion

NWN retained Tetra Tech and Historical Research Associates, Inc. (HRA) to collect information about historical, cultural, and archaeological resources within the facility Site Boundary for the Project. The Site Boundary is the analysis area for cultural resources. To identify these resources, HRA conducted a records review followed by field surveys. The records review included all areas within one mile of the analysis area for the Project. Field surveys were conducted within the analysis area where landowner access had been obtained. The results of the surveys are summarized in **Exhibit S** of this Request.

Conclusion

There are no historic or cultural resources identified within the analysis area that are on private lands, on public lands, or listed on the National Register of Historic Places. Documentation supporting these conclusions is presented in **Exhibit S** of this Request.

K. Recreation (OAR 345-022-0100)

Under this standard, EFSC must find that the design, construction, and operation of the Project, taking into account mitigation, are not likely to result in a significant adverse impact to important recreational opportunities in the analysis area. EFSC considers the following factors in judging the importance of the recreational opportunity:

(a) Any special designation or management of the location;

(b) The degree of demand;

(c) Outstanding or unusual qualities;

(d) Availability of rareness; and

(e) Irreplaceability or irretrievability of the opportunity.

Discussion

NWN retained Tetra Tech to identify recreational opportunities within the analysis area through the collection and review of existing published and unpublished information available from desktop research sources.

In general, recreation activities in the vicinity of the Project consist of hiking, fishing, boating, camping, bicycling, organized sports, photography, game and bird hunting, and sightseeing. These activities may occur in numerous locations both inside and outside the analysis area; however, most of these activities occur only on an informal basis within the analysis area and therefore do not rise to a level of importance sufficient to require analysis under OAR 345-022-0100(1).

However, recreation opportunities identified within the analysis area were evaluated for "importance" based on the criteria outlined in OAR 345-022-0100. Specifically, the importance of each recreation opportunity was rated based on:

- Any special designation or management of the location;
- The degree of demand;
- Outstanding or unusual qualities;
- Availability or rareness; and
- Irreplaceability or irretrievability of the opportunity.

There are three identified recreational opportunities within the analysis area. These are:

- The JBHR;
- The Lower Columbia River Water Trail; and
- One bicycle tour route publicized by Ride Oregon: the Vernonia to Astoria bike route.

Each of these recreational opportunities is described in **Exhibit T** of this Request, along with an assessment of its importance.

Conclusion

Of the three recreation resources identified in the analysis area, none is considered to be an important resource for the purposes of this Request. Documentation supporting these conclusions is presented in **Exhibit T** of this Request.

L. Public Services (OAR 345-022-0110)

Under this standard, EFSC must find that the construction and operation of the Project, taking into account mitigation, "are not likely to result in significant adverse impact to the ability of public and private providers within the analysis area * * * to provide: sewers and sewage treatment, water, storm water drainage, solid waste management, housing, traffic safety, police and fire protection, health care and schools." OAR 345-022-0110(1).

Discussion

NWN retained Tetra Tech to analyze the Project for significant adverse impacts to public services during construction and operation. The analysis is primarily based on secondary data compiled from federal, state, and local government agencies. State and local governments were also contacted directly for data on potentially affected public services. The potential effects of the

Project are evaluated with respect to the ability of public and private providers within the analysis area to provide sewers and sewage treatment, water, stormwater drainage, solid waste management, housing, traffic safety, police and fire protection, health care, and schools. Key Project-related variables used in this analysis include projected construction and operations employment, traffic volumes, and waste generation. A detailed discussion of the Project's potential adverse impacts to public services is provided in **Exhibit U** of this Request.

Conclusion

Construction and operation of the Project will have no significant adverse impacts to public services, including sewers, sewage treatment, water, stormwater drainage, solid waste management, housing, traffic safety, police and fire protection, health care, and schools. Documentation supporting these conclusions is presented in **Exhibit R** of this Request.

M. Waste Minimization (OAR 345-022-0120)

Under EFSC's waste minimization standard, OAR 345-022-0120, the applicant must show that its solid waste and wastewater plans are likely to minimize the generation of solid waste and wastewater in the construction, operation, and retirement of the facility, and that its plans to manage the accumulation, storage, disposal, and transportation of waste are likely to result in minimal adverse impact on surrounding and adjacent areas.

OAR 345-021-0010(1)(v) requires the applicant to provide information relating to solid waste and wastewater minimization plans, including:

(A) A description of the major types of solid waste and wastewater that construction, operation and retirement of the facility are likely to generate, including an estimate of the amount of solid waste and wastewater.

(B) A description of any structures, systems and equipment for management and disposal of solid waste, wastewater and stormwater.

(C) A discussion of any actions or restrictions proposed by the applicant to reduce consumptive water use during construction and operation of the facility.

(D) The applicant's plans to minimize, recycle or reuse the solid waste and wastewater described in (A).

(E) A description of adverse impact on surrounding and adjacent areas from the accumulation, storage, disposal and transportation of solid waste, wastewater and stormwater during construction and operation of the facility.

(F) Evidence that adverse impacts described in (D) are like to be minimal, taking into account any measures the applicant proposed to avoid, reduce or otherwise mitigate the impacts.

(G) The applicant's proposed monitoring program, if any, for minimization of solid waste and wastewater impacts.

Discussion

To address the waste minimization standard, this discussion describes NWN's plans to minimize the generation of solid waste and wastewater, to minimize the use of water, and to recycle or reuse solid waste and wastewaters.

NWN has in place a hazardous and non-hazardous waste reduction and recycling program for all of its facilities, and as shown in **Exhibit V-1**, NWN implements a waste reduction and sustainability program for all of its activities and operations. Recycling/reuse is a priority for the company and, as described below, will be administered during the construction phase of the Project.

1. Solid Waste

a. Construction Phase

Consistent with existing Site Certificate conditions, upon completion of construction, NWN will dispose of all temporary structures not required for future use, and all timber, brush, refuse, and flammable or combustible materials resulting from the clearing of land or from construction of the Project. Solid wastes will be generated during the construction phase of the Project in the quantities outlined in **Table V-1**. These wastes will consist of non-hazardous construction materials including scrap steel, welding rod, and erosion control materials such as silt fencing and bio-bags. Consistent with existing Site Certificate conditions, the scrap steel and welding rod will be collected and transported to a recycling facility. The silt fence material and bio-bags will be transported to a local landfill. Straw bales and stump grinding chips will be used as mulch where practicable. For bentonite, which is used during the HDD process, NWN will seek agricultural landowner approval for land application. If land application reuse of this material is not feasible, bentonite will be placed in local landfills. All waste will be accumulated within temporary construction areas prior to transport to the recycling facility or landfill, so there will be no impact to surrounding or adjacent areas.

Management and Handling of Concrete Washout. After concrete is placed at a construction site, concrete washout is expected to be performed at or in the vicinity of the concrete placement. Concrete washout is defined as "water rinsing" of the chute of the concrete truck, the hopper of the concrete pump truck, and any tools or other equipment used to move or form concrete that must be washed out to prevent the residual concrete from hardening on and in the equipment. Washing of the inside of the concrete trucks is expected to be done at the individual batch plant sites, not at the placement site. The truck chute, pump truck hopper, and other tools may be rinsed on-site with the wastewater being collected in eco-buckets or similar approved collection devices.

Concrete washout will be performed only in designated areas in accordance with the Erosion and Sediment Control Plan (ESCP), which will be completed prior to construction as required by the NPDES 1200-C Construction Stormwater Permit issued by the Oregon Department of Environmental Quality (DEQ). The BMPs to manage concrete washout are identified in the ESCP presented in **Exhibit I**.

An example BMP for conducting on-site washing includes using an "eco-bucket," which is suspended from the bottom of the concrete truck chute to catch wastewater, which is then pumped or dumped back into the concrete drum when full, or into other approved sites that are located away from surface waters. A concrete washout area can be a lined pit or bermed area large enough to contain the liquid and solid waste, and prevent release of wastewater and/or sediments into streams and waterways. Alternatively, prefabricated concrete washout facilities may be provided; these facilities can be carried on a trailer or fitted with wheels to move from site to site as needed.

Washout areas will be inspected daily during active construction periods to prevent overrun and to ensure that they are situated in an environmentally prudent manner. Waste material (*i.e.*, eco-buckets or similar) will be removed to an appropriate disposal site as soon as reasonably possible. Construction operators will be closely monitored to ensure proper management of concrete washout. With these safeguards in place, concrete washouts will be covered by the Project NPDES 1200-C permit that NWN will obtain from DEQ prior to construction. All excess concrete will be sent back to the batch plant for recycling along with hardened concrete in designated washout areas.

b. Operational Phase

There will be no continual generation of either hazardous or non-hazardous solid waste during the operation of the Project. Because there will be no continual generation of waste, no monitoring program is proposed.

c. Retirement Phase

Consistent with existing Site Certificate conditions, prior to termination of the Site Certificate, NWN will retire the Project site sufficiently to restore it to a useful condition. All materials stored in buildings or located in process equipment will be removed, all buildings and steel structures will be disassembled, and all concrete slabs will be broken up and transported to a recycling facility or landfill. Any structural fill removed from the NMCS location (to restore soils for productive commercial forestry purposes) will be recycled and reused. If a monitoring plan is required for operation, retirement would fall under the existing plan. No hazardous substances will be generated during the retirement phase; therefore, no additional monitoring plan will be required.

Several small sections of the NMTP will be removed during the retirement process and recycled at an appropriate facility. The remainder of the NMTP will be retired in place. Other than this small volume of metal from the NMTP and the small volume of building materials from the NMCS, there would be no generation of either hazardous or non-hazardous solid waste during the retirement of the related and supporting facilities proposed in this Request.

2. Wastewater

a. Construction Phase

During Project construction, waters from local sources will be used for directional boring, hydrostatic testing of the pipeline, and dust abatement. *See* **Exhibit O**. Waters used during the HDD

process are reused several times. The water is first used to hydrostatically test the section prior to pullback of the pipeline's HDD sections. The test water is then reused by the drilling process. The excess mud from the drilling process is collected and placed through a process to separate the bentonite, sands, and water for reuse. The bentonite and water are used again in the drilling process. When the drilling process is complete, the water then is used for dust abatement if needed. The estimated volume of water required for HDD construction, preliminary hydrostatic testing, and dust abatement is 2.26 million gallons, and up to 2.2 million gallons of water are estimated for the final hydrostatic testing of the completed pipeline.

The used water for the final hydrostatic testing (up to 2.2 million gallons) will be discharged to the wastewater facility located at PGE's Beaver Generating Station under its current NPDES Waste Discharge Permit. That permit is presented in **Exhibit E**.

When necessary, wastewater generated during pipeline and compressor station construction will be stored in the new pipe and/or in baker tanks for reuse. Reuse will include, but will not be limited to, the mixing of drilling fluids and/or dust abatement via water truck. In the event the wastewater cannot be reused, it will be transferred from the storage vessel(s) to a water truck for transport to the wastewater facility at PGE's Beaver Generating facility for disposal. All wastewater will be accumulated within the temporary construction areas prior reuse or disposal, resulting in no impact to surrounding or adjacent areas.

b. Operational Phase

There may be generation of wastewater during the initial cycles of the operation of the storage wells. All waters will be disposed of in a manner consistent with requirements specified in approved permits. However, following the initial cycles of the operation of the storage wells, there may be up to 35,000 gallons of saline wastewater generated over a 75-day I/W cycle. Wastewater from the storage wells will be collected and disposed of in either an EPA Class II Injection Well or a local wastewater treatment plant. Choosing two disposal methods supplies redundant options for wastewater disposal. For example, if the injection well could not handle additional water for a day, the back-up option of the treatment plant could be utilized. The treatment plant discussed here is the Municipal Treatment Plant located in the town of St. Helens. Water will be transported to the plant via water trucks. The plant has the ability to accept up to 5,000 gallons of produced water a day. No permit modification would be necessary for the plant to accept this wastewater.

The volumes of wastewater will diminish over time as the reservoir is cycled between injection and withdrawal to a net zero or *de minimis* amount. Once de minimis amounts are being produced, the produced waters will be dropped out of the gas stream by a separator and collected in a tank located within the produced water 3-sided shed. (Figure B-1) In addition, any oily water produced during the general operation of the compressor station will be collected in the oily water tank located within the liquid storage shed. As needed, the water will be pumped into a tank in the back of a pick-up and transported to Miller Station. Once at Miller Station, the water will be transferred to a produced water/stormwater holding tank until the next batch of water is processed through an evaporator. Waste oil will be collected by a recycling vendor and hauled to a recycling facility.

c. Retirement Phase

There will be no generation of wastewater during the retirement of the NMCS or NMTP.

Conclusion

NWN's solid waste and wastewater plans minimize generation of solid waste and wastewater in the construction, operation, and retirement phases of the Project. As described above, generation of solid wastes and wastewater will be minimal and short-term, and primarily limited to the construction phase. When solid waste or wastewater is generated, it will be recycled immediately, reused, or properly disposed of. No accumulation or storage of solid wastes or wastewater is proposed. For these reasons, there will be no significant adverse impacts to surrounding or adjacent areas, and no monitoring program will be necessary for solid waste or wastewater management. The existing conditions in the Consolidated Site Certificate, pp. 11-12, sufficiently address waste minimization concerns for this Request.

VIII. DIVISION 24 STANDARDS (OAR 345-027-0060(1)(e), (f))

A. Public Health and Safety Standards for Surface Facilities Related to Underground Gas Storage Reservoirs (OAR 345-024-0030)

To issue a site certificate for a proposed surface facility related to an underground gas storage reservoir, EFSC must make the following findings:

(1) The proposed facility is located at distances in accordance with the schedule below from any existing permanent habitable dwelling:

(a) Major facilities, such as compressor stations, stripping plants and main line dehydration stations – 700 feet.

(b) Minor facilities, such as offices, warehouses, equipment shops and odorant storage and injection equipment – 50 feet.

(c) Compressors rated less than 1,000 horsepower – 350 feet.

(d) Roads and road maintenance equipment housing – 50 feet.

(2) The applicant has developed a program using technology that is both practicable and reliable to monitor the facility to ensure the public health and safety (OAR 345-024-0030.)

Response: The NMCS, containing compressors and main line dehydration stations, will be located more than 9,100 feet (1.7 miles) from the closest existing permanent habitable dwelling. That exceeds all distances listed in OAR 345-024-0030 (1)(a), (b), (c) and (d).

Operations of the storage facility will be integrated such that they will be monitored and controlled remotely by trained operators at Miller Station, approximately five miles away by road. The new NMCS will be constructed so as to not need staffing 24 hours per day during routine operations. The compressor station site will be constructed on a hardened, rocked surface, and will be enclosed by security fencing, with yard lighting installed for security purposes. Surveillance and intrusion

detection systems will be in place to monitor the security of the remote facility, and fire detection and suppression systems will be installed within the compressor station. NWN will maintain fire suppression systems, automatic shut-off valves, and blowdowns to address fire considerations. In addition to Miller Station's 24-hour-per-day monitoring, NWN Gas Control, located in Portland, Oregon, will continue to provide additional monitoring of the newly integrated facilities on a 24-hour basis.

B. Carbon Dioxide Emission Standards and Offsets for Nongenerating Energy Facilities; Standard for Nongenerating Energy Facilities (OAR 345-024-0620)

To issue a site certificate for a nongenerating energy facility that emits carbon dioxide, EFSC must find that the net carbon dioxide emissions rate of the proposed facility does not exceed 0.504 pounds of carbon dioxide per horsepower hour. EFSC shall determine whether the carbon dioxide emissions standard is met as follows:

(1) The Council shall determine the gross carbon dioxide emissions that are reasonably likely to result from the operation of the proposed energy facility. The Council shall base such determination on the proposed design of the energy facility. In determining gross carbon dioxide emissions for a nongenerating facility, the Council shall calculate carbon dioxide emissions for a 30-year period unless the applicant requests, and the Council adopts in the site certificate, a different period. The Council shall determine gross carbon dioxide emissions based on its findings of the reasonably likely operation of the energy facility. The Council shall use a rate of 117 pounds of carbon dioxide per million Btu of natural gas fuel (higher heating value) * * * (OAR 345-024-0620(1)).

Response: The NMCS will compress natural gas using two natural gas-fired, internal combustion engine-driven compressors. Each engine has a rated capacity of 1,775 horsepower (HP). A conservative estimate of the injection and withdrawal cycle was developed by assuming that gas was either being withdrawn at the maximum rate of 120 million standard cubic feet per day (MMscf/day) or injected at the maximum rate of 56 MMscf/day for 350 days per year, and that the system was never idle except during planned operational shutdowns. Under this conservative operating assumption, the engines would operate for 5,740 hours per year (approximately 16.4 hours per day).

Calculated horsepower requirements are based on the injection and withdrawal assumptions and a conservative emissions assumption of a single engine loaded at 1,182 HP and a maximum inlet air temperature of 105º F. At these loading conditions, the fuel consumption rate for the proposed engines is 8,066 British Thermal Units per brake horsepower-hour (Btu/bhp-hr) on a higher heating value basis. This set of assumptions is conservative over the 30-year time period for the carbon dioxide offset calculations. The following calculation is the expected cumulative carbon dioxide emissions for the 30 years:

$$\frac{5{,}740 \text{ hours}}{\text{year}} \times 30 \text{ years} \quad \frac{9.5 \text{ MMBtu}}{\text{hour}} \times \frac{117 \text{ lbs. } CO_2}{\text{MMBtu}} \times \frac{\text{ton}}{2{,}000 \text{ lbs.}} =$$

96,039 tons CO_2 emissions maximum over a 30-year period.

Notes:

1. The manufacturer's supplied data for the engine CO_2 emissions at 105º F range from 0.97 to 1.09 pounds per bhp-hr.
2. The annual fuel use, based on the assumptions stated above, and a higher heating value of 1,040 Btu/scf for natural gas is 52.62 MMscf.
3. With no thermal energy to cogeneration, the estimated efficiency of the North Mist compressors is 31.6 percent, based on 1 hp-hr = 2545.382 Btu, and 8,066 Btu/hp-hr at the calculated single engine HP load.

The following calculation uses the same operating assumptions to calculate the allowable CO_2 emissions based on 0.504 pounds of CO_2 per horsepower hour (hp-hr):

$$\frac{5{,}740 \text{ hours}}{\text{year}} \times 30 \text{ years} \quad \times 1{,}182 \text{ HP} \quad \times \frac{0.504 \text{ lbs. } CO_2}{\text{hp-hr}} \times \frac{\text{ton}}{2{,}000 \text{ lbs.}} =$$

51,292 tons of CO_2 allowable under the standard.

Therefore, the remaining emissions reduction needed to meet the standard under a conservative estimate of maximum 30-year operations is:

96,039 tons CO_2 – 51,292 tons of CO_2 = 44,747 tons over 30 years.

(1) For any remaining emissions reduction necessary to meet the applicable standard, the applicant may elect to use any of the means described in OAR 345-024-0630 or any combination thereof. The Council shall determine the amount of carbon dioxide or other greenhouse gas emissions reduction that is reasonably likely to result from the applicant's offsets and whether the resulting net carbon dioxide emissions meet the applicable carbon dioxide emissions standard. The amount of greenhouse gas emissions means the pounds of carbon dioxide and the carbon dioxide equivalent of other greenhouse gases. For methane, one pound of methane is equivalent to 23 pounds of carbon dioxide. For nitrous oxide, one pound of nitrous oxide is equivalent to 296 pounds of carbon dioxide (OAR 345-024-0620(2)).

Response: NWN wishes to meet the applicable standard by means of OAR 345-024-0630(2) and OAR 345-024-0580 by providing offset funds at the rate of $1.27 for each ton of remaining CO_2 emissions reduction needed. This would result in a CO_2 offset fund of $56,829 (44,747 tons emission reduction x $1.27 offset cost = $56,829 offset).

(1) If the applicant elects to comply with the standard using the means described in OAR 345-024-0630(1) * * * (OAR 345-024-0620(3)).

Response: NWN does not elect to comply in this manner.

(1) Before beginning construction, the certificate holder shall notify the Department of Energy in writing of its final selection of an equipment manufacturer and shall submit a written design information report to the Department sufficient to verify the facility's designed rate of fuel use and its nominal capacity for each fuel type. In the site certificate, the Council may specify other information to be included in the report. The Department shall use the information the certificate holder provides in the report as the basis for calculating, according to the site certificate, the amount of greenhouse gas emissions reductions the certificate holder must provide under OAR 345-024-0630 (OAR 345-024-0620(4)).

Response: NWN will use Caterpillar 3606 Engines. A site-specific technical data sheet is included at the end of this analysis as **Exhibit Y-1**.

(1) In the site certificate, the Council shall specify the schedule by which the certificate holder shall provide offsets. In the schedule, the Council shall specify the amount and timing of offsets the certificate holder must provide to an offset credit account. In determining the amount and timing of offsets, the Council may consider the estimate of total offsets that may be required for the facility and the minimum amount of offsets needed for effective offset projects. The Department shall maintain the record of the offset credit account (OAR 345-024-0620(5)).

Response: NWN assumes that the emission offset credit will be paid in a single installment.

Means of Compliance for Nongenerating Energy Facilities (OAR 345-024-0630)

The applicant may elect to use any of the following means, or any combination thereof, to comply with the carbon dioxide emissions standard for nongenerating energy facilities:

(1) Implementing offset projects directly or through a third party * * * (OAR 345-024-0630(1)).

Response: NWN does not choose this method of compliance.

(2) Providing offset funds, directly or through a third party, in an amount deemed sufficient to produce the reduction in greenhouse gas emissions necessary to meet the applicable carbon dioxide emissions standard according to the schedule set forth pursuant to OAR 345-024-0620(5). The applicant or third party shall use the funds as specified in OAR 345-024-0710. The Council shall deem the payment of the monetary offset rate, pursuant to OAR 345-024-0580, to result in a reduction of one ton of carbon dioxide

emissions. The Council shall determine the offset funds using the monetary offset rate and the level of emissions reduction required to meet the applicable standard. If the Council issues a site certificate based on this section, the Council may not adjust the amount of the offset funds based on the actual performance of offsets (OAR 345-024-0630(2)).

(3) Any other means that the Council adopts by rule * * * (OAR 345-024-0630(3)).

Response: NWN will provide offset funds directly, as outlined in (2) above. The organization selected by NWN for receipt of the funds is National Climate Trust (Oregon Business Registration Number 455822-93). Proof of 501(c)(3) status for the organization is included at the end of **Exhibit Y-2**. In addition to the offset funds outlined in (2) above, NWN will provide an additional amount to be included in the one-time payment of up to 10 percent of the offset fund amount (an additional $5,683) if requested by the organization as specified in OAR 345-024-0710(4).

(4) Each year after beginning commercial operation, the certificate holder shall report to the Department of Energy data showing the amount and type of fossil fuels used by the facility and its horsepower-hours of operation. The Council shall specify in the site certificate how the Department shall use those data to calculate the gross carbon dioxide emissions from the facility during the report year and the net emissions in excess of the carbon dioxide emissions standard. The Department shall then subtract excess emissions from the offset credit account. The Council shall specify in the site certificate the minimum amount of offset credits that a certificate holder shall provide to establish the offset credit account. The Council may specify an amount of offset credits equal to the total offsets required for the facility. The Council shall specify the minimum amount of offset credits that a certificate holder must maintain in the account and the minimum amount of offset credits the certificate holder shall provide to replenish the account. The Department shall notify the certificate holder when it must replenish its offset credit account according to the conditions in the site certificate. The certificate holder shall maintain a positive balance in the offset credit account for 30 years, unless the Council specifies a different period in the site certificate (OAR 345-024-0630(4)).

Response: NWN recommends the use of the simple equations outlined above to determine compliance, using the actual annual horsepower-hours and actual annual million Btu of fuel consumption. NWN suggests establishing the offset account with a balance of 44,747 tons of CO_2. This is the projected 30-year offset for the project operations. Given the relatively small amount of offset credits in comparison to a power plant, a single deposit with no future adjustments would be most practical in terms of the effort expended by EFSC and NWN for compliance.

(5) If the certificate holder is replenishing its offset credit account by meeting the monetary path payment requirement described in OAR 345-024-710, the certificate holder may replenish its offset credit account without amending the site certificate by using the calculation methodology detailed in conditions that the Council adopts in the site certificate (OAR 345-024-0630(5)).

Response: NWN suggests establishing the offset account with a balance of 44,747 tons of CO_2. This is the projected 30-year offset for the project operations. Given the relatively small amount of offset credits in comparison to a power plant, a single deposit with no future adjustments would be most practical in terms of the effort expended by EFSC and NWN for compliance.

(6) If the certificate holder proposes to replenish the offset credit account under OAR 345-024-0630(1), the Council may amend the site certificate conditions to ensure that the proposed offset projects are implemented (OAR 345-024-0630(6)).

Response: NWN does not wish to use this compliance method.

Conclusion

As described above, taking into account offsets, the net carbon dioxide emissions rate of the Project will not exceed 0.504 pounds of carbon dioxide per horsepower hour. The Project complies with the CO_2 standard for nongenerating energy facilities.

IX. OTHER STANDARDS AND PERMITS

A. Noise

Exhibit X provides an analysis of the noise resulting from the construction and operation of the NMCS and associated natural gas transmission pipeline. This analysis includes the information required by OAR 345-021-0010(1)(x), and is provided to support a finding by EFSC that the proposed facilities comply with the DEQ noise control standards in OAR 340-035-0035. **Exhibit X** also supports the noise impacts discussed in **Exhibit L** and **Exhibit T**.

Discussion

OAR 340-035-0035 contains the Oregon Noise Control Regulations for Industry and Commerce (Oregon Noise Control Regulations). The Oregon Noise Control Regulations limit the allowable sound emissions of industrial and commercial noise sources in several ways; specifically, limits are placed on allowable statistical sound levels, on allowable octave band sound pressure levels, and on impulsive sound levels. For new noise sources located on previously unused sites, there is an additional limit on the allowable increase in two statistical noise descriptors: the L10 (sound level exceeded 10 percent of the time) and the L50 (sound level exceeded 50 percent of the time). The L10 and L50 sound levels may not increase by more than 10 A-weighted decibels (dBA) over existing levels in any hour. Impulse-type sounds are not expected as a result of this Project.

Operational noise levels will be subject to the Oregon Noise Control Regulations. The nighttime noise limits are the most restrictive and will determine the overall limits that will have to be met at the nearest residence. The nighttime statistical limits applicable to sound emanating from the compressor station are shown in **Exhibit X,** Table X-1.

Because the NMCS will be located on a site that has not been previously used for industrial purposes, the L10 and L50 noise levels may not increase by more than 10 dBA over existing measured baseline levels, in addition to the limits shown in **Exhibit X,** Table X-1. There are limits

on the noise that can be emitted in various frequencies. These regulations control the characteristics of a noise so that excessive whine or hum does not occur. The nighttime frequency limits applicable to the compressor station facilities are shown in **Exhibit X,** Table X-2.

Columbia County has a noise control ordinance that prohibits unreasonable noise affecting noise-sensitive units (any vehicle, building, or structure adapted for overnight accommodation of persons). There is a prohibition on noise that exceeds 50 dBA during nighttime hours (10 p.m. to 7 a.m.), and 60 dBA during daytime hours (7 a.m. to 10 p.m.). The standard is exceeded if noise levels are higher than the standard for more than 10 percent of any 20-minute period (20-minute L10).

Industrial and construction activities such as the construction and operation of the NMCS and associated natural gas pipeline are exempt from regulation.

As fully discussed in **Exhibit X**, the calculated increase in sound levels at the nearest residences as a result of simultaneous maximum operations of the compressor stations is three to five dBA. The maximum calculated cumulative contribution from the compressor stations at any residence is 26 dBA. These calculated increases are well below the maximum allowable 10 dBA increase. The calculated sound levels are very conservative. It is improbable that all equipment would operate simultaneously. **Figure X-1** shows that even with very conservative estimation methods, calculated sound levels at residences and in the town of Mist are in the mid-20s dBA or below. If audible, these levels would be barely noticeable and highly unlikely to cause annoyance. Sound levels at residences will be far below the applicable octave band sound levels allowable and described in **Exhibit X,** Table X-2.

A single blow-down valve will be located on the pipeline. The valve will be used to vent gas in the case of an emergency, or if maintenance or repair of the pipeline must be performed. This is expected to occur very infrequently. The valving will be buried; however, venting of the gas can be very loud if not equipped with a silencer, and could startle animals or people if they are near the valve during use. The valve will be located at an existing industrial-use site in the silviculture-use area south of Highway 30 and well away from residential uses.

Conclusion

Calculated operational noise levels are well within the DEQ's noise control standards in OAR 340-035-0035, as discussed in detail in the previous sections of this Request. Construction noise is exempt from regulation by the state of Oregon and Columbia County. Contractors are required to comply with all federal, state, and local regulations governing equipment source levels. In addition, contractors will be required to comply with any specific noise provisions of the contract documents. Documentation supporting these conclusions is presented in **Exhibit X** of this Request.

B. Air Quality

NWN is applying for a new Department of Environmental Quality (DEQ) Standard Air Contaminant Discharge Permit (ACDP) for the proposed NMCS.

Discussion

The previous DEQ air permit was issued in 2001. For Amendment No. 9, NWN and DEQ determined that the Facility modifications at that time would not cause air criteria exceedances above the permit limits for described pollutants. For the North Mist Project and the NMCS, a new ACDP is required. Final design has not begun for the Facility and the exact equipment layout may change within the general Facility boundaries. Primary emission sources at the Facility will be two natural gas-fired engines used to drive the compressors, and related equipment. Minor sources of emissions will be three natural gas-fired, engine-driven emergency generators; fugitive gas emissions from valves, seals, and flanges; and emissions from the liquid storage vessel for produced water and pigging liquids (if any). The corresponding operation of the engine-driven compressors will range from no operation when the reservoir pressures or pipeline pressures allow gas free flow, to concurrent operation of both engine-driven compressors. NWN will secure the required ACDP prior to commencement of operations.

Conclusion

A copy of the DEQ ACDP Application is attached to **Exhibit E**. As has been the case historically, NWN will comply with its air permit.

X. PROPERTY OWNERS LOCATED WITHIN OR ADJACENT TO SITE OF THE FACILITY (OAR 345-027-0060(1)(g))

OAR 345-027-0060(g) requires that, if an amendment would change the Site Boundary, extend the deadlines for beginning or completing construction, or change the legal description of the facility, an updated list of the owners of property located within or adjacent to the site of the facility, as described in OAR 345-021-0010(1)(f), must be provided.

Discussion

Because this Request proposes a change to the Site Boundary, a revised property owner list is set forth at **Exhibit F**.

Conclusion

The property owner list set forth at **Exhibit F** satisfies this standard.

XI. CONCLUSION

For the foregoing reasons, NWN respectfully requests approval of its Request.

LIST OF EXHIBITS

A – Applicant Information

B – Project Description

C – Project Location and Maps

D – Organizational Expertise

E – Permits Needed for Construction and Operation

F – Property Ownership

G – Material Analysis

H – Geologic Hazards Evaluation

I – Soil Evaluation

J – Wetlands and Other Jurisdictional Waters

K – Land Use

L – Protected Areas

M – Financial Capability and Assurance

N – Need for Facility

O – Water Use

P – Fish and Wildlife Habitats and Species

Q – Threatened and Endangered Species

R – Scenic Resources

S – Historic, Cultural, and Archeological Resources

T – Recreation

U – Public Services

V – Waste Management

W – Site Restoration

X – Noise

Y – Carbon Dioxide Emissions and Offsets

CC – Additional Statutes, Rules, and Ordinances

DD – Specific Standards for Surface Facilities Related to Underground Gas Storage

Exhibit A

Applicant Information

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The details normally discussed in this Exhibit are included in the **Project Description and OAR Division 27 Compliance** document, which can be found at the beginning of this Request for Amendment to Site Certificate.

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FIGURES

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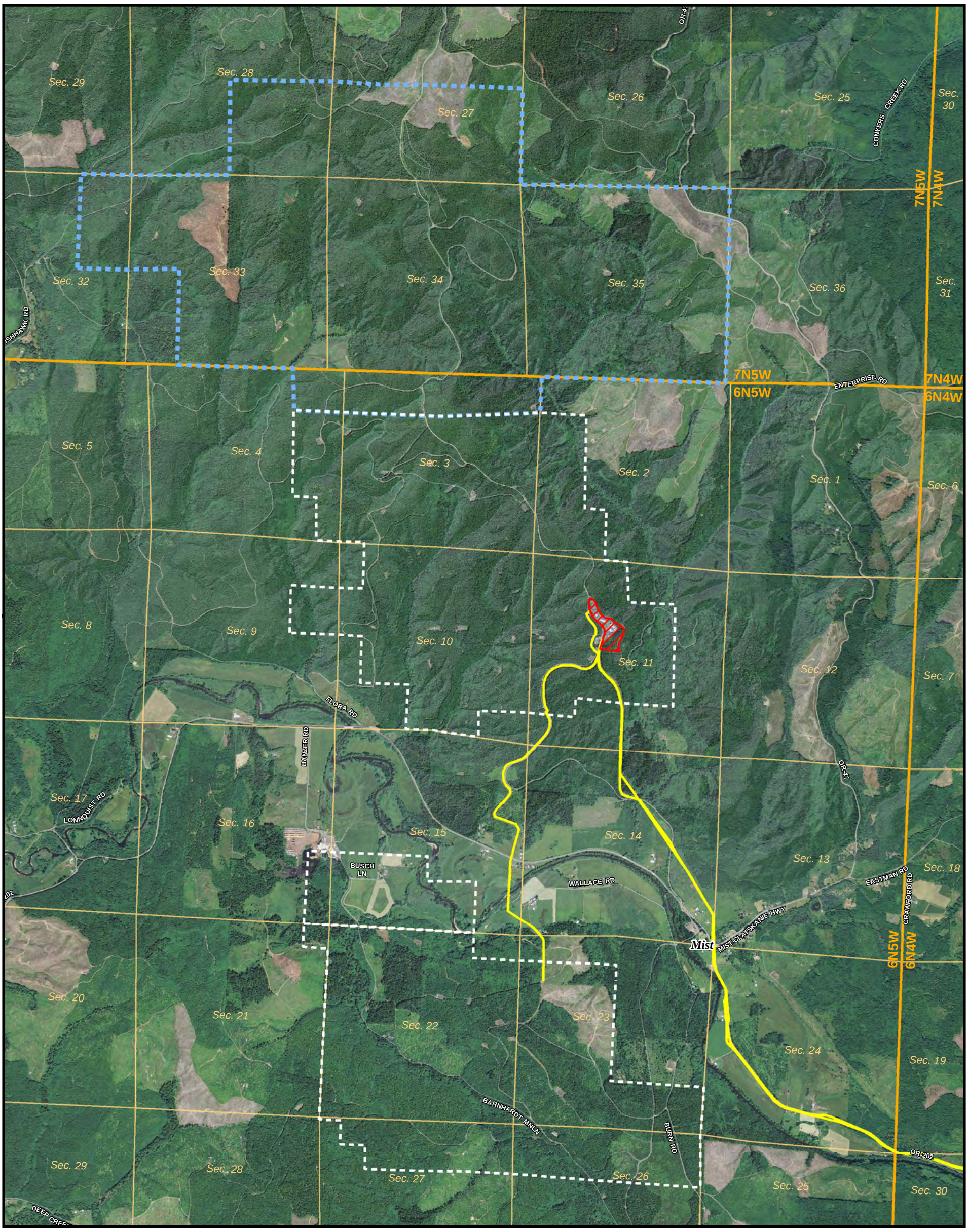


NW Natural

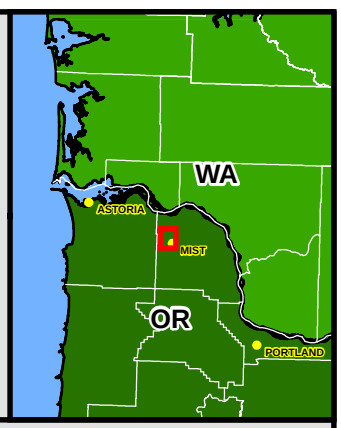
North Mist Expansion Project

Request for Amendment No. 11

Columbia County, OR
November 2015

Figure A-1
Existing and Expanded Storage Site Boundaries

- Proposed Expansion Area
- Approved EFSC Boundary
- Miller Station
- Existing NW Natural Pipeline Corridor



NAD_1927_StatePlane_Oregon_North_FIPS_3601

0 0.25 0.5 1 1.5 2 Miles

Data Source: NW Natural North Mist Expansion Project

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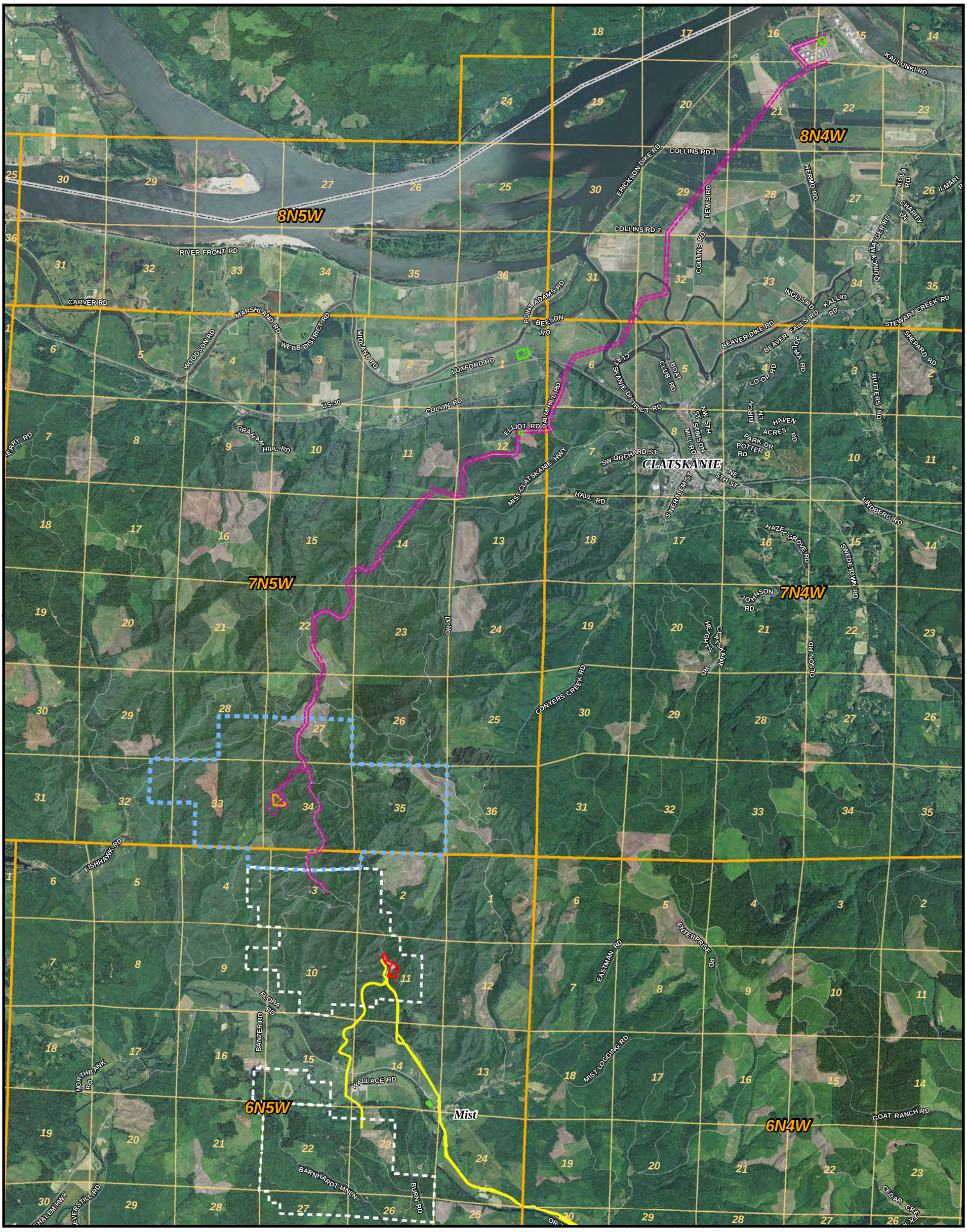


NW Natural

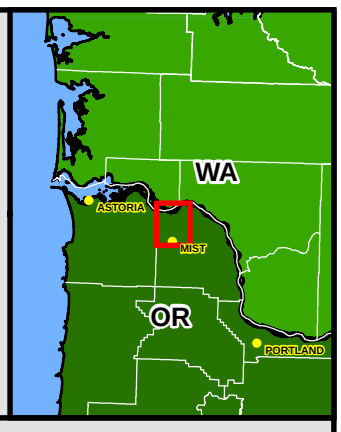
North Mist Expansion Project

Request for Amendment No. 11

Columbia County, OR
November 2015

Figure A-2
Site Boundary With NMTP

- Pipe Storage
- 200 feet Wide Study Corridor
- Miller Station
- Proposed North Mist Compressor Station
- Proposed Expansion Area
- Approved EFSC Boundary
- Existing NW Natural Pipeline Corridor
- State Boundary



NAD_1927_StatePlane_Oregon_North_FIPS_3601

0 0.5 1 2 3 4 Miles

Data Source: NW Natural North Mist Expansion Project

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EXHIBIT A-1:

RESTATED ARTICLES OF INCORPORATION

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RESTATED ARTICLES OF INCORPORATION

of

NORTHWEST NATURAL GAS COMPANY

as Filed and Amended June 3, 2008

AMENDED AND RESTATED ARTICLES OF INCORPORATION
OF
NORTHWEST NATURAL GAS COMPANY

(These Amended and Restated Articles of Incorporation of Northwest Natural Gas Company supersede its theretofore existing Restated Articles of Incorporation and all amendments thereto.)

ARTICLE I

The name of this corporation is NORTHWEST NATURAL GAS COMPANY, and its duration shall be perpetual.

ARTICLE II

The purposes of the corporation are to engage in any lawful activity for which corporations may be organized under the Oregon Business Corporation Act.

ARTICLE III

A. The aggregate number of shares of capital stock which the corporation shall have authority to issue is 103,500,000 shares, divided into 3,500,000 shares of Preferred Stock, issuable in series as hereinafter provided, and 100,000,000 shares of Common Stock.

B. A statement of the preferences, limitations and relative rights of each class of capital stock of the corporation, namely, the Preferred Stock and the Common Stock, of the variations in the relative rights and preferences as between series of the Preferred Stock, insofar as the same are fixed by these Restated Articles of Incorporation, and of the authority vested in the board of directors of the corporation to establish series of Preferred Stock and to fix and determine the variations in the relative rights and preferences as between series insofar as the same are not fixed by these Restated Articles of Incorporation, is as follows:

Preferred Stock

1. The shares of the Preferred Stock may be divided into and issued in series. Each series shall be so designated as to distinguish the shares thereof from the shares of all other series of the Preferred Stock and all other classes of capital stock of the corporation. To the extent that these Restated Articles of Incorporation shall not have established series of the Preferred Stock and fixed and determined the variations in the relative rights and preferences as between series, the board of directors shall have authority, and is hereby expressly vested with authority, to divide the Preferred Stock into series and, within the limitations set forth in these Restated Articles of Incorporation and such limitations as may be provided by law, to fix and determine the relative rights and preferences of any series of the Preferred Stock so established. Such action by the board of directors shall be expressed in a resolution or resolutions adopted by it prior to the issuance of shares of each series, which resolution or resolutions shall also set forth the distinguishing designation of the particular series of the Preferred Stock established thereby. Without limiting the generality of the foregoing, authority is hereby expressly vested in the board of directors so to fix and determine with respect to any series of the Preferred Stock:

   (a) The rate of dividend and the relative preference of each series in the payment of dividends;

   (b) The price at which and the terms and conditions on which shares may be redeemed;

   (c) The amount payable upon shares in the event of voluntary and involuntary liquidation and the relative preference of each series on liquidation;

   (d) Sinking fund provisions, if any, for the redemption or purchase of shares;

   (e) The terms and conditions, if any, on which shares may be converted if the shares of any series are issued with the privilege of conversion; and

(f) Any other relative right or preference as permitted by law.

All shares of the Preferred Stock of the same series shall be identical except that shares of the same series issued at different times may vary as to the dates from which dividends thereon shall be cumulative; and all shares of the Preferred Stock, irrespective of series, shall constitute one and the same class of stock and shall be identical except as to the designation thereof, the date or dates from which dividends on shares thereof shall be cumulative, and the relative rights and preferences set forth above in clauses (a) through (f) of this subdivision, as to which there may be variations between different series. Except as otherwise may be provided by law or by the resolutions establishing any series of Preferred Stock in accordance with the foregoing provisions of this subdivision, whenever the written consent, affirmative vote, or other action on the part of the holders of the Preferred Stock may be required for any purpose, such consent, vote or other action shall be taken by the holders of the Preferred Stock as a single class irrespective of series and not by different series.

2. The holders of shares of the Preferred Stock of each series shall be entitled to receive dividends, when and as declared by the board of directors, out of any funds legally available for the payment of dividends, at the annual rate fixed and determined with respect to each series either by these Restated Articles of Incorporation or in accordance with subdivision III. B. 1., and no more, payable quarterly on the 15th day of February, May, August and November in each year or on such other date or dates as the board of directors shall determine in the resolutions establishing such series. Such dividends shall be cumulative in the case of shares of each series either from the date of issuance of shares of such series or from the first day of the current dividend period within which shares of such series shall be issued, as the board of directors shall determine, so that if dividends on all outstanding shares of each particular series of the Preferred Stock, at the annual dividend rates fixed and determined either by these Restated Articles of Incorporation or in accordance with subdivision III. B. 1., shall not have been paid or declared and set apart for payment for all past dividend periods and for the then current dividend periods, the deficiency shall be fully paid or dividends equal thereto declared and set apart for payment at said rates before any dividends on the Common Stock shall be paid or declared and set apart for payment. No interest, or sum of money in lieu of interest, shall be payable in respect of any dividend payment or payments which may be in arrears.

3. In the event of any dissolution, liquidation or winding up of the corporation, before any distribution or payment shall be made to the holders of the Common Stock, the holders of the Preferred Stock of each series then outstanding shall be entitled to be paid out of the net assets of the corporation available for distribution to its shareholders the respective amounts per share fixed and determined with respect to each series either by these Restated Articles of Incorporation or in accordance with subdivision III. B. 1., and no more. If upon dissolution, liquidation or winding up of the corporation, whether voluntary or involuntary, the net assets of the corporation available for distribution to its shareholders shall be insufficient to pay the holders of all outstanding shares of Preferred Stock of all series the full amounts to which they shall be respectively entitled as aforesaid, the net assets of the corporation so available for distribution shall be distributed to the holders of Preferred Stock in accordance with the relative preferences of each series of Preferred Stock established either by these Restated Articles of Incorporation or in accordance with subdivision III. B. 1. For the purposes of this subdivision, any dissolution, liquidation or winding up which may arise out of or result from the condemnation or purchase of all or a major portion of the properties of the corporation by (i) the United States Government or any authority, agency or instrumentality thereof (ii) a State of the United States or any political subdivision, authority, agency or instrumentality thereof, or (iii) a district, cooperative or other association or entity not organized for profit, shall be deemed to be an involuntary dissolution, liquidation or winding up; and a consolidation, merger or amalgamation of the corporation with or into any other corporation or corporations shall not be deemed to be a dissolution, liquidation or winding up of the corporation, whether voluntary or involuntary.

4. The holders of shares of the Preferred Stock shall have no right to vote in the election of directors or for any other purpose, except as may be otherwise provided by law or by resolutions establishing any series of Preferred Stock in accordance with subdivision III. B. 1. Holders of Preferred Stock shall be entitled to notice of each meeting of shareholders at which they shall have any right to vote, but shall not be entitled to notice of any other meeting of shareholders.

Common Stock

5. Subject to the limitations set forth in subdivisions III. B. 2. (and subject to the rights of any class of stock hereafter authorized), dividends may be paid upon the Common Stock when and as declared by the board of directors of the corporation out of any funds legally available for the payment of dividends.

6. Subject to the limitations set forth in subdivisions III. B. 3. (and subject to the rights of any other class of stock hereafter authorized), upon any dissolution, liquidation or winding up of the corporation, whether voluntary or involuntary, the net assets of the corporation shall be distributed ratably to the holders of the Common Stock.

7. Except as may be otherwise provided by law or by the resolutions establishing any series of Preferred Stock in accordance with subdivision III. B. 1., the holders of the Common Stock shall have the exclusive right to vote for the election of directors and for all other purposes. In the election of directors of the corporation, every holder of record of any share or shares of the Common Stock of the corporation shall have the right to cast as many votes for one candidate as shall equal the number of such shares multiplied by the number of directors to be elected, or to distribute such number of votes among any two or more candidates for such election.

8. Upon the issuance for money or other consideration of any shares of capital stock of the corporation, or of any security convertible into capital stock of the corporation, no holder of shares of the capital stock, irrespective of the class or kind thereof, shall have any preemptive or other right to subscribe for, purchase or receive any proportionate or other amount of such shares of capital stock, or such security convertible into capital stock, proposed to be issued; and the board of directors may cause the corporation to dispose of all or any of such shares of capital stock, or of any such security convertible into capital stock, as and when said board may determine, free of any such right, either by offering the same to the corporation's then shareholders or by otherwise selling or disposing of such shares of other securities, as the board of directors may deem advisable.

ARTICLE IV

A. The business and affairs of the corporation shall be managed by a board of directors. Except as provided in subdivision B. below, the number of members of the board, their classifications and terms of office, and the manner of their election and removal shall be as follows:

1. The number of directors shall be that number, not less than nine or more than thirteen, determined from time to time by resolution adopted by affirmative vote of a majority of the entire board of directors. The directors shall be divided into three classes, designated Class I, Class II, and Class III. Each class shall consist, as nearly as possible, of one-third of the total number of directors. At the 1984 annual meeting of shareholders, Class I directors shall be elected for a one-year term, Class II directors for a two-year term, and Class III directors for a three-year term. At each succeeding annual meeting of shareholders, successors to directors whose terms expire at that annual meeting shall be of the same class as the directors they succeed, and shall be elected for three-year terms. If the number of directors should be changed by resolution of the board of directors, any increase or decrease shall be apportioned among the classes so as to maintain the number of directors in each class as nearly equal as possible, but in no case shall a decrease in the number of directors shorten the term of any incumbent director.

2. A director shall hold office until the annual meeting for the year in which his or her term shall expire and until his or her successor shall have been elected and qualified, subject, however, to prior death, resignation, retirement or removal from office. Any newly created directorship resulting from an increase in the number of directors and any other vacancy on the board of directors, however caused, may be filled by the affirmative vote of a majority of the directors then in office, although less than a quorum, or by a sole remaining director.

3. One or more of the directors may be removed with or without cause by the affirmative vote of the holders of not less than two-thirds of the shares entitled to vote thereon at a meeting of the shareholders called

expressly for that purpose; provided, however, that for as long as the corporation shall have cumulative voting, if fewer than all the directors should be candidates for removal, no one of them shall be removed if the votes cast against his or her removal would be sufficient to elect him or her if then cumulatively voted at an election of the class of directors of which he or she shall be a part.

4. No person, except those persons nominated by the board, shall be eligible for election as a director at any annual or special meeting of shareholders unless a written request that his or her name be placed in nomination shall be received from a shareholder of record entitled to vote at such election by the secretary of the corporation not later than the latter of (a) the thirtieth day prior to the date fixed for the meeting, or (b) the tenth day after the mailing of notice of that meeting, together with the written consent of the nominee to serve as a director.

B. Notwithstanding the provisions of subdivision A. above, whenever the holders of any one or more classes of the capital stock of the corporation shall have the right, voting separately as a class or classes, to elect directors at an annual or special meeting of shareholders, the election, term of office, filling of vacancies and other features of such directorships shall be governed by the provisions of these Restated Articles of Incorporation applicable thereto. Directors so elected shall not be divided into classes unless expressly provided by such provisions, and during their prescribed terms of office, the board of directors shall consist of such directors in addition to the directors determined as provided in subdivision A. above.

C. This Article IV may not be repealed or amended in any respect unless such action shall be approved by the affirmative vote of the holders of not less than two-thirds of the shares entitled to vote at an election of directors determined as provided in subdivision A. above, at a meeting of the shareholders called expressly for that purpose.

ARTICLE V

A. For purposes of this Article V:

1. The term "Affiliate", as used to indicate a relationship with a specified "Persons" (as hereinafter defined), shall mean a Person that directly or indirectly through one or more intermediaries, controls, or is controlled by, or is under common control with, the Person specified.

2. The term "Associate", as used to indicate a relationship with a specified Person, shall mean (a) any Person (other than the corporation) of which such specified Person is a director, officer, partner, trustee, guardian, fiduciary or official or is, directly or indirectly, the beneficial owner of 10% or more of any class of equity securities or any beneficial interest, (b) any Person who is a director, officer, partner, trustee, guardian, fiduciary or official or is, directly or indirectly, the beneficial owner of 10% or more of any class of equity securities or any beneficial interest of or in such specified Person (other than the corporation), and (c) any relative or spouse of such specified Person, or any relative of such spouse who has the same home as such specified Person.

3. The term "Beneficial Owner" shall have the meaning set forth in Rule 13d-3 of the General Rules and Regulations under the Securities Exchange Act of 1934 as in effect on April 9, 1984; provided, however, that, notwithstanding the provisions of such Rule, a Person shall be deemed to be the Beneficial Owner of any share of the capital stock of the corporation that such Person shall have the right to acquire at any time pursuant to any agreement, contract, arrangement or understanding, or upon exercise of conversion rights, warrants or options, or otherwise, and any such share of capital stock shall be deemed to be outstanding for purposes of subdivision V.A.9.

4. The term "Business Transaction" shall include, without limitation, (a) any merger, consolidation or plan of exchange of the corporation, or any Person controlled by or under common control with the corporation, with or into any "Related Person" (as hereinafter defined), (b) any merger, consolidation or plan of exchange of a Related Person with or into the corporation or any Person controlled by or under common control with the corporation, (c) any sale, lease, exchange, transfer or other disposition (in one transaction or a series of transactions) including without limitation a mortgage or any other security device, of all or

any "Substantial Part" (as hereinafter defined) of the property and assets of the corporation, or any Person controlled by or under common control with the corporation, to or with a Related Person, (d) any purchase, lease, exchange, transfer or other acquisition (in one transaction or a series of transactions), including without limitation a mortgage or any other security device, of all or any Substantial Part of the property and assets of a Related Person, by or with the corporation or any Person controlled by or under common control with the corporation, (e) any recapitalization of the corporation that would have the effect of increasing the voting power of a Related Person, (f) the issuance, sale, exchange or other disposition of any securities of the corporation, or of any Person controlled by or under common control with the corporation, by the corporation or by any Person controlled by or under common control with the corporation, (g) any liquidation, spinoff, splitoff, splitup or dissolution of the corporation, and (h) any agreement, contract or other arrangement providing for any of the transactions described in this subdivision.

5. The term "Continuing Director" shall mean a director who was a director of the corporation on April 9, 1984 and a director who shall become a director subsequent thereto whose election, or whose nomination for election by the shareholders, shall have been approved by a vote of a majority of the then Continuing Directors.

6. The term "Highest Purchase Price" shall mean, with respect to the shares of any class or series of the capital stock of the corporation, the highest amount of consideration paid by a Related Person for a share of the same class and series at any time regardless of whether the share was acquired before or after such Related Person became a Related Person; provided, however, that the Highest Purchase Price shall be appropriately adjusted to reflect the occurrence of any reclassification, recapitalization, stock split, reverse stock split or other readjustment in the number of outstanding shares of that class or series, or the declaration of a stock dividend thereon. The Highest Purchase Price shall include any brokerage commissions, transfer taxes and soliciting dealers' fees paid by such Related Person with respect to any shares of the capital stock acquired by such Related Person.

7. The term "Other Consideration" shall include, without limitation, capital stock to be retained by the shareholders of the corporation in a Business Transaction in which the corporation shall be the survivor.

8. The term "Person" shall mean any natural person, corporation, partnership, trust, firm, association, government, governmental. agency or any other entity whether acting in an individual, fiduciary or other capacity.

9. The term "Related Person" shall mean (a) any Person which, together with its Affiliates and Associates, shall be the Beneficial Owner in the aggregate of 10 percent or more of the capital stock of the corporation, and (b) any Affiliate or Associate (other than the corporation or a wholly owned subsidiary of the corporation) of any such Person. Two or more Persons acting in concert for the purpose of acquiring, holding or disposing of the capital stock of the corporation shall be deemed to be a "Related Person". A Related Person shall be deemed to have acquired a share of capital stock at the time when such Related Person became the Beneficial Owner thereof. With respect to the shares of the capital stock of the corporation owned by any Related Person, if the price paid for such shares cannot be determined by a majority of the Continuing Directors, the price so paid shall be deemed to be the market price of the shares in question at the time when such Related Person became the Beneficial Owner thereof.

10. The term "Substantial Part" shall mean 10% or more of the fair market value of the total assets of a Person, as reflected on the most recent balance sheet of such Person available to the Continuing Directors on the date of mailing of the notice of the meeting of shareholders called for the purpose of voting with respect to a Business Transaction involving the assets constituting any such Substantial Part.

B. The corporation shall not enter into any Business Transaction with a Related Person or in which a Related Person shall have an interest (except proportionately as a shareholder of the corporation) without first obtaining both (1) the affirmative vote of the holders of not less than two-thirds of the outstanding shares of the capital stock of the corporation not held by such Related Person, and (2) the determination of a majority of the Continuing Directors that the cash or fair market value of the property, securities or Other Consideration to be received per share by the holders, other than such Related Person, of the shares of each class or series of the

capital stock of the corporation in such Business Transaction shall not be less than the Highest Purchase Price paid by such Related Person in acquiring any of its holdings of shares of the same class or series, unless the Continuing Directors by a majority vote shall either (a) have expressly approved the acquisition of the shares of the capital stock of the corporation that caused such Related Person to become a Related Person, or (b) have expressly approved such Business Transaction.

C. For the purposes of this Article V, a majority of the Continuing Directors shall have the power to make a good faith determination, on the basis of information known to them, of: (1) the number of shares of capital stock of the corporation of which any Person shall be the Beneficial Owner, (2) whether a Person is an Affiliate or Associate of another Person, (3) whether a Person has an agreement, contract, arrangement or understanding with another Person as to the matters referred to in subdivision V.A.3. or clause (h) of subdivision V.A.4., (4) the Highest Purchase Price paid by a Related Person for shares of any class or series of the capital stock, (5) whether the assets subject to any Business Transaction constitute a Substantial Part, (6) whether any Business Transaction is one in which a Related Person has an interest (except proportionately as a shareholder of the corporation), and (7) such other matters with respect to which a determination may be required under this Article V.

D. In determining whether to give their approval as provided in subdivision V.B., the Continuing Directors shall give due consideration to all relevant factors involved, including, without limitation, (1) the value of the corporation in a freely negotiated transaction and its future value as an independent entity, (2) the recognition of gain or loss to the corporation for tax purposes or the postponement of such recognition in a tax-free transaction, (3) the anticipated developments of the business of the corporation not yet reflected in the price of its shares, and (4) the impact on employees, customers, suppliers and the public generally within the geographical area it serves.

E. This Article V may not be repealed or amended in any respect unless such action shall be approved by the affirmative vote of the holders of not less than two-thirds of the capital stock of the corporation not held by a Related Person at a meeting of the shareholders called expressly for that purpose.

ARTICLE VI

No director of the corporation shall be personally liable to the corporation or its shareholders for monetary damages for conduct as a director; provided that this Article VI shall not eliminate the liability of a director for any act or omission for which such elimination of liability is not permitted under the Oregon Business Corporation Act. No amendment to the Oregon Business Corporation Act that further limits the acts or omissions for which elimination of liability is permitted shall affect the liability of a director for any act or omission which occurs prior to the effective date of such amendment.

ARTICLE VII

The corporation shall indemnify to the fullest extent then permitted by law any person who is made, or threatened to be made, a party to any threatened, pending or completed action, suit or proceeding, whether civil, criminal, administrative, investigative or otherwise (including an action, suit or proceeding by or in the right of the corporation) by reason of the fact that the person is or was a director or officer of the corporation or is or was serving at the request of the corporation as a director or officer of another corporation, partnership, joint venture, trust or other enterprise against all judgments, amounts paid in settlement, fines and such expenses (including attorneys' fees), actually and reasonably incurred in connection therewith. This Article shall not be deemed exclusive of any other provisions for indemnification of directors and officers that may be included in any statute, bylaw, agreement, vote of shareholders or directors or otherwise, both as to action in any official capacity and as to action in another capacity while holding an office.

As amended June 3, 2008.

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Exhibit B

Project Description

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The details normally discussed in this Exhibit are included in the **Project Description and OAR Division 27 Compliance** document, which can be found at the beginning of this Request for Amendment to Site Certificate.

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FIGURES

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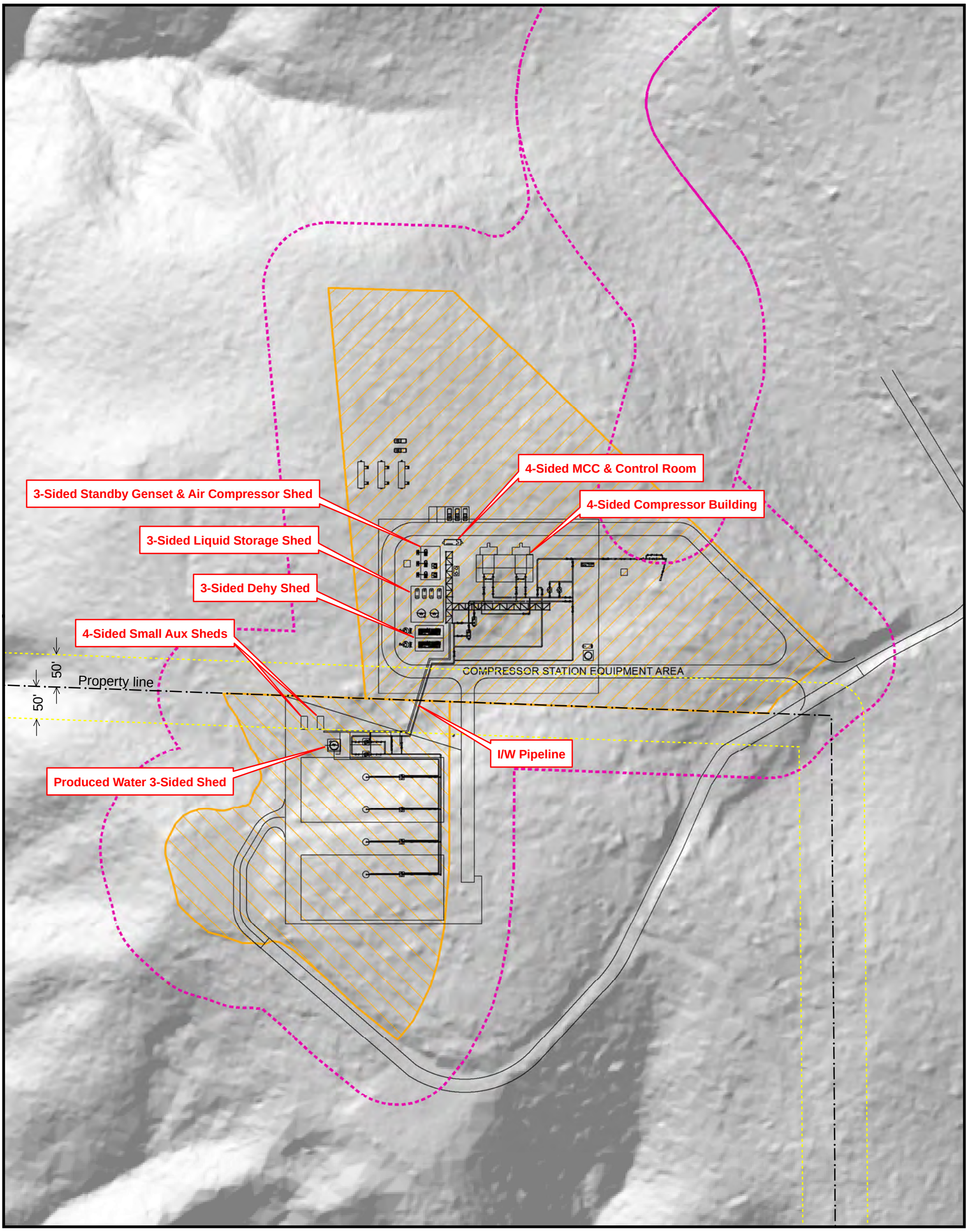


NW Natural

North Mist Expansion Project

Request for Amendment No. 11

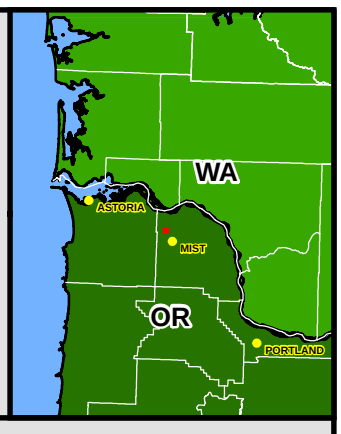
Columbia County, OR
November 2015

Figure B-1
NMCS & Well Pad

Preliminary Route 200 feet Wide Study Corridor

Proposed North Mist Compressor Station

Proposed Well Pad



NAD_1927_StatePlane_Oregon_North_FIPS_3601

0 37.5 75 150 225 300 Feet

Data Source: NW Natural North Mist Expansion Project

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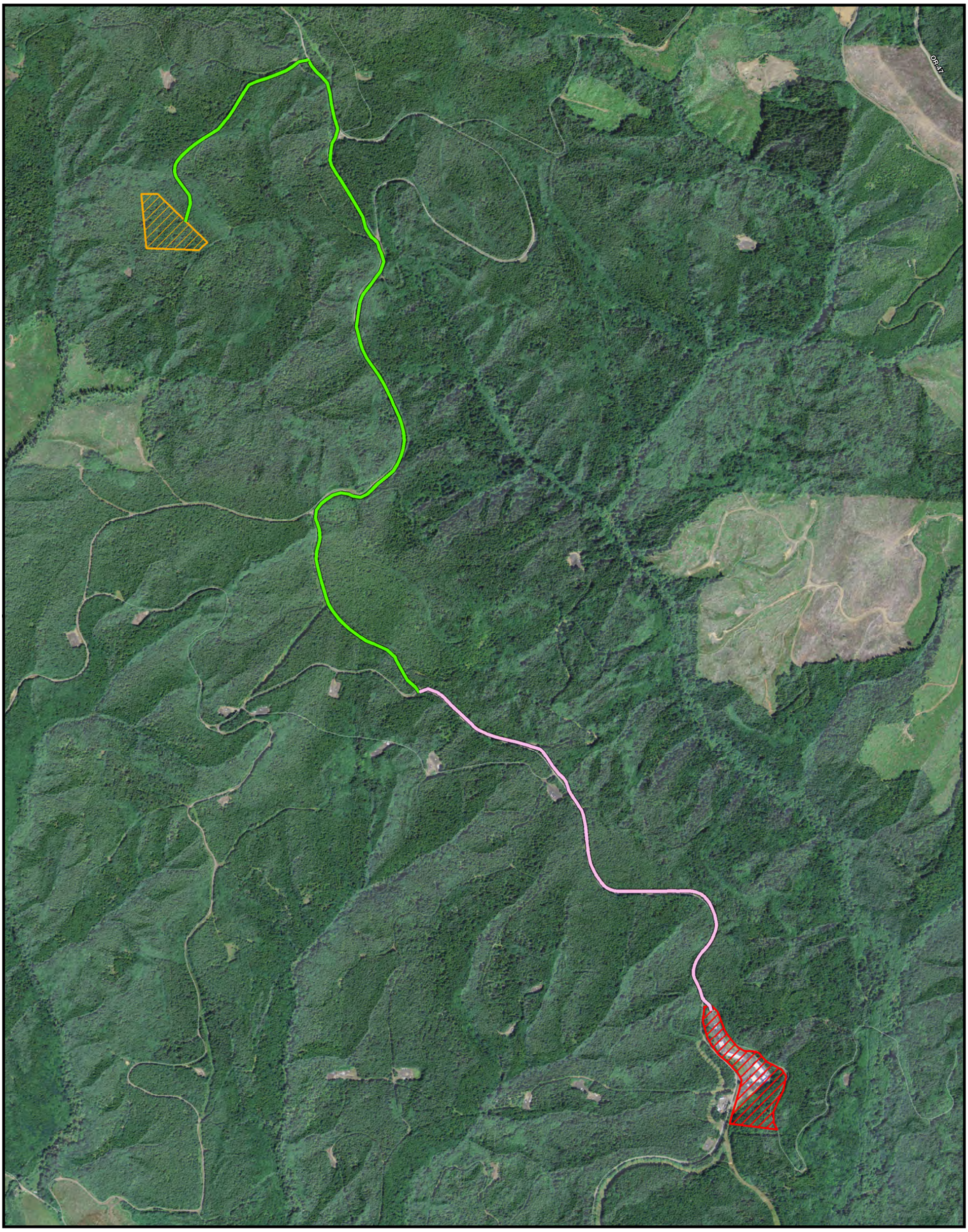


NW Natural

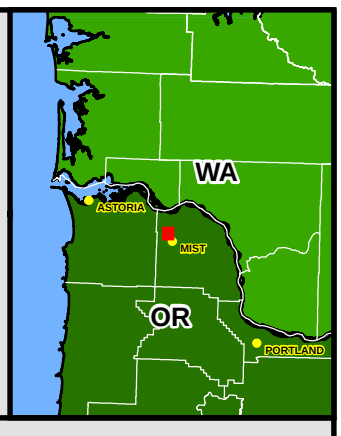
North Mist Expansion Project

Request for Amendment No. 11

Columbia County, OR
November 2015

Figure B-2
Conduit Locations

- Proposed Conduit
- Existing Conduit
- Miller Station
- Proposed North Mist Compressor Station

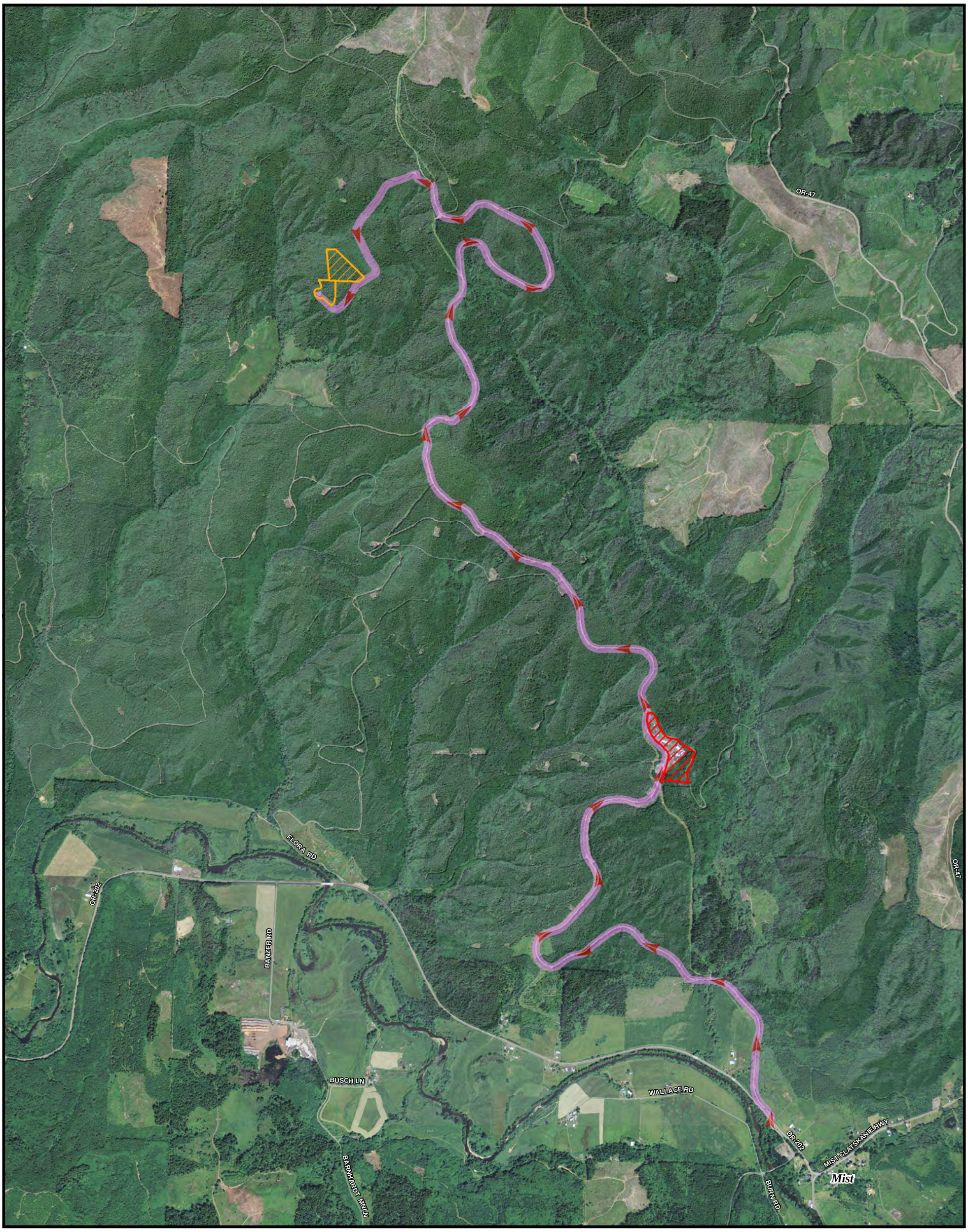


NAD_1927_StatePlane_Oregon_North_FIPS_3601

0 0.075 0.15 0.3 0.45 0.6 Miles

Data Source: NW Natural North Mist Expansion Project

I:\GISprojects\Emerald\Emerald\workspace\2015.04.09 NMEP Amendment 11 B-2 Conduit Locations.mxd 4/9/2015



NW Natural

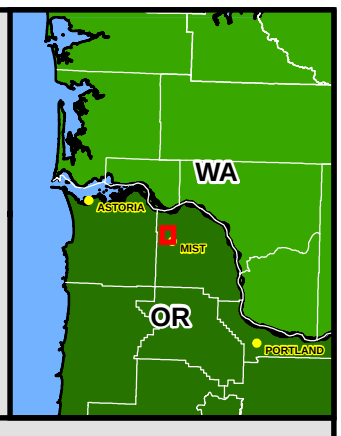
North Mist Expansion Project

Request for Amendment No. 11

Columbia County, OR
November 2015

Figure B-3
Access Route

- Access Road to Proposed Compressor Station
- Miller Station
- Proposed North Mist Compressor Station
- Proposed Well Pad



NAD_1927_StatePlane_Oregon_North_FIPS_3601

0 0.125 0.25 0.5 0.75 1 Miles

Data Source: NW Natural North Mist Expansion Project

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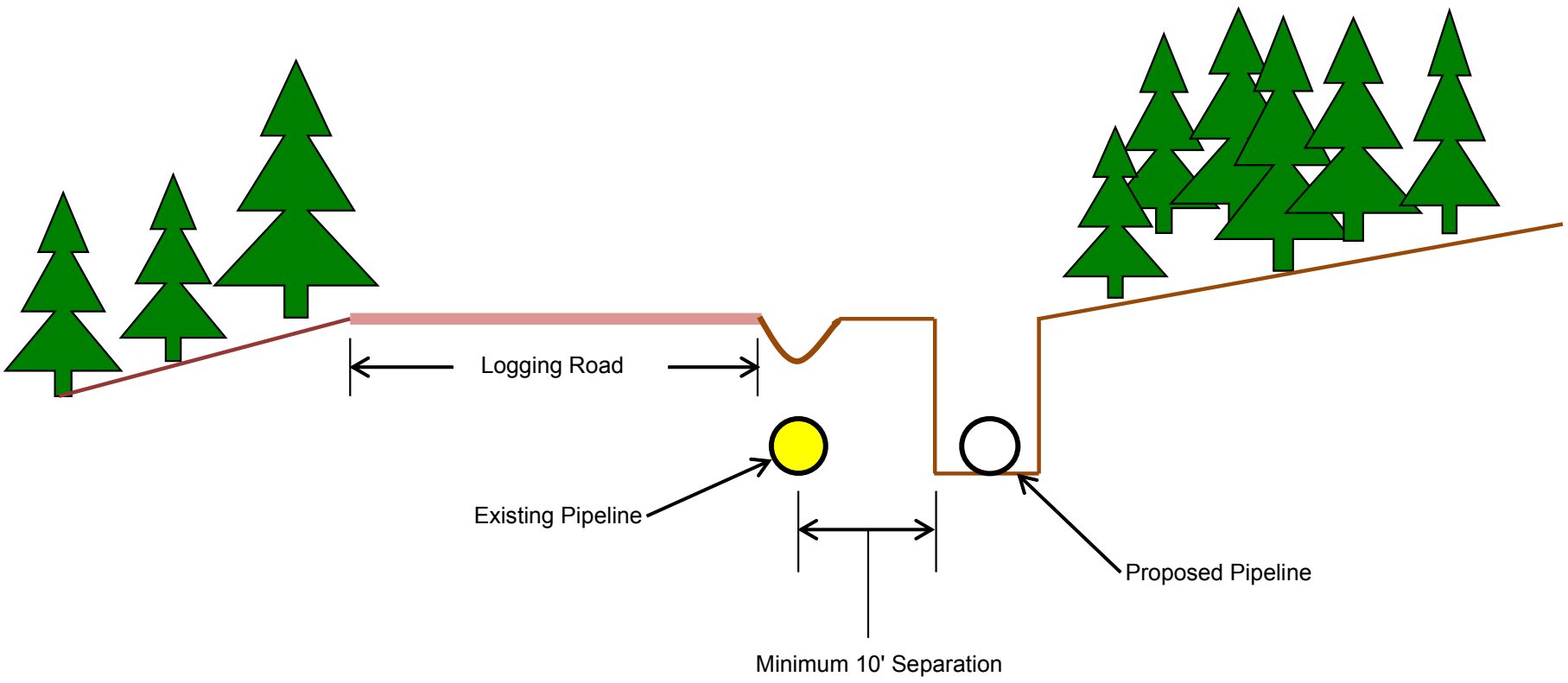

NW Natural

North Mist Expansion Project

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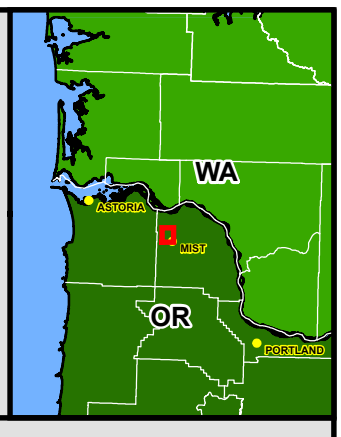
Figure B-4
Forest Area Construction Profile
Existing Pipeline



Data Source: NW Natural North Mist Expansion Project

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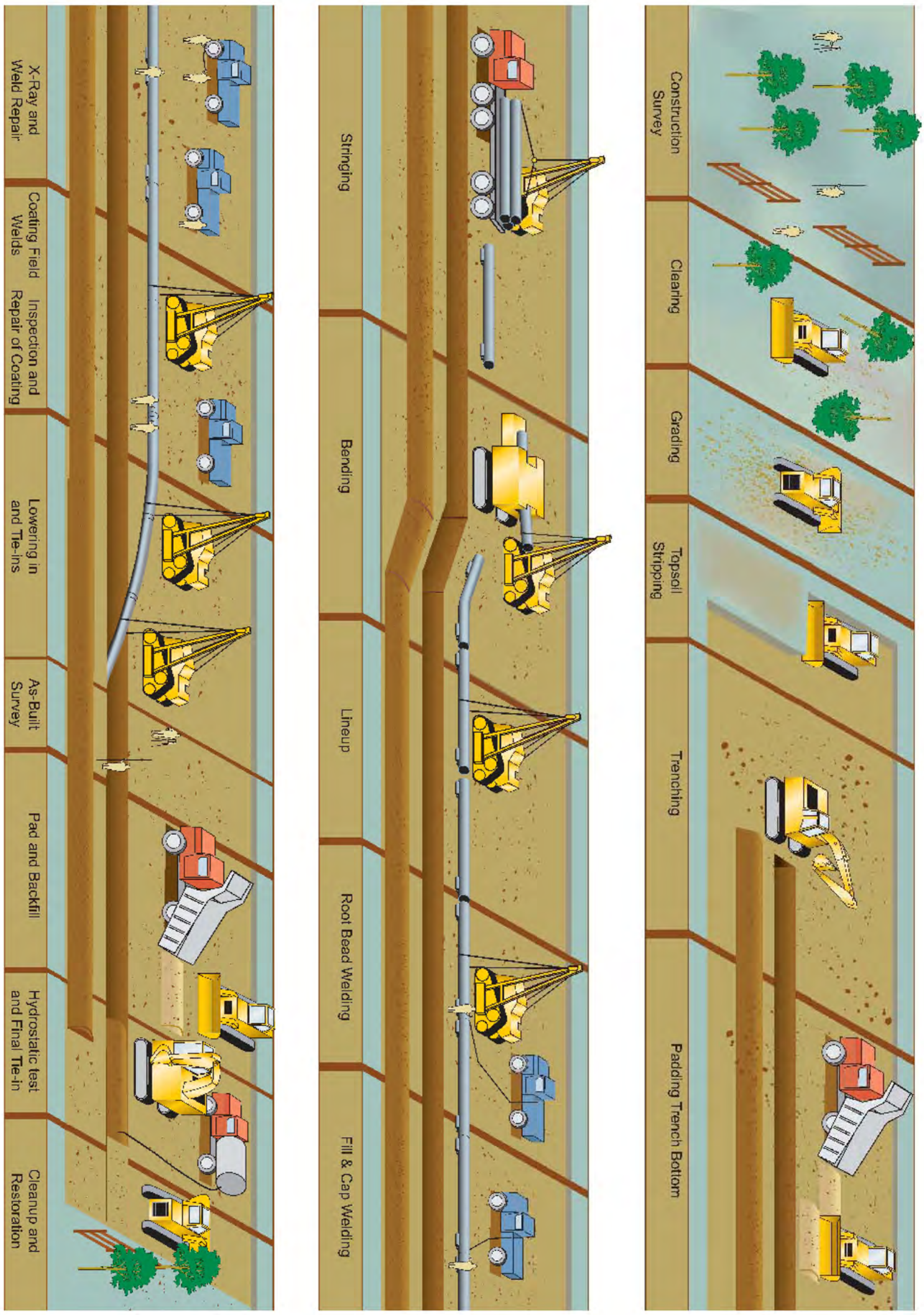


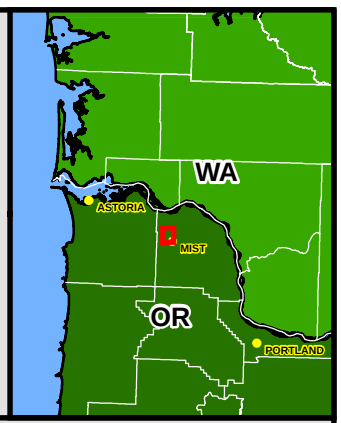
NW Natural

North Mist Expansion Project

Request for Amendment No. 11

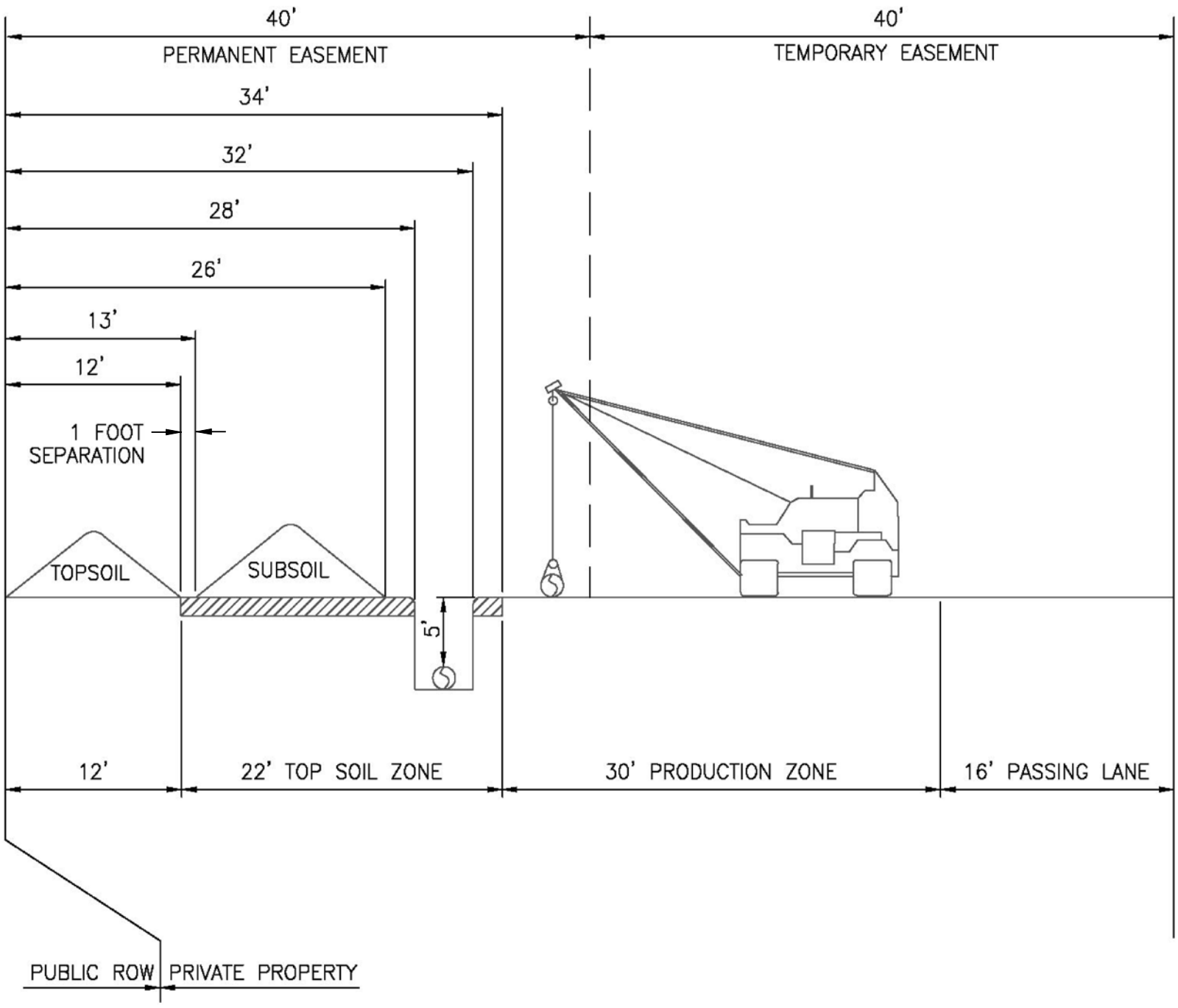
Columbia County, OR
November 2015

Figure B-5
Overall NMTP
Construction Typical



Data Source: NW Natural North Mist Expansion Project

I:\GISprojects\Emerald\Emerald\workspace\2015.04.21 NMEP Amendment 11 B-5 Overall NMTP Construction Typical.mxd 4/21/2015



NOTES:

1. FOR AGRICULTURAL AREAS.
2. EXCAVATED SUBSOIL SHALL NOT BE MIXED WITH STRIPPED TOPSOIL.
3. STORE TOPSOIL SEPARATELY FROM SUBSOIL WITH A MINIMUM 1 FOOT SEPARATION.
4. THE CONSTRUCTION WORK AREA MAY EXCEED A WIDTH OF 80 FEET FOR CERTAIN SITE-SPECIFIC CONDITIONS AS IDENTIFIED IN THE CONSTRUCTION LINE LIST OR BY OTHER DESIGNATED PROJECT PROCEDURES.
5. THE ARRANGEMENT OF THE PERMANENT EASEMENT AND THE TEMPORARY WORK SPACE MAY VARY AND THE LOCATION OF THE PIPELINE WITHIN THE PERMANENT EASEMENT MAY VARY, AS DETERMINED BY NW NATURAL.

NW Natural

North Mist Expansion Project

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Columbia County, OR
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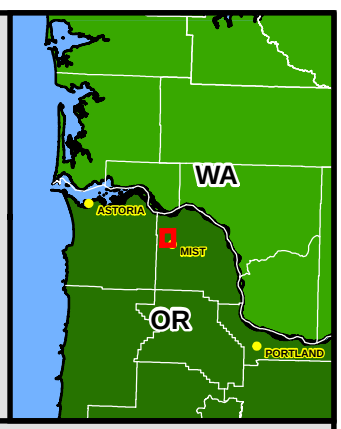
Figure B-6
NMTP Construction Typical



Data Source: NW Natural North Mist Expansion Project

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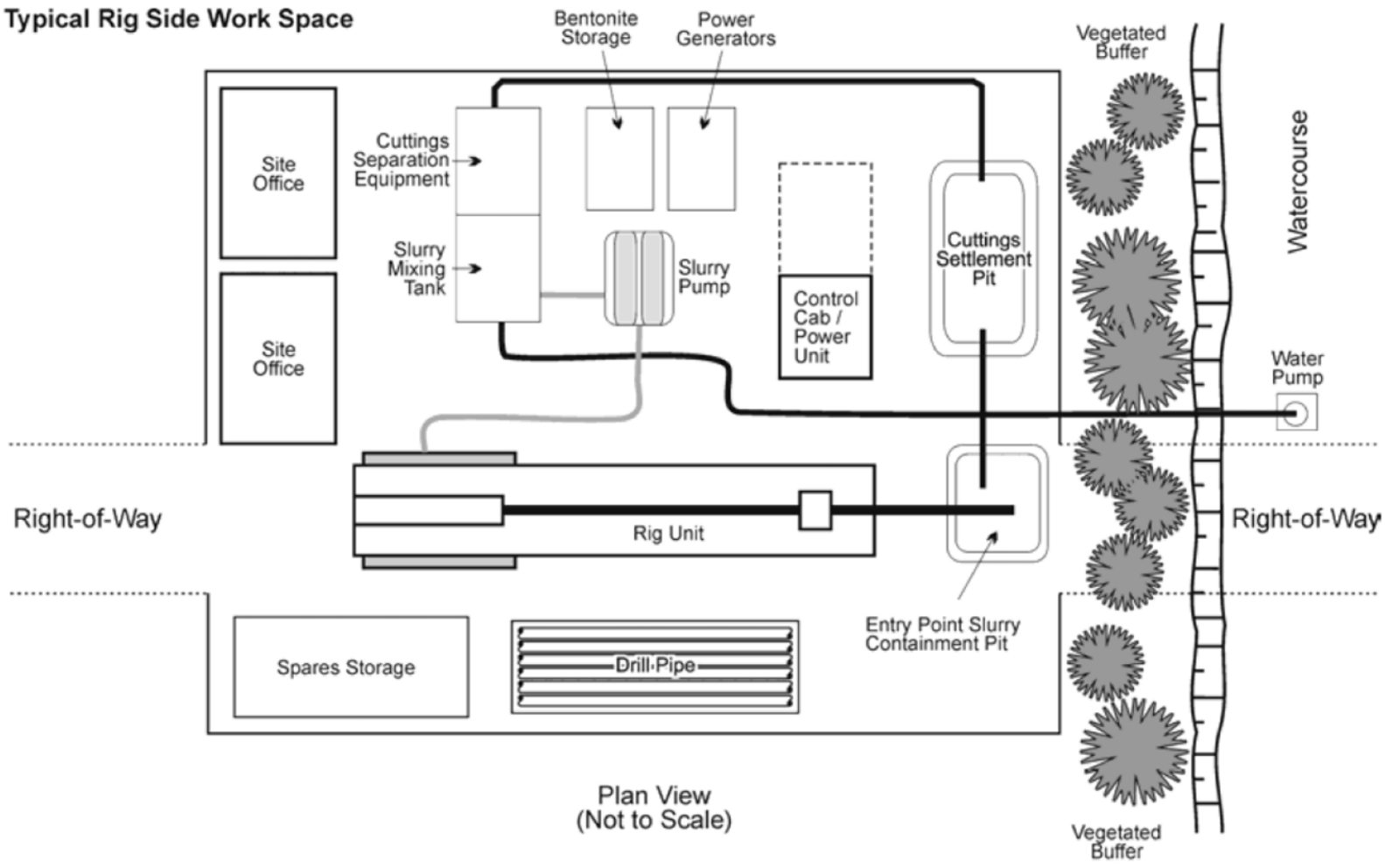
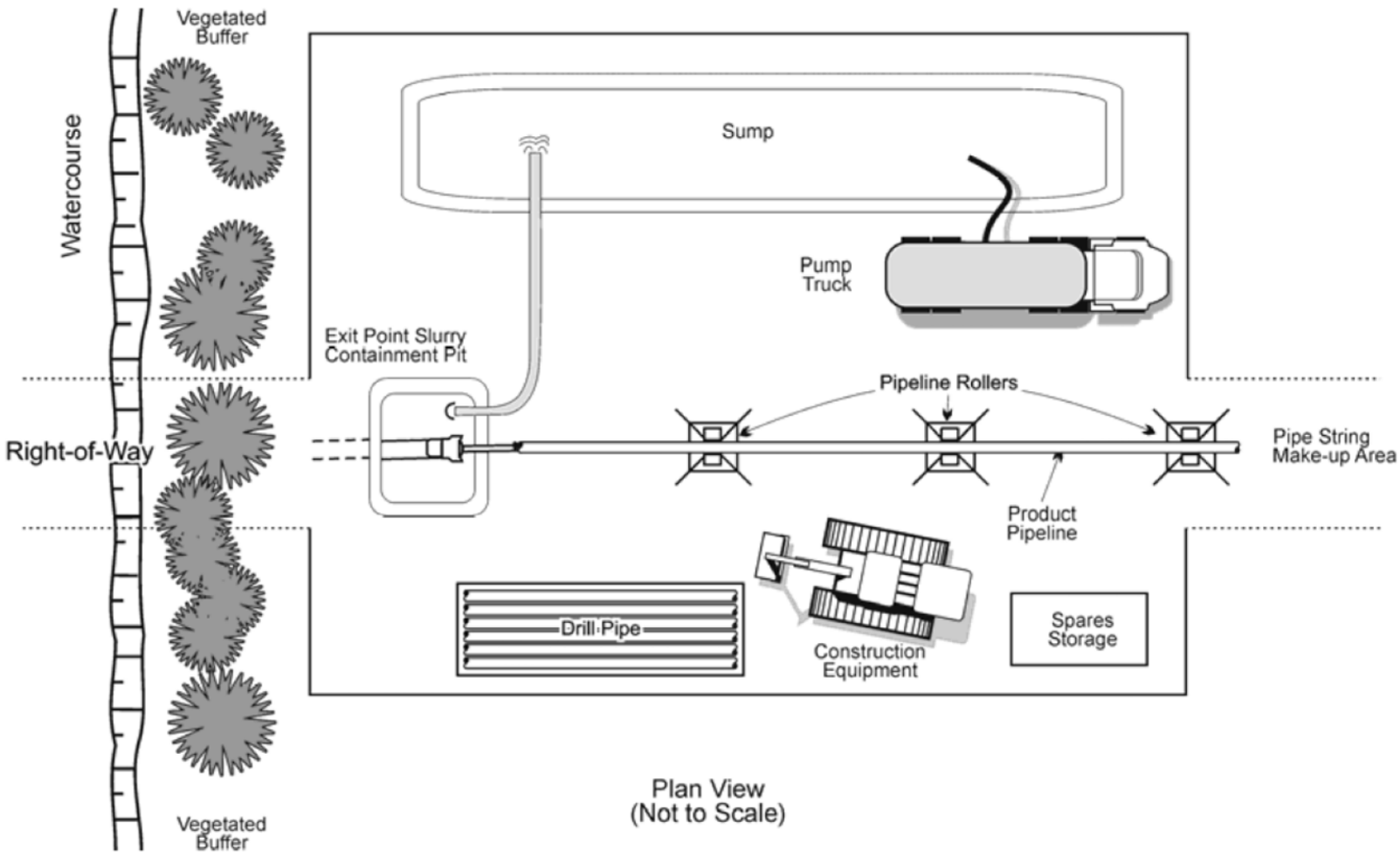
(A) Typical Rig Side Work Space



Plan View
(Not to Scale)

(B) Typical Pipe Side Layout



Plan View
(Not to Scale)

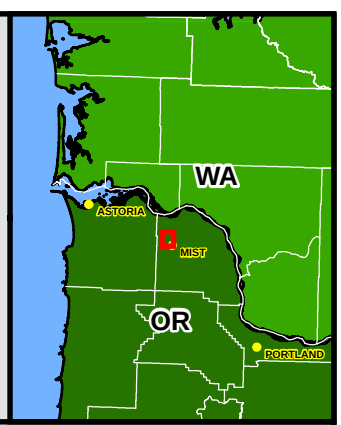
Source: Adapted from ASCE 1996

NW Natural
North Mist Expansion Project

Request for Amendment No. 11

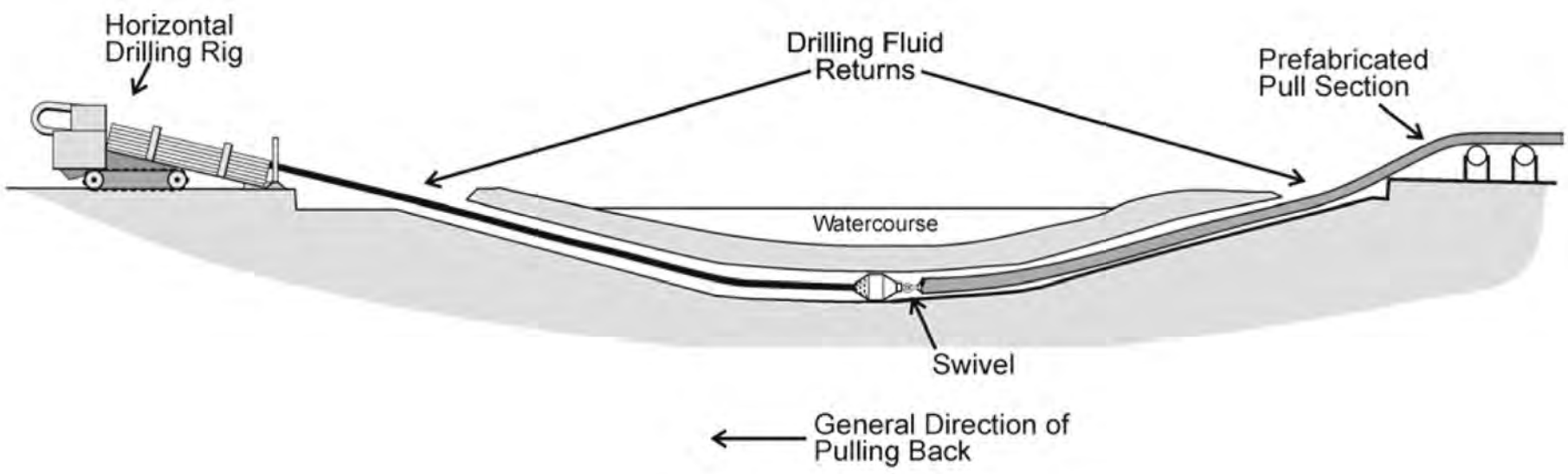
Columbia County, OR
November 2015

Figure B-7
HDD Bore Pad Workspace and Site Layout Construction Typical



Data Source: NW Natural North Mist Expansion Project

I:\GISprojects\Emerald\Emerald\workspace\2015.04.09 NMEP Amendment 11 B-7 HDD Bore Pad Workspace and Site Layout Construction Typical.mxd 4/9/2015



Profile
(Not to Scale)

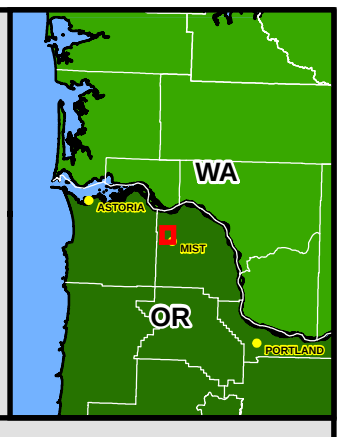
Source: Adapted from ASCE 1996, TERA 1998

NW Natural
North Mist Expansion Project

Request for Amendment No. 11

Columbia County, OR
November 2015

Figure B-8
HDD Bore Profile
Construction Typical



Data Source: NW Natural North Mist Expansion Project

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EXHIBIT B-1:

PUBLIC UTILITY COMMISSION OF OREGON STAFF REPORT

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ITEM NO. 1

PUBLIC UTILITY COMMISSION OF OREGON
STAFF REPORT
PUBLIC MEETING DATE: October 14, 2014

REGULAR **X** **CONSENT** ____ **EFFECTIVE DATE** **October 15, 2014**

DATE: October 2, 2014

TO: Public Utility Commission

FROM: Erik Colville

THROUGH: Jason Eisdorfer and Aster Adams

SUBJECT: NORTHWEST NATURAL: (Advice No. 14-7) Adds Schedules 90 and 91 for Firm Storage Service with No-Notice Withdrawal, and Firm Storage Service with No-Notice Withdrawal and Direct Connection to South Mist Pipeline.

STAFF RECOMMENDATION:

Subject to the Schedule 90 Conditions of Approval presented in Attachment 1, Staff recommends that NW Natural's Application for Waiver of Less Than Statutory Notice (LSN) be approved along with its request for approval of Advice No. 14-7 (Schedules 90 and 91), as revised September 26, 2014, to become effective October 15, 2014.

DISCUSSION:

Northwest Natural Gas Company (NWN) filed Advice No. 14-7 on May 21, 2014, proposing to add Schedules 90 and 91 for Firm Storage Service with No-Notice Withdrawal, and Firm Storage Service with No-Notice Withdrawal and Direct Connection to South Mist Pipeline. Supplements A and B were filed September 26, 2014. Supplement A also included an application for an LSN. Supplement C was filed September 30, 2014, and Supplement D was filed October 2, 2014.

The purpose of this filing is to request approval for new intrastate no-notice withdrawal storage service to be made available under two new rate schedules, the availability of which is dependent upon the customer location relative to such customer's access to certain NWN pipeline facilities. The two rate schedules are: Rate Schedule 90 "Firm Storage Service with No-Notice Withdrawal" and Rate Schedule 91 "Firm Storage Service with No-Notice Withdrawal and Direct Connection to South Mist Pipeline." In summary, these rate schedules would provide NWN an ability to deliver a unique

storage service to customers that have agreed to pay all costs associated with the service (including the necessary capital additions). In providing such service, NWN would recover its cost of service, including its authorized cost of capital.

The only customer known at this time is Portland General Electric (PGE). The approval of Schedule 90 by the Public Utility Commission of Oregon (OPUC) is a condition precedent under the terms of a Precedent Agreement between NWN and PGE for service to the Port Westward 2 generating plant. The Precedent Agreement between NWN and PGE documents an agreement that the Schedule 90 Service Agreement with PGE will be for a 30-year initial term, with three unilateral elective 10-year extensions. In the case of PGE, the new Non-Core Mist Storage facilities to be constructed are known as the North Mist expansion. In the interim before the North Mist expansion is operational, NWN will provide PGE with no-notice storage service utilizing existing Mist storage capacity and deliverability.

The North Mist expansion proposed to serve PGE will not be shared with or used by core ratepayers. NWN notes that:

- Revenues are not subject to sharing under Schedule 185 (optimization revenue sharing); and

- The new storage capacity built in order to serve PGE is not subject to recall for core ratepayer use.

NWN's analysis supporting its 2014 Integrated Resource Plan (IRP) shows that an additional build-out of storage capacity at North Mist for core ratepayers is a component of the least cost portfolio in all future scenarios, although the timing of that build-out varies significantly by scenario. The earliest date on which expanded capacity would be needed from North Mist for core ratepayers would be 2020. The expansion proposed for PGE in the North Mist Field will involve only a portion of the available resources. If North Mist's Adams reservoir is built out for PGE under this tariff, sufficient capacity remains in the other reservoirs that can be built out to meet forecast requirements for core ratepayers. The possibility for core ratepayer need in the future for storage capacity at North Mist is a driver for the Schedule 90 Conditions of Approval discussed below and presented in Attachment 1.

<u>Utility Service</u>

Staff considered in its evaluation of this filing is that of delineating what may be considered a utility service. This matter is addressed in the OPUC enabling statutes and case precedent. These statutes and case precedent support the conclusion that no-

notice storage service falls within the definition of utility service. ORS 756.010(8) provides that the term "service" "is used in its broadest and most inclusive sense and includes equipment and facilities related to providing the service or the product served." In the instance of PGE as the initial customer for Schedule 90 service, PGE will be an industrial customer, located within NWN's service territory, purchasing gas storage and transportation services to power its Port Westward 2 plant. As such, the offering of no-notice storage service falls well within this broad definition. Staff concludes that Schedules 90 and 91 may be offered as utility services.

Staff's Review Criteria

Criteria Staff considered in reviewing and recommending whether or not to approve NWN's request to provide no-notice storage service include:

a. Are the tariffs structured to apply to all qualified customers?

b. Do the rates proposed cover the costs for offering the service or is it a subsidized rate?

c. Is there a net benefit to other ratepayers?

Staff's Analysis

Staff's review of the no-notice storage service tariff filings included the filings themselves, the cost of service approach, and the revised tariff pages filed in response to Staff and other party input. Staff did not explore alternative no-notice storage service approaches because NWN's filing asks for approval of a specific approach. Staff's analysis of the review criteria is as follows:

a. Are the tariffs structured to apply to all qualified customers?

In OPUC Data Request 4 Staff requested that NWN provide support for the Storage Charge/Formula Rate in Schedule 90 and the rates in Schedule 91. Staff's findings from review of NWN's data request response follow.

Schedule 90

The formula rate included in Schedule 90's Service Agreement uses the standard total cost of service formula approach used by utilities for rate making purposes (revenue requirement and cost of service studies). As a result, Staff concludes the Storage

Charge/Formula Rate is applicable to all similarly situated customers and qualified customers.

Schedule 91

The Schedule 91 rate structure is identical to the rate structure for Schedule 80 Firm Storage Service,[1] with the exception of a provision for adjusting the maximum stated charges if the requested service requires NWN to make additional facilities investments. In this case, NWN will require that the requesting customer pay the full cost of any such investment. As a result, customers that do not request additional storage facility investments will all be covered by the proposed rates. Customers requesting additional storage facility investments will also all be covered by the proposed rates, with additional charges to pay the full cost of any such investments.

Staff was concerned with the provision included on page 1 of the tariff related to new storage capacity development. There was no detailed structure presented in the filing for the terms of a binding agreement for Mist expansion, or how the rate would be structured to ensure core ratepayers do not subsidize a Mist expansion. Having no specific binding agreement terms or rate structure would leave Staff with nothing specific to review or the Commission to approve. To avoid attempting to structure in this tariff how a possible future storage capacity development might occur, Staff recommended and NWN agreed to include in its revised Schedule 91 tariff filing, that new storage capacity development is subject to Commission approval before offering the service.

Staff concludes the Schedule 91 tariff, as revised, applies to all similarly situated and qualified customers. For those customers requesting additional storage capacity development, NWN will seek Commission approval before offering the service.

b. Do the rates proposed cover the costs for offering the service or is it a subsidized rate?

A key consideration in answering this question is to analyze the rates proposed by NWN, given that the rate schedules are for an “above-the-line” service.[2] The answer to this question involves a comparison of NWN incremental costs associated with these services as compared to the revenues received. A rate is subsidized if the rate does

[1] NWN Advice No. 14-4 Schedule 80 Firm Storage Service, dated February 28, 2014, identified that Schedule 80 first went into effect on November 23, 2005, on an experimental basis.
[2] “Above-the-line” is understood by Staff to mean that the service is provided under NWN’s regulated tariffs and utilizes the financial assets, plant, and human resources with which it provides other tariff-based services.

not fully recover the incremental costs associated with the service. In OPUC Data Request 4, Staff requested NWN to provide support for the Storage Charge/Formula Rate in Schedule 90 and the rates in Schedule 91. Staff's findings from review of NWN's data request response follow.

Schedule 90

As the tariff is structured Schedule 90 customers will be billed a monthly per dekatherm (Dth) storage charge and a monthly actual fuel use charge.

The formula rate included in Schedule 90's Service Agreement uses the standard total cost of service formula approach used by utilities for rate making purposes (revenue requirement and cost of service studies). The formula matches all of the costs of Schedule 90 to their revenue requirement. Customers who take service under Schedule 90 will pay their proportional share of the cost of service; therefore, it is intended that the total capital, administrative and general, and operation and maintenance expenses of the North Mist expansion will be passed onto customers of Schedule 90 only and will not be allocated to core utility ratepayers.

While the Storage Charge/Formula Rate uses the standard total cost of service formula approach used in ratemaking Staff and parties were concerned that all applicable service offering development, operation and maintenance expenses, and administrative and general expenses were not captured in the formula "G" factors. In response to these concerns, NWN expanded the description of the formula "G" factors to specifically identify the categories of expenses included, and added a formula "G4" factor to capture prudently incurred expenses that are not allocable to pipeline, compressor, or reservoir cost elements. The need for relative certainty that all applicable expenses will be captured in the formula rate is a driver for the Schedule 90 Conditions of Approval discussed below and presented in Attachment 1.

Staff concludes that with the additions related to the formula "G" factors, and the Schedule 90 Conditions of Approval, the Schedule 90 Storage Charge/Formula Rate will cover the costs for offering the service and it will not be subsidized by other ratepayers.

Schedule 91

As the tariff is structured Schedule 91 customers will be billed a monthly per Dth charge for deliverability reservation, capacity, and overrun. In addition, the customer will be billed monthly for monthly actual fuel use.

The rate structure proposed for Schedule 91 is intended to be the FERC approved rates adopted for Schedule 80 Firm Storage Service. After filing the proposed Schedule 91, NWN became aware that, as proposed, Schedule 91 did not reflect the updated February 11, 2014, FERC approved rates that are shown in Schedule 80.[3] A revised filing of the Schedule 91 tariff by NWN corrected this discrepancy.

The Schedule 91 rate structure is identical to the rate structure for Schedule 80 service, with the exception of a provision for adjusting the maximum stated charges if the requested service requires NWN to undertake additional storage capacity development. In this case, NWN will require that the requesting customer pay the full cost of any such development, and obtain Commission approval for the new storage capacity development before offering the service.

Staff concludes that Schedule 91 rates cover the costs for offering the service and avoid subsidies from other ratepayers to the same extent as Schedule 80 rates do. Staff's finding hinged upon NWN's revision to the Schedule 91 tariff filing that new storage capacity development must be brought to the Commission for approval before the service is offered.

c. Is there a net benefit to other ratepayers?

NWN's proposed no-notice storage service could be offered as either a utility service or an unregulated service. Because NWN proposes to offer the service as an "above-the-line" service, other ratepayers must not only be protected from the service offerings, but must also receive a net benefit from the services.

Staff and NWN (in its response to OPUC Data Request 9) identified the following net benefits to other ratepayers from the proposed Schedule 90 and Schedule 91 services:

- Certain of NWN's overhead costs of constructing capital projects will be recoverable from Schedule 90 customers, through an allocation of construction overhead costs to the capital investments made to provide the service. This relieves other ratepayers from bearing costs that otherwise would be allocated to other utility projects, but are now in part allocated to the capital costs paid specifically by the Schedule 90 customer;

- Schedule 91 service will generate revenues that will be shared with other ratepayers through Schedule 185 (optimization revenue sharing), providing a net benefit to those other ratepayers;

[3] See NWN OPUC Advice 14-4 dated February 28, 2014, approving Rate Schedule 80 revisions effective April 1, 2014.

- Schedules 90 and 91 will create the potential for new large retail customers using certain NWN pipeline facilities thus diluting system fixed costs and providing a net benefit for other ratepayers;

- Schedules 90 and 91 benefit gas-electric utility coordination thereby allowing for more efficient utilization of resources which results in a net benefit to other ratepayers; and

- PGE's customers (many of whom are also NWN customers) will benefit by PGE being able to take advantage of a unique no-notice service for supplying generation to balance loads, at minimum cost.

Staff finds that Schedule 90 and 91 will provide net benefits to other ratepayers.

Schedule 90 Conditions of Approval

Since NWN filed Advice No. 14-7, several meetings between NWN, Staff, Citizens' Utility Board of Oregon and Northwest Industrial Gas Users were held to identify and discuss concerns raised by the filing. Ultimately, the parties' concerns fell into two general categories: (1) The parties wanted to be sure that Schedule 90 customers will bear all costs—both direct and indirect— incurred by NWN to deliver Schedule 90 service; and (2) The parties wanted assurance that NWN core ratepayers have not paid for the assets that will be used to provide Schedule 90 service, and that if they have, ratepayers be adequately compensated for the use of those assets to provide Schedule 90 service.

Through discussions and discovery around these concerns, NWN made or confirmed a number of commitments to the parties regarding Schedule 90 service. To ensure that these commitments are enforceable by the Commission, NWN requested that these commitments be made a part of any Commission order approving Schedule 90 in the form of conditions. The conditions are presented in Attachment 1.

Conclusion

Staff identified three potential paths for going forward:

1. Approve the no-notice storage service tariff filing, as revised by NWN on September 26, 2014;

2. Suspend the no-notice storage service tariff filing and open a brief, focused investigation; or

3. Suspend the no-notice storage service tariff filing and open a contested case docket.

The proposed no-notice storage service falls well within the broad statutory definition. Staff concludes that NWN should be allowed to provide no-notice storage service as a regulated utility service.

Staff finds that Schedule 91 compliments Schedule 90 by providing similar no-notice storage service to customers in the southern portion of the NWN service territory that Schedule 90 provides to those in the northern portion. This insures that these services will be offered to all similarly situated customers of NWN. In addition, offering no-notice storage service is generally seen as a net benefit to ratepayers. Also, Staff's analysis and the discussion above show the proposed no-notice storage service tariff satisfies reasonable regulatory criteria. Therefore, Staff concludes that NWN Advice No. 14-7 for no-notice storage services should be approved as revised September 26, 2014.

PROPOSED COMMISSION MOTION:

Subject to the Schedule 90 Conditions of Approval presented in Attachment 1, NW Natural's application for an LSN be approved along with its request for approval of Advice No. 14-7 (Schedules 90 and 91), as revised September 26, 2014, to become effective October 15, 2014.

Advice No. 14-7 Staff Report
Attachment 1

Schedule 90 Conditions of Approval

Cost Recovery

1. As an overarching principle, NWN is committed that all direct and indirect costs incurred by the Company to provide Schedule 90 service will be allocated to and recovered from Schedule 90 customers. NWN agrees to work collaboratively with the parties and to be subject to future processes for Staff and stakeholder review of accounting entries and supporting documentation to ensure an appropriate cost allocation.

2. The costs of any utility personnel that work on the planning and construction of the non-Core Mist Storage for the provision of RS 90 service will be charged to the RS 90 customers as provided in the customer's agreement. (With respect to PGE, NWN and PGE have agreed to implement this commitment through allocating such costs to PGE as capital. NWN agrees that there will be a credit provided to core customers to offset the costs that would otherwise be in rates, but which are allocated to PGE. NWN will seek to pass that credit through to customers as a one-time credit when the project goes into service, subject to gaining any necessary approvals of the Commission required to affect the credit).

3. In the event that NWN and the applicable Schedule 90 customer determine that, after Schedule 90 service is initiated, utility resources will be used in any way to provide ongoing service to that Schedule 90 customer, NWN will develop a shared services-type agreement that allocates utility costs to the Schedule 90 customer. NWN commits to providing an opportunity for stakeholders to review and comment on such agreement and raise any concerns to the Commission prior to effectiveness of such services-type agreement.

4. NWN will further clarify the costs that will be recoverable from Schedule 90 customers under the general rate formula contained in the service agreement. Specifically, NWN confirms that operation and maintenance activities such as accounting, financial reporting, customer service, communications and monitoring, control room services and general management are included. NWN is currently working with PGE on an amendment to the service agreement that would capture these elements, and NWN will add them to the generic service agreement filed with the Commission as part of its original filing on Schedule 90.

Core Customer Interests in Assets Used to Provide Schedule 90 Service

5. NWN will make appropriate provisions to compensate non-Schedule 90 customers for any use of assets for which they have paid in providing Schedule 90 service. (With respect to PGE's Schedule 90 service, which will be provided through a development of the Adams Pool at North Mist, NWN has confirmed that all costs associated with the Adams Pool have remained in "Construction Work in Progress," and have not affected rates, with one exception. The one exception is that recoverable gas costs associated with the pool have been included in inventories for general customers, included in rate base, and expensed over time at a calendar Weighted Average Cost of Gas or other average-cost rate as used by customers. NWN proposes to negotiate with PGE for PGE's purchase of any remaining recoverable gas at market prices taking into account the quality and location of the gas, and credit general customers as though it was a sale of a rate base item).

6. NWN will continue, through its IRP process, to refine cost estimates, timing, and least-cost planning related to any future expansion of North Mist reservoirs, other than the Adams reservoir, for non-Schedule 90 customers. NWN recognizes that the Staff and stakeholders retain all of their rights to participate in that process and determine their positions on the issues surrounding future expansion of North Mist for non-Schedule 90 customers, and NWN commits to work collaboratively on those issues.

7. NWN commits that in any future proceeding regarding the review for prudence of any expansion or proposed expansion of Mist for non-Schedule 90 customers, it will provide access to information that is required to perform an analysis of the costs that would have been associated with developing the Adams Pool for non-Schedule 90 customers versus the costs of any other pool that is ultimately developed for non-Schedule 90 customers.

8. NWN's determinations related to the use of the Adams Pool may be raised by any party as an issue during the future prudence review related to any expansion or proposed expansion of Mist for non-Schedule 90 customers. All parties would reserve their rights to take any position in that future proceeding with respect to any such issues raised, including the relevance of the other parties' arguments.

EXHIBIT B-2:

OREGON PUBLIC UTILITY COMMISSION MINUTES OF PUBLIC MEETING

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OREGON PUBLIC UTILITY COMMISSION
MINUTES OF PUBLIC MEETING

9:30 a.m.
October 14, 2014
Main Hearing Room
3930 Fairview Industrial Dr SE
Salem, Oregon 97302

Present: Commissioner John Savage and Commissioner Steve Bloom; Mike Grant, Chief Administrative Law Judge; and Mike Weirich, Attorney-in-Charge, Department of Justice; Mark Thompson, NW Natural; Bob Jenks, CUB; Tommy Brooks, NIGU; Linda Gervais and Tom Pardee, Avista; Erik Colville and Kristi Collins of staff.

CONSENT AGENDA

Motion was made by Commissioner Bloom to adopt the Consent Agenda.

Voting for: Commissioners Savage and Bloom.
Voting against: None.

REGULAR AGENDA

1. NORTHWEST NATURAL:
(Advice No. 14-7) Adds Schedules 90 and 91 for Firm Storage Service with No-Notice Withdrawal, and Firm Storage Service with No-Notice Withdrawal and Direct Connection to South Mist Pipeline

Erik Colville presented Staff's Report and Recommendations. Mark Thompson of NW Natural, Bob Jenks of Cub and Tommy Brooks of NIGU made comments**.**

Motion was made by Commissioner Bloom to adopt Staff's Recommendation: Subject to the Schedule 90 Conditions of Approval presented in Attachment 1, Staff recommends that NW Natural's Application for Waiver of Less Than Statutory Notice (LSN) be approved along with its request for approval of Advice No. 14-7 (Schedules 90 and 91), as revised September 26, 2014, to become effective October 15, 2014.

Voting for: Commissioners Savage and Bloom.
Voting against: None

2. AVISTA UTILITIES:
(Docket No. LC 61) Presentation of the 2014 Integrated Resource Plan. Informational

only.

Eric Colville introduced Linda Gervais and Tom Pardee from Avista who then presented the IRP presentation.

Meeting adjourned at 10:05am.

EXHIBIT B-3:

RS 90 APPROVAL LETTER

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Oregon
John A. Kitzhaber, MD, Governor

Public Utility Commission
3930 Fairview Industrial Dr SE
Salem, OR 97302-1166
Mailing Address: PO Box 1088
Salem, OR 97308-1088
Consumer Services
1-800-522-2404
Local: 503-378-6600
Administrative Services
503-373-7394

October 14, 2014

NORTHWEST NATURAL
ONITA KING
220 NW 2ND AVE
PORTLAND OR 97209-3991

RE: Advice No. 14-7

On May 5, 2014, Northwest Natural filed revised sheets for inclusion in its tariff, PUC OR No. 25. On May 21, 2014 an extension of the effective date was filed. Subsequent extension requests were also filed on July 14, July 23, and September 11, 2014. On September 26, 2014 two supplemental filings were made along with an application to Waive Less than Statutory Notice. On September 30, 2014 an additional supplement along with an additional application to Waive Less than Statutory Notice were filed. On October 2, 2014 a final replacement filing was made.

This filing adds Schedules 90 and 91 for Firm Storage Service with No-Notice Withdrawal, and Firm Storage Service with No-Notice Withdrawal and Direct Connection to South Mist Pipeline.

In accordance with a decision of the Commission in the Public Meeting of October 14, 2014, the following sheets will become effective with service rendered on and after October 15, 2014:

Fourth Revision of Sheet iv
First Revision of Sheet 00.6
Third Revision of Sheet 185-1
Original Sheet 90-1
Original Sheet 90-2
Original Sheet 90-3
Original Sheet 90-4
Original Sheet 90-5
Original Sheet 90-6
Original Sheet 90-7
Original Sheet 90-8
Original Sheet 90-9
Original Sheet 90-10

Original Sheet 90-11
Original Sheet 90-12
Original Sheet 90-13
Original Sheet 90-14
Original Sheet 90-15
Original Sheet 90-16
Original Sheet 90-17
Original Sheet 91-1
Original Sheet 91-2
Original Sheet 91-3
Original Sheet 91-4
Original Sheet 91-5
Original Sheet 91-6
Original Sheet 91-7
Original Sheet 91-8
Original Sheet 91-9
Original Sheet 91-10
Original Sheet 91-11
Original Sheet 91-12
Original Sheet 91-13
Original Sheet 91-14
Original Sheet 91-15
Original Sheet 91-16
Original Sheet 91-17
Original Sheet 91-18
Original Sheet 91-19
Original Sheet 91-20

One receipted copy of each sheet is returned for your files, as well as an executed copy of the request to Waive Less than Statutory Notice.

Aster R. Adams, Ph.D.
Program Manager
Energy Resources & Planning
(503) 378-5363
aster.adams@state.or.us

nwn14-7

Enclosures

EXHIBIT B-4:

CONSOLIDATED, RESTATED, AND AMENDED UNDERGROUND STORAGE FACILITY SITE CERTIFICATION AGREEMENT

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Exhibit B-4

CONSOLIDATED, RESTATED, AND AMENDED UNDERGROUND STORAGE FACILITY

SITE CERTIFICATION AGREEMENT

for the

MIST SITE

between

The State of Oregon

acting by and through its

ENERGY FACILITY SITING COUNCIL

and

NORTHWEST NATURAL GAS COMPANY

~~May~~ _____ 20~~08~~15

This Certification Agreement is made and entered into in the manner provided by ORS 469.300 through ORS 469.570 and ORS 469.992, by and between the State of Oregon (State), acting by and through its Energy Facility Siting Council (EFSC) and Oregon Natural Gas Development Corporation (ONG), a wholly owned subsidiary of Northwest Natural Gas Company (NWN). Any reference herein to ONG shall also include NWN.

I. SITE CERTIFICATION

A. This agreement certifies that, to the extent authorized by state law and those warranties and conditions set forth herein, the State approves and authorizes the construction and operation of an underground storage facility for natural gas and related or supporting facilities at the Mist Site, in the manner described in NWN's site certificate application, this agreement, and the record of the administrative hearings held pursuant to ORS 469.300 through ORS 469.570, including supporting testimony filed by ONG or NWN with EFSC. This approval by the State binds the State and all counties, cities and political subdivisions in the State as to the approval of the site and the construction and operation of the

underground storage reservoir and related or supporting facilities, subject only to the conditions of this agreement. However, each agency and county that issues a permit, license or certificate shall continue to exercise enforcement authority over such permit, license or certificate.

B. This certificate requires NWN to comply with applicable state laws or EFSC rules as they exist on the date it is executed by EFSC, and with stricter state laws or EFSC rules adopted subsequent thereto if compliance with such stricter state laws or EFSC rules is necessary to avoid a clear danger to the public health and safety.

C. The Site Certificate has been amended 9 times, as follows:

1. Amendment 1, approved October 24, 1987, amended the site map and amended certain conditions regarding monitoring for safety and vibration.

2. Amendment 2, approved August 2, 1988, amended the site map to allow the addition of a monitoring well.

3. Amendment 3, approved September 21, 1990, amended the site map to replace two poorly functioning injection/withdrawal wells and add two new wells to increase capacity during the "heating season."

4. Amendment 4, approved July 21, 1997, enlarged the site boundary and authorized NWN to develop related and supporting surface facilities associated with new underground storage reservoirs in the Calvin Creek Storage Area, and upgrade related and supporting surface facilities at NWN's Miller Station. The amendment also authorized NWN to develop and operate new pipelines connecting the storage facilities at Calvin Creek to Miller Station. It authorized the replacement of two reciprocating compressors with one turbine driven compressor with rated horse power of 5,035 BHP at Miller Station, subject to an operating limitation to 6,650 total horsepower.[1] It added new conditions regarding the development of new related and supporting facilities associated with the Calvin Creek Storage area and Miller Station improvements. This Amendment increased the total throughput of the facility to 145 million cubic feet per day (MMcfd).

[1] The Council imposed the operating limitation in response to a request for a contested case by United Pipefitters Local 290. See Section III.A, Final Order Approving Amendment 4.

The Site Certificate to Amendment 4 covered the Miller Station improvements and the pipelines and other surface facilities. The underground storage reservoirs were under the Department of Geology and Mineral Industries (DOGAMI) jurisdiction.[2]

5. Amendment 5, approved March 13, 1998, replaced the Site Certificate amendment process set forth in section VII of the Site Certificate with the process set forth in Council rules at OAR 345 Division 7.

6. Amendment 6, approved March 30, 1999, authorized NWN to develop related and supporting facilities associated with new underground storage reservoirs in the Calvin Creek storage area. The amendment also removed operating restrictions at the Miller compression station (added in Amendment 4) and added new Site Certificate conditions associated with further development of the Calvin Creek storage area.

7. Amendment 7, approved November 17, 2000, authorized NWN to increase the allowed throughput at the Mist storage facility from 190 million cubic feet per day ("MMcfd") to 245 MMcfd.

8. Amendment 8, approved October 26, 2001, authorized NWN to increase the allowed throughput from 245 MMcfd to 317 MMcfd and to install a new 7324 BHP turbine driven compressor and a new injection/monitoring well, served by existing pipelines. The compressor authorized by

---

[2] State law grants DOGAMI broad authority "to regulate the underground storage of natural gas and the drilling and operation of any wells required therefor." ORS 520.095(16). DOGAMI has exercised this authority through the adoption of comprehensive rules governing underground storage facilities at OAR 632 Division 10.

When EFSC approved the Site Certificate for the Mist Site in 1981, its jurisdiction included the surface and underground components of the facility. In 1993, the siting law was amended to included within the Council's jurisdiction only the "surface facility related to an underground gas storage reservoir that, at design injection or withdrawal rates, will receive or deliver more than 50 million cubic feet of natural or synthetic gas per day, and require more than 4,000 horsepower of natural gas compression to operate ***." ORS 469.300(11)(a)(I).

Underground storage reservoirs, injection, withdrawal, and monitoring wells, and individual wellhead equipment remain under DOGAMI's pervasive authority over the wells and other subsurface components. ORS 469.300(11)(a)(I)(i)-(ii).

Amendment 8 is subject to EFSC's carbon dioxide standards at OAR 345 Division 24.

9. Amendment 9, approved December 5, 2003, authorized NWN to increase the allowed throughput from 317 MMcfd to 515 MMcfd. It authorized the construction of improvements at Miller Station, including the installation of new dehydration facilities and gas quality and monitoring equipment. It also authorized NWN to develop related and supporting facilities associated with new underground storage reservoirs in the Calvin Creek storage area. The amendment also allowed NWN to terminate the vibration monitoring program created in Amendment 1.

10. The 1981 site certificate and first nine amendments were stand alone documents. Amendment 10, approved May 30, 2008, consolidated these documents into a single unified site certificate. Amendment 10 made no substantive changes to the facility or the site certificate.

11. Amendment 11, approved _____, expanded the site boundary and authorized NWN to include the Adams storage reservoir, as well as the Newton, Medicine, Crater, and Stegosaur future storage areas. The amendment authorized NWN to develop only the Adams reservoir as a new underground storage area, to construct a new compressor station, the North Mist Compressor Station, and to construct an approximately 13-mile natural gas transmission pipeline, the North Mist Transmission Pipeline, between the NMCS and Portland General Electric's Port Westward Industrial Park (PWIP). It also authorized NWN to increase the allowed throughput from 515 MMcfd to 635 MMcfd.

II. SITE DESCRIPTION OF THE UNDERGROUND STORAGE RESERVOIR AND RELATED OR SUPPORTING FACILITIES

The underground storage reservoir and related or supporting facilities to be constructed and operated consist of:[3]

[3] NWN has adopted nomenclature for the phases of its gas storage operation at Mist. NWN refers to facilities permitted under the original 1981 permit as "phase 1." NWN refers to the development of storage pools in the Calvin Creek area permitted in 1997 under Amendment 4 as "phase 2." NWN refers to development permitted in amendment 6, coupled with the pipeline expansion authorized in amendment 2 to the South Mist Feeder Pipeline Site Certificate, as "phase 3."

Exhibit B-4

A. **Original Site**: Two naturally existing underground gas reservoirs (the Flora and Bruer pools) in portions of 3 sections of land all in Township 6 North, Range 5 West of the Willamette Meridian in Columbia County, Oregon, containing 940 acres, more or less from the surface of the earth to the base of the Clark and Wilson Sands and the stratigraphic equivalent thereof, which in the case of the Bruer pool was identified at a measured depth of 3,095 feet in the REC CC#1 RD 1 well and in the case of the Flora pool was identified at measured depth of 2,760 feet in REC CC#33-3 well and are entirely within project boundaries shown in Appendix 1 attached hereto and by reference incorporated herein; and

B. **Calvin Creek**: Naturally existing underground gas reservoirs located in the Calvin Creek area, which is located on the south side of the Nehalem River approximately 2.5 miles south of Miller Station, as shown in Appendix 2. The Calvin Creek storage area is connected to the original facility by two 16-inch pipelines which cross under the Nehalem River in a corridor 200 feet wide and terminate at the Busch Valve Station, as shown in Appendix 2. The 6, 8, and 12-inch pipelines begin at the Busch Valve Station and terminate at the well sites. The 6, 8, and 12-inch pipelines are each located within a 200 foot wide corridor that has been characterized in orders approving Amendments 4-9 or changes to the facility that received Department concurrence under OAR 345-027-0050(5).

C. **Miller Station**: The Miller Compression Station, shown in Appendix 1, is located contiguous to the Bruer Flora storage area. Miller Station contains the natural gas fired compressors, a staffed operations and maintenance building, and other ancillary process equipment. Emissions from the compressors are permitted under an air contaminant discharge permit (ACDP) issued by the Department of Environmental Quality. Miller Station contains the following compressors:

1. Two 500 HP Caterpillar reciprocating compressors removed pursuant to Amendment 4.

2. Two 1350 HP Superior reciprocating compressors not subject to EFSC CO_2 standards.

3. One 5035 BHP Allison KC-5 turbine driven compressor installed in 1997 pursuant to Amendment 4 and not subject to EFSC CO_2 standards.

4. One 7324 BHP Allison KC-7 turbine driven compressor installed in 2001 pursuant to Amendment 8 and subject to EFSC CO_2 standards.

D. **North Mist Expansion Area**: The North Mist Expansion Area, shown in Appendix 3, includes the Adams storage area and the North Mist Transmission

Pipeline corridor, as well as the Newton, Medicine, Crater, and Stegosaur future storage areas. The storage expansion area is located north of the Nehalem River. The North Mist Transmission Pipeline corridor traverses a north, northeast track from the North Mist Compressor Station to the PWIP.

~~D.~~E. **North Mist Compressor Station**: The North Mist Compressor Station, shown in Appendix 3, is located within the North Mist Expansion Area. The North Mist Compressor Station serves only the Adams reservoir, having the capability not only to compress the gas for injection into and withdrawal from the reservoir, but also to measure and control the gas flow and dehydrate the gas as needed during withdrawal. The North Mist Compressor Station has a total installed compression of approximately 3,600 BHP provided by two gas-fueled compressors.

III. WARRANTIES

In consideration of the execution of this Certification Agreement by the EFSC and pursuant to ORS 469.400(4) and ORS 469.470(3) the following warranties are made:

A. Financial Ability

NWN warrants that it has reasonable assurance of obtaining sufficient financial resources to construct and operate the underground storage facility and related and supporting facilities including funds necessary to cover construction costs, operating costs for the design lifetime of the underground storage facility, and the costs of permanently shutting the underground storage facility down and maintaining it in a safe condition.

B. Ability to Construct and Operate

NWN warrants that it has the ability to take those actions necessary to ensure that the underground storage facility and related and supporting facilities will be constructed and operated in a manner consistent with its representations regarding effects on the public health, safety and welfare contained in its site certificate application, and supporting testimony and the terms and conditions of this agreement including compliance with all design, quality assurance and personnel qualifications and training requirements.

C. Protection of Public health and Safety

NWN warrants that it will take those actions, including compliance with all State and Federal statutes, rules and regulations, necessary to ensure that construction and operation of the Mist underground storage facility poses no danger to the public health and safety.

Exhibit B-4

IV. CONDITIONS

The following conditions are provided pursuant to the provision of ORS 469.401.

A. State and Federal Law

1. NWN and EFSC shall abide by local ordinances and state law and the rules of the Council in effect on the date of this Site Certificate, except that upon a clear showing of a significant threat to the public health, safety or the environment that requires application of later-adopted laws or rules, EFSC may, pursuant to ORS 469.401(2), require NWN to comply with such later-adopted laws or rules.

2. Nothing in this agreement shall relieve NWN from complying with requirements of Federal laws and regulations which may be applicable to construction and operation of the underground storage reservoir and associated facilities, and with the terms and conditions of any permits and licenses which may be issued to NWN by pertinent federal agencies.

B. Control of Site

Prior to commencement of construction of the facility NWN shall present evidence satisfactory to EFSC that NWN has access to and full control over the underground reservoirs and sites for the related and supporting facilities, whether by ownership, lease or easement or otherwise as necessary to: Construct and maintain the underground reservoir, compressors, pipelines, injection withdrawal and other wells, and access roads to the facility necessary for the construction, operation, monitoring and regulation of the underground storage reservoir.

C. General Conditions

1. **Location**: Related or supporting facilities shall not be located at less than the minimum distances from any existing permanent habitable dwelling specified in OAR 345-024-0030 in effect on the date of this Certificate. [Amendment 10]

2. **Pipelines**: All pipelines in the project site shall be designed, built and operated in compliance with the requirements of the U.S. Department of Transportation set forth in Title 49, Code of Federal Regulations Part 192 subpart C in effect on the date of this Certificate, as administered by the Public Utility Commissioner of Oregon.

3. **Noise**: All compressors, pipelines, roads and related facilities shall be designed, constructed, installed and operated in such a manner so as not to violate the standards specified by the Oregon Department of Environmental Quality in OAR 340-35-35 (Noise Control Regulation) in effect on the date of this Certificate.

4. **Wells**: Operation, maintenance and abandonment of all wells on the site shall be in compliance with the applicable provision of ORS Chapter 520 and OAR Chapter 632 Division 10, in effect on the date of this Certificate, as administered by DOGAMI.

5. **Monitoring Program**: Deleted and superseded by conditions in Amendment 4. [Amendments 1,9, 10]

6. **Water Quality Protection**: NWN shall construct, build and operate surface facilities related to the underground gas storage reservoir so as to prevent emissions of pollution into ground or surface water in violation of rules at OAR Chapter 340 administered by DEQ. [Amendment 10]

7. **Fragile Soils**: Deleted and superseded by specific conditions related to soils. [Amendment 10]

8. **Socio-Economic Impacts**: Deleted and superseded by specific conditions related to public services. [Amendment 10]

9. **Water Rights**: NWN shall design, build and operate the surface facilities related to the underground gas storage reservoir in accordance with limited use licenses issued by the Department of Water Resources under Amendments 4-9. [Amendment 10]

10. **Applicants' Representations**: The facility shall be designed, built and operated in compliance with the representations made by ONG or NWN in satisfaction EFSC standards at OAR 345 Divisions 22 and 24. [Amendment 10]

11. **Gas Pressure**: NWN shall notify EFSC and Columbia County when it applies to DOGAMI for an increase in reservoir gas pressure. [Amendments 1, 10]

V. APPROVALS

The following approvals, permits, licenses, or certificates by governmental agencies are

considered necessary to construct and operate the surface facilities related to the underground gas storage reservoir. Consistent with provisions of ORS 469.401 and 469.504 and any administrative rules adopted thereunder, NWN shall make application for these approvals, permits, licenses, or certificates, paying all applicable fees prior to construction of the facility or later as appropriate.

1. **Department of Geology and Mineral Industries**: Well drilling and other permits required by ORS Chapter 520 and OAR Chapter 632 Division 10.

2. **Department of Environmental Quality**: Air Contaminant Discharge Permit for the operation of the Mist underground storage facility.

3. **Public Utility Commissioner**: Compliance inspection of pipelines, pursuant to Title 49 CFR, Part 192 as necessary.

4. **Department of Consumer and Business Services**: Pressure vessel inspection, State Fire Marshall approvals and plan review of construction drawings.

5. **Department of Transportation**: Single trip permits for oversize or overweight loads.

6. **Columbia County**: Building, plumbing, electrical permits, and conditional land use permits. [Amendment 1]

VI. AMENDMENT OF SITE CERTIFICATE AGREEMENT

Amendments to this Site Certificate shall be governed by duly adopted rules of the Energy Facility Siting Council for the amendment of site certificates. As of the date of the execution of Amendment 5, the Council rules applicable to the amendment of this Site Certificate are OAR 345-027-0050, 0060, 0070 and 0080.

Changes to the facility that involve a change to the site boundary shall be reviewed as set forth in OAR 345-027-0050(2)(b). Changes to the facility that involve the installation of pipelines or other surface facilities on land that is within the site boundary but that has not been characterized (ground truthed) in a previous Council order can be implemented without an amendment subject to Department review described at OAR 345-027-0050(5). Changes to the facility that involve the installation of pipelines or other surface facilities that have been characterized in a previous Council order or Department concurrence under section (5) may be implemented and reported under OAR 345-027-0050(4). In addition to these circumstances, pursuant to OAR 345-027-0050(5), NWN may ask the Department to determine whether a proposed change requires an amendment.

Exhibit B-4

VII. CONDITIONS UNDER AMENDMENTS

A. Conditions related to EFSC Rules at OAR Chapter 345 Division 27

1. Prior to any amendment that changes the site, NWN shall submit to the Oregon Department of Energy (ODOE) a legal description of the Project site to be appended to the Site Certificate prior to construction. [Amendments 4,8]

2. The Project shall be designed, constructed, operated and retired:

   a. Substantially as described in the amended Site Certificate;

   b. In compliance with the requirements of ORS Chapter 469, applicable Council rules, and applicable state and local laws, rules and ordinances in effect at the time the Council issues or amends the Site Certificate; and

   c. In compliance with all applicable permit requirements of other state agencies. [Amendment 4]

3. No construction, including clearing of a right of way, except for the initial survey, may commence on any part of the facility until the certificate holder has adequate control, or has the statutory authority to gain control, of the lands on which clearing or construction will occur. [Amendment 4]

4. NWN shall, to the extent practical, prevent any condition from developing on the Project site that would preclude restoration of the site to a useful condition. [Amendments 4, 10]

5. NWN shall restore vegetation to the extent practicable and shall landscape portions of the area disturbed by Project construction in a manner compatible with its surroundings and/or proposed future use. Upon completion of Project construction, NWN shall dispose of all temporary structures not required for future use and all timber, brush, refuse and flammable materials or combustible material resulting from the clearing of land or from construction of the facility. [Amendment 4]

6. NWN may operate all compressors installed as of January 11, 2008 at full rated capacity.[4] [Amendments 6, 10]

7. NWN shall notify ODOE, the State Building Codes Division and DOGAMI promptly if site investigations or trenching reveal that conditions in the foundation rocks differ significantly from those described in the Application for Amendment 6, 8, or 9. The Council may, at such time, require the certificate holder to propose additional mitigating actions in consultation with the Department of Geology and Mineral Industries and the Building Codes Division. [Amendment 6]

8. NWN shall notify ODOE, the State Building Codes Division and DOGAMI promptly if shear zones, artesian aquifers, deformations or clastic dikes are found at or in the vicinity of the site. [Amendment 6]

9. NWN shall submit to ODOE copies of all incident reports involving the certified pipeline required under 49 CFR § 192.709. [Amendment 6]

10. Pursuant to Amendment 11~~9~~, the permitted daily throughput of the facility is ~~515~~635 MMcfd. [Amendments 7, 8, 9, 11]

11. NWN shall establish, in consultation with affected state agencies and local governments, monitoring programs as required by the Site Certificate for impact on resources protected by the standards of OAR Chapter Divisions 22 and 24, and to ensure compliance with the Site Certificate. [Amendment 6]

12. If NWN becomes aware of a significant environmental change or impact attributable to the facility, NWN shall submit to ODOE as soon as possible a written report identifying the issue and assessing the impact on the facility and any affected Site Certificate conditions. [Amendment 6]

B. Conditions related to EFSC Standards at OAR Chapter 345 Division 22

1. **Conditions Generally Applicable to the Facility**

a. Socio Economic Impact

[4] Amendment 4, issued in 1997, contained a condition limiting total horsepower at Miller Station. The Council removed this limitation in 1999 under Amendment 6. No further operating limits apply to compression at Miller Station.

(1) NWN shall provide the Mist Birkenfield Rural Fire Protection District with an annual tour of the Miller Station to familiarize personnel with the facility in case of an emergency. [Amendment 4]

b. Waste Minimization

(1) NWN shall transport construction waste materials to an appropriate recycling facility or to an approved sanitary landfill for nonrecyclable goods. NWN shall collect scrap steel and welding rods for transportation to a recycling facility. Silt fence and straw bales shall be transported to an approved landfill. [Amendment 4]

(2) Nonhazardous wastes associated with the Project such as crankcase oil, triethylene glycol and oil/water separator oils shall be collected, transported and recycled by a vendor as bunker fuel. Oily rags and oil filters shall be incinerated off site by a permitted disposal facility. Granular activated carbon will be collected and sent to a permitted facility for regeneration. NWN may use alternate methods of disposal if approved by ODOE. [Amendment 4]

(3) Water used for pressure testing shall be disposed of in a manner consistent with approved permits. [Amendment 4]

c. Retirement

(1) Prior to termination of the Site Certificate, NWN shall retire the Project site sufficiently to restore it to a useful condition. Site restoration shall include, but not be limited to, steps to:

(a) Remove any hazardous material stored in buildings or located in process equipment and dispose of them following applicable state hazardous materials statutes and rules,

(b) Disassemble the buildings and steel structures, break up the concrete slabs, and dispose of these materials either as scrap or at an appropriate landfill,

(c) Remove above ground portions of all pipelines,

(d) If necessary, revegetate the area, including pipeline rights-of-ways, to prevent erosion and encourage habitat development,

(e) Inspect all pipelines and remove any hazardous materials found, and dispose of hazardous materials generated from cleaning the pipelines in accordance with applicable state hazardous materials statutes and rules. [Amendment 4]

2. **Conditions Applicable to Amendment 4**

a. Structural and Soils

(1) The pipeline corridor shall be as shown on Figure G-1 of Exhibit 10 of the Application for Amendment 4. Changes in pipeline corridor shall require prior Council approval. [Amendment 4]

(2) NWN shall construct modifications to Miller Station substantially in accordance with the recommendations in Exhibit 11, Section 7 of the Application for Amendment 4. In the vicinity of the new compressor building, the adjacent equipment, in the dehydration area and in areas where there will be heavy loads and traffic, all fill will be classed as "structural fill." This fill will utilize imported soil and will be compacted as specified in Section 7.1.3 of Exhibit 11 of the Application for Amendment 4. For trench backfill in unimproved areas (no surface traffic), the backfill above pipe will consist of removed soil placed with nominal compaction, as specified in Section 7.1.3 of Exhibit 11 of the Application for Amendment 4. [Amendment 4]

(3) NWN shall design and construct pipelines substantially in accordance with the recommendations in Section 8 of Exhibit 11 of the Application for Amendment 4. [Amendment 4]

b. Fish and Wildlife Habitat

Exhibit B-4

(1) NWN shall utilize directional drilling for the pipeline installation at the Nehalem River. Drilling shall begin at points no closer than 300 feet from the river bank and shall place the pipeline at least 20 feet below the river bed. [Amendment 4]

(2) NWN shall minimize impacts for the Category 2 wetland north of highway 202 by taking steps including but not limited to:

(a) using a single trench for dual pipelines and keeping the installation as narrow as possible while remaining consistent with safety and practical installation requirements.

(b) timing construction for the dry time of year, not to extend beyond November 15, 1997.

(c) separating and returning topsoil to the trench backfill surface for pipelines and installing clay barriers at each end of the wetland crossing.

(d) avoiding the rest of the wetland during construction by use of the existing road through the wetland for construction equipment. [Amendment 4]

(3) NWN shall restore habitat in the Category 2 wetland to the north of highway 202 to preconstruction conditions within two growing seasons. [Amendment 4]

(4) NWN shall minimize the loss of habitat in forested areas and clear cuts by allowing vegetation to grow back in the construction corridor except for the 40 foot area directly over the pipeline. NWN shall restore surface vegetation in farmed areas. [Amendment 4]

(5) NWN shall time the crossing of any small tributaries or creeks during the dry period, and shall restore the stream bed and stream banks before the rainy season, not to extend beyond November 15, 1997. [Amendment 4]

(6) NWN shall minimize impact to wetlands by separating the upper foot of topsoil from the rest of the trench spoils and replacing it on the top of the trench. [Amendment 4]

(7) NWN shall filter any water pumped from the trench during construction to remove sediments before it is returned to the wetland. [Amendment 4]

(8) NWN shall complete pipeline construction through the wetland by November 15, 1997. [Amendment 4]

c. Historic, Archeological and Cultural

(1) A qualified archeologist shall monitor all grading and excavation activities associated with boring operations. If any artifacts or other cultural materials that might qualify as "archeological objects" as defined at ORS 358.905(1)(c) are identified, ground disturbing activities will cease until the archeologist can evaluate their potential significance. If the material is likely to be eligible for listing on the National Register of Historic Places or to qualify as archeological objects or sites, as defined at ORS 358.905(j)(c), NWN shall consult with the State Historic Preservation Office ("SHPO") and will comply with the archeological permit requirement administered by the SHPO as set forth in OAR 736 Division 51. [Amendment 4]

3. **Conditions Applicable to Amendment 6**

a. Structural and Soils

(1) The pipeline corridor shall be substantially as shown on Figure G-l of Exhibit 14 of the Application for Amendment 6. NWN may change the pipeline corridor by obtaining ODOE or EFSC concurrence as described in OAR 345-027-0050. [Amendments 6, 10]

(2) NWN shall design and construct the pipelines substantially in accordance with the recommendations in Sections 5.2 and 5.3 of Exhibit 14 of the Application for Amendment 6. [Amendment 6]

b. Land Use

(1) NWN shall provide Columbia County Land Development Services (LDS) with drawings showing the final locations of all wells (underground natural gas storage facilities) and pipelines as constructed. [Amendment 6]

(2) NWN shall submit to LDS a letter from the Oregon Department of Transportation that all of ODOT's permit requirements have been met. [Amendment 6]

(3) NWN shall submit to LDS a letter from the Mist-Birkenfeld & Vernonia Fire Districts stating that all fire safety concerns have been addressed. [Amendment 6]

c. Fish and Wildlife Habitat

(1) NWN shall return the construction area to approximately its original grade, and revegetate the disturbed areas using appropriate plant species. NWN will allow and encourage natural vegetation to return in the disturbed area, except that NWN may prevent large trees from growing in the permanent maintenance right-of-way which shall be as narrow as practicable and no greater than 40 feet wide. [Amendment 6]

(2) During construction NWN shall use appropriate erosion control and sediment control measures, such as those in Washington County Erosion Control Plans Technical Guidance Book (February 1994), as necessary to prevent material from leaving the construction area or adversely affecting water quality in nearby and downslope streams. NWN shall also use best management practices (BMP) and follow Oregon Department of Forestry, Forest Practice Administrative Rules during construction. [Amendment 6]

4. **Conditions Applicable to Amendments 8 and 9**

a. Structural and Soils

(1) NWN shall design the modifications authorized by Amendments 8 and 9 in accordance with the seismic design

factors shown in Table 2 of GeoEngineers' September 18, 2001 report "EFSC Structural Standard Information, Miller Station Gas Compression Facility, Mist, Oregon." [Amendments 8, 9]

(2) NWN shall design, engineer and construct the modifications authorized by Amendments 8 and 9 substantially in accordance with the recommendations in the section entitled "Non-Seismic Design and Construction Recommendations" in GeoEngineers' September 18, 2001 report "EFSC Structural Standard Information, Miller Station Gas Compression Facility, Mist, Oregon. [Amendments 8, 9]

5. **Conditions Applicable to Amendment 9**

a. Structural and Soils

(1) During construction authorized by Amendment 9, NWN shall implement the recommendations in Exhibit 6, section 7 of the application for Amendment 9. [Amendment 9]

b. Fish and Wildlife Habitat

(1) During the construction under Amendment 9, NWN will minimize removal of vegetation to the extent practical. [Amendment 9]

(2) Where an Amendment 9 pipeline is installed adjacent to an existing one, the permanent easement will be only 10 feet wider than the existing one. However, where the Schlicker pool pipeline approaches the Busch valve station, the permanent easement may be 30 feet wider than the existing one to allow installation of surface equipment. [Amendment 9]

(3) NWN will use the erosion control measures required for the NPDES 1200-C (a federal permit) and Best Management Practices (BMPs) to prevent erosion of soil into the ephemeral stream channel during construction of the Amendment 9 pipelines. [Amendment 9]

(4) Following construction of the pipelines for Amendment 9, NWN will allow and encourage native vegetation to grow back in the temporary construction easement and staging areas. [Amendment 9]

(5) Where revegetation is necessary in the permanent right-of-way for the pipelines constructed under Amendment 9, NWN will plant vegetation that provides forage for big game species. [Amendment 9]

(6) During pipeline construction for Amendment 9, NWN will restore any stream channels to pre-construction conditions, including grades, contours, morphology and substrate and will take measures to prevent scouring of stream slopes. [Amendment 9]

(7) At stream crossings, crews will use hand tools to control [right-of-way] vegetation in the permanent easement for the Amendment 9 pipelines. [Amendment 9]

(8) Construction of the Busch well pipeline will follow the US Fish and Wildlife Service scheduling and distance guidelines to avoid adverse impact to the bald eagle nest. [Amendment 9]

C. Conditions Related to EFSC Standards at OAR Chapter 345 Division 24

Under ORS 469.401(2), EFSC must impose conditions in the Site Certificate for the protection of public health and safety. Throughout this Site Certificate are conditions related to other decisional criteria that are ultimately intended to protect public health and safety. The following conditions protect public health and safety specifically with regard to EFSC standards for surface facilities related to underground natural gas storage and natural gas pipelines.

1. **Conditions Applicable to this Facility**

a. NWN shall design, construct, operate and retire the Project in accordance with applicable statutes, rules and ordinances. [Amendment 4]

b. NWN shall construct all pipelines in accordance with the requirements of the U.S. Department of Transportation as set forth in Title 49, Code of Federal Regulations Part 192. [Amendment 4]

c. Isolation valves shall be located at both ends of the 16 inch pipelines connecting Miller Station and the Busch Valve Station and at both ends of the eight inch and six inch pipelines connecting the well sites with the sixteen inch pipeline at the Busch Valve Station. [Amendment 4]

d. NWN shall maintain a program to monitor the proposed pipeline to ensure protection of the public health and safety, including but not limited to:

(1) Pressure sensing devices positioned at Miller Station and near the wellheads to relay critical information to both Miller Station and, as needed, from Miller Station to the Portland gas control center,

(2) high and low pressure alarms monitored on a 24 basis to detect and locate areas where pressure variations may indicate abnormal conditions, and

(3) emergency response personnel on duty 24 hours per day, at Miller Station or in Portland, trained to respond to situations that require immediate attention. [Amendment 4]

2. **Condition Applicable to Amendment 4**

a. Within two months of initial startup of the new compressor, NWN shall conduct noise surveys at the two locations previously tested on February 20 and 21, 1997 to demonstrate compliance with DEQ Noise regulations at OAR 340-35-0035. Sound measurements shall be made with all compressors running at within 5% of horsepower permitted by this Site Certificate. Measurements shall be made at each location during atmospheric conditions best for sound propagation. Sound monitoring shall not be conducted when winds are in excess of 5 mph. [Amendment 4]

3. **Condition Applicable to Amendment 8**

a. Within six months of initial startup of the new compressor authorized by Amendment 8, NWN shall conduct noise surveys at the locations previously tested pursuant to Amendment 4 to demonstrate compliance with DEQ Noise regulations at OAR 340-035-0035. Sound measurements shall be made with the compressor authorized by Amendment 8 running at within 5% of rated horsepower. Measurements shall be made at a time when weather and atmospheric conditions are comparable in terms of sound propagation to the conditions that existed during the measurements taken pursuant to Amendment 4. NWN shall mathematically add the sound from this compressor to the sound from compressors installed prior to Amendment 8, as measured in the tests required by Amendment 4. NWN shall add instrument error to the noise measurements and shall treat instrument errors as cumulative. NWN shall promptly notify ODOE if the total from this mathematical addition exceeds the limits in Table 8 of OAR 340-035-0035. [Amendment 8]

D. Other Amendment-Specific Conditions

1. **Conditions Applicable to Amendment 4**

a. Conditions for DSL Removal Fill Permit

Construction of the Project will require a Removal\Fill permit from the Department of State Lands (DSL). The Council, in consultation with DSL, approves the activities associated with the Removal\Fill permit, subject to the following conditions:

(1) NWN shall minimize impacts for the Category 2 wetland north of highway 202 by taking steps including but not limited to:

(a) using a single trench for dual pipelines and keeping the installation as narrow as possible while remaining consistent with safety and practical installation requirements.

(b) timing construction for the dry time of year, not to extend beyond November 15.

(c) separating and returning topsoil to the trench backfill surface for pipelines and installing clay barriers at each end of the wetland crossing.

(d) avoiding the rest of the wetland crossing during construction by use of the existing road through the wetland for construction equipment. [Amendment 4]

(2) NWN shall restore habitat in the Category 2 wetland to the north of highway 202 to preconstruction conditions within two growing seasons. [Amendment 4]

(3) NWN shall minimize impact to wetlands by separating the upper foot of topsoil from the rest of the trench spoils and replacing it on the top of the trench. [Amendment 4]

(4) NWN shall filter any water pumped from the trench during construction to remove sediments before it is returned to the wetland. [Amendment 4]

(5) NWN shall complete pipeline construction through the wetland by November 15, 1997. [Amendment 4]

(6) Turbidity shall not exceed 10% above natural stream turbidities as a result of the project except that the Department of Environmental Quality allows that the 10% limit may be exceeded for a limited duration, provided all practicable erosion control measures have been implemented, including but not limited to:

(a) use of filter bags, sediment fences, catch basins or other means to prevent off site movement of soil

(b) use of impervious covers for stockpiles left unattended or during a rain event,

(c) waste materials and spoils shall be placed on uplands, such that the material cannot reenter a waterway or wetland, and

(d) all areas of soil disturbance shall be seeded or otherwise revegetated with native species upon

completion of construction to prevent subsequent erosion. [Amendment 4]

b. Conditions Related to Limited Water Use Permit

(1) Construction of the Project will require a one-time use of approximately 300,000 gallons of water for pipeline testing. This use will require a Limited Water Use permit from the Water Resources Department. The water would be withdrawn from the Nehalem River. The Council approves this use, subject to the following conditions and in consultation with the Water Resources Department:

(a) The licensee shall install, maintain and operate fish screening and by-pass devices as required by the Oregon Department of Fish and Wildlife to prevent fish from entering the proposed diversion. The required screens and by-pass devices are to be in place, functional and approved by an Oregon Department of Fish and Wildlife representative prior to diversion of any water. [Amendment 4]

(b) The use shall be allowed only at times when the Watermaster has determined the flows of the source stream, namely the Nehalem River, are sufficient to satisfy instream water rights. [Amendment 4]

(c) The licensee shall give notice to the Watermaster not less than 15 days or more than 60 days in advance of using the water. The notice shall include the location of the diversion and place of use, the quantity of water to be diverted and the intended use. [Amendment 4]

(d) The licensee shall maintain a record of use, including the total number of hours of pumping, an estimate of the total quantity pumped, and the categories of beneficial use to which the water is applied. The record of use shall be submitted to the Watermaster upon request. [Amendment 4]

(e) The limited license is effective for use between September 15, 1997 and November 15, 1997. [Amendment 4]

c. Conditions Related to DEQ WPCF permit

Construction of the Project will require a one-time discharge of the water used for pipeline testing. The water will be discharged by land application to a pasture located near the Nehalem River and in the vicinity of the directional drilling site. This discharge requires a Water Pollution Control Facilities (WPCF) permit from the Department of Environmental Quality (DEQ). The Council approves this activity, subject to the following conditions and in consultation with DEQ:

(1) No discharge to State waters is permitted. All waste water shall be distributed on land for dissipation by evapotranspiration and controlled seepage by following sound irrigation practices so as to prevent:

(a) Prolonged ponding of waste on the ground surface;

(b) Surface runoff or subsurface drainage through drainage tile;

(c) Creation of odors, fly and mosquito breeding and other nuisance conditions, and

(d) The overloading of land with nutrients or organics. [Amendment 4]

(2) NWN shall, during all times of disposal, provide personnel whose primary responsibilities are to assure the continuous performance of the disposal system within the limitations of the permit. [Amendment 4]

(3) Prior to land disposal of the waste water it shall be treated by filtering through straw bales. [Amendment 4]

(4) Unless approved by EFSC and DEQ, waste water that is disposed of on land but not used to irrigate crops shall be disposed of on a deep-rooted cover crop to ensure

maximum infiltration and evapotranspiration rate. [Amendment 4]

(5) Prior to constructing or modifying any waste water control facilities, detailed plans and specifications shall be approved in writing by EFSC and DEQ. [Amendment 4]

(6) An adequate contingency plan for prevention and handling of spills and unplanned discharges shall be in force at all times. A program of employee orientation and education shall be maintained to ensure awareness of the necessity for good inplant control and proper action in the event of a spill or accident. [Amendment 4]

2. **Conditions Applicable to Amendment 8**

a. Condition under OAR 345 Division 27

(1) NWN must decommission the new equipment and portion of the facility described in Amendment 8 and restore the site to a useful and non-hazardous condition as provided in OAR 345-022-0130 and the retirement plan previously described in the Order Approving Amendment 4. In addition, immediately upon execution of Amendment 8 to the Site Certificate, NWN must provide EFSC with a surety bond or other form of financial assurance, which shall guarantee NWN's obligation and indemnify the state from any failure by NWN to decommission the new equipment and portion of the facility described in Amendment 8 and restore the site to a useful and non-hazardous condition as provided in OAR 345-022-0130 and the retirement plan previously described in the order approving Amendment 4 to the Site Certificate. The Council delegates authority for approval of the bond to the Council chair. The amount of the bond or financial assurance must be $400,000 in 2001 dollars. The calculation of 2001 dollars shall be made using the U.S. Gross Domestic Product Implicit Price Deflator, as published by the U. S. Department of Commerce, Bureau of Economic Analysis, or any successor agency (the "index"). If, at any time, the index is no longer published, the Council will select a comparable replacement index. [Amendment 8]

b. Conditions under OAR 345 Division 24

(1) Immediately upon execution of Site Certificate Amendment 8 authorizing the compressor described in NWN's Request for Amendment 8 ("new compressor"), NWN shall report to EFSC the design and operating parameters of the new compressor, as specified in subsections (a) through (c).

(a) NWN shall notify the Council in writing of its final selection of a gas turbine compressor vendor. [Amendment 8]

(b) NWN shall submit written design information sufficient to verify the new compressor's designed heat rate (higher heating value) and its nominal capacity. NWN shall include an affidavit certifying the heat rate and nominal capacity of the new compressor. [Amendment 8]

(c) NWN shall specify the estimated annual average hours that it reasonably expects to operate the new compressor. [Amendment 8]

(2) NWN shall submit all monetary path payment requirement calculations to the Office of Energy ("Office") for verification in a timely manner prior to making payments to The Climate Trust. NWN shall use the contracted design parameters for nominal capacity and heat rate of the new compressor, along with the estimated annual hours of operation, that it reports pursuant to Condition (1) to calculate the estimated monetary path payment requirement. For the purposes of this Site Certificate, the "monetary path payment requirement" means the offset funds determined pursuant to OAR 345-024-0630 and the selection and contracting funds that NWN must disburse to The Climate Trust, as the qualified organization, pursuant to OAR 345-024-0710 and this Site Certificate. [Amendment 8]

(a) The net carbon dioxide emissions rate for the new compressor shall not exceed 0.522 pounds of carbon dioxide per horsepower hour. [Amendment 8]

(b) The offset fund rate for the monetary path payment requirement shall be $0.85 per ton of carbon dioxide (in 2001 dollars). For the initial monetary path payment that NWN must make prior to beginning construction, the calculation of 2001 dollars shall he made using the US Gross Domestic Product Implicit Price Deflator, as published by the US Department of Commerce, Bureau of Economic Analysis, or any successor agency ("the index"). The amount of the payment requirement shall increase annually by the percentage increase in the index and shall be pro-rated within the year to the date of disbursement to The Climate Trust from October 26, 2001. If at any time the index is no longer published, the Council shall select a comparable calculation of 2001 dollars. [Amendment 8]

(c) NWN shall offset excess carbon dioxide emissions using the monetary path as described in OAR 345-024-0710 and this Site Certificate. Contracting and selecting funds shall equal twenty (20) percent of the value of any offset funds up to the first $250,000 (in 2001 dollars) and 4.286 percent of the value of any offset funds in excess of $250,000 (in 2001 dollars). [Amendment 8]

(3) Immediately upon execution of this Site Certificate Amendment 8, NWN shall pay cash to The Climate Trust in the full amount of the monetary path payment requirement (in 2001 dollars) as determined by the calculations set forth in Condition (2). [Amendment 8]

(4) The Office shall establish an "offset credit account." The initial offset credit account shall be the total carbon dioxide offsets for which NWN has provided offset funds to The Climate Trust, pursuant to Condition (3). [Amendment 8]

(5) Each year after beginning commercial operation of the new compressor ("annual carbon dioxide reporting period"), NWN shall report to ODOE the annual hours the new compressor operated and its fuel use in Btu. NWN shall

provide the annual report to the Office within 30 days of the anniversary date of beginning commercial operation of the new compressor. [Amendment 8]

(a) The Office shall calculate the excess carbon dioxide emissions during each annual carbon dioxide reporting period and subtract those emissions from the offset credit account annually. [Amendment 8]

(b) If the offset credit account contains fewer than 6,000 tons of carbon dioxide offset credits, NWN shall replenish the offset credit account. NWN shall replenish the offset credit account equivalent to the full amount of the estimated future excess emissions. The Office shall estimate excess emissions for the remaining period of the deemed 30-year life of the facility, based on the average annual excess carbon dioxide emissions in the prior three years. The Office shall calculate the estimated future excess emissions of the new compressor and notify NWN of the amount of payment required, using the monetary path, to replenish the offset credit account. [Amendments 8,9]

(c) Notwithstanding the index identified in Condition (2)(b), pursuant to OAR 345-024-0710(6)(a) the formula to calculate the rate for the dollar value per ton of carbon dioxide offsets by which NWN shall replenish its offset credit account through the monetary path shall be $0.85 times (1.0891 to the power “t”); where “t” is the elapsed time in years between October 26, 2001, and the date the Office notifies NWN that it must replenish its offset credit account, pursuant of OAR 345-024-0630(4). Fractional years shall be calculated by dividing the number of elapsed days in excess of a whole year by 365. [Amendment 8]

(d) The Office shall calculate additional contracting and selection funds pursuant to Condition 2(c).

(e) NWN shall disburse in cash the additional monetary path payment requirement to replenish the offset credit account to The Climate Trust within 30 days after notification by the Office of the amount that NWN owes. [Amendment 8]

(6) The new gas turbine compressor shall be fueled solely with pipeline quality natural gas or with synthetic gas with a carbon content per million Btu no greater than pipeline quality natural gas. The Office shall use a rate of 117 pounds of carbon dioxide per million Btu of natural gas fuel to calculate carbon dioxide emissions. [Amendment 8]

3. **Condition Applicable to Amendment 9**

a. Condition under OAR 345 Division 27

(1) Before beginning the construction authorized under Amendment 9, NWN shall submit to the State of Oregon, through the Council, a bond or letter of credit, satisfactory to the Council, in the amount of $500,000 in 2003 dollars. This condition may be satisfied by a new financial instrument or by updating the bond submitted pursuant to Amendment 8. [Amendment 9]

4. **Conditions Applicable to Amendment 11**

a. NWN shall continue to monitor on an annual basis in accordance with NW Natural's landslide monitoring program: (1) the inactive landslide 3-048-029 identified along the proposed North Mist Transmission Pipeline alignment from MP 2.85 to 3.25 and from approximate MP 3.57 to 3.82 and (2) the inactive landslide 3-043-031-B identified at the North Mist Compressor Station site. [Amendment 11]

b. NWN shall implement the Agricultural Impact Mitigation Plan for the North Mist Expansion Project. [Amendment 11]

c. In forested timber lands, NWN shall allow native vegetation, including trees, within the maintenance easement for the North Mist Transmission Pipeline, except in a ten-foot-wide zone over

the pipeline, where only grasses, forbs, and shrubs will be allowed. [Amendment 11]

d. NWN shall control vegetation within the maintenance easement for the North Mist Transmission Pipeline by mechanical means wherever practicable. If herbicides must be used, herbicides will be applied in accordance with all state and federal regulations. [Amendment 11]

e. NWN will conduct maintenance activities during daylight hours outside of dawn and dusk to the extent practicable to reduce the risk of vehicle collision with Columbia white-tailed deer. [Amendment 11]

VIII. SUCCESSORS AND ASSIGNS

This agreement is binding upon NWN and any co-owners, partners or joint venturers of NWN in the construction and operation of the underground storage facility and related and supporting facilities and upon any successors in interest to or assignees of either NWN or any co-owner, partner or joint venturer.

IN WITNESS WHEREOF, this Site Certificate Agreement has been executed by the State of Oregon, acting by and through its Energy Facility Siting Council, and Northwest Natural Co. as below subscribed on this day of May 30, 2008.

ENERGY FACILITY SITING COUNCIL

By: _____ Date: _____
~~Robert Shiprack~~Barry Beyeler, EFSC Chair

NORTHWEST NATURAL

By: _____ Date: _____
Northwest Natural Co.

Exhibit B-4

APPENDIX 1: Map of Breuer-Flora Storage Area and Miller Station
APPENDIX 2: Map of Calvin Creek Storage Area

EXHIBIT B-5:

PROPOSED CHANGES TO OPERATIONAL CONDITIONS

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Condition VII.A.10, which concerns the permitted daily throughput of the Facility, would be amended as follows:

> 10. Pursuant to Amendment ~~9~~11, the permitted daily throughput of the Facility is ~~515~~635 MMcfd. [Amendments 7, 8, 9, 11]

In addition, NWN proposes to add the following operational conditions:

> NWN shall continue to monitor on an annual basis in accordance with NW Natural's landslide monitoring program: (1) the inactive landslide 3-048-029 identified along the proposed North Mist Transmission Pipeline alignment from MP 2.85 to 3.25 and from approximate MP 3.57 to 3.82 and (2) the inactive landslide 3-043-031-B identified at the North Mist Compressor Station site.
>
> NWN shall implement the Agricultural Impact Mitigation Plan for the North Mist Expansion Project.
>
> In forested timber lands, NWN shall allow native vegetation, including trees, within the maintenance easement for the North Mist Transmission Pipeline, except in a ten-foot-wide zone over the pipeline, where only grasses, forbs, and shrubs will be allowed.
>
> NWN shall control vegetation within the maintenance easement for the North Mist Transmission Pipeline by mechanical means wherever practicable. If herbicides must be used, herbicides will be applied in accordance with all state and federal regulations.

NWN will conduct maintenance activities during daylight hours outside of dawn and dusk to the extent practicable to reduce the risk of vehicle collision with Columbia white-tailed deer.

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EXHIBIT B-6:

APPENDIX 3 – EXISTING AND EXPANDED STORAGE SITE BOUNDARIES

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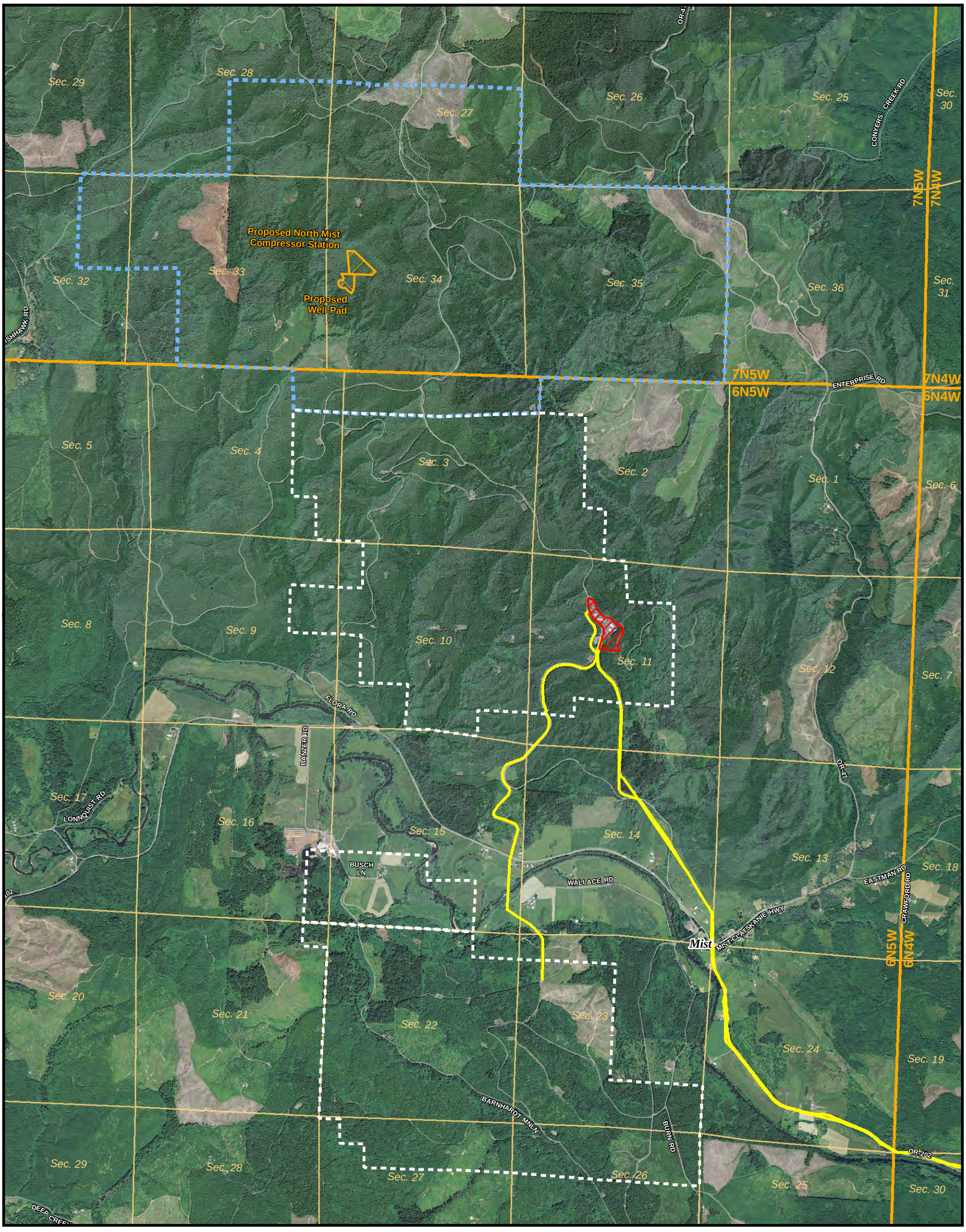


NW Natural

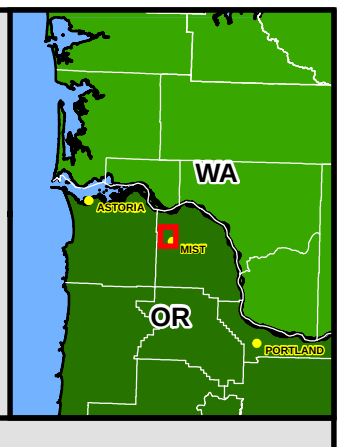
North Mist Expansion Project

Request for Amendment No. 11

Columbia County, OR
November 2015

Appendix 3
Existing and Expanded Storage Site Boundaries

- Proposed North Mist Compressor Station
- Proposed Well Pad
- Proposed Expansion Area
- Approved EFSC Boundary
- Existing NW Natural Pipeline Corridor
- Miller Station



NAD_1927_StatePlane_Oregon_North_FIPS_3601

0 0.25 0.5 1 1.5 2 Miles

Data Source: NW Natural North Mist Expansion Project

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Exhibit C

Project Location and Maps

North Mist Expansion Project

November 2015

Prepared for

Northwest Natural Gas

Prepared by

Tetra Tech, Inc.

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Figure C-2. Detailed Project Layout and Impact Maps

Acronyms and Abbreviations

NWN	Northwest Natural Gas
OAR	Oregon Administrative Rule
Project	North Mist Expansion Project
PWIP	Port Westward Industrial Park
US-#	US Highway #

1.0 Introduction

Exhibit C was prepared to meet the submittal requirements of Oregon Administrative Rule (OAR) 345-021-0010(1)(c) paragraphs (A) and (B); paragraph (C) is not applicable. As required, this Exhibit provides a set of maps which show the location of Northwest Natural Gas's (NWN)'s North Mist Expansion Project (Project), including related and supporting facilities, and areas of temporary and permanent disturbance.

2.0 General Location

The Project consists of an approximately 13 mile-long underground gas pipeline with aboveground facilities including a well pad, compressor station and mainline block valve, and associated temporary satellite construction areas. A complete description is found in the Project Description section of this application.

The Project is located entirely within Columbia County, Oregon and, except for underground crossings of public roads and a railroad, is proposed entirely on privately-owned lands. The pipeline would originate at NWN's Mist Gas Storage Facility, approximately 2.8 miles north-northwest of the community of Mist, and would run generally north for about 3.25 miles, then northeasterly to the Port Westward Industrial Park (PWIP) facilities located on the south bank of the Columbia River approximately 5 miles north-northeast of Clatskanie, passing about 1.5 miles northwest of that city.

Figure C-1 is a vicinity map showing the location of the Project in relation to existing roads, communities, water bodies, and other major geographic features.

The Project would be located in two distinctly different types of land forms and land uses; the boundary between these coincides approximately with US Highway 30 (US-30). The area to the north of US-30 is a flat floodplain, and dedicated primarily to agricultural uses including commercial tree farms. The area to the south of US-30 is mountainous, and dedicated almost entirely to commercial forest use.

3.0 Specific Location of Project Facilities

Figure C-2 is a map set showing the Project Site Boundary, which includes the locations of all permanent and temporary facility disturbance areas, at a scale of 1:2,400 (1 inch=200 feet). These figures also show the location of the Project in relation to existing roads, water bodies, and other topographic features. Please note that due to the variable spatial accuracy of the displayed data layers, some features may not reflect what is actually on the ground. The Site Boundary contains a total of 399.5 acres.

Most of the Project would be underground with no permanent surface impact footprint. Permanent aboveground facilities would be limited to a new compressor station and associated well pad near the Project's southern origin, and a mainline valve block along the pipeline about 1.5 miles west of Clatskanie near Project milepost 6.4.

In order to minimize impacts to natural resource including agricultural lands, the pipeline north of US-30, with the exception of a 0.3-mile stretch is proposed to be installed by HDD, using a total of nine temporary bore pads and limited additional temporary trenching within the flood plain area.

Nearly all of the pipeline south of US-30 and two short segments north of US-30, approximately 10.1 miles in total including the conduit, would be installed through open trenching. Where open trenching is used the area disturbed by the work would be restored following completion of construction. The portions of the Project to be installed by trenching versus HDD are identified on Figures C-2 through C-34. These figures also show the location and extent of HDD laydown areas; these extend out of bore pads in the opposite direction of the bore, and serve as an area to assemble pipe segments prior to installation.

Other temporary disturbance areas include three construction staging facilities, including a pipe storage yard along US-30 about 2 miles west of Clatskanie, a storage yard within an existing log yard about 1.5 miles west of Clatskanie, and an existing log yard in the town of Mist along with XX construction work areas along the pipeline route. These are all identified on the Figure C-2maps.

The Project would be located adjacent to the existing North Coast Feeder, a 12-inch gas pipeline, along portions of its route. NWN defines "adjacent" for this purpose as within 25 feet of the existing pipeline. **Table C-1** indicates which segments of the Project would be adjacent to the existing pipeline, and indicates the starting and ending mileposts for those segments. The table is organized sequentially by Project milepost.

Table C-1. Project Segments Adjacent to an Existing Pipeline

Project Segment	Segment Starting Milepost	Segment Ending Milepost	Adjacent [1/]
Segment A	0	0.5	No
Conduit	0.5	2.26 (End of conduit)	Yes
Segment B	0.5	1.68	Yes
Segment C	1.68	2.4	No
Segment C	2.4	3.01	Yes
Segment C	3.01	3.71	No
Segment D	3.71	4.67	Yes
Segment E	4.67	5.44	No
Segment F	5.44	6.34	No
Segment G	6.34	6.71	Yes
Segment G	6.71	7.25	No
Bore 1	7.25	7.6	No
Bore 2	7.6	8.2	No
Bore 3	8.2	8.72	No
Trench	8.72	9.0	No
Bore 4	9.0	9.7	No

Table C-1. Project Segments Adjacent to an Existing Pipeline			
Project Segment	**Segment Starting Milepost**	**Segment Ending Milepost**	**Adjacent 1/**
Bore 5	9.7	10.4	No
Bore 6	10.4	11.15	No
Bore 7	11.15	11.84	No
Bore 8	11.84	12.2	No
Segment G	N/A – within PWIP		Yes
Segment G	N/A – within PWIP		Yes
1/ Adjacent for this purpose is defined as within 25 feet of the existing North Coast Feeder pipeline			

Table C-2 indicates the general location of the Project by Township, Range, and Section, and finally by the Tax Lot identification number of parcels directly affected by permanent or temporary Project facilities or disturbance areas.

Table C-2. Project Location by Township, Range, Section and Tax Lot Number				
Township	**Range**	**Section**	**Tax Lot**	**Tax Lot ID Number**
6N	5W	3	300	6N5W00 300
6N	5W	3	500	6N5W00 500
6N	5W	3	501	6N5W00 501
6N	5W	3	600	6N5W00 600
6N	5W	14	100	6N5W1400 100
6N	5W	3, 4, 9, 10	700	6N5W00 700
7N	4W	6	100	7N4W 600 100
7N	4W	6	200	7N4W 600 200
7N	4W	6	300	7N4W 600 300
7N	4W	6	500	7N4W 600 500
7N	4W	6	599	7N4W 600 599
7N	4W	6	1100	7N4W 600 1100
7N	4W	6	1101	7N4W 600 1101
7N	4W	6	1400	7N4W 600 1400
7N	4W	6	1400	7N4W 600 1400
7N	4W	7	1000	7N4W 700 1000
7N	4W	7	1000	7N4W 700 1000
7N	4W	7	1000	7N4W 700 1000
7N	4W	7	1001	7N4W 700 1001
7N	4W	7	1100	7N4W 700 1100
7N	5W	1	1100	7N5W 100 1100
7N	5W	14, 15, 21, 22, 26, 27	1300	7N5W00 1300
7N	5W	14	1400	7N5W00 1400
7N	5W	22, 27, 28	2200	7N5W00 2200
7N	5W	27	3100	7N5W00 3100
7N	5W	34, 35	4500	7N5W00 4500
7N	5W	34	4600	7N5W00 4600
7N	5W	34	4700	7N5W00 4700

Table C-2. Project Location by Township, Range, Section and Tax Lot Number				
Township	**Range**	**Section**	**Tax Lot**	**Tax Lot ID Number**
7N	5W	34	4800	7N5W00 4800
7N	5W	33, 34	5000	7N5W00 5000
7N	5W	11	601	7N5W1100 601
7N	5W	12	100	7N5W1200 100
7N	5W	12	100	7N5W1200 100
7N	5W	12	201	7N5W1200 201
7N	5W	12	300	7N5W1200 300
7N	5W	12	400	7N5W1200 400
7N	5W	12	401	7N5W1200 401
7N	5W	12	500	7N5W1200 500
8N	4W	15	500	8N4W1500 500
8N	4W	15	600	8N4W1500 600
8N	4W	16	200	8N4W1600 200
8N	4W	16	300	8N4W1600 300
8N	4W	16	400	8N4W1600 400
8N	4W	21	100	8N4W2100 100
8N	4W	21	200	8N4W2100 200
8N	4W	21	400	8N4W2100 400
8N	4W	21	500	8N4W2100 500
8N	4W	21	700	8N4W2100 700
8N	4W	22	1100	8N4W2200 1100
8N	4W	28	101	8N4W2800 101
8N	4W	28	200	8N4W2800 200
8N	4W	29	200	8N4W2900 200
8N	4W	29	300	8N4W2900 300
8N	4W	31	500	8N4W3100 500
8N	4W	32	900	8N4W3200 900
8N	4W	32	1000	8N4W3200 1000
8N	4W	32	1100	8N4W3200 1100
8N	4W	32	1200	8N4W3200 1200

Note: This table includes Township, Range, and Section numbers that are not included in the Site Boundary description (Section IB of the Project Description and OAR Division 27 Compliance document) because listed taxlots often include sections that are not within the Site Boundary.

4.0 Temporary and Permanent Disturbance Areas

Table C-3 presents assumptions regarding disturbance areas related to each component of the Project.

Table C-3. Disturbance Assumptions		
Disturbance Type	**Temporary Disturbance 1/**	**Permanent Disturbance**
Bored pipeline segments	None	None
HDD bore pads	200 feet x 200 feet square (0.9 acres)	None
HDD laydown areas	50-foot wide corridor; length variable	None
Trenched pipeline segments	80-foot wide corridor; as narrow as 20 feet in some constrained segments	None
Trenched conduit segments	80-foot wide corridor; as narrow as 20 feet in some constrained segments	None
Additional trench work areas	Size unique by location; occurs at limited locations along pipeline route; vary in size from about 20 feet up to 80 feet in width and 80 to 1,500 feet in length	None
North Mist Compressor Station	None	7.11 acres
Well pad	None	3.62 acres
Bark and Haul Storage Yard	1.6 acres	None
Weyerhaeuser Storage Yard (200x200)	0.9 acres	None
Kynsi Storage Yard	7.4 acres	None
PWIP Storage Yard	3.1 acres	None
Mainline block valve	None	40 feet x 60 feet (0.06 acres)
1/ These are maximum values and do not necessarily represent exact estimated impact as shown in Table C-4.		

Table C-4 presents the Project's temporary and permanent disturbance footprint, for each facility component individually, and summarized for the Project as a whole. Based on the disturbance assumptions provided above, the Project would have a total permanent disturbance area of approximately 10.8 acres, and a total temporary disturbance area of approximately 133 acres. These totals are intended to represent the maximum allowable impacts associated with the Project as currently designed; further refinements to the Project as may occur during final engineering design which would serve to reduce the Project's impact footprint.

Table C-4. Impact Area Summary			
Disturbance Type	**Impact Multiplier**	**Temporary Disturbance (acres)**	**Permanent Disturbance (acres)**
Bored pipeline segments	4.7 miles	0	0
HDD bore pads	9 pads	8.6	0
HDD laydown areas	3.01 miles	12.2	0
Trenched pipeline segments	8.4 miles	74.9	0
Trenched conduit pipeline segments	1.7 miles	16.4	0

Table C-4. Impact Area Summary			
Disturbance Type	**Impact Multiplier**	**Temporary Disturbance (acres)**	**Permanent Disturbance (acres)**
Additional trench work areas	Unique by area	3.6	0
North Mist Compressor Station	1	0	7.11
Well pad	1	0	3.62
Bark and Haul Storage Yard	1	1.6	0
Weyerhaeuser Storage Yard (200x200)	1	0.9	0
Kynsi Storage Yard	1	7.4	0
PWIP Storage Yard	1	3.1	0
Mainline block valve	1	0	0.06
Project Total[1/]	**-**	**130.9**	**10.79**
1/ Disturbance totals do not equal the sum of the columns, since disturbance areas of different types overlap.			

5.0 Submittal Requirements and Approval Standards

5.1 Submittal Requirements

Table C-5. Submittal Requirements Matrix	
Requirement	**Location**
OAR 345-021-0010(1)(c) Information about the location of the proposed facility, including:	
(A) A map or maps showing the proposed locations of the energy facility site, all related or supporting facility sites and all areas that might be temporarily disturbed during construction of the facility in relation to major roads, water bodies, cities and towns, important landmarks and topographic features, using a scale of 1 inch = 2000 feet or smaller when necessary to show detail;	Figures C-1 and C-2
(B) A description of the location of the proposed energy facility site, the proposed site of each related or supporting facility and areas of temporary disturbance, including the total land area (in acres) within the proposed site boundary, the total area of permanent disturbance, and the total area of temporary disturbance. If a proposed pipeline or transmission line is to follow an existing road, pipeline or transmission line, the applicant shall state to which side of the existing road, pipeline or transmission line the proposed facility will run, to the extent this is known.	Sections 3 and 4 Tables C-1, C-2, and C-3
(C) For energy generation facilities, a map showing the approximate locations of any other energy generation facilities that are known to the applicant to be permitted at the state or local level within the study area as defined in OAR 345-001-0010 for impacts to public services.	Not Applicable

5.2 Approval Standard

OAR 345 Division 22 does not provide an approval standard specific to Exhibit C.

FIGURES

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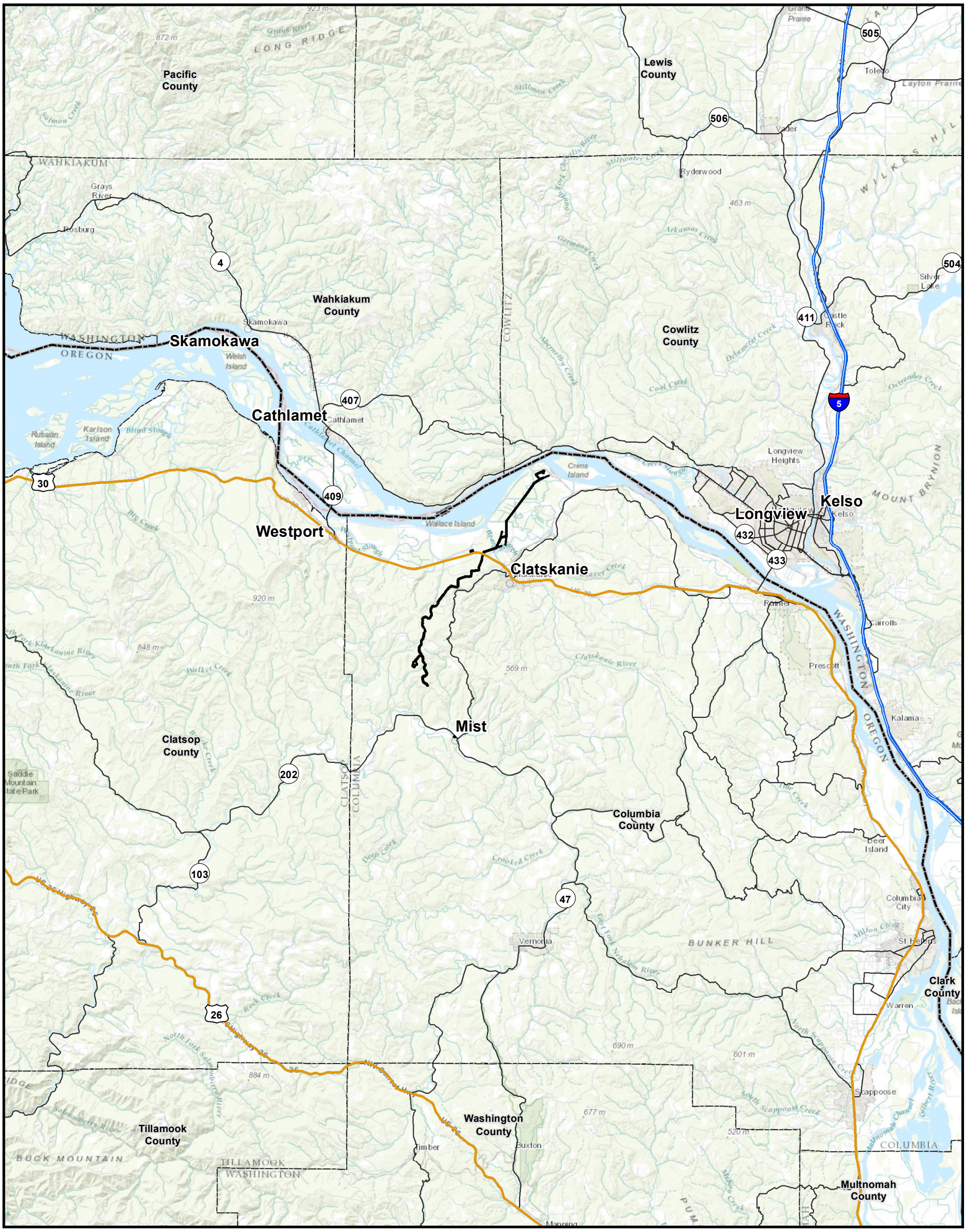

NW Natural

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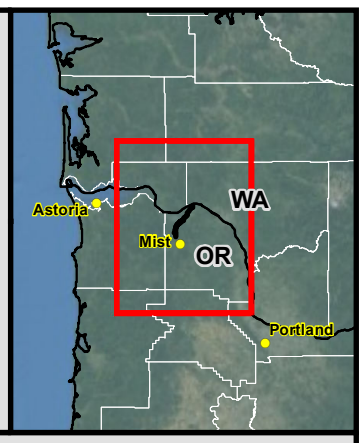
Figure C-1
Project Vicinity Map

Site Boundary
City/Town
Interstate Highway
Secondary Highway
Secondary Road
County Boundary
State Boundary



1:275,000 WGS84 UTM Zone 10

0 0.5 1 2 3 4 5 Miles

Data Sources NW Natural: project facilities / Tetra Tech: survey area, habitat type and category / ESRI: roads, political boundaries, background imagery

TETRA TECH

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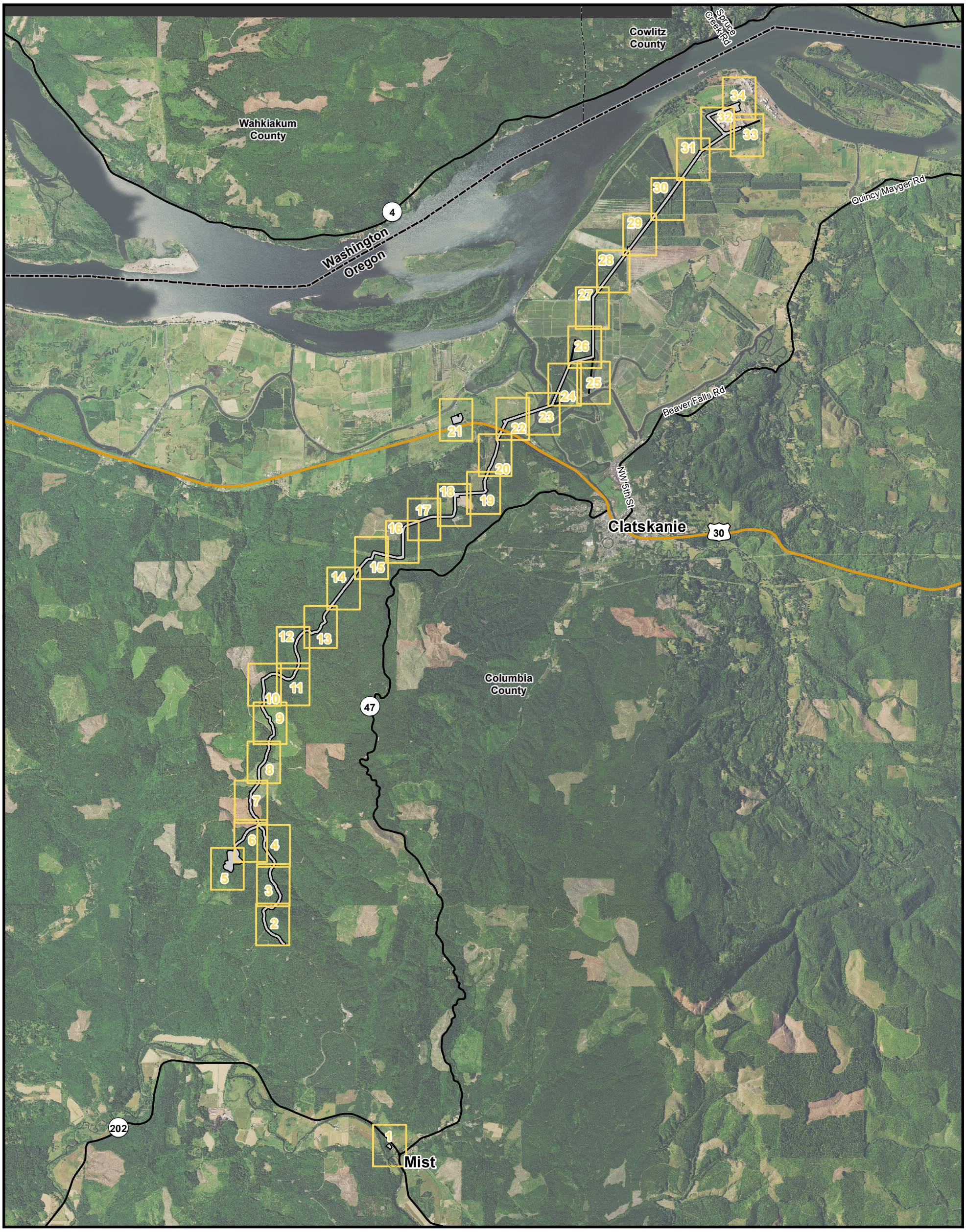

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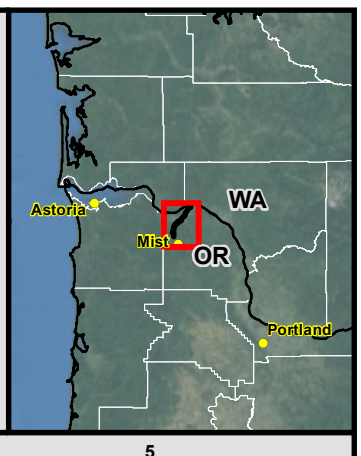
Figure C-2
Index Map

Site Boundary
Map Grid
City/Town
Secondary Highway
Secondary Road
County Boundary
State Boundary



1:70,000 WGS84 UTM Zone 10

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Data Sources NW Natural: project facilities / Tetra Tech: survey area, habitat type and category / ESRI: roads, political boundaries, background imagery

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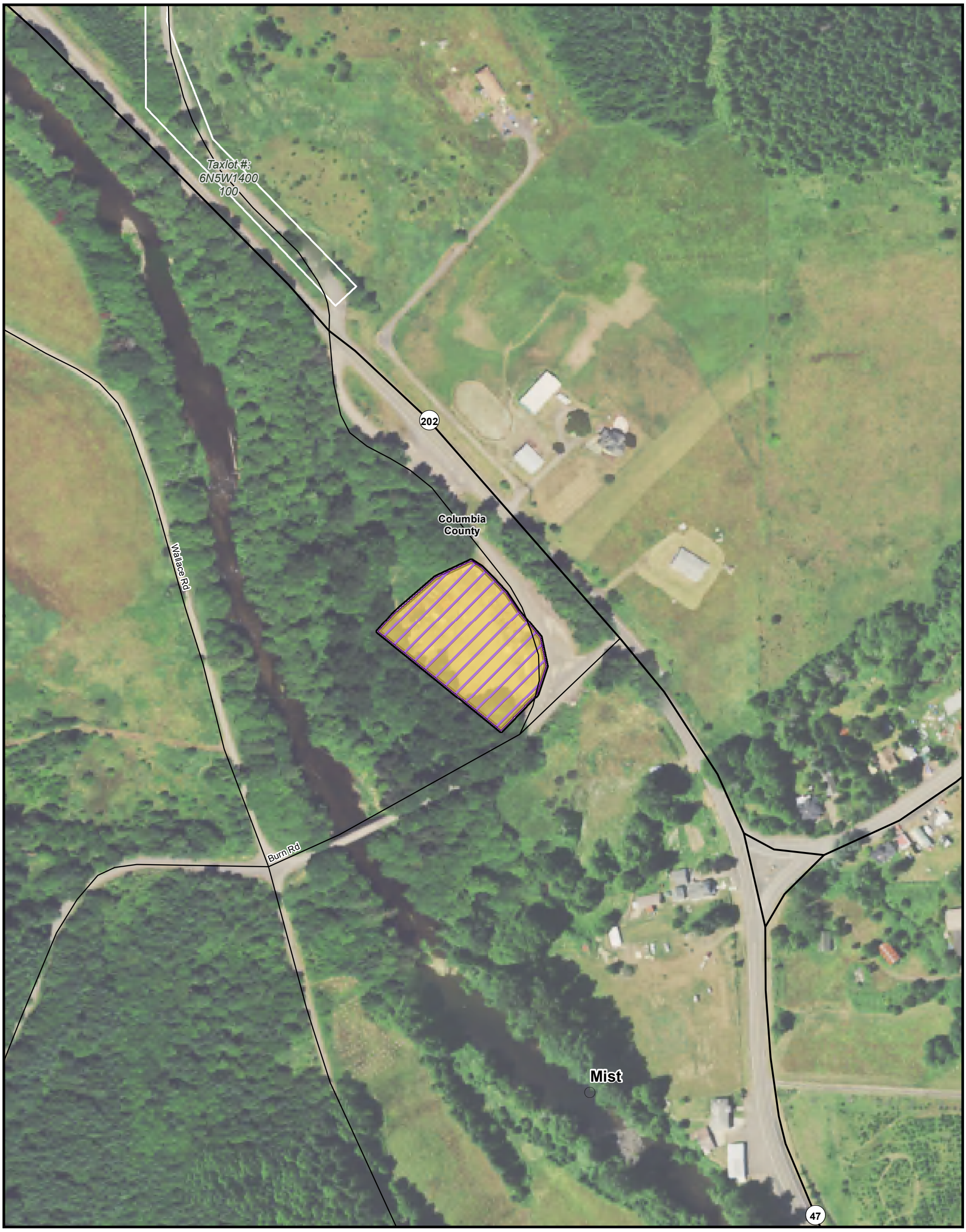

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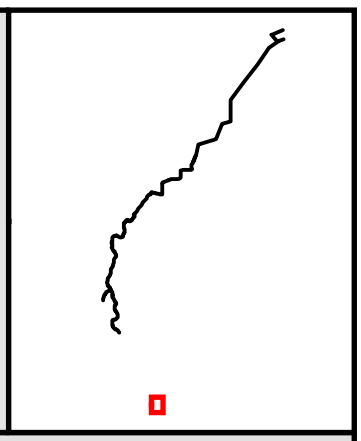
Figure C-2.1

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Taxlot Boundary
- Pipe Storage
- Temporary Impact
- City/Town
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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Figure C-2.2

Detailed Project Layout and Impact Maps (2015-02-23 Design)

Site Boundary
Mile Post
1/10 Mile Post
Corridor
Proposed Conduit
Taxlot Boundary
Temporary Impact
Local Road
County Boundary
State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.

1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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Figure C-2.3

Detailed Project Layout and Impact Maps (2015-02-23 Design)

Site Boundary
1/10 Mile Post
Corridor
Proposed Conduit
Taxlot Boundary
Temporary Impact
Local Road
County Boundary
State Boundary

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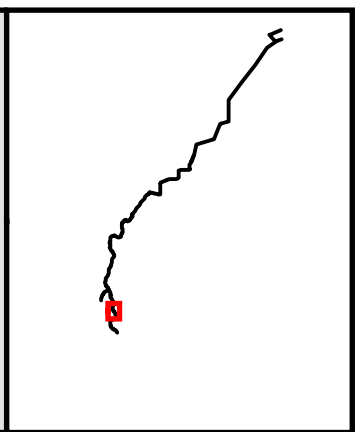

1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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Figure C-2.4

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post
- Corridor
- Trench
- Proposed Conduit
- Taxlot Boundary
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.

1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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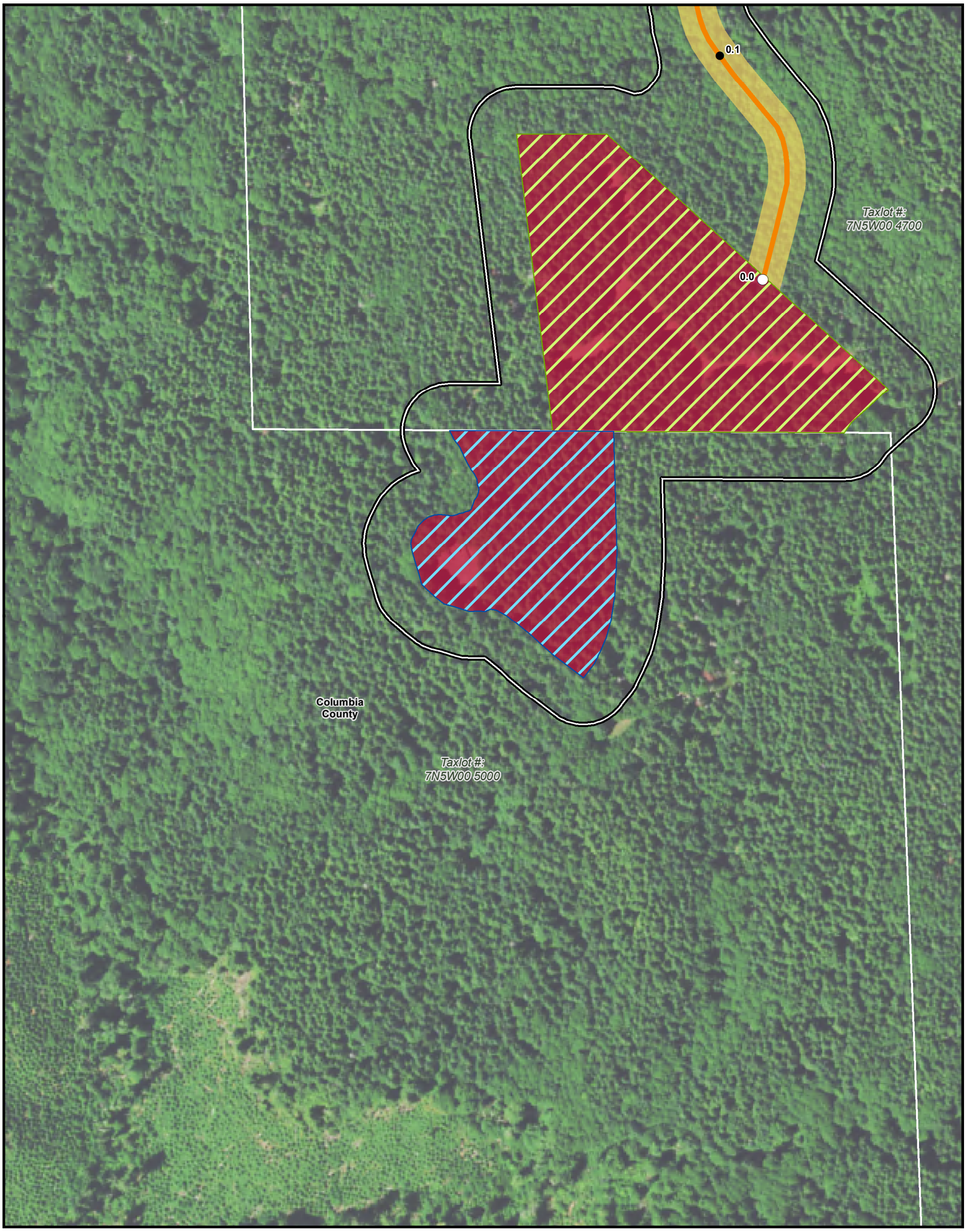

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Figure C-2.5

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post
- Corridor
- Trench
- Taxlot Boundary
- Compressor Station
- Well Pad
- Permanent Impact
- Temporary Impact
- County Boundary
- State Boundary

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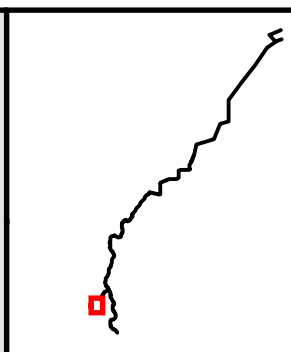

1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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Figure C-2.6

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post

Corridor

- Trench
- Proposed Conduit
- Taxlot Boundary
- Compressor Station
- Temporary Extra Work Space
- Permanent Impact
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.

1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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Figure C-2.7

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post

Corridor

- Trench
- Taxlot Boundary
- Temporary Extra Work Space
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

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1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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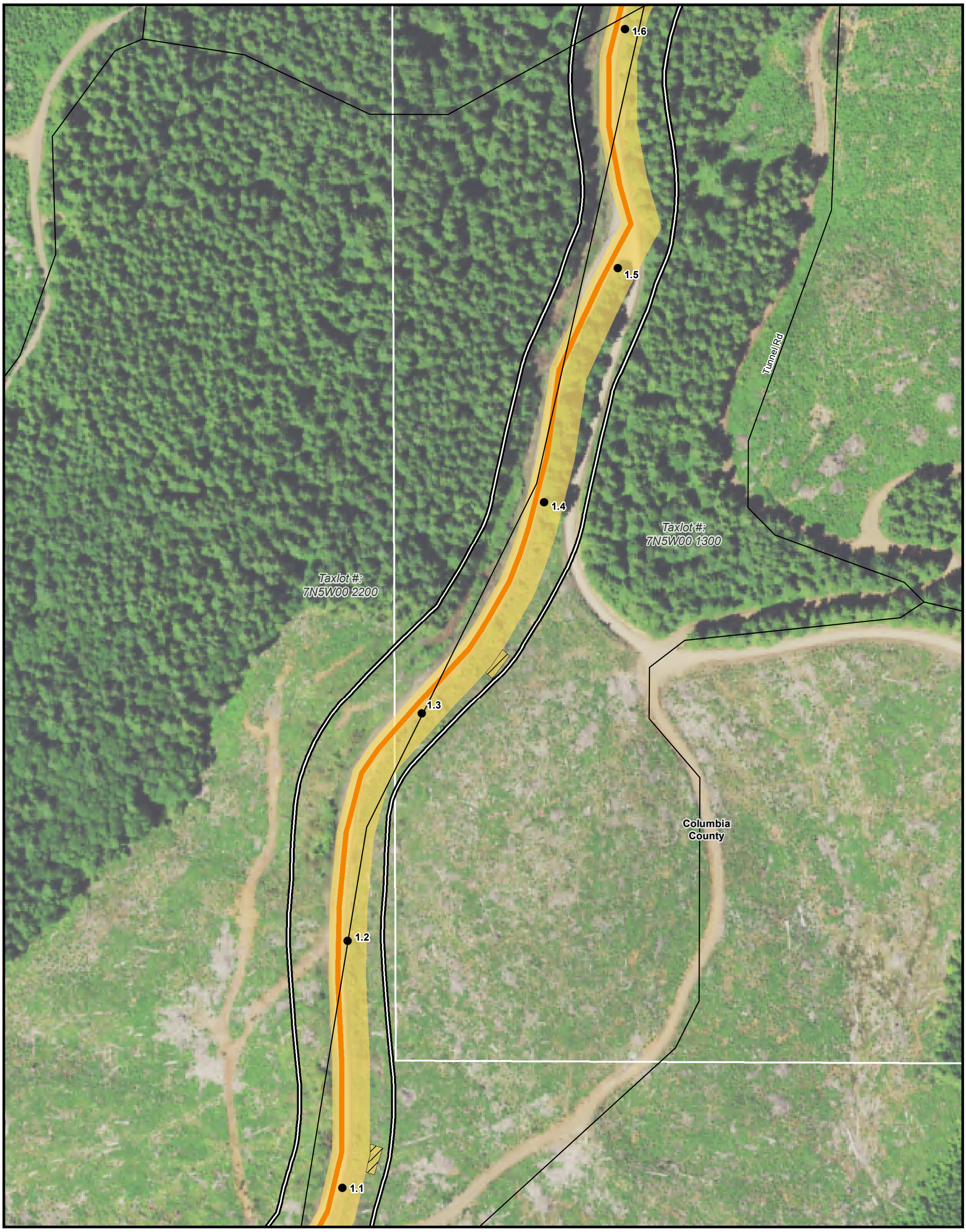

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Figure C-2.8

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- 1/10 Mile Post
- Corridor
- Trench
- Taxlot Boundary
- Temporary Extra Work Space
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

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1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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Figure C-2.9

Detailed Project Layout and Impact Maps (2015-02-23 Design)

Site Boundary
Mile Post
1/10 Mile Post
Corridor
Trench
Taxlot Boundary
Temporary Extra Work Space
Temporary Impact
Local Road
County Boundary
State Boundary

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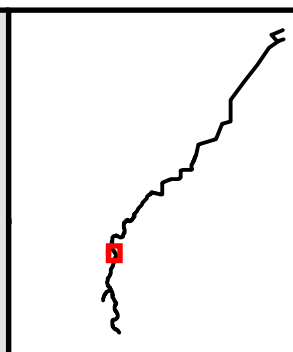

1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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Figure C-2.10

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- 1/10 Mile Post
- Corridor
- Trench
- Taxlot Boundary
- Temporary Extra Work Space
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

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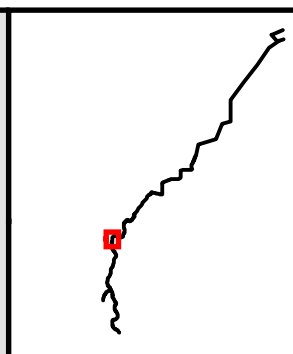

N 1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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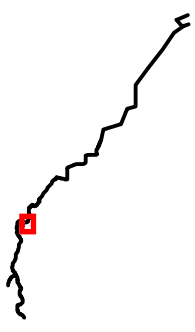
Figure C-2.11

Detailed Project Layout and Impact Maps (2015-02-23 Design)

Site Boundary
1/10 Mile Post
Corridor
Trench
Taxlot Boundary
Temporary Extra Work Space
Temporary Impact
Local Road
County Boundary
State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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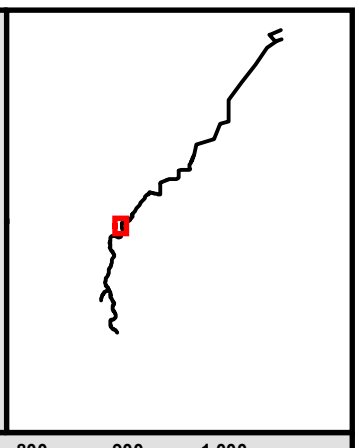
Figure C-2.12

Detailed Project Layout and Impact Maps (2015-02-23 Design)

Site Boundary
Mile Post
1/10 Mile Post
Corridor
Trench
Taxlot Boundary
Temporary Extra Work Space
Temporary Impact
Local Road
County Boundary
State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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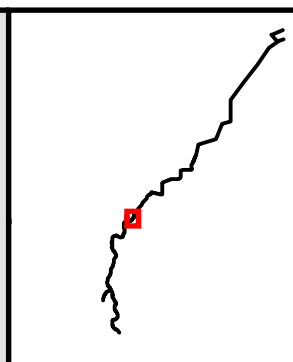
Figure C-2.13

Detailed Project Layout and Impact Maps (2015-02-23 Design)

Site Boundary
1/10 Mile Post
Corridor
Trench
Taxlot Boundary
Temporary Extra Work Space
Temporary Impact
Local Road
County Boundary
State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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Figure C-2.14

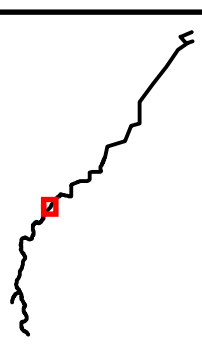
Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post
- Local Road
- County Boundary
- State Boundary

Corridor

- Trench
- Taxlot Boundary
- Temporary Impact

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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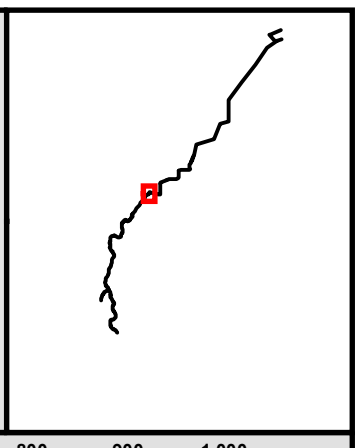
Figure C-2.15

Detailed Project Layout and Impact Maps (2015-02-23 Design)

Site Boundary
1/10 Mile Post
Corridor
Trench
Taxlot Boundary
Temporary Impact
Local Road
County Boundary
State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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Figure C-2.16

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post

Corridor

- Trench
- Taxlot Boundary
- Temporary Extra Work Space
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.

1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

TETRA TECH

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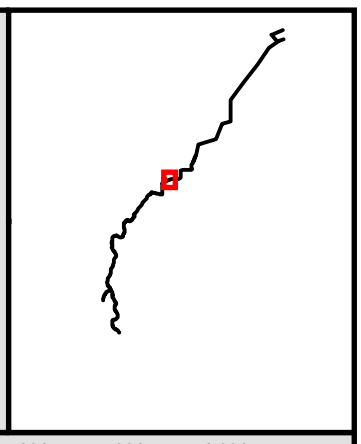
Figure C-2.17

Detailed Project Layout and Impact Maps (2015-02-23 Design)

Site Boundary
1/10 Mile Post
Corridor
Trench
Taxlot Boundary
Temporary Impact
Local Road
County Boundary
State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

TETRA TECH

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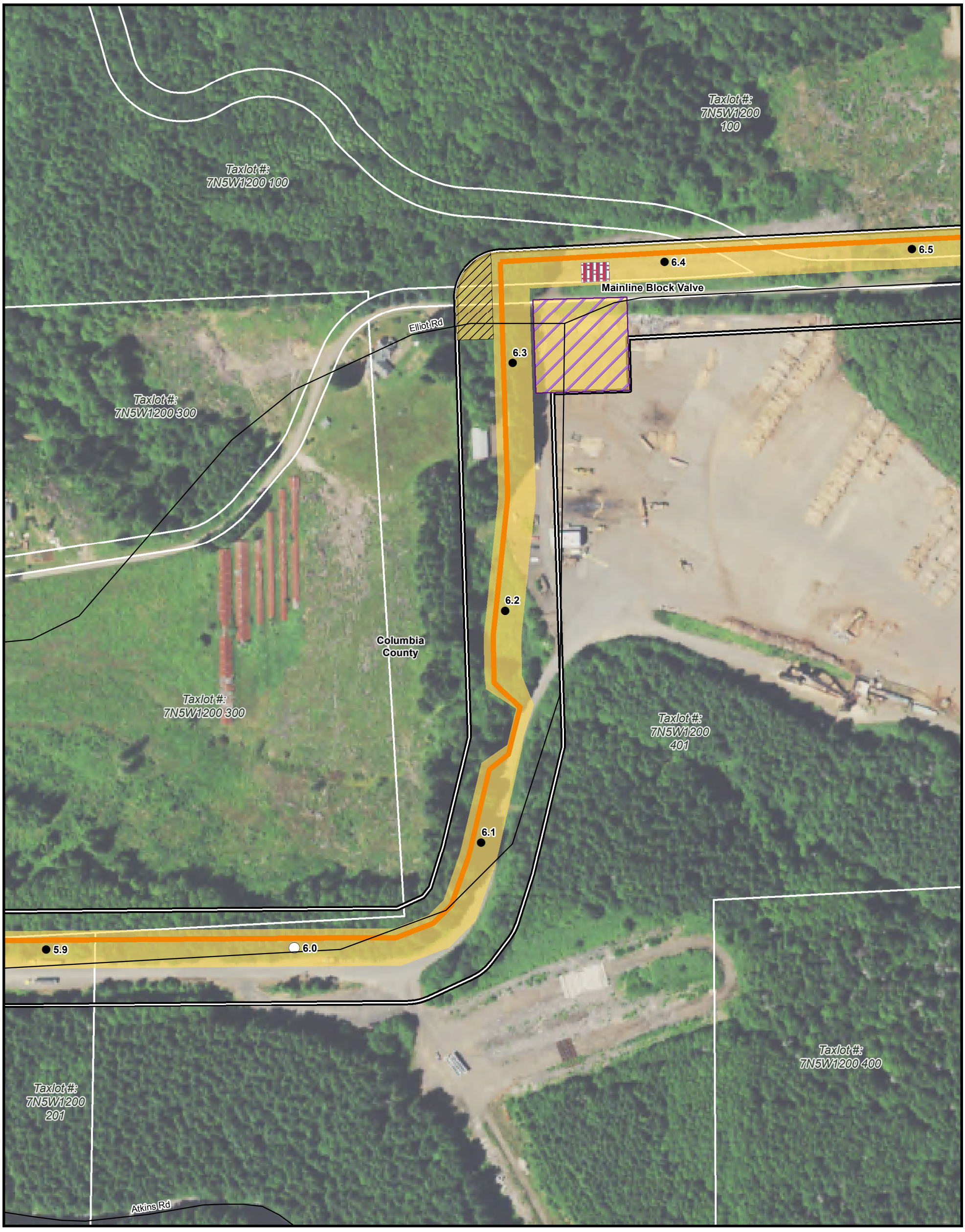

NW Natural

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Figure C-2.18

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post

Corridor

- Trench
- Mainline Block Valve
- Taxlot Boundary
- Pipe Storage
- Temporary Extra Work Space
- Permanent Impact
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.

1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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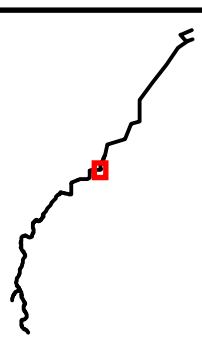
Figure C-2.19

Detailed Project Layout and Impact Maps (2015-02-23 Design)

Site Boundary
1/10 Mile Post
Corridor
Trench
Taxlot Boundary
Laydown
Temporary Impact
Local Road
County Boundary
State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

TETRA TECH

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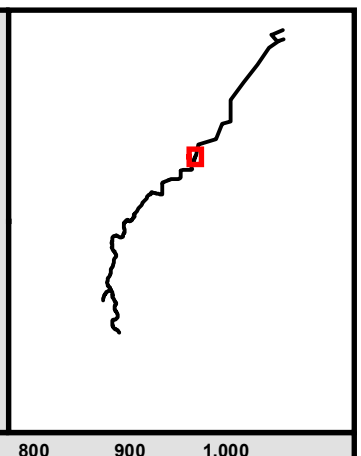
Figure C-2.20

Detailed Project Layout and Impact Maps (2015-02-23 Design)

Site Boundary
Mile Post
1/10 Mile Post
Corridor
Bore
Trench
Taxlot Boundary
Laydown
Temporary Impact
Local Road
County Boundary
State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

TETRA TECH

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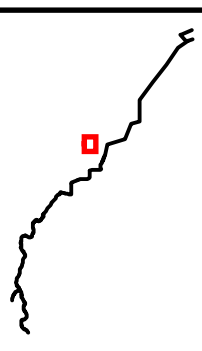
Figure C-2.21

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Taxlot Boundary
- Pipe Storage
- Temporary Impact
- Secondary Highway
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

TETRA TECH

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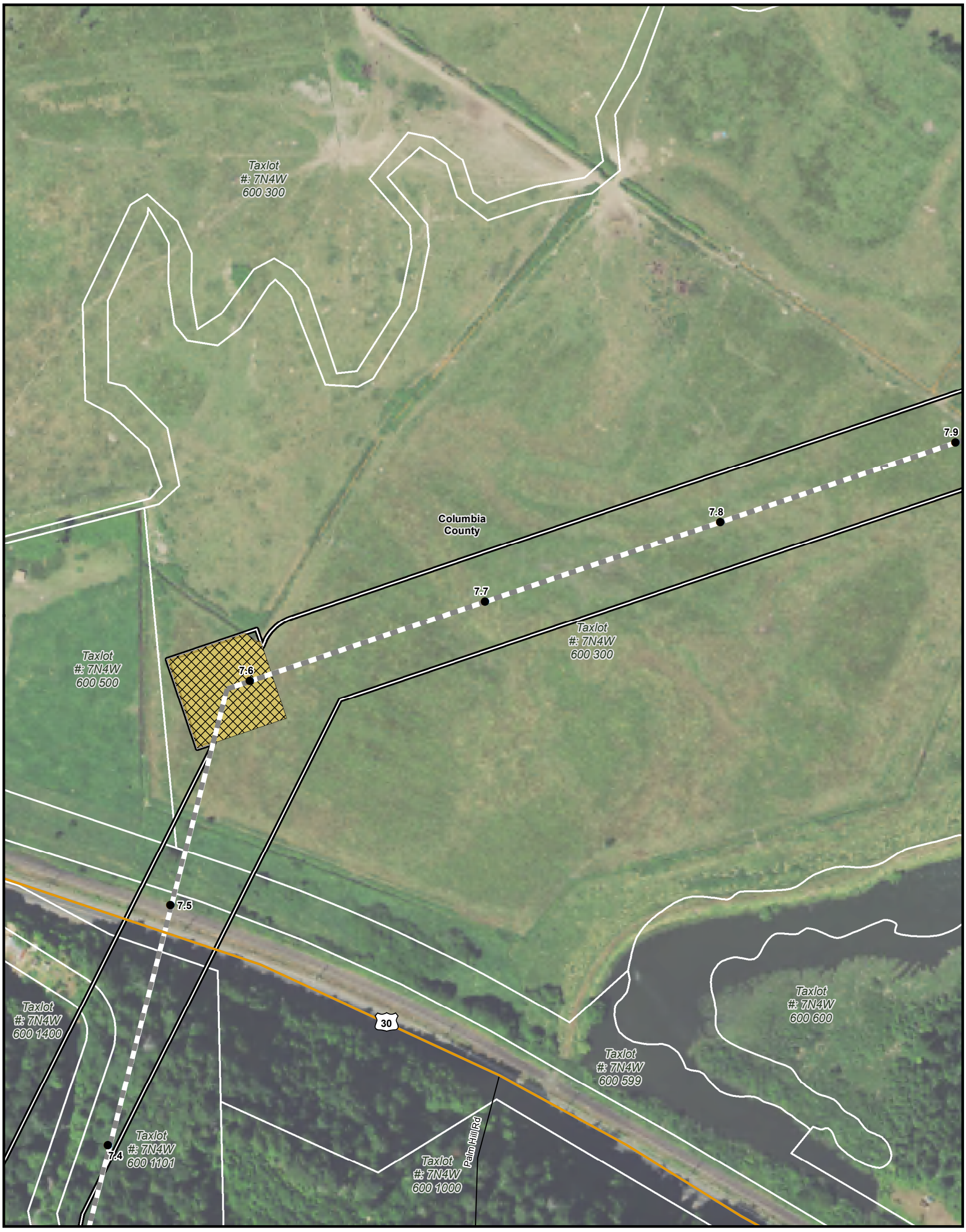

NW Natural

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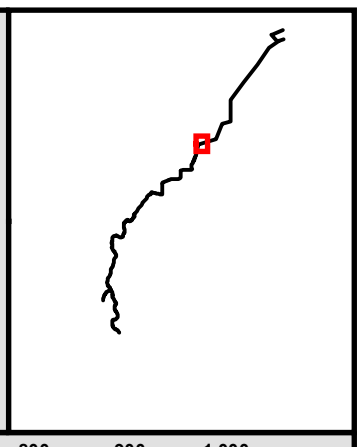
Figure C-2.22

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- 1/10 Mile Post
- Corridor
- Bore
- Taxlot Boundary
- Bore Pad
- Temporary Impact
- Secondary Highway
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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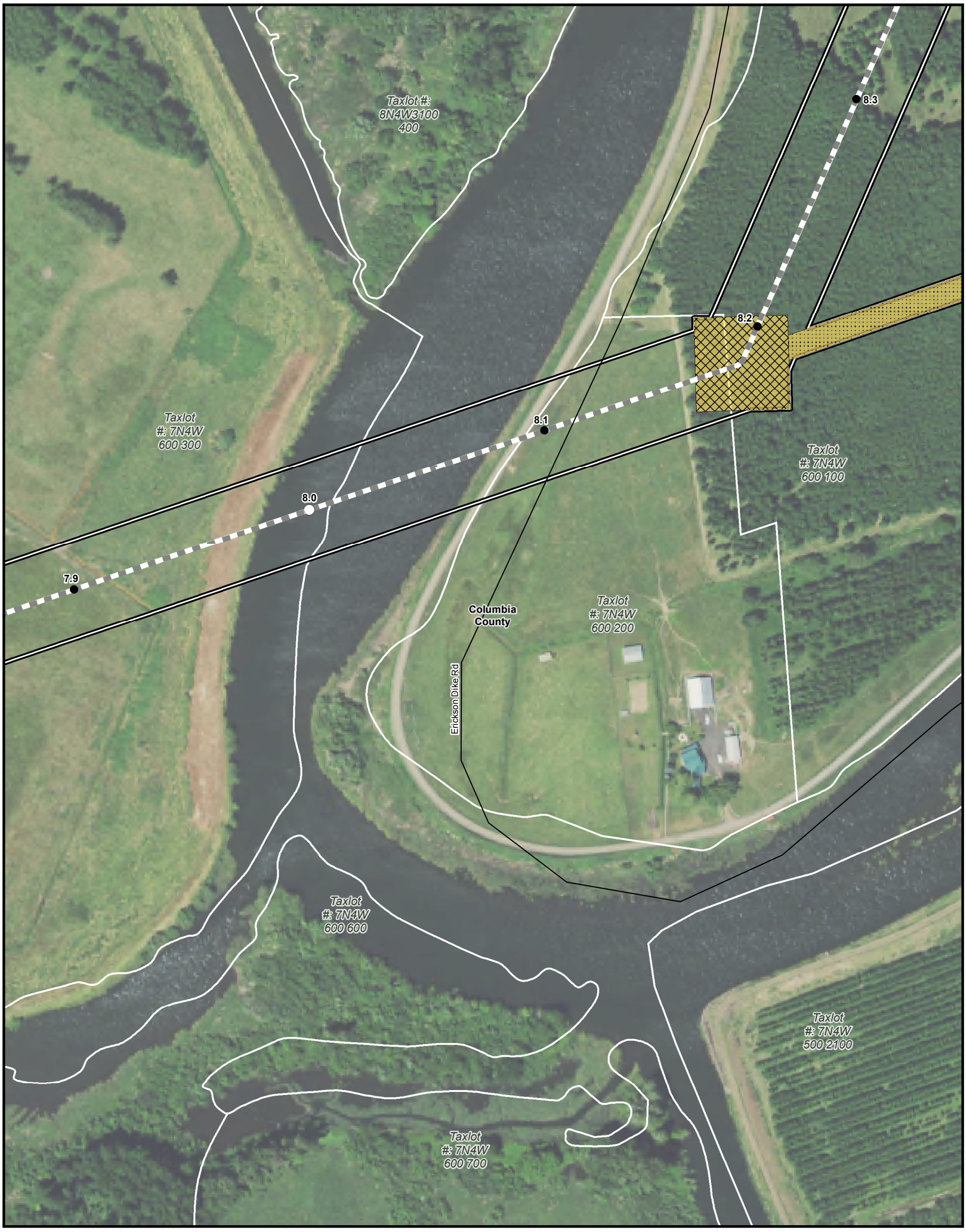

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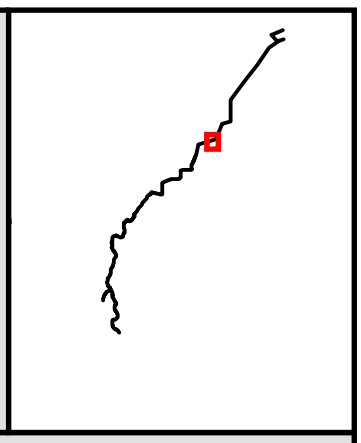
Figure C-2.23

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post
- Corridor
- Bore
- Taxlot Boundary
- Bore Pad
- Laydown
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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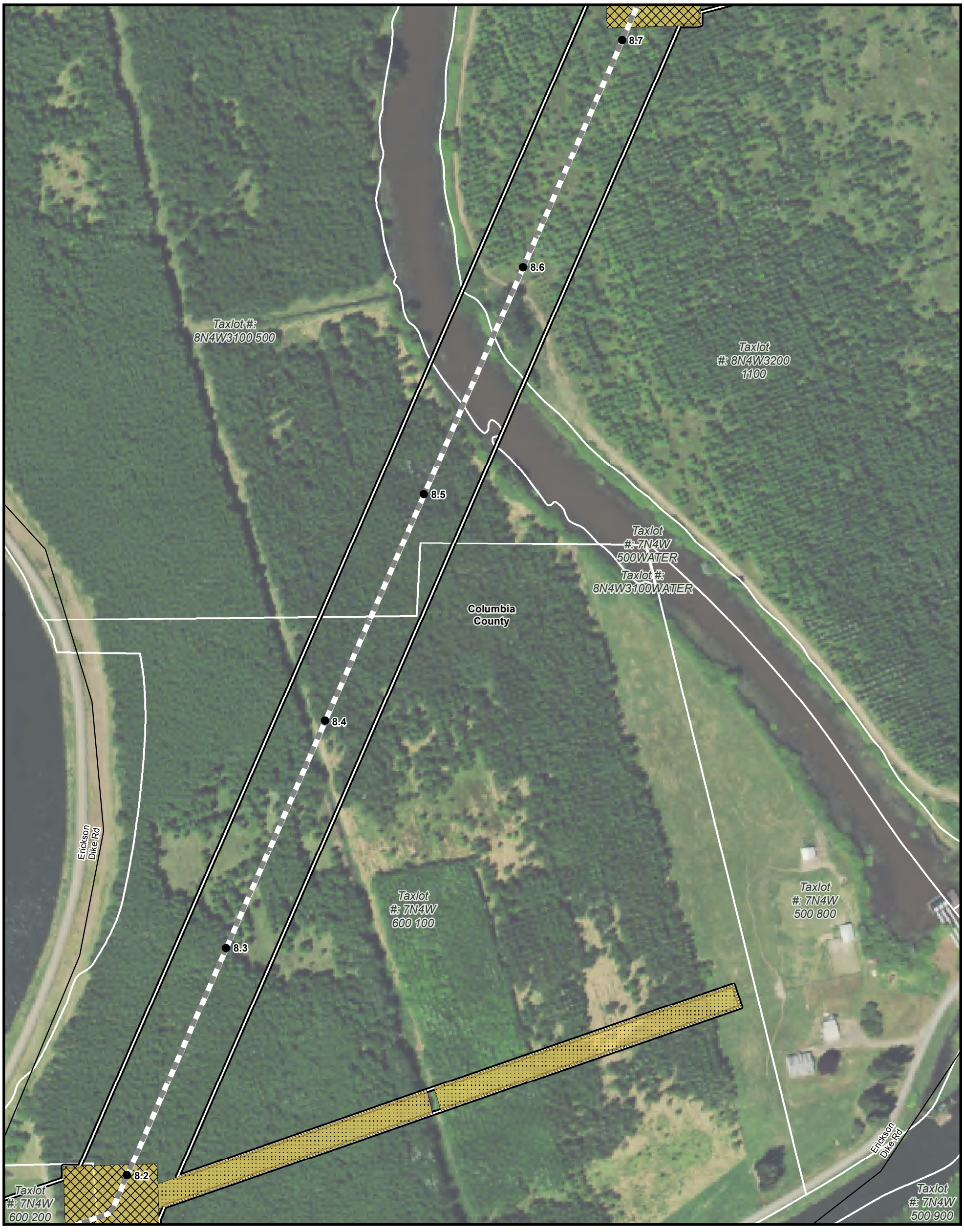

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Figure C-2.24

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- 1/10 Mile Post
- Corridor
- Bore
- Taxlot Boundary
- Bore Pad
- Laydown
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.

1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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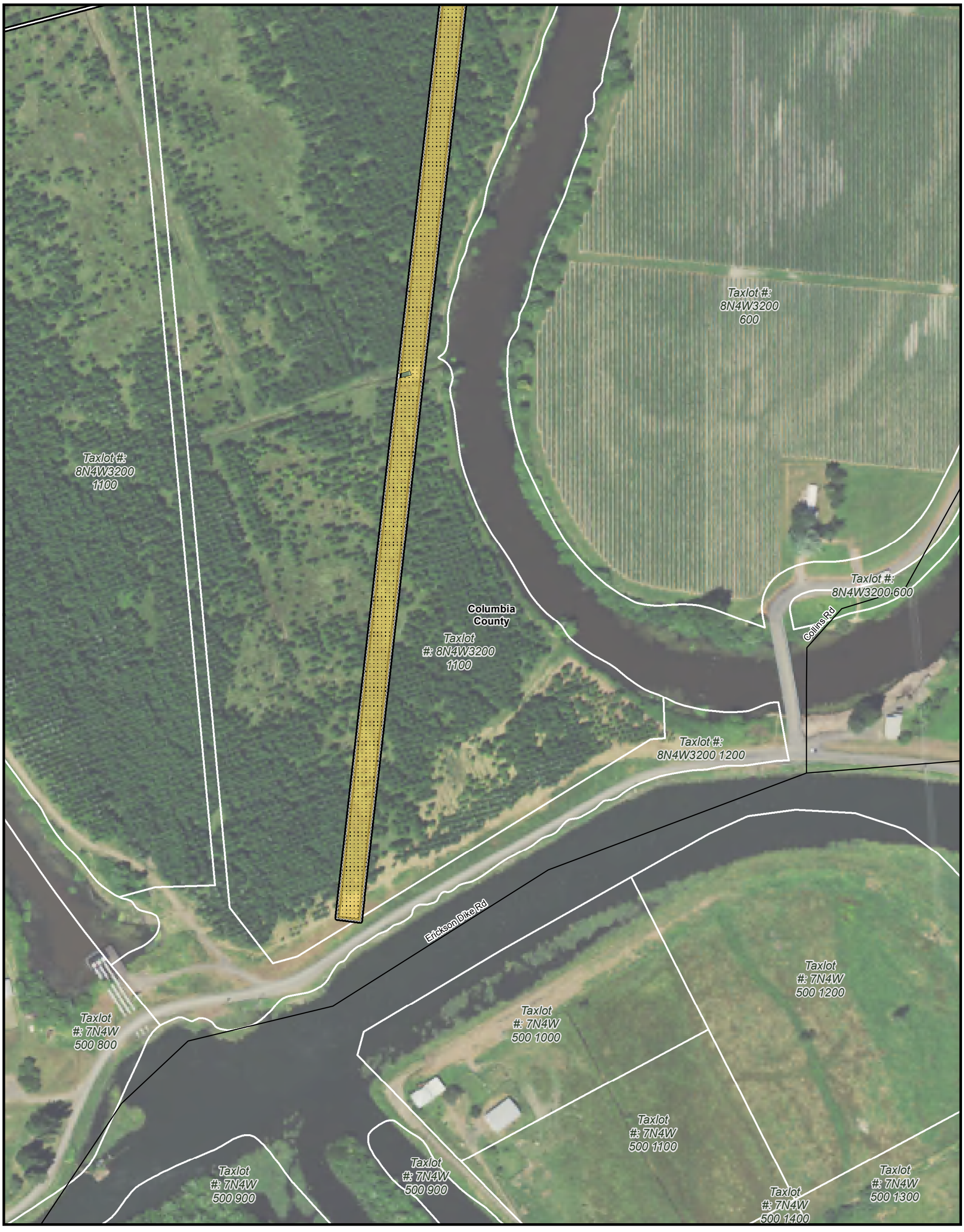

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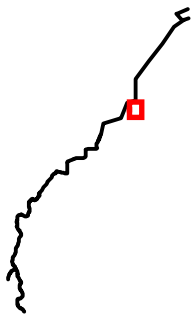
Figure C-2.25

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Taxlot Boundary
- Laydown
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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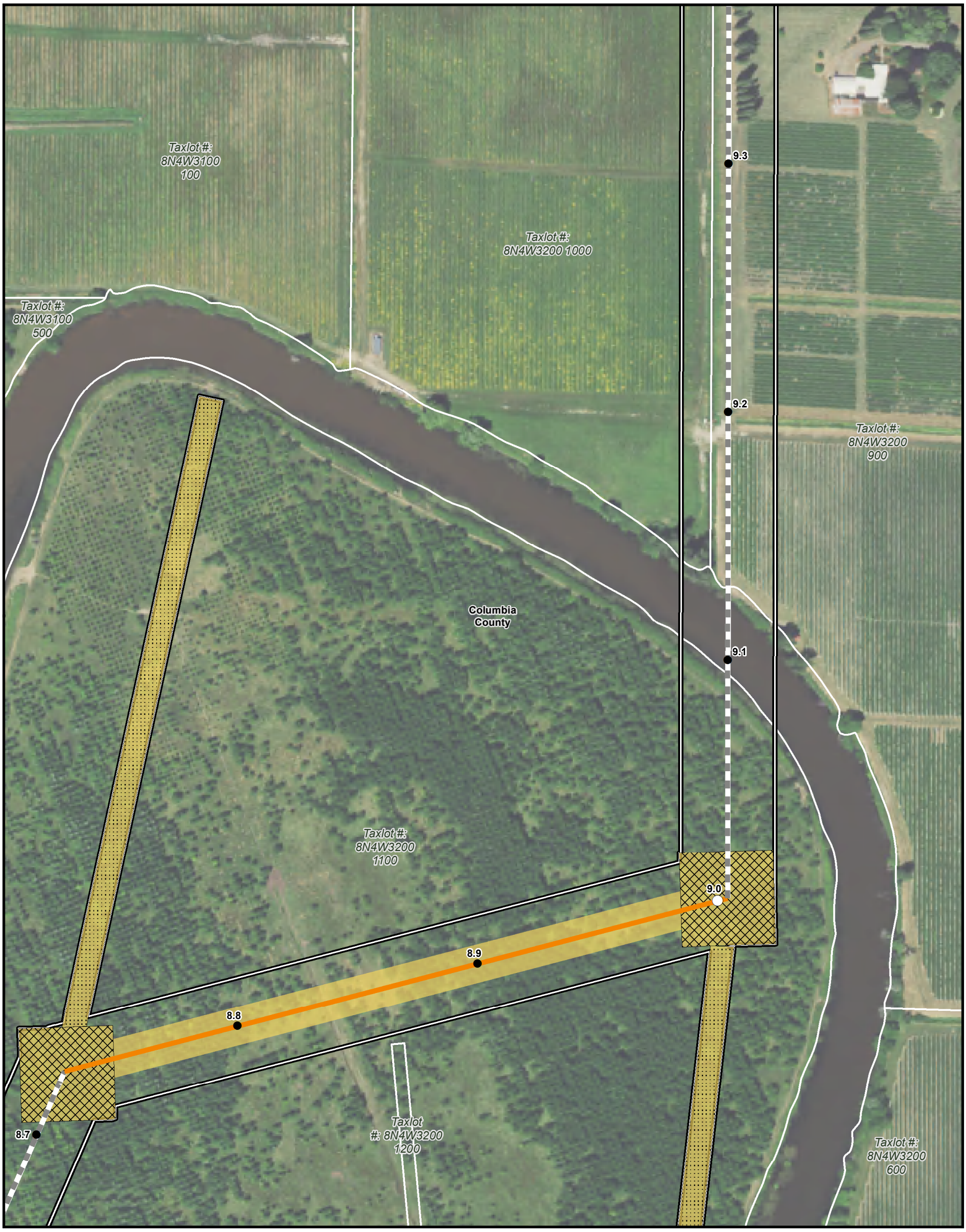

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Figure C-2.26

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post
- Corridor
- Bore
- Trench
- Taxlot Boundary
- Bore Pad
- Laydown
- Temporary Impact
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.

1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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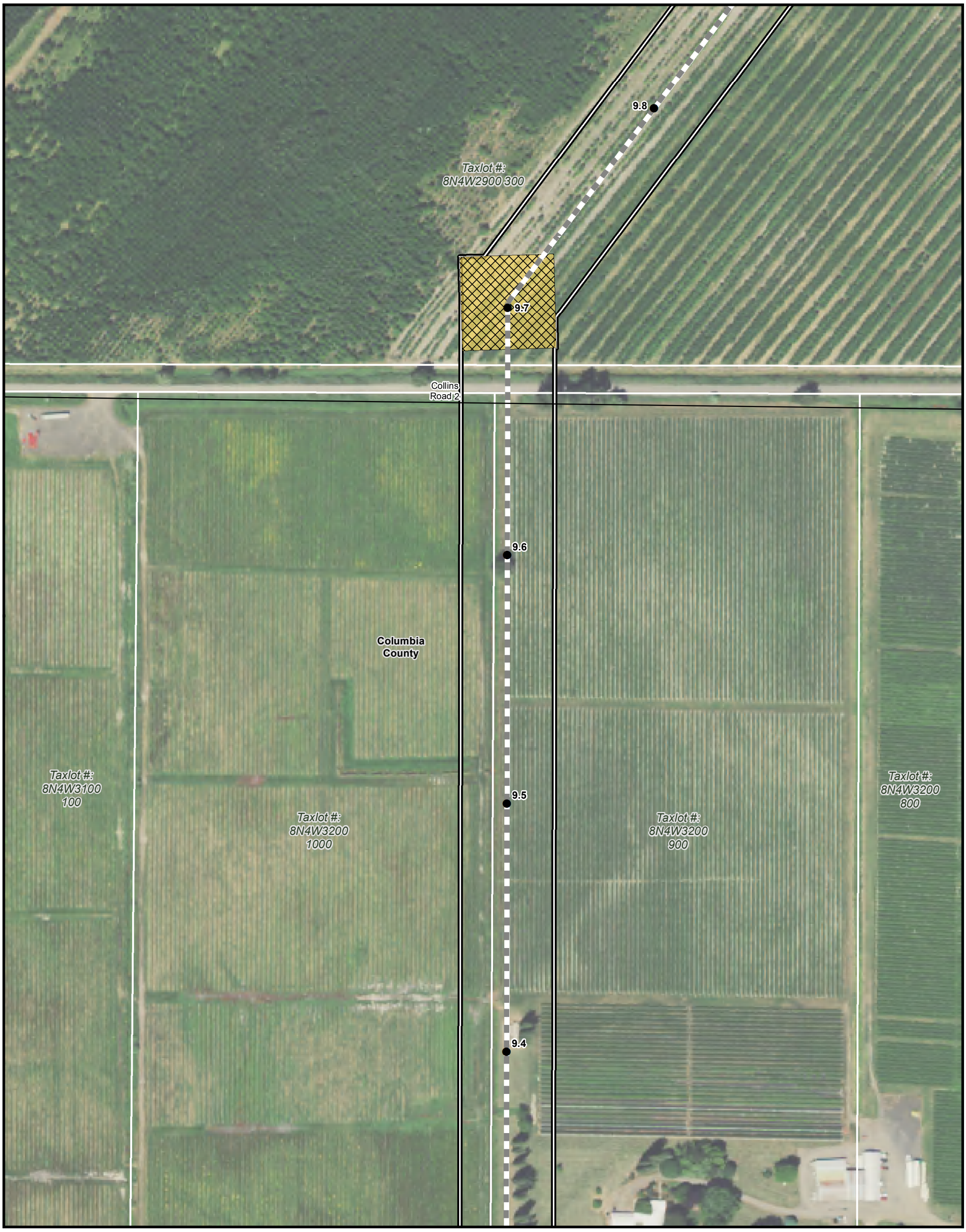

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Figure C-2.27

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- 1/10 Mile Post
- Corridor
- Bore
- Taxlot Boundary
- Bore Pad
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.

1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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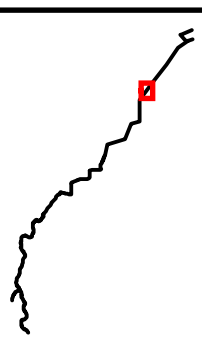
Figure C-2.28

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post
- Corridor
- Bore
- Taxlot Boundary
- Bore Pad
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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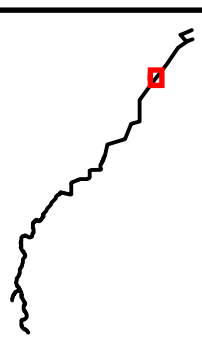
Figure C-2.29

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- 1/10 Mile Post
- Corridor
- Bore
- Taxlot Boundary
- Bore Pad
- Laydown
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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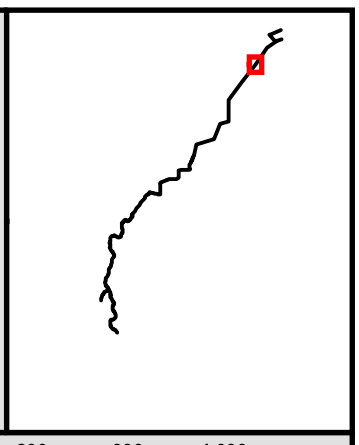
Figure C-2.30

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post
- Corridor
- Bore
- Taxlot Boundary
- Bore Pad
- Laydown
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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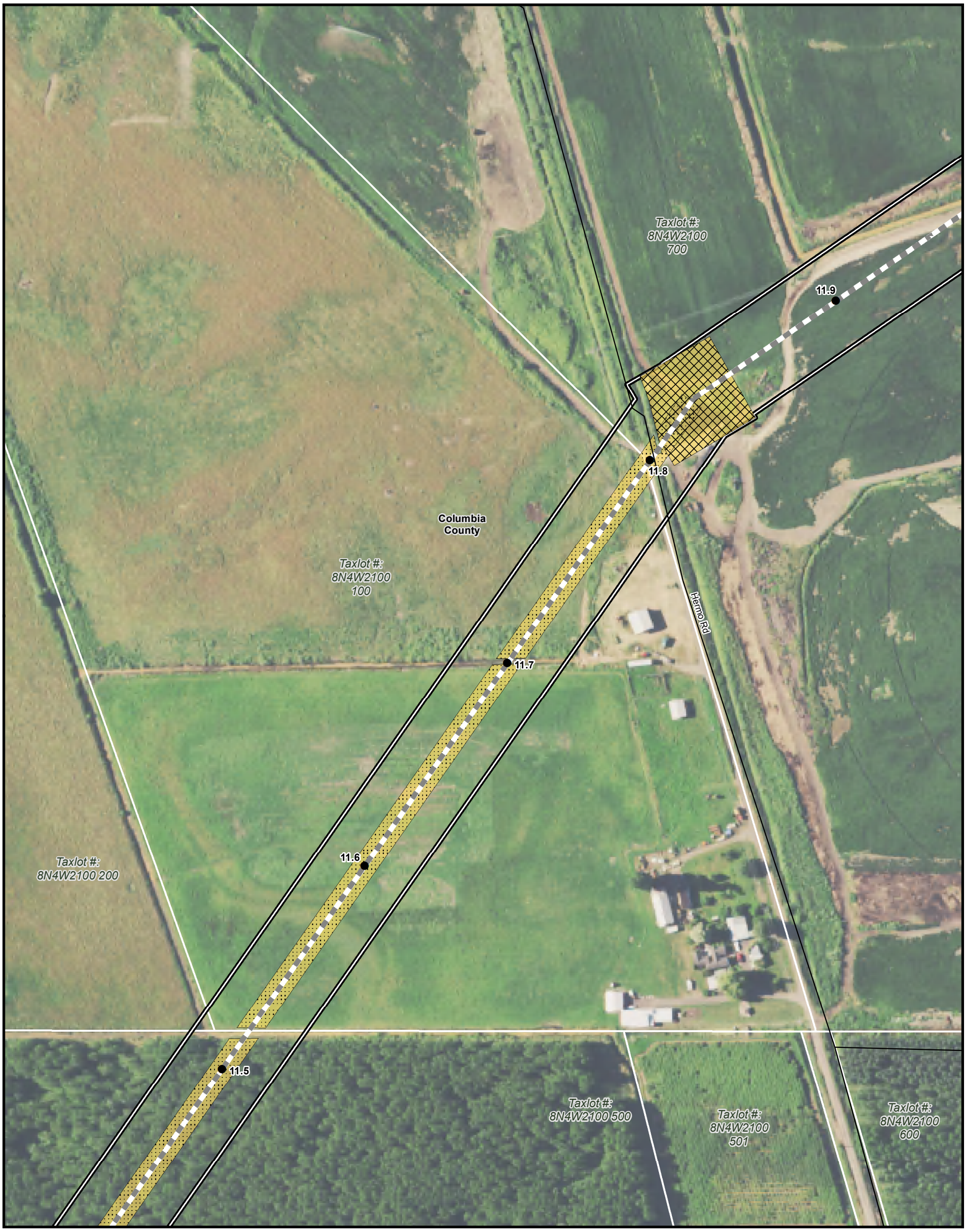

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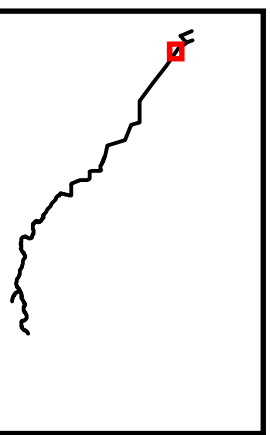
Figure C-2.31

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- 1/10 Mile Post
- Corridor
- Bore
- Taxlot Boundary
- Bore Pad
- Laydown
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

TETRA TECH

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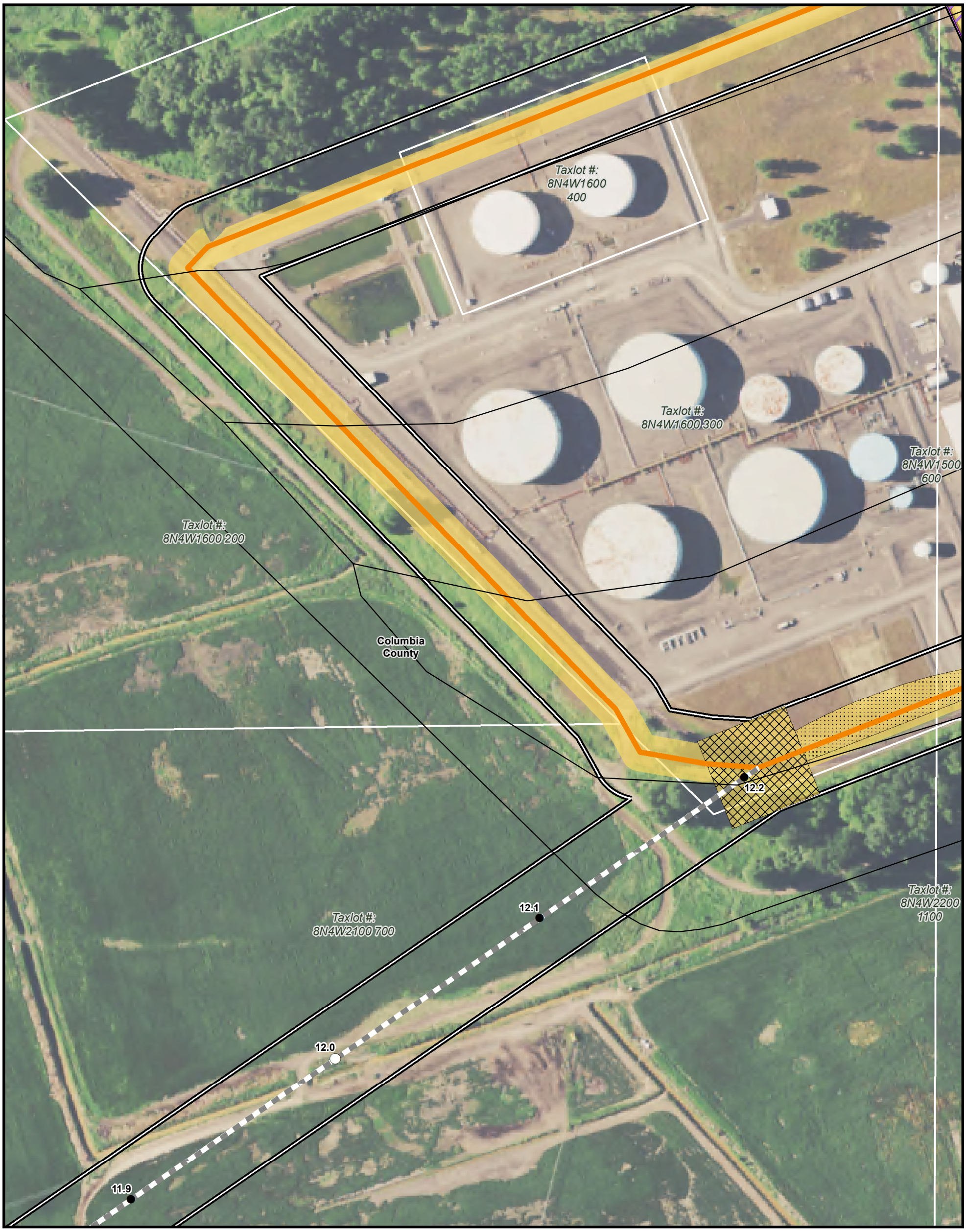

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Figure C-2.32

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Mile Post
- 1/10 Mile Post
- Corridor
- Bore
- Trench
- Taxlot Boundary
- Pipe Storage
- Bore Pad
- Laydown
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.

1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

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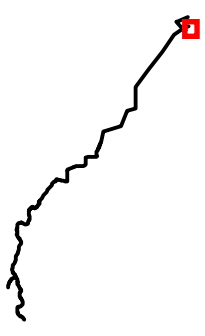
Figure C-2.33

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Corridor
- Trench
- Taxlot Boundary
- Laydown
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 1 inch = 200 feet WGS84 UTM Zone 10

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

TETRA TECH

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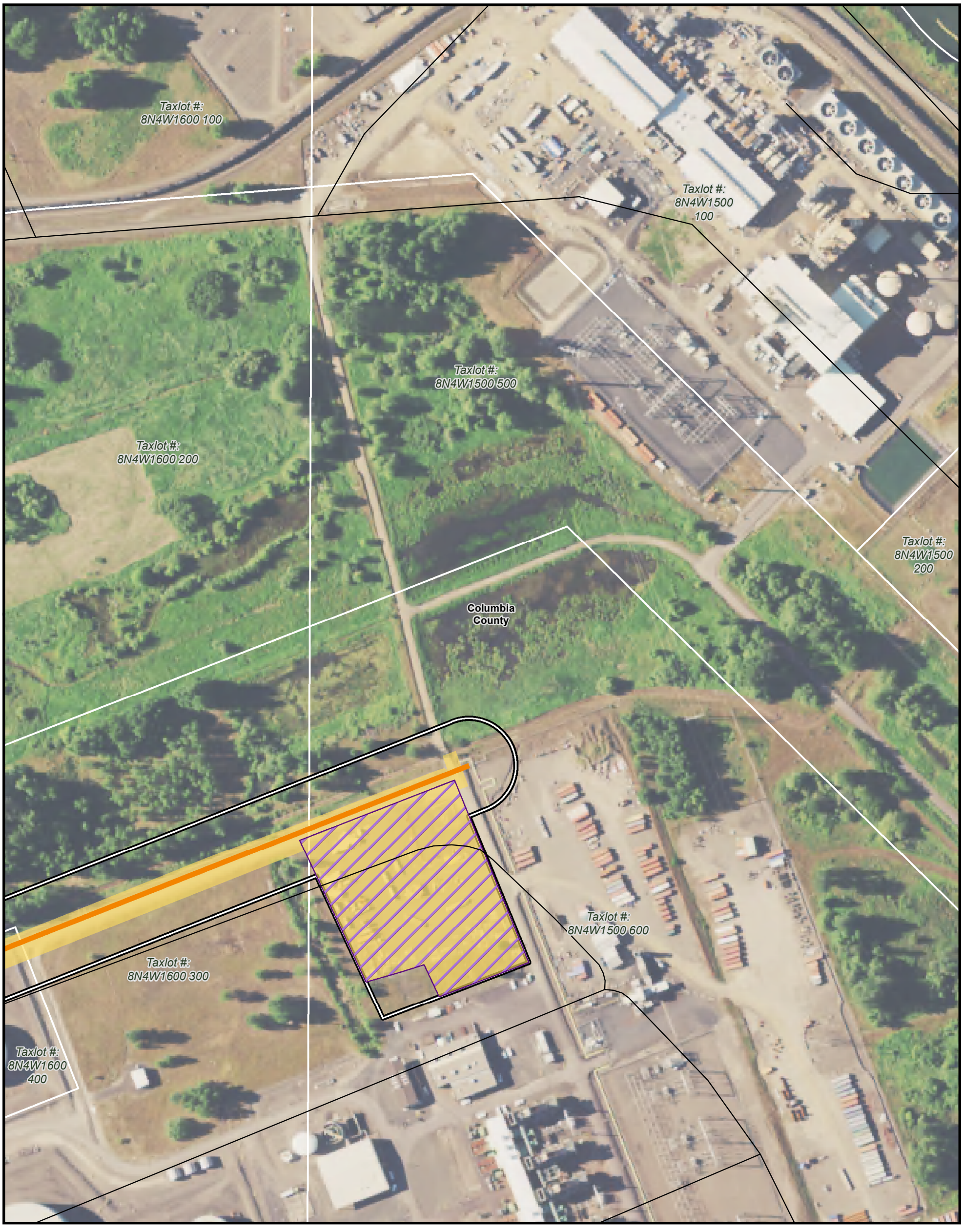


NW Natural

North Mist Expansion Project

Request for Amendment to Site Certificate

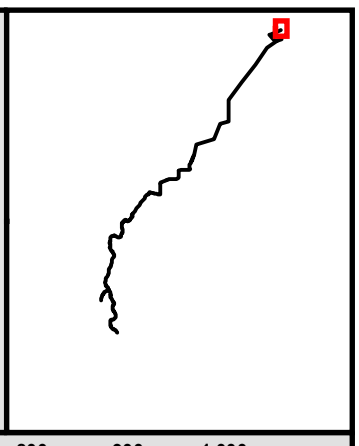
Columbia County, OR
November 2015

Figure C-2.34

Detailed Project Layout and Impact Maps (2015-02-23 Design)

- Site Boundary
- Corridor
- Trench
- Taxlot Boundary
- Pipe Storage
- Temporary Impact
- Local Road
- County Boundary
- State Boundary

*Due to the variable spatial accuracy of all the displayed data layers, some features appear to be overlapping which may not reflect what is on the ground.



1:2,400 **1 inch = 200 feet** **WGS84 UTM Zone 10**

0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

Data Sources NW Natural: project facilities / ESRI: roads, political boundaries, background imagery

TETRA TECH

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Exhibit D

Organizational Expertise

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The details normally discussed in this Exhibit are included in the **Project Description and OAR Division 27 Compliance** document, which can be found at the beginning of this Request for Amendment to Site Certificate.

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Exhibit E

Permits Needed for Construction and Operation

North Mist Expansion Project

November 2015

Northwest Natural Gas

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Attachment E-5. Federal Concurrence Letters

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1.0 Overview

OAR 345-021-0010(1)(e) *Information about permits needed for construction and operation of the facility, including:*

Response: The following sections list information about the permits required for the construction and operation of the proposed North Mist Expansion Project (Project).

2.0 Identification and Description of Required Permits

OAR 345-021-0010(1)(e)(A) *Identification of all federal, state and local government permits related to the siting of the proposed facility, a legal citation of the statute, rule or ordinance governing each permit, and the name, mailing address, email address and telephone number of the agency or office responsible for each permit.*

OAR 345-021-0010(1)(e)(B) *A description of each permit, the reasons the permit is needed for construction or operation of the facility and the applicant's analysis of whether the permit should or should not be included in and governed by the site certificate.*

2.1 Federal Permits

Response: **Table E-1** identifies and describes the federal permits required for construction and operation of the Project.

Table E-1. Federal Permits Required for Construction and Operation			
Permit Name	**Agency Name and Contact**	**Authority**	**Description**
Clean Water Act Section 404 Individual Permit	U.S. Army Corps of Engineers (USACE) Portland District Section 404 Permitting Richard Chong Richard.Chong@usace.army.mil 333 SW First Avenue Portland, Oregon 97208-2946 (503) 808-4510	Sections 10 and 14 of the Rivers and Harbors Act , Sections 401, 404, and 408 of the Clean Water Act (CWA), Section 7 of the Endangered Species Act (ESA), Section 106 of the National Historic Preservation Act (NHPA)	Section 404 of the CWA regulates the discharge of dredged or fill material into the waters of the United States. 33 USC § 1344(a). Under Section 404, the USACE has established two mechanisms for authorizing regulated discharges: individual permits and general permits. Whereas individual permits are issued following an evaluation of a specific structure or work in accordance with USACE's regulations, general permits "authorize a category or categories of activities in specific geographic regions or nationwide." 33 CFR § 320.1(c). Nationwide permits ("NWP") are a type of general permit issued by USACE's Chief of Engineers. For activities associated with the construction of utility lines, coverage under NWP 12, Utility Line Activities, is available provided the activity does not result in the loss of greater than 1/2-acre of waters of the United States for each "single and complete project." The USACE has determined that an individual permit will be required because the impacts associated with the Project will exceed the 1/2-acre threshold. The USACE will address compliance with the ESA, NHPA, and other related authorities through the CWA Section 404 permitting process.

2.2 State Permits Not Federally Delegated

Response: Table E-2 identifies and describes the state permits not federally delegated that are required for construction and operation of the Project.

Table E-2. State Permits Not Federally Delegated

Permit Name	Agency Name and Contact	Authority	Description
Amendment to Site Certificate	Energy Facility Siting Council (EFSC) Oregon Department of Energy 625 Marion Street NE Salem, OR 97301 (503) 378-4040	ORS 469.300 - 469.563; OAR 345, Divisions 1, 21-24, 26-27	The Project involves the expansion of the Mist Underground Natural Gas Storage Facility ("Facility"). EFSC issued the Site Certificate authorizing the Facility in 1981 and, since 1981, has approved nine substantive amendments. Pursuant to a Declaratory Ruling issued on June 21, 2013, EFSC authorized the Applicant to seek an amendment to the Site Certificate for approval of the Project.
Archaeological Excavation Permit	Oregon Parks and Recreation Department State Historic Preservation Office (SHPO) 725 Summer Street NE, Suite C Salem, OR 97301 (503) 986-0671 dennis.griffin@state.or.us	The National Historic Preservation Act (16 U.S.C. 470 et seq,) ; 7 CFR Part 3100; ORS Chapters 97, 358, and 390; OAR Chapter 736, Division 50	During construction of the proposed Project, if an archaeological site is discovered, all construction will cease and the Applicant will report the finding to the SHPO immediately. In that instance, SHPO will require an archaeological excavation permit. *See* Exhibit S for further discussion. Should this permit be required, it will be obtained directly from SHPO and should not be included in or governed by the Site Certificate.
Removal/Fill Permit	Oregon Department of State Lands (ODSL) Aquatic Resources Management Program 775 Summer Street NE, Suite 100 Salem, Oregon 97301-1279 Dan Cary, PWS Aquatic Resource Lead dan.cary.@state.or.us	Oregon's Removal-Fill Law (ORS 196.795-990)	Minor temporary impacts will occur to waters of the state at several locations along the proposed North Mist Transmission Pipeline. *See* Exhibit J for further discussion.
Limited Water Use License	Oregon Water Resources Department (OWRD) 725 Summer Street NE, Suite A Salem, OR 97301	Rules and regulations pursuant to ORS 537	Limited licenses provide permission from the OWRD to divert and use water for a short-term or fixed duration for certain beneficial uses. The Applicant is proposing to divert water from the Beaver Slough on a short-term basis for construction of the Project.

Table E-2. State Permits Not Federally Delegated			
Permit Name	**Agency Name and Contact**	**Authority**	**Description**
Gas Well Drill Permit **Miscellaneous Permit**	State of Oregon Department of Geology and Mineral Industries (DOGAMI) 229 Broadalbin Street SW Albany, Oregon 97321-2246 (541) 967-2039	Rules and regulations pursuant to ORS 520.	The construction of the Project will require the conversion of the Adams reservoir from a production reservoir to a storage reservoir. That conversion will require the installation of four injection/withdrawal wells, the installation of one new monitoring well, and the conversion of two existing wells to monitoring wells. The Adams reservoir will have gas injected into it at a pressure above the discovery pressure. These permits will be obtained directly from DOGAMI and should not be included in or governed by the Site Certificate.
Oversize Load Movement Permit/Load Registration	Oregon Department of Transportation 123 NW Flanders Street Portland, OR 97209 (503) 731-8200	OAR Chapter 734, Division 51, Division 82; ORS 818.030	Primary access to the Project site is off Highways 30 and 47. If large or overweight equipment needs to be moved across State roads, a permit will be required. *See* Exhibit U for further discussion. This permit/load registration will be obtained directly from ODOT by the contractor and should not be included in or governed by the Site Certificate.

2.3 State Permits Federally Delegated

Response: **Table E-3** identifies and describes the state permits federally delegated that are required for construction and operation of the Project.

Table E-3. State Permits Federally Delegated

Permit Name	Agency Name and Contact	Authority	Description
Air Contaminant Discharge Permit (ACDP)	Oregon Department of Environmental Quality (ODEQ) 811 SW Sixth Avenue Portland, OR 97204 (503) 229-5696 deqinfo@deq.state.or.us U.S. Environmental Protection Agency 1200 6th Street Seattle, WA 90101 (206) 553-1200 epa-seattle@epa.gov	ORS Chapters 468 and 468A; OAR Chapter 340, Divisions 216, Table 1, Part C (4) – source subject to significant air quality regulations	ODEQ will issue a permit for the Project that meets the requirements of the Clean Air Act, Federal and State regulations The Project will be subject to at least one significant federal air quality program, either a New Source Performance Standard (NSPS), or a National Emission Standard for hazardous Air Pollutants (NESHAP), and is expected to have emissions that allow permitting under a Standard Air Contaminant Discharge Permit. This permit will be obtained directly from ODEQ and should not be included in or governed by the Site Certificate.
National Pollutant Discharge Elimination System (NPDES) 1200-C Construction Stormwater Permit	ODEQ 811 SW Sixth Avenue Portland, OR 97204 (503) 229-5696 deqinfo@deq.state.or.us	Clean Water Act (33 USC Sections 1342 et seq.); 40 CFR Parts 6, 122 and 124; ORS Chapter 468 and 468B; OAR Chapter 340, Division 45 and 52	A NPDES 1200-C Construction Stormwater Permit regulates stormwater runoff from construction activities and is necessary prior to construction of the Project. *See* Exhibit I for further discussion. This permit will be obtained directly from ODEQ and should not be included in or governed by the Site Certificate.

2.4 Third-Party Federally Delegated Permits

Response: **Table E-4** identifies and describes the third-party federally delegated permits required for construction and operation of the Project.

Table E-4. Third-Party Federally Delegated Permits Required for Construction and Operation

Permit Name	Agency Name and Contact	Authority	Description
Water Pollution Control Facilities Permit (WPCF) **Permit# 101690**	ODEQ Northwest Region 2020 SW Fourth Avenue, Suite 400 Portland, Oregon 97201-4987 Permit Issued to: Enerfin Resources Northwest Limited Partnership 2500 City West Blvd., Suite 400 Houston, Texas 77042	Federal Safe Drinking Water Act (SDWA) for underground injection control activities for Class II injection wells under 40 CFR, parts 144.21, 144.25, 144.31, 146.22, 146.23 and 144.24. OAR 340-040-0030; 340-044-0014, -0015, and -0035; 340-045	This permit was issued pursuant to the requirements of the SDWA for underground injection control activities for Class II injection wells. Until this permit expires or is modified or revoked, the permittee is authorized to modify or operate the existing underground injection control Class II injection systems (well #44-21-65 and well #13-1-65), and to construct, operate and maintain up to two additional injection wells during the current permit cycle, in conformance with requirements, limitations, and conditions set forth in the permit and the OARs. This permit was obtained directly from ODEQ and should not be included in or governed by the Site Certificate.
National Pollutant Discharge Elimination System Waste Discharge Permit (NPDES) **Permit # 101209** **File # 70805**	ODEQ Northwest Region 2020 SW Fourth Avenue, Suite 400 Portland, Oregon 97201-4987 Permit Issued to: Portland General Electric 121 SW Salmon Street, 3WTCR05 Portland, Oregon 97204	Clean Water Act (33 USC Sections 1342 et seq.); 40 CFR Parts 6, 122 and 124; ORS Chapter 468 and 468B; OAR Chapter 340, Division 45 and 52	A NPDES Waste Discharge Permit regulates the operation of a wastewater collection, treatment, control and disposal system and discharge to public waters adequately treated wastewaters only from the authorized discharge point or points established in the permit. This permit was obtained directly from ODEQ and should not be included in or governed by the Site Certificate.

2.5 Local Permits

Response: **Table E-5** identifies and describes the local permits required for construction and operation of the Project.

Table E-5. Local Permits[1/]

Permit Name	Agency Name and Contact	Authority	Description
Columbia County: **Conditional Use Approval** **Building Permit** **Flood Protection – Certificate of Elevation** **Stream/Wetland Protection** **Stormwater and Erosion Control**	Columbia County Land Development Services Department Columbia County Courthouse, Room 105 230 Strand Street St. Helens, Oregon 97051 (503) 397-1501 Glen Higgins Glen.Higgins@co.columbia.or.us	Columbia County Code, 2010 Oregon Structural, Specialty Code (Based on 2009 IBC), 2014 Oregon Mechanical Specialty Code (Based on 2012 IMC & IFGC), 2011 Oregon Plumbing Specialty Code (Based on 2009 UPC), 2011 Oregon Electrical Specialty Code (Based on 2011 NEC), 2010 Oregon Fire Code	A conditional use permit is required for Project improvements located within the County's Primary Agriculture and Primary Forest zones. The Applicant has elected to obtain a Council determination under ORS Chapter 469.504(1)(b) for the major components and related or supporting facilities associated with the Project. However, as with previous amendments to the Site Certificate, the Applicant will obtain local land use approval of the well pads from Columbia County. For the major components and related and supporting facilities that will be permitted through EFSC, the Applicant demonstrates compliance with the conditional use standards, as well as other applicable substantive criteria, in Exhibit K. For the well pads, the Applicant will demonstrate compliance with applicable standards through the local conditional use permitting process. The other county permits listed will be secured directly from the County prior to construction.
Columbia County Road Access Permit **Public Road Construction Permit**	Columbia County Road Department 1054 Oregon Street St. Helens, Oregon 97051 (503) 397-5090	Columbia County Code	Issuance of a County Road access permit is required as part of a County Building Permit. Issuance of a Public Road Construction Permit is required for construction of utilities with county road rights of way.

1. Subject in part to EFSC determination pursuant to ORS 469.501(1)(b).

3.0 Permit Applications Not Federally Delegated

OAR 345-021-0010(1)(e)(C)

For any state or local government permits, licenses or certificates that are proposed to be included in and governed by the site certificate, evidence to support findings by the Council that construction and operation of the proposed facility will comply with the statutes, rules and standards applicable to the permit. The applicant may show this evidence:

(i) In Exhibit J for permits related to wetlands;

Response: Please see Exhibit J for permits related to wetlands.

(ii) In Exhibit O for permits related to water rights.

Response: Please see Exhibit O for permits related to water rights.

4.0 Permit Applications Federally Delegated

OAR 345-021-0010(1)(e)(D)

For federally-delegated permit applications, evidence that the responsible agency has received a permit application and the estimated date when the responsible agency will complete its review and issue a permit decision.

Response: The Applicant has prepared an ACDP application for submittal to ODEQ. **Attachment E-1** includes a copy of the ACDP application that was submitted to ODEQ in April, 2015 and **Attachment E-5** includes a concurrence letter from ODEQ with an estimated review timeline.

The Applicant has prepared a NPDES 1200-C permit application to permit stormwater discharges associated with construction of the Project. **Attachment E-2** includes a copy of the 1200-C application that was submitted to ODEQ in April, 2015, and Attachment E-5 includes a concurrence letter from ODEQ with an estimated review timeline.

Minor temporary impacts will occur to waters of the U.S.. These impacts will total more than 0.5 acres and will require the Project to acquire a CWA Section 404 individual permit from the USACE Portland District. **Exhibit J** includes a copy of the CWA Section 404 permit application that was submitted to the USACE in April, 2015. The Applicant has yet to receive a concurrence letter from USACE with an estimated review timeline but will submit the letter as a supplement to this exhibit upon receipt.

5.0 Third-Party State or Local Permits

OAR 345-021-0010(1)(e)(E) *If the applicant relies on a state or local government permit or approval issued to a third party, identification of any such third-party permit and for each:*

- *(i) Evidence that the applicant has, or has a reasonable likelihood of entering into, a contract or other agreement with the third party for access to the resource or service to be secured by that permit.*
- *(ii) Evidence that the third party has, or has a reasonable likelihood of obtaining, the necessary permit.*
- *(iii) As assessment of the impact of the proposed facility on any permits that a third party has obtained and on which the applicant relies to comply with any applicable Council standard.*

Response: The Applicant will not rely on any state or local permits issued to third parties; therefore, this criterion is not applicable.

6.0 Third-Party Federally Delegated Permits

OAR 345-021-0010(1)(e)(F) *If the applicant relies on a federally-delegated permit issued to a third party, identification of any such third-party permit and for each:*

- *(i) Evidence that the applicant has, or has a reasonable likelihood of entering into, a contract or other agreement with the third party for access to the resource or service to be secured by that permit.*
- *(ii) Evidence that the responsible agency has received a permit application.*
- *(iii) The estimated date when the responsible agency will complete its review and issue a permit decision.*

Response: The Applicant will utilize an underground injection well for the disposal of saline process water, pursuant to ODEQ WPCF permit# 101690, which was issued to Enerfin Resources. The permit is current and expires January 31, 2021. The applicant has entered into an agreement with Enerfin to utilize the underground injection well and its WPCF permit. The WPCF permit and agreement with Enerfin are presented in **Attachment E-3** of this exhibit. ODEQ will acknowledge the Applicant's coverage under the existing permit prior to start of underground injections.

The applicant will also utilize an existing wastewater treatment plant at PGE's Beaver Generating Station that is currently permitted under NPDES Waste Discharge Permit# 101209, which was issued to PGE. This permit expired November 30, 2012 but has been administratively extended by ODEQ to facilitate review of the timely-filed renewal application. The applicant has entered into an agreement with PGE to utilize the wastewater treatment facility and its NPDES permit. The NPDES permit, documentation of its extension, and agreement with PGE are presented in **Attachment E-4** of this exhibit. ODEQ will acknowledge the Applicant's coverage under the existing permit prior to wastewater discharges into the treatment facility.

7.0 Monitoring

OAR 345-021-0010(1)(e)(G) *The applicant's proposed monitoring program, if any, for compliance with permit conditions.*

Response: The Applicant will comply with monitoring requirements prescribed by the Council and any jurisdictions responsible for granting permits or approvals for the Project. Proposed monitoring programs are described in the applicable Exhibits of this Request, as follows:

- Erosion and Sediment Control, see **Exhibit I.**
- Wetland Disturbance, see **Exhibit J.**
- Construction-related wildlife habitat and species disturbance, see **Exhibit P.**
- Threatened and endangered species disturbance, see **Exhibit Q.**
- Scenic resources disturbance, see **Exhibit R.**
- Cultural resources disturbance, see **Exhibit S.**
- Recreational resources disturbance, see **Exhibit T.**
- Public services disturbance, see **Exhibit U.**
- Stormwater, wastewater, and hazardous materials, see **Project Description and Division 27 Compliance.**
- Noise, see **Exhibit X.**

8.0 Summary

On the basis of the information presented above, the Applicant has satisfied the requirements of OAR 345-021-0010(1)(e).

ATTACHMENT E-1:

AIR CONTAINMENT DISCHARGE PERMIT

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GEI Consultants

Consulting Engineers and Scientists

Standard ACDP Application

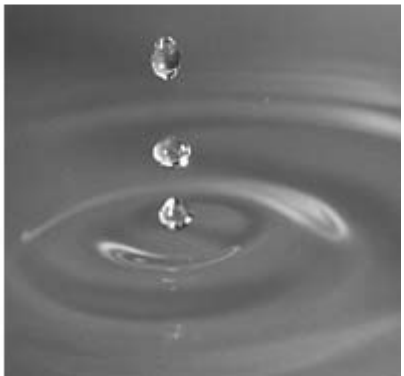
North Mist Expansion Project

Prepared for:

NW Natural

Prepared by:
GEI Consultants, Inc.
700 NE Multnomah Street, Suite 230
Portland, OR 97232

April 2015



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1. Department of Environmental Quality Forms

1.1 Land Use Compatibility

This Air Contaminant Discharge Permit Application is being submitted for a project that will receive approval through the Oregon Energy Facility Siting Council (EFSC). The Land Use Compatibility Statement is processed through the EFSC Application process and is not submitted separately with this application.

1.2 Form AQ101 – Administrative Information

1.3 Form AQ102 – Facility Description

1.4 Form AQ210 – Device, Internal Combustion Engines and Turbines

1.5 Form AQ230 – Device, Miscellaneous, TEG Regenerator

1.6 Form AQ231 – Operation and Maintenance

1.7 Form AQ307 – Miscellaneous Control Device, CO Catalyst

1.8 Form AQ402 – Plant site Emissions Detail

1.9 Form AQ403 – Hazardous Air Pollutant Emissions Detail

Print Form

ADMINISTRATIVE INFORMATION

FOR DEQ USE ONLY	
Permit Number:	Type of Application:
Application No:	**RNW ____ MOD ____ NEW ____ EXT ___**
Date Received :	
Regional Office:	**Check No. Amount $**

1. Company	**2. Facility Location**
Legal Name: NW Natural Gas Company dba NW Natural	Name: North Mist Compressor Station
Mailing Address: 220 NW Second Avenue	Street Address: Off private logging road, northwest of Mist, Oregon
City, State, Zip Code: Portland, OR 97209	City, County, Zip Code: Columbia County, OR
Number of employees: 1,100	
3. Site Contact Person	**4. Standard Industrial Classification Code(s)**
Name: Michael Hayward	Primary: 221210 Natural Gas Distribution
Title: Manager, Environment and Sustainability	Secondary: *none*
Telephone number: 503-226-4211 x4327	**5. Other DEQ Permits**
Fax. number: 503-721-2523	This is currently being determined. No other permits are anticipated at this time.
e-mail address: mjh@nwnatural.com	

6. Permit Action:

- ☐ New Simple ACDP
- ☐ New Construction ACDP
- ☒ New Standard ACDP
- ☐ New Standard ACDP (PSD/NSR)
- ☐ Renewal of an existing permit without changes (include form AQ403 for Standard ACDPs)
- ☐ Renewal of an existing permit with changes (include form AQ403 for Standard ACDPs)
- ☐ Modification of existing permit

7. Signature

I hereby apply for permission to discharge air contaminants in the State of Oregon, as stated or described in this application, and certify that the information contained in this application and the schedules and exhibits appended hereto, are true and correct to the best of my knowledge and belief.

Michael J. Hayward	Manager, Environment and Sustainability
Name of official (Printed or Typed)	Title of official and phone number
Signature of official	April 15, 2015 Date

FEE INFORMATION

(Make the check payable to DEQ)

Note: The initial application fees and annual fees specified below (OAR 340-216-0020, Table 2, Parts 1 and 2) are only required for initial permit applications. These fees are not required for an application to renew or modify an existing permit. The appropriate specific activity fee(s) specified below (OAR 340-216-0020, Table 2, Part 3) applies to permit modifications or may be in addition to initial permit application fees.

OAR 340-216-0020, Table 2, Part 1 – INITIAL PERMITTING APPLICATION FEES:	
Short Term Activity ACDP	
Simple ACDP	
Construction ACDP	
Standard ACDP	$14,400
Standard ACDP (PSD/NSR)	
OAR 340-216-0020, TABLE 2, PART 2 - ANNUAL FEES:	
Simple ACDP – Low fee class	
Simple ACDP – High fee class	
Standard ACDP	$9,216
OAR 340-216-0020, TABLE 2, PART 3 - SPECIFIC ACTIVITY FEES:	
Non-technical permit modification	
Non-PSD/NSR basic technical permit modification	
Non-PSD/NSR simple technical permit modification	
Non-PSD/NSR moderate technical permit modification	
Non-PSD/NSR complex technical permit modification	
PSD/NSR modification	
Modeling review (outside PSD/NSR)	
Public hearing at applicant's request	
State MACT determination	
TOTAL FEES	$23,616

SUBMIT TWO COPIES OF THE COMPLETED APPLICATION TO:

New or Modified Permits (include fees):	**Permit Renewals (no fees):**
Oregon Department of Environmental Quality Business Office 811 SW Sixth Avenue Portland, OR 97204-1390	Oregon Department of Environmental Quality Air Quality Program, Northwest Region Office 2020 SW 4th Avenue, Suite 400 Portland, Oregon 97201-4987

FACILITY DESCRIPTION

Facility Name: North Mist Compressor Station Permit Number: _____

1. Description of facility and processes:

NW Natural proposes to construct and operate a natural gas compressor station to serve a new underground storage reservoir in the Mist underground storage area. The compressor station will provide compression for the Adams reservoir. The proposed North Mist Compressor Station (NMCS) will be capable of delivering 120 million standard cubic feet per day (MMscfd) to the Port Westward Industrial Park facilities near the Beaver terminus of the Kelso Beaver ("KB") Pipeline through a new transmission pipeline with capacity to accommodate current needs and reasonably foreseeable future customer load requirements. This capacity will serve peak and flexible gas supply to meet immediate needs for PGE's electric generation facilities near Clatskanie, Oregon.

Major equipment will be two natural gas-fired, engine driven compressors, and two triethylene glycol gas dehydration systems. Minor equipment will be three natural gas-fired engine driven emergency generators, and fugitive emissions from valves, flanges, seals, and tanks.

Please refer to Figure 2, Process Flow Diagram for more details.

3. Attach plot plan.

4. Attach process flow diagram.

5. Attach a city map or drawing showing the facility location.

Facility Name: North Mist Compressor Station Permit Number:

Engine Information

1.	Device ID Number	C-210 and C-220
2.	Existing or future?	Future
3.	Date construction commenced	Jun 1, 2016
4.	Date installed/completed	
5.	Special controls (if applicable)	CO catalyst, A/F ratio
6.	Manufacturer	Caterpillar
7.	Date manufactured	
8.	Maximum rating (MMbtu/hr for turbines, Hp for others)	1,775 HP each
9.	Control device(s) (y/n; if y, identification number(s))	Yes, CD-210, CD-220

10. Description of device:

The device(s) are two identical Caterpillar Model G3606 natural gas-fired, engines that will be used to drive the compressors. CD-210 and CD-220 are two identical CO catalysts required to meet the 40 CFR 60 Subpart JJJJ Emissions standards.

The engines have not been purchased.

Operating Schedule

11.	Projected maximum hours/day	24
12.	Projected maximum hours/year	5,726 for both

Fuel Information

13. Fuel usage:

	Type	Hourly usage	Annual usage
Primary	natural gas	15 MMBtu/hr each	85,972 MMBtu for both
Back-up	NA		
Other	NA		

Stack Information

14.	Exit height (ft)	approx. 30 feet
15.	Exit diameter (ft)	TBD during final design
16.	Design flowrate (dscf)	TBD during final design

Monitoring Information

17. Monitoring equipment

fuel flow (y/n)	Yes	recorder? (y/n)	Yes
engine load (y/n).	Yes	recorder? (y/n)	Yes
other (specify)	air/fuel ratio	recorder? (y/n)	No

Facility Name: North Mist Compressor Station Permit Number:

Process Information

1. ID Number: Gly RS-1, Gly RS-2 (2 identical units)
2. Descriptive name: Triethylene Glycol (TEG) Regeneration Skids
3. Existing or future? Future
4. Date commenced: Construction will commence approximately mid-2016
5. Date installed/completed:

6. Description of process:

Wet natural gas is withdrawn from the underground storage, and processed through a contact tower with lean (water free) glycol. The contact tower is not a source of air emissions. The dry gas goes to the pipeline after dehydration.

Once the glycol has absorbed water, it must be regenerated (water removed) before it is cycled back to the contact tower. Regeneration of the glycol emits VOCs, and HAPs. To regenerate the glycol, it is sent to the regeneration skids where the water is stripped from the glycol by pressure reduction in a flash tank, and thermal regeneration (reboiler, gas stripping, condensation). To reduce emissions, the stripping gas is used as fuel in the reboiler.

Operating Schedule

7. Seasonal or year-round? Year around
8. Batch or continuous operation? continuous at varying loads
9. Projected maximum hours/day 24
10. Projected maximum hours/year 2,673 at normal operation, 5,727 at idle (low flow)
11. Process/device capacity:

	Short term capacity		Annual usage	
Raw materials	amount	units	amount	units
Wet natural gas	120	MMscf/day	15,750	MMscf/year
Products				
Dry natural gas	120	MMscf/day	15,750	MMscf/year

12. Control device(s) (yes/no?) If yes, provide the ID number and complete and attached the applicable series AQ300 form(s).

No. Process modification as pollution prevention is proposed for emissions control of HAPs.

OPERATION AND MAINTENACE PRACTICES

1. Facility Name: North Mist Compressor Station

2. Permit Number:

3. Emission Point or Fugitive Emission Source ID	4. Criteria Pollutants Emitted	5. Emission Level Depends on O&M (yes/no)	6. O&M Option Number(s) Selected	7. Describe specific O&M work practices or Emission Action Levels to ensure that the process, control device or fugitive emission source is operated and maintained at the highest reasonable efficiency and effectiveness to minimize emissions.
C-210 Engine	PM10/2.5, NOx, CO, VOC	Yes	1 and 2	Compliance with 40 CFR 60, Subpart JJJJ, see attached Tables of requirements
C-220 Engine	PM10/2.5, NOx, CO, VOC	Yes	1 and 2	Compliance with 40 CFR 60, Subpart JJJJ, see attached Tables of requirements
fugitives	VOC	Yes	1	Compliance with 40 CFR 98, Subpart W

Facility Name: North Mist Compressor Station Permit Number:

1.	Control Device ID	CD-210, CD-220
2.	Process/Device(s) Controlled	Engines C-210 and C-220
3.	Year installed	TBD
4.	Manufacturer/Model No.	TBD
5.	Control Efficiency(%)	90% for CO, 60% for VOC
6.	Design inlet gas flow rate (acfm)	TBD
7.	Design parameter(s)	TBD
8.	Inlet gas pretreatment? (yes/no) If yes, list control device ID and complete a separate control device form	No
9.	Describe the Control Device	

The Caterpillar G3606 engines require a CO catalyst to meet the emission standards under 40 CFR 60, Subpart JJJJ. The engines will be purchased with the appropriate catalysts and control systems. Detailed information for the catalyst will be available during final design of the facility.

Facility Name: North Mist Compressor Station *Permit Number:*

1. Emissions Point	Production Rates		4. Pollutant	Emissions Factors			Emissions	
	2. Short-term (Specify units)	3. Annual (Specify units)		5. Short-term	6. Long-term	7. Reference(s)	8. Short-term (Specify units)	9. Annual (tons/year)
C-210, C-220	30 MMBtu/hr	85,972 MMBtu	PM10/2.5	0.04831 lb/MMBtu	0.04831 lb/MMBtu	EPA, AP-42	1.4 lb/hr	2.1
	0.0288 MMscf/hr	165 MMscf/yr	SO2	2.6 lb/MMscf	1.7 lb/MMscf	DEQ	0.075 lb/hr	0.1
	3,550 HP	10,163,650 hp-hr/yr	NOx	1.0 gm/hp-hr	1.0 gm/hp-hr	Subpart JJJJ Std	7.8 lb/hr	11.2
			CO	2.0 gm/hp-hr	2.0 gm/hp-hr	Subpart JJJJ Std	15.7 lb/hr	22.4
			VOC	0.7 gm/hp-hr	0.7 gm/hp-hr	Subpart JJJJ Std	5.5 lb/hr	7.8
			HAP	0.31 gm/hp-hr	0.31 gm/hp-hr	Mnft Data	2.4 lb/hr	3.5
			CO2	495 gm/hp-hr	495 gm/hp-hr	Mnft Data		5034 (metric)
GlyRS-1,RS-2	120 MMscf/day	15,750 MMscf/yr	VOC	0.239 lb/MMscf	0.239 lb/MMscf	GlyCalc Model	29.7 lb/day	1.9
			HAP	0.029 lb/MMscf	0.029 lb/MMscf	GlyCalc Model	3.5 lb/day	0.2
			CHG (CO2e)	43.02 lb/MMscf	43.02 lb/MMscf	GlyCalc Model		307 (metric)
	961.5 scf/hr	8.4 MMscf/yr	NOx	94 lb/MMscf	94 lb/MMscf	EPA, AP-42	0.09 lb/hr	0.4
			CO	84 lb/MMscf	84 lb/MMscf	EPA, AP-42	0.08 lb/hr	0.4
fugitives	120 MMscf/day	15,750 MMscf/yr	GHG (CO2e)	4.2 lb/MMscf	4.2 lb/MMscf	EPA		30.1 (metric)
Example	200 tons of rock/hr	400,000 tons	PM	0.04 lb/ton	0.04 lb/ton	DEQ	8.0 lb/hr	8.0

Facility Name: North Mist Compressor Station Permit Number: _____

Emissions Data

1. Emissions Point	2. Annual Production Rate (specify units)	3. Pollutant	4. Emission Factor	5. EF reference	6. Annual Emissions (tons/yr)
Please see attached	spreadsheet for	HAP emissions	calculations		

Applications for Standard ACDPs must also include the most recent Toxics Release Inventory report, if applicable (see instructions).

2. Introduction and Project Description

NW Natural proposes to construct and operate a natural gas compressor station to serve new underground storage reservoirs in the Mist underground storage area. The compressor station will provide compression for the Adams Reservoir. The proposed North Mist Compressor Station (NMCS) will be capable of delivering 120 million standard cubic feet per day (MMscfd) to the Port Westward Industrial Park facilities near the Beaver terminus of the Kelso Beaver ("KB") Pipeline through a new transmission pipeline, with capacity to accommodate current needs and reasonably foreseeable future customer load requirements. This capacity will serve peak and flexible gas supply to meet immediate needs for PGE's electric generation facilities near Clatskanie, Oregon.

Operations of the storage facility will be integrated such that they will be monitored and remotely controlled by trained operators at Miller Station, approximately 5 miles away by road. NW Natural will maintain fire extinguishers, fire prevention and suppression equipment, and emergency shutdown and station venting systems to address fire considerations. In addition to Miller Station's 24-hour per day monitoring, NW Natural Gas Control, located in Portland, Oregon, will continue to provide additional monitoring of the newly integrated facilities on a 24-hour basis.

The new NMCS will serve only the Adams Reservoir, having the capability not only to compress the gas for injection into and withdrawal from the reservoir, but also to measure and control the gas flow and dehydrate the gas as needed during withdrawal. The proposed compressor facility will have total installed compression of approximately 3,600 brake horsepower (HP) provided by two natural gas-fueled engine-driven compressors.

The NMCS's compressor equipment will include the following attributes:

<u>Estimated daily injection and withdrawal rates</u>:
Injection: Variable – 10 to 56 MMscfd
Withdrawal: Variable – 10 to 120 MMscfd

<u>Horsepower compression required to operate at design injection or withdrawal rates</u>:
Variable – zero to 3,550 HP

<u>Operating pressure range</u>: 250 to 1100 psig (pounds per square inch)

NW Natural is applying for a new Standard Air Contaminant Discharge Permit (ACDP) for the proposed NMCS located in a rural, timber management area, northwest of the town of Mist, Oregon. Figure 1 is a Facility Location Map for the proposed NMCS. The nearest residential areas to the NMCS are approximately 2 miles to the west near Fishhawk Lake, and to the south in the town of Mist. The land immediately surrounding the proposed NMCS

site is used for silviculture and has typical timber harvest and management activities occurring on an ongoing basis. A Facility Plot Plan is included in Appendix A. This is a very preliminary facility concept. Final design has not begun for the facility and the exact equipment layout may change within the general facility boundaries. In addition, the Plot Plan shows a space for thermal oxidizers. However, an analysis proposing process controls for the Triethylene Glycol (TEG) dehydration equipment as Pollution Prevention in lieu of end-of-pipe controls is provided and no end-of pipe control for the TEG is proposed.

3. Emissions

Natural gas received at the NMCS for injection will be pipeline quality gas that has already been processed for removal of sulfur and natural gas liquids by the producers prior to entry into the pipeline transportation system. The injection and withdrawal process will not alter the composition of the gas other than the absorption of water during storage. As a result, the natural gas will require removal of water during withdrawal, and prior to delivery to pipelines.

3.1 Emission Sources and Emission Estimation Methods

Primary emission sources at the facility will be two natural gas-fired engines used to drive the compressors, and two TEG units. The TEG units will be split systems with the contact towers (non-emitting) separated from the glycol regeneration skids housing the reboilers and flash tanks. Minor sources of emissions will be three natural gas-fired, engine-driven emergency generators; fugitive gas emissions from valves, seals, and flanges; and emissions from the liquid storage vessel for produced water and pigging liquids (if any).

As shown in Section 2 of this report (Project Description), there is a wide operating pressure range for the underground storage reservoirs. The corresponding operation of the engine-driven compressors will range from no operation when the reservoir pressures or pipeline pressures allow gas free flow, to concurrent operation of both engine-driven compressors. A conservative estimate of the potential to emit (PTE) for the facility was based on information from NW Natural's engineer and design team developed for the preliminary design of the facility. The PTE was based on the maximum emissions resulting either from both engine generators operating at 50 percent load, or a single engine generator operating at 100 percent load. Based on the widest expected range of pressure conditions at the reservoir and KB Pipeline connection, this PTE scenario is very conservative for annual emissions.

The following information sources were used to estimate emissions:

- Manufacturer's data
- GRI-GlyCalc® Version 4.0, GRI-00/0102, July 2000

- Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I, January 1995, U.S. Environmental Protection Agency (EPA)
- Protocol for Equipment Leak Emission Estimates, EPA, November 1995, EPA-453/R-95-017

3.2 Pollution Prevention Measures

NW Natural has been proactive in designing pollution control into the NMCS. The following pollution control measures are part of the proposed facility design and are implemented in addition to meeting regulatory requirements:

- The natural gas handling compressors will use dry seals. This reduces fugitive emissions of greenhouse gases (GHG), volatile organics, and hazardous air pollutants (HAPs).
- Pneumatic devices will use compressed air for actuation (not natural gas). This reduces fugitive emissions of greenhouse gases (GHG), volatile organics, and hazardous air pollutants (HAPs).
- Water removal equipment (TEG contact towers) will be located immediately after the well piping in the process flow. This removes moisture from the gas prior to entry into the plant piping and eliminates the need to use methanol for dew point suppression. This substantially reduces HAP emissions from the TEG dehydration system.

If a typical facility arrangement were used at the NMCS (similar to the arrangement currently used at the Miller Station and many other plants), an estimated 16,000 gallons per year of methanol would be required for dew point suppression at the NMCS. This would result in approximately 54 tons per year of uncontrolled HAP emissions from the TEGs, and approximately 2.7 tons per year if controlled by thermal oxidation with 95 percent destruction efficiency. With the modified process design, the estimated HAP emissions from the TEG systems are approximately 0.2 tons per year and methanol injection is not required.

3.3 Emission Summary and Requested Plant Site Emission Limits

The estimated PTE for the NMCS and the requested Plant Site Emission Limits (PSELs) are shown in Table 1. Supporting emissions calculations are included in Appendix B.

Table 1: Estimated Project Emissions Summary (tons per year)

	$PM_{10}/PM_{2.5}$	NO_x	CO	VOC	HAPs	GHG (metric tons, CO2e)
Estimated PTE	2.1	11.6	22.8	9.7	3.7	5,371
Requested PSEL	14/9	39	99	39	NA	NA

4. Regulatory Review

4.1 Background – New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP)

Determination of applicability for 40 CFR 60, Subpart OOOO (NSPS), and 40 CFR 63, Subparts HH, and HHH (NESHAP) was based on a review of the federal register preamble for the Proposed Rule (Federal Register, Vol. 76, No. 163, Tuesday, August 23, 2011), and the Final Rule (Federal Register, Vol. 77, No. 159, August 16, 2012). EPA issued additional revisions to the rules after this date that did not influence the applicability determination.

NW Natural is defined as being in the Standard Industrial Classification for Natural Gas Distribution (SIC 221210). NW Natural operates underground storage facilities that are more typically included in the Transmission and Storage Segment. This complicates the determination of "affected facilities" under the NSPS and NESHAP regulations.

EPA specifically included SIC 221210 as an industrial source category affected by the promulgation of Subparts OOOO, HH, and HHH in the preamble to the Proposed Rule. Additionally, on page 52744 of the Federal Register notice for the Proposed Rule EPA defines the natural gas sector as all operations from the well to the customer. Each of the natural gas "segments" is discussed in turn for 1) natural gas processing, 2) natural gas transmission, and 3) natural gas distribution. The segments are discussed operationally and underground storage (subsurface storage) is included in the transmission segment. From this operational discussion, applicability of the regulations appears to be intended on a functional definition of the operating segments, as opposed to the SIC of the facility owner. The discussion of the decision not to regulate compressors in the transmission, storage, and distribution segments in the Final Rule (page 49498) shows clear intention to include emission sources in the distribution segment in the overall range of the rule. The specific applicability discussion that follows for the NSPS and NESHAP regulations use this operational segment basis for determining applicability.

4.2 New Source Performance Standards (NSPS)

Federal NSPS were reviewed for applicability. Most are clearly non-applicable because the standard regulates a type of facility or equipment that is not present at the NMCS. The following standards are non-applicable for the reason listed:

40 CFR 60 Subpart KKK – Equipment Leaks of Volatile Organic Compounds (VOC) from Onshore Natural Gas Processing Plants is non-applicable because the NMCS is not a gas processing plant.

40 CFR 60 Subpart OOOO – Crude Oil and Natural Gas Production, Transmission and Distribution. The regulation is applicable to facilities that commenced construction after August 23, 2011. Applicability is discussed for each of the facility types defined in the regulation below. The only equipment potentially subject to the regulation is the produced water storage tank. Emissions from the tank are expected to be well below the applicability threshold and this regulation is not expected to be applicable.

- 60.5365 (a) Each gas well affected facility – non-applicable because it applies to gas wells drilled primarily for gas production.
- 60.5365(b) Each centrifugal compressor affected facility and (c) Each reciprocating compressor affected facility – non-applicable because it applies to compressors between the wellhead and the point of custody to the natural gas transmission and storage segment.
- 60.5365(d) Pneumatic controllers in the oil production, natural gas production, and natural gas processing plants – non-applicable because the NMCS is not a natural gas production or processing facility.
- 60.5365(e) Each storage vessel affected facility – applicable based on the operational definition of "storage segment" discussed above. The affected facility is each single storage vessel located in the oil and natural gas production segment, natural gas processing segment or natural gas transmission and storage segment, and has the potential for VOC emissions equal to or greater than 6 tons per year. Process vessels such as surge control, bottoms receivers or knockout vessels are not storage vessel affected facilities. Storage tanks that collect condensates and pigging liquids are included as storage vessels. The produced water tank is potentially an affected facility, but will have emissions below 6 tons per year. Emissions will be verified within 30 days of the start of withdrawal operations.
- 60.5365(f) and (g) – Affected facilities are natural gas processing plants and sweetening units - non-applicable because NMCS is not a processing plant.
- 60.5365(h) – Applies to gas wells drilled primarily for gas production and is non-applicable.

40 CFR 60, Subpart JJJJ – Stationary Spark Ignition Internal Combustion Engines is applicable to engines purchased after June 12, 2006 and manufactured after July 1, 2007 for engines with a maximum HP greater than 500, or manufactured after January 1, 2009 for emergency engines with a maximum HP greater than 25 [§60.4230(a)(4) and (6)]. Details of the applicable portions of the regulation are discussed below and shown in Tables 2 and 3. Owners and operators of engines subject to Subpart JJJJ and located at an area source are exempt from the requirement to obtain a Title V permit as a result of Subpart JJJJ applicability [§60.4230(c)].

The five engines proposed for the NMCS facility are subject to 40 CFR 60 Subpart JJJJ for Spark Ignition Reciprocating Internal Combustion Engines (RICE). All of the proposed engines are new, and will be model year 2013 or later at the time of purchase. The following information is pertinent to the Subpart JJJJ regulation for the Caterpillar Model G3606 engines planned to drive the compressors, and the three PSI Model 8.8 engines planned to

drive the emergency electrical generators. The Manufacturer's exhaust emissions compliance statements are included in Appendix C.

Table 2: Summary of 40 CFR Part 60 Subpart JJJJ Standards of Performance Applicable to PSI Emergency Engines

Emission Standards §60.4233(e), Table 1 §60.4234	Emergency-only certification, after 1/1/2009, (HP≥130): NOx: 2.0 grams/HP-hour CO: 4.0 grams/HP-hour VOC: 1.0 grams/HP-hour The emission standards must be met over the life of the engine.
Importing/Installing §60.4236(c) and (e)	You may not install an engine that does not meet the Emission Standards after January 1, 2011. This requirement does not apply to modified or reconstructed engines, or to engines that were removed from one existing location and reinstalled at a new location.
Monitoring Requirements §60.4237(b)	If your engine is 130≤HP<500 HP, and was built on or after 1/1/2011, and does not meet the standards applicable to non-emergency engines, you must install a non-resettable hour meter. The meters must be installed upon startup of the engine.
Compliance Requirements – for purchase of a certified engine §60.4243(b)(1), and (a)(1) or (a)(2), and (f)	1) You must purchase an engine certified to the applicable Emission Standards. 2) Maintain the engine and control device according to the manufacturer's emission-related written instructions. 3) Keep records of conducted maintenance to demonstrate compliance. 4) Adjust engine settings according to and consistent with the manufacturer's instructions – if this is done, your engine will not be considered out of compliance. 5) Meet the requirements of 40 CFR 1068, Subparts A through D – these are broad compliance provisions such as anti-tampering that you should meet with your normal operations. 6) If you do not operate and maintain the certified engine and control device according to the manufacturer's emission related written instructions, the engine will be considered non-certified and will be subject to the compliance requirements for non-certified engines shown in §60.4243(a)(2)(ii) – keep a maintenance plan, operate consistent with good air pollution control practice, and conduct an initial performance test within 1 year to demonstrate compliance. On-going performance tests are not required unless the engine is rebuilt or undergoes major repair or maintenance.
Emergency Operations §60.4243(e)	You may operate the engine using propane for a maximum of 100 hours per year as an alternative fuel solely during emergency operations, but must keep records of such use.
Air-to-Fuel Ratio (AFR) Controller §60.4243(g)	If the engine is equipped with an AFR controller, the AFR controller must be maintained and operated appropriately in order to ensure proper operation of the engine and control device to minimize emissions at all times.

Table 2: Summary of 40 CFR Part 60 Subpart JJJJ Standards of Performance Applicable to PSI Emergency Engines (continued)

Compliance Requirements – Emergency Engines §60.4243(d)	If you operate an emergency RICE under this regulation, you must do the following for the engine not to be reclassified as non-emergency: 1) There is no time limit on the use of emergency stationary RICE in emergency situations. 2) You may operate your emergency RICE for any combination of the purposes below for a maximum of 100 hours per calendar year: i. Maintenance checks and readiness testing provided the tests are recommended by federal, state, or local government, the manufacturer, the vendor, the regional transmission organization or the insurance company associated with the engine. ii. Emergency demand response for periods in which the Reliability Coordinator under the NERC Reliability Standard EOP-002-3, Capacity and Energy Emergencies, or other authorized entity has declared an Energy Emergency Alert Level 2. iii. During periods where there is a deviation of voltage or frequency of 5% or greater below standard voltage or frequency. 3) Emergency RICE may be operated for up to 50 hours per calendar year in non-emergency situations. The 50 hours per year are counted as part of the 100 hours per year for maintenance and testing and emergency demand response as specified in item 2) above. Unless special provisions under 40 CFR 60.4243 (d)(3)(i) are met, the 50 hours for non-emergency situations cannot be used for peak shaving or non-emergency demand response, or to generate income or otherwise supply power as part of a financial arrangement with another entity.
Recordkeeping – Keep Records for 5 years §60.4245(a)	1) All notifications submitted for compliance with this subpart and all supporting documentation. 2) Maintenance conducted on the engine. 3) Engine certification from the manufacturer and information as required in 40 CFR Parts 90, 1048, 1054, and 1060 as applicable. 4) If non-certified operations occur, maintain records of initial performance test for compliance with emission limits, maintenance plan and compliance with good air pollution practices. 5) Maintain documentation of hours of engine use for various purposes to document non-exceedance of the 50 and 100 hour limitations. Document the cause of the emergency if emergency use.
General Provisions 40 CFR 60, Subpart A	Most of the general provisions are either not applicable or add no additional specific requirements beyond those shown in this table.
Assumptions of Applicability in this Table: • Engines: Model PSI8.8, certified to emergency-only emission standards • 243 HP, without catalysts and air/fuel ratio controllers • The engines will not produce power in a financial arrangement with another entity	

Table 3: Summary of 40 CFR Part 60 Subpart JJJJ Standards of Performance Applicable to Caterpillar Engines Driving Compressors

Emission Standards §60.4233(e), Table 1 §60.4234	Non-Emergency SI Natural Gas, after 7/1/2010, (HP≥500): NOx: 1.0 grams/HP-hour CO: 2.0 grams/HP-hour VOC: 0.7 grams/HP-hour The emission standards must be met over the life of the engine.
Importing/Installing §60.4236(b) and (e)	You may not install an engine that does not meet the Emission Standards after July 1, 2009. This requirement does not apply to modified or reconstructed engines, or to engines that were removed from one existing location and reinstalled at a new location.
Compliance Requirements – for purchase of a non-certified engine §60.4243(b)(2)(ii)	1) Keep a maintenance plan and records of conducted maintenance. 2) To the extent practicable, maintain and operate the engine in a manner consistent with good air pollution control practice for minimizing emissions. 3) Conduct an initial performance test within 60 days of achieving the maximum production rate, but not later than 180 days after initial startup. 4) Conduct on-going performance tests every 8,760 hours of operation, or every 3 years, whichever comes first. 5) Performance testing must be performed in accordance with §60.4244.
Emergency Operations §60.4243(e)	You may operate the engine using propane for a maximum of 100 hours per year as an alternative fuel solely during emergency operations, but must keep records of such use.
Air-to-Fuel Ratio (AFR) Controller §60.4243(g)	The AFR controller must be maintained and operated appropriately in order to ensure proper operation of the engine and control device to minimize emissions at all times.
Testing Requirements §60.4244 §60.8	1) Each performance test must be conducted within 10% of 100% (or the highest achievable) load according to requirements in §60.8 and under specific conditions in Table 2 to Subpart JJJJ of Part 60. 2) You may not conduct performance tests during periods of startup, shutdown, or malfunction. If your engine is non-operational, you do not need to start the engine solely to perform testing. You must conduct the performance test immediately upon startup of the engine. 3) You must conduct three separate test runs for each performance test required. Each test run must be conducted within 10% of 100% (or highest achievable) load and last at least 1 hour. 4) You must determine compliance with the NOx, CO, and VOC standards following the specific methods in §60.4244(d), (e), and (f). 5) You must provide at least 30 days prior notice of any performance test to EPA. You must provide appropriate sampling ports, platforms, access, and utilities for sampling.
Notifications and Recordkeeping – keep records for 5 years §60.4245(a)	1) All notifications submitted for compliance with this subpart and all supporting documentation. 2) Records of maintenance conducted on the engine. 3) Documentation that the engine meets the standards – results of performance tests. 4) Submit and maintain records of your initial notification as required in §60.7(a)(1) – this is the date the engine is ordered and notification to EPA is within 30 days after this date. 5) Submit a copy of each performance test (to EPA) within 60 days after the test is completed.
General Provisions 40 CFR 60, Subpart A	Check specific applicability of §60.4 – Address, §60.7 – Notification and Recordkeeping (only as required by §60.4245), §60.8 Performance Tests. Other portions of the General Provisions do not add specific requirements for this facility.
Assumptions of Applicability in this Table: • Engines: Caterpillar Model G3606, non-certified engines • 1,775 HP, with CO catalyst and air/fuel ratio controller	

4.3 National Emission Standards for Hazardous Air Pollutants (NESHAP)

Federal NESHAP were reviewed for applicability. No NESHAP apply to the NMCS. Most are clearly non-applicable because the standard regulates a type of facility or equipment that is not present at the NMCS. The following standards are non-applicable for the reason listed:

40 CFR 63, Subpart HH – Oil and Natural Gas Production Facilities, Major and Area Sources – affected facilities are gas processing plants and this is non-applicable.

40 CFR 63, Subpart HHH – Natural Gas Transmission and Storage Facilities – this regulation is applicable to major sources. The NMCS is an area source.

40 CFR 63, Subpart ZZZZ – Reciprocating Internal Combustion Engines – this regulation is applicable. Compliance will be demonstrated by complying with 40 CFR 60, Subpart JJJJ.

40 CFR 63, Subpart JJJJJJ – Industrial, Commercial, and Institutional Boiler – this regulation applies to area sources. Natural gas boilers are exempt and the regulation is not applicable to the NMCS.

4.4 Other Federal Regulations

40 CFR 98, Subpart NN – Suppliers of Natural Gas and Natural Gas Liquids. NW Natural is currently required to report under this regulation. Construction of the NMCS will not change the methods of calculation or facilities included in reporting.

40 CFR 98, Subpart W – Petroleum and Natural Gas Systems. NW Natural is currently required to report under this regulation. Construction of the NMCS will not change the methods of calculation, but will add new emitting equipment sources for which emissions will be reported.

4.5 Oregon Administrative Regulations (OAR)

Air quality regulations contained in Divisions 200 through 268 of the Oregon Administrative Rules (OAR) were reviewed and a discussion of regulations applicable to the project follows.

4.5.1 *Division 204 – Designation of Air Quality Areas*

The proposed facility is located in an area designated as attainment for all pollutants.

4.5.2 *Division 208 – Visible Emissions and Nuisance Requirements*

Table 4 shows the applicable requirements for the new equipment.

Table 4: Visible Emissions Applicable Requirements

Emission Unit	Applicable Requirement	Pollutant/ Parameter	Limit/ Standard
All	340-208-0110 (2)	Opacity	20% for a period(s) aggregating more than 3 minutes in any one hour

4.5.3 *Division 209 – Public Participation*

A Category III Public Notice will be required for the permit action. Once the draft permit is completed by DEQ staff, DEQ will provide notice of the proposed permit action and a minimum of 35 days for members of the public to submit written comments. DEQ will schedule a hearing to allow interested persons to submit oral or written comments if:

- DEQ determines that a hearing is necessary; or
- DEQ receives written requests from ten persons, or from an organization representing at least 10 persons, for a hearing within 35 days of the mailing of the public notice. DEQ will provide a minimum of 30 days' notice for a hearing, if one is scheduled.

4.5.4 *Division 210 – Stationary Source Notification Requirements*

No person is allowed to construct, install, or establish a new stationary source that will cause an increase in any regulated pollutant emissions without first notifying DEQ in writing [OAR 340-210-0215]. This ACDP Application meets the notification requirements of Division 210.

The proposed construction and operation of the NMCS will be a Type 3 change under this division [340-210-0225(3)]. Type 3 changes include construction or modification of stationary sources or air pollution control equipment where such a change would increase emissions above the Plant Site Emission Limit by more than the de minimis levels defined in OAR 340-200-0020 but less than the significant emission rate.

For Type 3 changes, the owner or operator must obtain either a Construction ACDP or a new or modified Standard ACDP in accordance with OAR chapter 340 Division 216 before proceeding with the construction or modification [340-210-0240(c)].

4.5.5 *Division 215 – Greenhouse Gas Reporting Requirements*

NW Natural currently reports under this division as a natural gas supplier. Reporting for the NMCS will be required if actual emissions from the facility are 2,500 metric tons of more of carbon dioxide equivalent (CO2e). CO2e estimated PTE for the NMCS is approximately 5,370 metric tons per year. Actual emissions will be well below this level. NW natural will calculate emissions and report under Division 215 as required. Once subject to reporting under this Division, reporting must continue unless emissions from the NMCS are below 2,500 metric tons per year for three consecutive years and the required notification is submitted to DEQ.

4.5.6 *Division 216 – Air Contaminant Discharge Permits*

The NMCS is a minor source with federal NSPS, and potential federal NESHAP applicable requirements and will operate under a Standard ACPD [OAR 340-216-8010, Table 1, Part C(4)]. The applicable NSPS and NESHAP have not yet been adopted into OAR 340-238-0060 or OAR 340-244-0220.

4.5.7 *Division 226 – General Emissions Standards*

A new emissions unit must use typically achievable control technology (TACT) for new or modified sources if:

- The new emissions unit is not subject to New Source Review requirements in OAR 340 division 224, an applicable Standard of Performance for New Stationary Sources in OAR 340 division 238, OAR 340-240-0110 through 340-240-0180, 340-240-0310(1), OAR 340-240-320 through 340-240-0430, or any other standard applicable only to new or modified sources in OAR 340 divisions 230, 234, 236, or 238 for the pollutant emitted;
- The source is required to have a permit;
- The new emissions unit would have emissions of any criteria pollutant equal to or greater than 1 ton per year in any area.

All engines proposed for the NMCS will be subject to an NSPS standard (40 CFR 60, Subpart JJJJ) that has not yet been adopted in Oregon. The TEG units at the NMCS are not subject to a standard under Divisions 224 (NSR), 238 (NSPS adopted by Oregon), 240 (Areas with Unique Air Quality Needs), 230 (Incinerators), 234 (Wood Products Industries), or 236 (Standards for Specific Industries). The TEG units are not subject to a federal NSPS that has not yet been adopted by Oregon and are subject to TACT.

The criteria pollutant emitted in the largest quantity by the TEG system is VOC at less than 2 tons per year. TACT is specified for control of criteria pollutants. No control is proposed as TACT for the TEG units. Please see additional discussion of proposed Pollution Prevention measures proposed voluntarily for control of HAP emissions from the TEG systems in the Pollution Prevention section of this report.

4.5.8 *Division 228 – Requirements for Fuel-Burning Equipment and Fuel Sulfur Content*

Table 5 shows the applicable requirements for specific equipment. Refer to Figure 2, Process Flow Diagram for an equipment legend.

Table 5: Fuel-Burning Equipment Applicable Requirements

Emission Unit	Applicable Requirement	Pollutant/ Parameter	Limit/ Standard
Gly RS-1 Reboiler	340-228-0210(b)	particulate	0.1 grains/scf
Gly RS-2 Reboiler	340-228-0210(b)	particulate	0.1 grains/scf

Figures

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0 1 2

SCALE, MILES

North Mist Compressor Station

NW Natural

GEI Consultants

Project 1501190

LOCATION MAP

April 2015

Figure 1

P:\1501190 - NWN\Figure 1 - Location Map.dwg Apr 2015

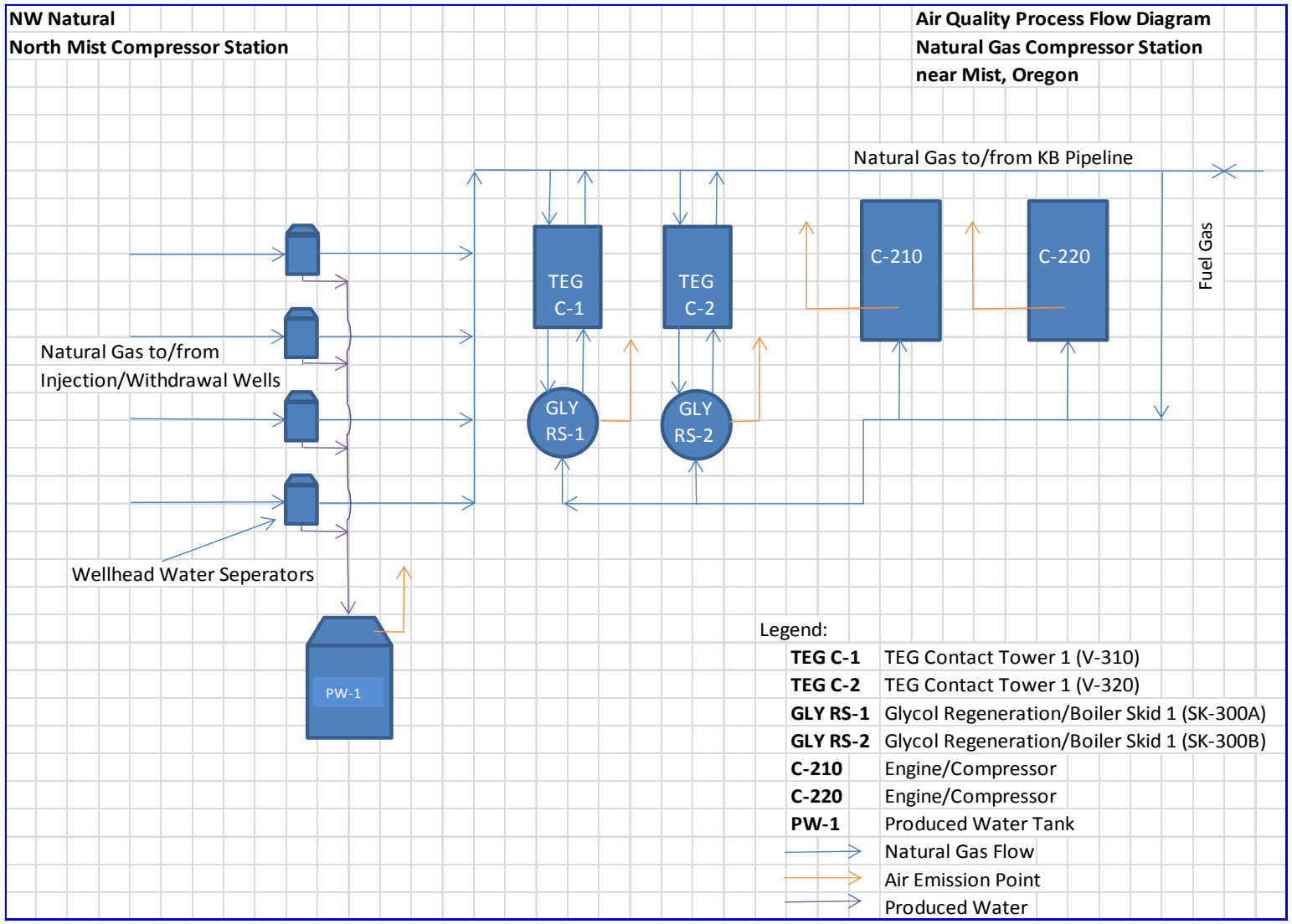

Figure 2: Process Flow Diagram

Appendix A Facility Plot Plan

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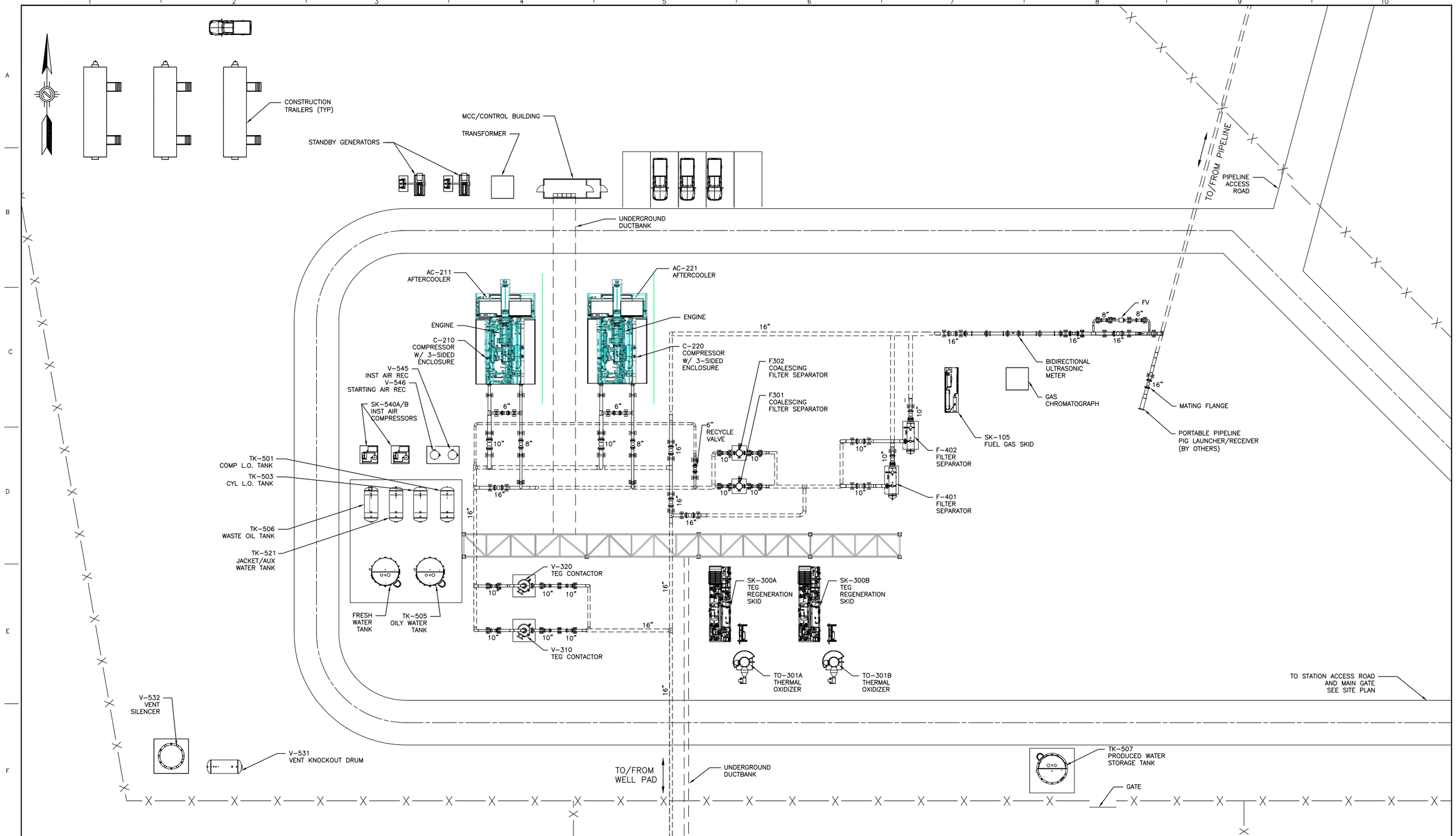

AECOM

2101 WEBSTER STREET SUITE 1800
OAKLAND, CA 94612-3060

PROJECT NO. 60337156

REFERENCE DRAWINGS

NOTES

NO.	DATE	REVISION	DES	DWN	CHK	APPR
A	1/23/15	ISSUED FOR DESIGN BASIS	MD	MD	RS	–

PROFESSIONAL SEAL

		DATE
SCALE:	1"=20'-0"	
DESIGNED BY	M DAVIS	1/23/15
DRAWN BY	M DAVIS	1/23/15
CHECKED BY	R. SEIBERT	1/28/15
APPROVED BY		
APPROVED BY		

1" = 20'-0" 0 5 10 15 20 30 40 60

PLOT PLAN
COMPRESSOR STATION

NORTH MIST COMPRESSOR STATION
NORTHWEST NATURAL

DWG NO. NMS01-M-0102

REV A

P:\60337156 NWN Mist\900 CAD-GIS\906 Mech\NMC01-M-0102.dwg – Jan 28, 2015 2:51pm

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Appendix B Emissions Calculations

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NW Natural - North Mist Compressor Station
Emissions Summary

Emission Source	Pollutant					
	PM10, PM2.5	NOx	CO	VOC	HAP	CO2e (metric tons)
Compressors	2.1	11.2	22.4	7.8	3.5	5033.8
TEG		0.4	0.4	1.9	0.2	307.3
Valves/Fittings						30.1
Total	**2.1**	**11.6**	**22.8**	**9.7**	**3.7**	**5371.3**
Requested PSEL	**14/9**	**39**	**99**	**39**		
Thresholds	**14/9**	**39**	**99**	**39**	**10/25**	**2500**

Notes:

SO2 emissions are negligible.

NW Natural - North Mist Compressor Station
Compressor Engine Emissions

Pollutant	Emission Factor		Emissions		
			lb/year	tons/year	metric tons/year
PM10/2.5 - filterable	0.0384	lb/MMBtu[1]			
PM10/2.5 - cond	0.00991	lb/MMBtu[1]			
PM10/2.5 - total	0.04831	lb/MMBtu[1]	4,153.3	2.1	
SO2	1.7	lb/MMscf[2]	140.5	0.1	
NOx	1.0	gm/hp-hr[3]	22,419.3	11.2	
CO	2.0	gm/hp-hr[3]	44,838.5	22.4	
VOC	0.7	gm/hp-hr[3]	15,693.5	7.8	
HAP	0.31	gm/hp-hr[4]	6,950.0	3.5	
CO2	495	gm/hp-hr[4]	11,097,533.3	5548.8	5033.8

1 - EPA, AP-42
2 - DEQ
3 - 40 CFR 60, Subpart JJJJ Emission Standard
4 - Manufacturer's Information

Compressors - PTE Operations Based on Reservoir Model
Assumptions:

50% load, 2 compressors

1775	hp each, rated capacity
888	hp each, 50% load
350	days/year
16.36	hours/day
5726	hours/year
453.6	gm/lb
8454	Btu/hp-hr
15.0	MMBtu/hr
0.014436831	MMscf/hr
1040	Btu/scf

NW Natural - North Mist Compressor Station
TEG Emissions

Assumptions:

Maximum Injection Rate =	56	MMscf/day		
Maximum Withdrawal Rate =	120	MMscf/day		
Ratio Injection/Withdrawal =	2.14			
Working Days/year =	350			
Max Equiv Injection =	238.6	days/year	5727	hrs/year
Max Equiv Withdrawal =	111.4	days/year	2673	hrs/year
Withdrawal gas flow to TEG =	120	MMscf/day		
Injection gas flow to TEG =	10.0	MMscf/day		
Pilot Burner:	1.0	MMBtu/hr		
	0.000961538	MMscf/hr	1040.0	Btu/scf

TEG Reboiler Gas Combustion

Pollutant	Emission Factor		Emissions lb/year	Emissions tons/year
PM10/2.5	2.5	lb/MMscf	21.1	0.01
SO2	1.7	lb/MMscf	14.3	0.01
NOx	94	lb/MMscf	791.8	**0.4**
CO	84	lb/MMscf	707.5	**0.4**
VOC	5.5	lb/MMscf	46.3	0.02

EPA AP-42 emission factors for residential boilers, DEQ for SO2

TEG Regnerator Emissions

	Emissions (tons/year)				
Process	**VOC**	**HAP**	**GHG (CH4)**	**GHG (CO2e)**	**GHG (CO2e, metric tons/yr)**
Injection	0.3	0.034	2.1	51.3	46.5
Withdrawal	1.6	0.188	11.5	287.5	260.8
Total	**1.9**	**0.2**			**307.3**

CH4 GWP = 25

TEG Pollution Prevention Analysis

2013 methanol use at Miller Station =	14,559.80	gallons
2013 gas through TEGat Miller Station =	14,153.89	MMcf
Ratio methanol used to gas througput	1.03	gallons/MMcf

NMCS TEG Maximum throughput = 238.6 days@ 10 MMcf/day + 111.4 days@ 120 MMcf/day =

	15,750	MMcf/year
Estimate, NMCS methanol use =	16,202	gallons/year @ 6.605 lb/gallon
	107,012	lbs/year
Estimated uncontrolled emissions =	54	tons/year
Estimated Emissions with TO =	2.7	tons/year

NW Natural - North Mist Compressor Station
Valves & Fittings Emissions

Emissions of VOC and GHG from the valves and fittings is negligible - 0.02 tpy VOC and 30 tpy CO2e.

Table 1 - Emission Calculations

Source	kg/hr/source as TOC[1]	to lb/hr/source as TOC	to lb/hr/source as VOC[2]	Total sources[3]	lb/hour VOC	lb/year VOC	lb/year methane
Valves	0.0045	0.0099	0.0002	44	0.0068	38.91	2318.7
Other (PRV, Comp, Vents)	0.0088	0.0194	0.0003	3	0.0009	5.19	309.2
Flanges/Connectors	0.0004	0.0009	0.0000	6	0.0001	0.46	27.4
Total					0.01	44.6	2655.3

1 - *Protocol for Equipment Leak Emission Estimates, November 1995 [EPA-453/R-95-017],*

Table 2-4. Oil and Gas Production Operations

2 - Calculated based on the gas composition - 1.6% VOC, 92.8% methane

3 - Based on preliminary design layout 1/29/2015

5726 hours/year

2.204623 lb/kg

Table 2 - Natural Gas Composition

	Mole %	MW	gm/mol	Wt%	Wt% TOC	Wt% VOC
Water	0.0005	33.0	0.0002	0.001		
Methane	95.0360	16.0	15.2438	90.305	92.8	
Ethane	2.3100	30.1	0.6946	4.115	4.2	
Propane	0.3590	44.1	0.1583	0.938	1.0	61.9
i-Butane	0.0540	58.1	0.0314	0.186	0.2	12.3
n-Butane	0.0600	58.1	0.0349	0.207	0.2	13.6
i-Pentane	0.0150	72.2	0.0108	0.064	0.1	4.2
n-Pentane	0.0110	72.2	0.0079	0.047	0.0	3.1
Hexane +	0.0145	86.2	0.0125	0.074	0.1	4.9
CO2	0.5410	44.0	0.2380	1.410	1.4	
N2	1.5990	28.0	0.4479	2.653		
TOTAL	100.0		16.8803	100.0	100.0	100.0
Percent by weight VOC					1.6	

Appendix C Manufacturer's Data for Engines

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G3606

CATERPILLAR®

GAS ENGINE SITE SPECIFIC TECHNICAL DATA
Exterran
AECOM 3606

GAS COMPRESSION APPLICATION

ENGINE SPEED (rpm):	1000
COMPRESSION RATIO:	9.2:1
AFTERCOOLER TYPE:	SCAC
AFTERCOOLER WATER INLET (°F):	130
JACKET WATER OUTLET (°F):	190
ASPIRATION:	TA
COOLING SYSTEM:	JW, OC+AC
CONTROL SYSTEM:	CIS/ADEM3
EXHAUST MANIFOLD:	DRY
COMBUSTION:	LOW EMISSION
NOx EMISSION LEVEL (g/bhp-hr NOx):	0.5

RATING STRATEGY:	STANDARD
RATING LEVEL:	CONTINUOUS
FUEL SYSTEM:	GAV WITH AIR FUEL RATIO CONTROL

SITE CONDITIONS:

FUEL:	Gas Analysis
FUEL PRESSURE RANGE(psig):	42.8-47.0
FUEL METHANE NUMBER:	90.1
FUEL LHV (Btu/scf):	917
ALTITUDE(ft):	1301
MAXIMUM INLET AIR TEMPERATURE(°F):	105
STANDARD RATED POWER:	1775 bhp@1000rpm

				MAXIMUM RATING	SITE RATING AT MAXIMUM INLET AIR TEMPERATURE		
RATING		**NOTES**	**LOAD**	**100%**	**100%**	**75%**	**50%**
ENGINE POWER	(WITHOUT FAN)	(1)	bhp	1775	1772	1329	888
INLET AIR TEMPERATURE			°F	104	105	105	105
ENGINE DATA							
FUEL CONSUMPTION (LHV)		(2)	Btu/bhp-hr	6860	6862	7105	7619
FUEL CONSUMPTION (HHV)		(2)	Btu/bhp-hr	7611	7613	7883	8454
AIR FLOW (@inlet air temp, 14.7 psia)	(WET)	(3)(4)	ft3/min	4970	4957	3833	2587
AIR FLOW	(WET)	(3)(4)	lb/hr	20925	20892	16154	10901
FUEL FLOW (60ºF, 14.7 psia)			scfm	221	221	172	123
INLET MANIFOLD PRESSURE		(5)	in Hg(abs)	74.3	74.2	57.8	41.2
EXHAUST TEMPERATURE - ENGINE OUTLET		(6)	°F	847	847	871	937
EXHAUST GAS FLOW (@engine outlet temp, 14.5 psia)	(WET)	(7)(4)	ft3/min	12221	12203	9606	6826
EXHAUST GAS MASS FLOW	(WET)	(7)(4)	lb/hr	21514	21480	16611	11228
EMISSIONS DATA - ENGINE OUT							
NOx (as NO2)		(8)(9)	g/bhp-hr	0.50	0.50	0.50	0.50
CO		(8)(9)	g/bhp-hr	2.75	2.75	2.74	2.75
THC (mol. wt. of 15.84)		(8)(9)	g/bhp-hr	6.30	6.30	6.51	6.77
NMHC (mol. wt. of 15.84)		(8)(9)	g/bhp-hr	0.95	0.95	0.98	1.02
NMNEHC (VOCs) (mol. wt. of 15.84)		(8)(9)(10)	g/bhp-hr	0.63	0.63	0.65	0.68
HCHO (Formaldehyde)		(8)(9)	g/bhp-hr	0.26	0.26	0.28	0.31
CO2		(8)(9)	g/bhp-hr	441	442	461	494
EXHAUST OXYGEN		(8)(11)	% DRY	12.8	12.8	12.1	11.1
HEAT REJECTION							
HEAT REJ. TO JACKET WATER (JW)		(12)	Btu/min	18683	18670	15537	12983
HEAT REJ. TO ATMOSPHERE		(12)	Btu/min	7103	7102	6620	6199
HEAT REJ. TO LUBE OIL (OC)		(12)	Btu/min	9133	9133	8672	8453
HEAT REJ. TO AFTERCOOLER (AC)		(12)(13)	Btu/min	18078	18078	9790	1915
COOLING SYSTEM SIZING CRITERIA							
TOTAL JACKET WATER CIRCUIT (JW)		(13)	Btu/min	20552			
TOTAL AFTERCOOLER CIRCUIT (OC+AC)		(13)(14)	Btu/min	29942			
A cooling system safety factor of 0% has been added to the cooling system sizing criteria.							

CONDITIONS AND DEFINITIONS

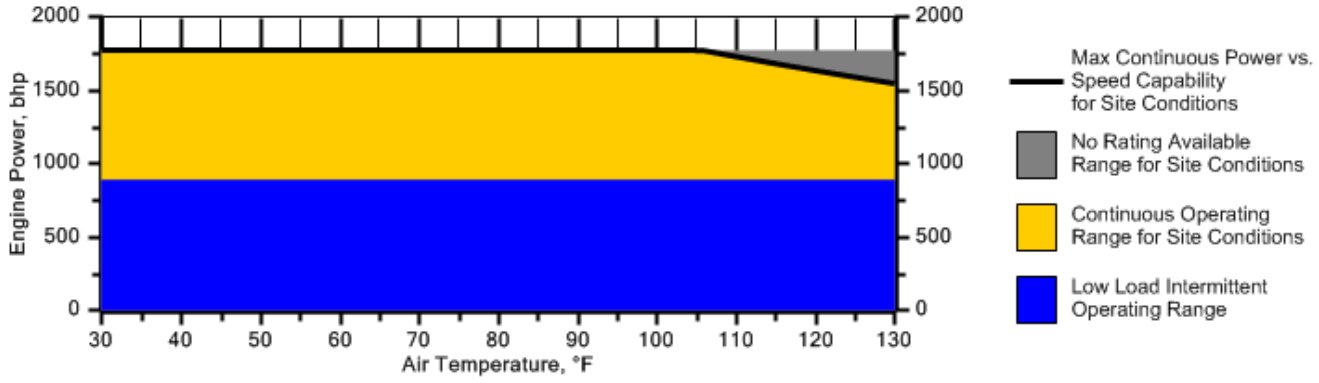
Engine rating obtained and presented in accordance with ISO 3046/1, adjusted for fuel, site altitude and site inlet air temperature. 100% rating at maximum inlet air temperature is the maximum engine capability for the specified fuel at site altitude and maximum site inlet air temperature. Maximum rating is the maximum capability at the specified aftercooler inlet temperature for the specified fuel at site altitude and reduced inlet air temperature. Lowest load point is the lowest continuous duty operating load allowed. No overload permitted at rating shown.

For notes information consult page three.

PREPARED BY: Michael Serrett, Exterran
Data generated by Gas Engine Rating Pro Version 5.01.01
Ref. Data Set DM8605-06-001, Printed 29Jan2015

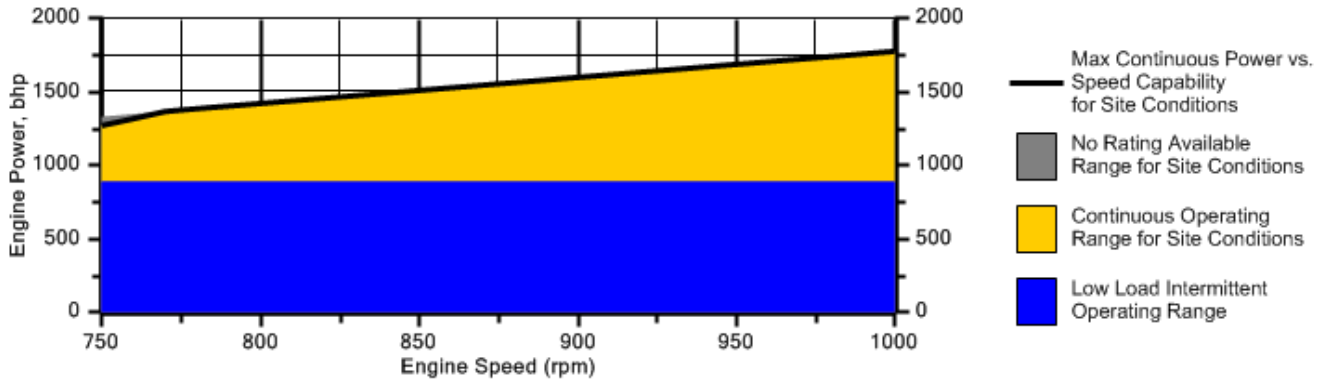
Engine Power vs. Inlet Air Temperature

Data represents temperature sweep at 1301 ft and 1000 rpm



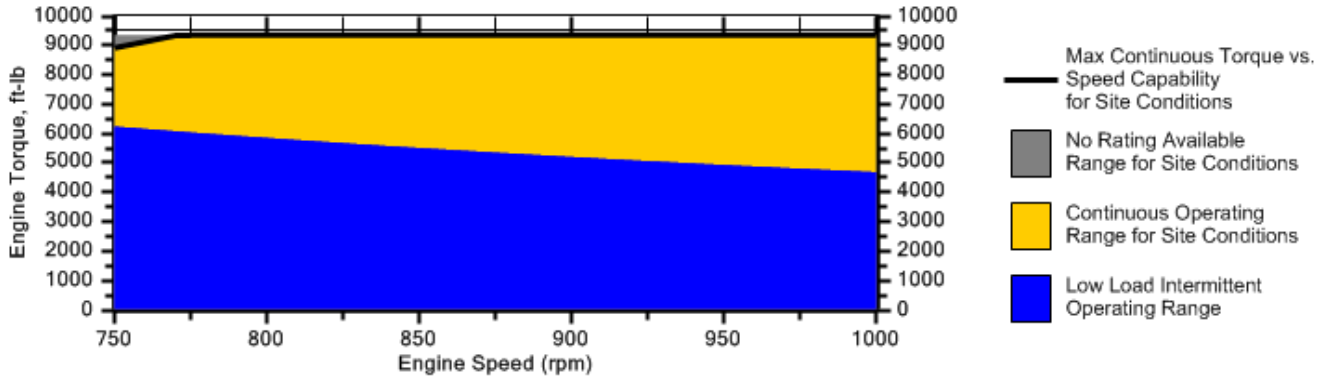
Engine Power vs. Engine Speed

Data represents speed sweep at 1301 ft and 105 °F



Engine Torque vs. Engine Speed

Data represents speed sweep at 1301 ft and 105 °F



Note: At site conditions of 1301 ft and 105°F inlet air temp., constant torque can be maintained down to 775 rpm. The minimum speed for loading at these conditions is 750 rpm.

NOTES

1. Engine rating is with two engine driven water pumps. Tolerance is ± 3% of full load.

2. Fuel consumption tolerance is ± 2.5% of full load data.

3. Air flow value is on a 'wet' basis. Flow is a nominal value with a tolerance of ± 5 %.

4. Inlet and Exhaust Restrictions must not exceed A&I limits based on full load flow rates from the standard technical data sheet.

5. Inlet manifold pressure is a nominal value with a tolerance of ± 5 %.

6. Exhaust temperature is a nominal value with a tolerance of (+)63°F, (-)54°F.

7. Exhaust flow value is on a "wet" basis. Flow is a nominal value with a tolerance of ± 6 %.

8. Emissions data is at engine exhaust flange prior to any after treatment.

9. Emission values are based on engine operating at steady state conditions. Fuel methane number cannot vary more than ± 3. Values listed are higher than nominal levels to allow for instrumentation, measurement, and engine-to-engine variations. They indicate "Not to Exceed" values. THC, NMHC, and NMNEHC do not include aldehydes. An oxidation catalyst may be required to meet Federal, State or local CO or HC requirements.

10. VOCs - Volatile organic compounds as defined in US EPA 40 CFR 60, subpart JJJJ

11. Exhaust Oxygen level is the result of adjusting the engine to operate at the specified NOx level. Tolerance is ± 0.5.

12. Heat rejection values are nominal. Tolerances, based on treated water, are ± 10% for jacket water circuit, ± 50% for radiation, ± 20% for lube oil circuit, and ± 5% for aftercooler circuit.

13. Aftercooler heat rejection includes an aftercooler heat rejection factor for the site elevation and inlet air temperature specified. Aftercooler heat rejection values at part load are for reference only. Do not use part load data for heat exchanger sizing.

14. Cooling system sizing criteria are maximum circuit heat rejection for the site, with applied tolerances.

Constituent	Abbrev	Mole %	Norm
Water Vapor	H2O	0.0005	0.0005
Methane	CH4	95.0360	95.0360
Ethane	C2H6	2.3100	2.3100
Propane	C3H8	0.3590	0.3590
Isobutane	iso-C4H1O	0.0540	0.0540
Norbutane	nor-C4H1O	0.0600	0.0600
Isopentane	iso-C5H12	0.0150	0.0150
Norpentane	nor-C5H12	0.0110	0.0110
Hexane	C6H14	0.0145	0.0145
Heptane	C7H16	0.0000	0.0000
Nitrogen	N2	1.5990	1.5990
Carbon Dioxide	CO2	0.5410	0.5410
Hydrogen Sulfide	H2S	0.0000	0.0000
Carbon Monoxide	CO	0.0000	0.0000
Hydrogen	H2	0.0000	0.0000
Oxygen	O2	0.0000	0.0000
Helium	HE	0.0000	0.0000
Neopentane	neo-C5H12	0.0000	0.0000
Octane	C8H18	0.0000	0.0000
Nonane	C9H20	0.0000	0.0000
Ethylene	C2H4	0.0000	0.0000
Propylene	C3H6	0.0000	0.0000
TOTAL (Volume %)		100.0000	100.0000

Fuel Makeup:	Gas Analysis
Unit of Measure:	English

Calculated Fuel Properties

Caterpillar Methane Number:	90.1
Lower Heating Value (Btu/scf):	917
Higher Heating Value (Btu/scf):	1017
WOBBE Index (Btu/scf):	1201
THC: Free Inert Ratio:	45.73
Total % Inerts (% N2, CO2, He):	2.14%
RPC (%) (To 905 Btu/scf Fuel):	100%
Compressibility Factor:	0.998
Stoich A/F Ratio (Vol/Vol):	9.58
Stoich A/F Ratio (Mass/Mass):	16.43
Specific Gravity (Relative to Air):	0.583
Specific Heat Constant (K):	1.312

CONDITIONS AND DEFINITIONS

Caterpillar Methane Number represents the knock resistance of a gaseous fuel. It should be used with the Caterpillar Fuel Usage Guide for the engine and rating to determine the rating for the fuel specified. A Fuel Usage Guide for each rating is included on page 2 of its standard technical data sheet.

RPC always applies to naturally aspirated (NA) engines, and turbocharged (TA or LE) engines only when they are derated for altitude and ambient site conditions.

Project specific technical data sheets generated by the Caterpillar Gas Engine Rating Pro program take the Caterpillar Methane Number and RPC into account when generating a site rating.

Fuel properties for Btu/scf calculations are at 60F and 14.696 psia.

Caterpillar shall have no liability in law or equity, for damages, consequently or otherwise, arising from use of program and related material or any part thereof.

FUEL LIQUIDS

Field gases, well head gases, and associated gases typically contain liquid water and heavy hydrocarbons entrained in the gas. To prevent detonation and severe damage to the engine, hydrocarbon liquids must not be allowed to enter the engine fuel system. To remove liquids, a liquid separator and coalescing filter are recommended, with an automatic drain and collection tank to prevent contamination of the ground in accordance with local codes and standards.

To avoid water condensation in the engine or fuel lines, limit the relative humidity of water in the fuel to 80% at the minimum fuel operating temperature.

ATTACHMENT E-2:

NPDES 1200C PERMIT

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DEQ USE ONLY
File #:
Application #:
LLID/RM:
River Mile:
Legal Name Confirmed: ☐
Notes:

DEPARTMENT OF ENVIRONMENTAL QUALITY
APPLICATION FOR NEW NPDES GENERAL PERMIT 1200-C

For stormwater discharges to surface waters from construction activities disturbing one acre or more that do not meet automatic coverage requirements.*

DEQ USE ONLY
Date Received:
Amount: $
Check #:
Check Name:
Deposit #:
Receipt #:
Notes:

*A project *may* be eligible for "automatic coverage" under NPDES general permit 1200-CN if stormwater *does not* discharge to a water body with a TMDL or 303(d) listing for sediment or turbidity *and* it meets one of the following criteria (see 1200-CN at http://www.deq.state.or.us/wq/wqpermit/docs/general/npdes1200cn/1200CNPermit.pdf):

1)Disturbs less than one acre and is located in Gresham, Troutdale, or Wood Village.

2)Disturbs less than five acres and is located in Albany, Corvallis, Eugene, Milwaukie, Multnomah Co. (unincorporated areas), Springfield, West Linn, or Wilsonville.

3)Disturbs less than five acres and is within the jurisdictions of Clackamas Co. Water Environment Services [Gladstone, areas within Clackamas Co. Service Dist. #1 (excluding Happy Valley), and areas within the Surface Water Management Agency of Clackamas Co. (including Rivergrove)], Clean Water Services (Banks, Beaverton, Cornelius, Durham, Forest Grove, Hillsboro, King City, North Plains, Sherwood, Tigard, Tualatin, and Washington Co. within Urban Growth Boundary), or Rogue Valley Sewer Services (Central Point, Phoenix, Talent, and portions of Jackson Co. in NPDES MS4 permit area).

Please answer all questions.

A. PROJECT INFORMATION

1. NW Natural
Applicant (entity legally responsible for permit)

Andrew Bauer, RG
Contact Name (if different from applicant)

220 NW 2nd Avenue
Address

Portland | Oregon | 97209
City | State | Zip

503-226-4211 | andrew.bauer@nwnatural.com
Telephone | E-Mail Address

2. Invoicing information (person or entity legally responsible for payment of annual fee invoice; not a third party independent of the applicant)

Invoice Contact Name (if different from applicant)

Address

City | State | Zip

Telephone | E-Mail Address

3. GeoEngineers, Inc.
Architect/Engineering Firm (Erosion & Sediment Control Plan)

Brian C. Ranney, CEG, CESCL
Project Manager

503-624-9274 | branney@geoengine
Telephone | E-Mail Address

4. Andrew Bauer
Applicant's Designated Erosion and Sediment Control Inspector

NW Natural
Company Name

503-226-4211 | andrew.bauer@nwnatural.com
Telephone | E-Mail Address

5. North Mist Expansion Project

Name of Project

N/A - Mist, Oregon to Portwestward, Oregon

Address or Cross Street

Multiple	Oregon	n/A
City	State	Zip

Columbia

County

6. Nature of Construction Activity

- ☐ Single Family (SIC Code 1521)
- ☐ Multi-Family Residential (SIC Code 1522)
- ☐ Commercial (SIC Code 1542)
- ☐ Industrial (SIC Code 1541)
- ☐ Highway (SIC Code 1611)
- ☒ Utilities (SIC Code 1623): natural gas pipeline
- ☐ Other (include SIC Code):

7. Approximate location of center of site:

Latitude: 46.0811

Longitude: -123.2780

For assistance: DEQ Location Tool at http://deqgisweb.deq.state.or.us/llid/llid.html*

8. Project Size:

Total Site Acreage (acres): 142.38

Total Disturbed Area (acres): 142.01

Total Number of Lots (if applicable): N/A

9. Stormwater runoff during construction will flow to:

- ☐ Infiltration device(s)
- ☒ Creek/Stream (provide name): Clatskanie River, Beaver Slough, Graham Creek, Larson Slough, McCoon Creek
- ☐ Ditch (provide name of receiving stream for ditch): Beaver Slough, Columbia River, Larson Slough
- ☐ Municipal storm sewer or drainage system (provide name of receiving stream for system):
- ☐ Other:

10. Stormwater runoff during construction discharges directly to or through a storm sewer or drainage system that discharges to a water body with a Total Maximum Daily Load (TMDL) or 303(d) listing for turbidity or sedimentation? ☒ YES ☐ NO

- ***For assistance: DEQ Lookup Tool at http://www.deq.state.or.us/WQ/TMDLs/basinmap.htm or DEQ Map/Table at http://deq12.deq.state.or.us/tmdl/default.aspx****

B. LAND USE COMPATIBILITY STATEMENT

Submit a DEQ Land Use Compatibility Statement (LUCS) form that has been completed by the local land use authority with this application. Attach the *original* LUCS and, if applicable, written findings by the local authority. DEQ will not process the application unless the local land use authority indicates on the LUCS form that the project is compatible with the local acknowledged comprehensive plan and land use regulations.

A copy of this form may be found at http://www.deq.state.or.us/pubs/permithandbook/lucs.htm*

C. SIGNATURE OF LEGALLY AUTHORIZED REPRESENTATIVE

The legally authorized representative *must* sign the application.

I hereby certify that the information contained in this application is true and correct to the best of my knowledge and belief. In addition, I agree to pay all permit fees required by Oregon Administrative Rules 340-045. This includes a compliance determination fee invoiced annually by DEQ to maintain the permit.

Andrew Bauer, RG

Name of Legally Authorized Representative (Type or Print)

Environmental Specialist

Title

Signature of Legally Authorized Representative

April 6, 2015

Date

APPLICATION AND FEE SUBMITTAL

To authorize permit registration, the following must be completed and submitted to the appropriate DEQ regional office or DEQ Agent (see list of offices in application instructions, pp. 3-4):

- ☐ DEQ application form signed by the Legally Authorized Representative and meeting the signature requirements below.
- ☐ DEQ LUCS by local land use authority indicating the activity is compatible with local acknowledged comprehensive plan and land use regulations. Include the Findings if so stated on the LUCS.
- ☐ Stormwater Erosion and Sediment Control Plan Narrative, if applicable.
- ☐ Stormwater Erosion and Sediment Control Plan Drawings; full-sized hard copy and electronic PDF files.
- ☐ Effective 12/1/14, the fee for a new application is $1,725 payable to Oregon DEQ and you must submit it with this application. Please note that DEQ will also invoice you for an annual fee of $875 if your project needs permit coverage for more than a year. These fees are subject to change; please visit http://www.deq.state.or.us/wq/wqpermit/stminfo.htm for current fees. If you are sending your application to a DEQ Agent, check with the DEQ Agent for appropriate fees and make check payable to the DEQ Agent.

Application Instructions

A. PROJECT INFORMATION

1. Enter the legal name of the applicant. Permit coverage will be issued to this entity. This is the person, business, public organization, or other entity responsible for ensuring that erosion and sediment controls are in place and in working order through the life of the project.
   - The name must be a legal, active name registered with the Oregon Department of Commerce, Corporation Division in Salem at 503-378-4752 or http://egov.sos.state.or.us/br/pkg_web_name_srch_inq.login, unless otherwise exempted by their rules. If the name of the applicant is not registered with the Corporation Division and the applicant is a business entity, attach legal documents that verify the entity's existence with the application. The applicant may not use an assumed business name.
   - Permit coverage may be transferred from one party to another. For example, a developer may apply for a permit and then transfer the permit to a contractor. Transfer forms are available from DEQ or at http://www.deq.state.or.us/wq/stormwater/constappl.htm.
2. Provide invoice contact information for billing of DEQ annual permit fee if different from the applicant in #1 above. This is the person or entity legally responsible for payment of the annual fee invoice, not a third party independent of the applicant.
3. Provide contact information for the Architect or Consulting Engineer who designed the Erosion and Sediment Control Plan (ESCP).
4. Provide information on the Erosion and Sediment Control Inspector. This is not a DEQ or DEQ Agent inspector; this is an inspector employed by the applicant. If the inspector has not been selected yet, please provide the name of consultant who prepared the ESCP and their ESC certification. When the inspector is selected, submit to DEQ or to the DEQ Agent, the name, contact information, training and experience (see condition A.12.b.iii of the 1200-C).
5. Provide the common name of the project (for example, the name of the subdivision), the location of the site with respect to crossroads in the area, and, if available, a street address.
6. Check the box that best describes the nature of the construction activity. If "other" is selected, describe the use and include a Standard Industrial Classification Code (visit http://www.osha.gov/pls/imis/sicsearch.html for codes).
7. Enter latitude and longitude for the approximate center of the site (DEQ Location Tool at http://deqgisweb.deq.state.or.us/llid/llid.html or at http://deqapp1/website/lit/data.asp).
8. Provide information on the project size as indicated (based on the total project and not just a single phase).
9. Indicate where stormwater runoff during construction will flow. Use your best judgment to determine the name of the receiving water body.
10. Indicate whether stormwater runoff during construction will discharge directly to or through a storm sewer or drainage system that discharges to a Total Maximum Daily Load (TMDL) or 303(d) listed water body for turbidity or sedimentation. To make this determination, the following tools are available on DEQ's website:
    - Map and table: http://www.deq.state.or.us/WQ/TMDLs/basinmap.htm
    - Lookup tool: http://deq12.deq.state.or.us/tmdl/default.aspx

B. LAND USE COMPATIBILITY STATEMENT

Complete as indicated.

C. SIGNATURE OF LEGALLY AUTHORIZED REPRESENTATIVE

DEFINITION OF LEGALLY AUTHORIZED REPRESENTATIVE:

Please also provide the information requested in brackets *[ ]*

- **Corporation** - president, secretary, treasurer, vice-president, or any person who performs principal business functions; or a manager of one or more facilities that is authorized in accordance to corporate procedure to sign such documents.
- **Partnership** - General partner *[list of general partners, their addresses, and telephone numbers]*.
- **Sole Proprietorship** - Owner(s) *[each owner must sign the application]*.
- **City, County, State, Federal, or other Public Facility** - Principal executive officer or ranking elected official.
- **Limited Liability Company** - Member *[articles of organization]*.
- **Trusts** – Acting trustee *[list of trustees, their addresses, and telephone numbers]*.

(please see 40 CFR §122.22 for more detail, if needed)

APPLICATION AND FEE SUBMITTAL

Submit this application, Narrative Parts I, II & III (if applicable), LUCS, Erosion and Sediment Control Plan(2 full-sized hard copies and 1 PDF copy), and the applicable fee to the appropriate DEQ regional office or DEQ Agent listed below. Contact the appropriate DEQ regional office or DEQ Agent for the best way to submit the electronic version of the ESCP.

- If you are in an area serviced by a DEQ Agent, check with the DEQ Agent for appropriate fees and make check payable to the DEQ Agent.
- If you are sending your application to DEQ, the fee for a new application is $1,725 payable to the Oregon DEQ. Please note that DEQ will also invoice you for an annual fee of $875 if your project needs permit coverage for more than a year. These fees are subject to change; visit http://www.deq.state.or.us/wq/wqpermit/stminfo.htm for current fees.

City of Eugene 99 W. 10th Avenue Eugene, OR 97401 541-682-2706	**City of Hermiston** 215 Gladys Avenue Hermiston, OR 97838 541-667-5025	**City of Troutdale** 342 SW 4th Street Troutdale, OR 97060 503-674-3300
Clean Water Services 2550 SW Hillsboro Highway Hillsboro, OR 97123 503-681-5101 *Includes Banks, Beaverton, Cornelius, Durham, Forest Grove, Gaston, Hillsboro, King City, North Plains, Sherwood, Tigard, Tualatin, and portions of Washington Co.*	**Rogue Valley Sewer Services** 138 West Vilas Road, PO Box 3130 Central Point, OR 97502 541-664-6300 *Includes Central Point, Phoenix, Talent, White City and portions of Jackson Co.*	**Clackamas Co. Water Environmental Services** 150 Beavercreek Road, Suite 430 Oregon City, OR 97045 503-742-4567 *Unincorporated Clackamas County and areas within the Cities of Rivergrove and Gladstone*
DEQ Northwest Region	DEQ Western Region	DEQ Eastern Region
DEQ Northwest Region 2020 SW 4th Avenue, Suite 400 Portland, OR 97201-4987 503-229-5263 or 1-800-452-4011	**DEQ Western Region** 165 East 7th Avenue, Suite 100 Eugene, OR 97401 541-687-7326 or 1-800-844-8467	**DEQ Eastern Region** 800 SE Emigrant Avenue, Suite 330 Pendleton, OR 97801 541-278-4605 or 1-800-304-3513

Clackamas	Benton	Lane	Baker	Hood River	Sherman
Clatsop	Coos	Lincoln	Crook	Jefferson	Umatilla
Columbia	Curry	Linn	Deschutes	Klamath	Union
Multnomah	Douglas	Marion	Gilliam	Lake	Wallowa
Tillamook	Jackson	Polk	Grant	Malheur	Wasco
Washington	Josephine	Yamhill	Harney	Marrow	Wheeler

Margaret D. Kirkpatrick
Vice President & General Counsel
Tel: 503.220.2356
Fax: 503.220.2584
Toll Free: 1.800.422.4012
e-mail: mdk@nwnatural.com

NW Natural
220 NW 2ND AVENUE
PORTLAND, OR 97209
TEL 503.226.4211
800.422.4012
www.nwnatural.com

October 24, 2011

Oregon Department of Environmental Quality
811 SW 6th Avenue
Portland 97204-1390

Washington State Department of Ecology
PO Box 47600
Olympia, WA 98504-7600

Re: Signature Authority on behalf of Margaret Kirkpatrick for Oregon DEQ and Washington DOE Permit Applications for NW Natural.

To Whom It May Concern:

The following named individuals, accompanied by their sample signatures, are delegated the authority to sign permit applications with Oregon Department of Environmental Quality and Washington State Department of Ecology, whether by hand or electronically, for Northwest Natural Gas Company ("NW Natural"), on behalf of myself, Margaret D. Kirkpatrick, an officer of NW Natural. This delegation will remain in effect until I revoke the authority in writing, or in any event upon separation of the named individual's employment from NW Natural.

Andrew Bauer _____

Michael Hayward _____

Todd Jones _____

John McDonald _____

My contact information is noted on the letterhead. Please call me if you have any questions.

Very Truly Yours,

Margaret D. Kirkpatrick

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ATTACHMENT E-3:

ENERFIN WATER POLLUTION CONTROL FACILITIES PERMIT

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ENERFIN RESOURCES

Houston · Tulsa · Bakersfield

April 6, 2015

Mr. Steve Walti
NW Natural Gas
220 NW Second Ave.
Portland, OR 97209

RE: SALT WATER DISPOSAL PERMIT #101690
Mist Gas Field, Columbia County, Oregon

Dear Steve:

NW Natural and Enerfin have been in discussions regarding the future use by NW Natural of Enerfin's salt water disposal well (SWDW), the CC 44-21-65, for the disposal of any produced waste water from NW Natural's anticipated development of the Adams Reservoir.

Enerfin's SWDW is currently permitted to allow for the disposal of waste water produced from natural gas wells in the Mist Gas Field which Enerfin owns and operates. In furtherance of NW Natural's permitting process for the Adams Reservoir development, it has requested that Enerfin attempt to modify and expand its WPCF Permit No. 101690 to allow for disposal of produced waste water from NW Natural's gas storage operations, specifically as it relates to wells within the Adams Reservoir.

Enerfin agrees to request the modification from the Oregon Department of Environmental Quality and NW Natural can rely on Enerfin's cooperation in the use of its SWDW as it proceeds with its permitting. However, both Enerfin and NW Natural acknowledge and understand that prior to any future use by NW Natural of Enerfin's SWDW, the parties shall enter into a mutually agreed upon SWDW Agreement setting forth the terms and conditions which shall govern the participation of NW Natural in the well.

Very truly yours,

Peggy Morgan
Land Manager

ACKNOWLEDGED and AGREED TO by NW Natural this 21 day of April, 2015.

cc: T. Imre, ERNW
T. Thomas, NW Natural

49774 Road 426, Suite B, Oakhurst, CA 93644
(559) 683-3637

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WATER POLLUTION CONTROL FACILITIES PERMIT

Department of Environmental Quality
Northwest Region
2020 SW Fourth Avenue, Suite 400, Portland, OR 97201-4987
Telephone: (503) 229-5263

Issued pursuant to ORS 468B.050

ISSUED TO:

Enerfin Resources
Northwest Limited Partnership
2500 CityWest Blvd., Ste. 400
Houston, TX 77042

SOURCES COVERED BY THIS PERMIT

Type of Waste	Method of Disposal
Formation Salt Water	Underground Injection

PLANT TYPE AND LOCATION:

Underground Injection Well(s)
Mist Gas Field
Well CC 44-21-65
UIC Registration ID No. 10042-1 & 2

RIVER BASIN INFORMATION:

Basin: North Coast-Lower Columbia
Sub-Basin: North Coast
LLID 1238951456889
County: Columbia
Nearest surface stream which would receive waste if it were to discharge: Ford Creek

Issued in response to Application No. 969511, received August 2, 2010.
This permit is issued based on the land use findings in the permit record.

Gregory L. Geist, Manager, Water Quality Source Control
Northwest Region

11/8/11
Date

PERMITTED ACTIVITIES

This permit is issued pursuant to the requirements of the federal Safe Drinking Water Act (SDWA) for underground injection control activities for Class II injection wells under 40 CFR, parts 144.21, 144.25, 144.31, 146.22, 146.23 and 144.24. Until this permit expires or is modified or revoked, the permittee is authorized to modify or operate the existing underground injection control Class II injection systems (well #44-21-65 and well #13-1-65), and to construct, operate and maintain up to two additional injection wells during the current permit cycle, in conformance with requirements, limitations, and conditions set forth in Oregon Administrative Rules (OAR) 340-040-0030; 340-044-0014, -0015, and -0035; 340-045; and in the attached schedules as follows:

	Page
Schedule A - Underground Injection Limitations	2
Schedule B - Minimum Monitoring and Reporting Requirements	3
Schedule F - General Conditions	4

Installation of any new injection wells, beyond the two additional injection wells allowed in the current permit cycle, will require a permit modification. Land application of any discharges are prohibited unless explicitly authorized in this permit.

SCHEDULE A
Underground Injection Limitations

1. Salt water extracted from the Clark and Wilson Sandstone of the Cowlitz Formation through natural gas production may be injected into the above formation via injection wells subject to the following conditions:
   a. The injection pressure must not exceed a surface (wellhead) injection pressure, determined by calculating the maximum allowable injection pressure equal to 1.0 psi/foot, multiplied by the actual depth to the top of the injection interval, minus the hydrostatic pressure of the injection fluid at that depth. The initial maximum allowable injection pressure is set at 1,019 psi, based on a depth of 1,890 feet to the top of the permitted injection interval, and a hydrostatic pressure of 871 psig (0.461 psi/ft. gradient) at that depth. The Department of Environmental Quality (DEQ) and the Department of Geology and Mineral Industries (DOGAMI) must approve in writing any injection pressure greater than 1,019 psi.
   b. Injection is permitted for the Clark and Wilson Sandstone members of the Cowlitz Formation in the gross subsurface interval of approximately 1,890 to 1,936 feet below ground surface (bgs).

2. If at any time the injection well loses mechanical integrity, and injected fluids are likely to enter any zone other than the approved zone of Schedule A, condition 1.b, injection must cease immediately until mechanical integrity can be reestablished and maintained.

3. The permittee must not inject any hazardous wastes as defined in the Resource Conservation and Recovery Act (RCRA), (see 40 Code of Federal Regulations (CFR) Section 261), at any time during facility operations.

4. The permitted injection well must be used only for the injection of fluid produced in association with the Cowlitz Formation natural gas production in the Mist gas field, and produced only from wells that the permittee owns and operates.

5. Fluids injected other than those described in paragraph 4. above must be limited to de minimis amounts of well treatment fluids such as dilute acids and corrosion inhibiting fluids that do not harm or pose a threat of any harm to human health or the environment. Injection of any fluids other than those described in paragraph 2.b. of this Schedule must be reported to DEQ and DOGAMI no later than thirty (30) days after the date of injection.

6. The only injection well currently approved for use is CC 44-21-65. Additional injection wells (including CC 13-1-65, not currently in use), may be added after successful completion of a Mechanical Integrity Test (MIT), and upon written approval from DEQ and DOGAMI .

7. Any new injection well put into service must be constructed to comply with DOGAMI and Oregon Water Resources Department well construction requirements.

8. Any new injection well put into service must:

   a. Have a packer installed above the injection zone, and
   b. The permittee must provide written documentation to DEQ that the packer has been installed and tested before the well is put into service.

9. Any sumps or mud pits used as part of injection activities must meet the DOGAMI permit requirements of

ID No. G-224, General, Part 1, and must be lined with an impervious liner to prevent migration of fluids into the subsurface.

10. Issuance of this permit does not relieve the permittee from the responsibility to comply with the requirements of Columbia County or other federal, state or local agencies, or DOGAMI permit conditions.

11. All water produced from the natural gas wells must be injected into the approved zone through an approved well.

12. The permittee must not inject into any underground source of drinking water.

13. On-site disposal of drilling mud filtrate is not authorized under this permit. The permittee may apply for a separate WPCF permit for land application of drilling mud filtrate with Total Dissolved Solids (TDS) of less than 5,000 mg/l, provided the underlying groundwater TDS does not exceed 500 mg/l.

SCHEDULE B
Minimum Monitoring and Reporting Requirements

1. The permittee must monitor the operation and efficiency of the injection well(s) and the injected liquids. Unless DEQ otherwise agrees in writing, monitoring must include, but not necessarily be limited to, the following parameters and minimum frequencies:

Item or Parameter	Minimum Frequency	Type of Sample
Quantity injected into well	Weekly	Measurement (barrels)
Injection pressure at wellhead	Weekly	Measurement (psi)
Any change in formation pressure	Daily	Measurement (psi)
pH	Annually	Grab
Specific Gravity	Annually	Grab
Bicarbonate	Annually	Grab
Chloride	Annually	Grab
Sulfate	Annually	Grab
Calcium	Annually	Grab
Magnesium	Annually	Grab
Total Hardness	Annually	Grab
Total Iron	Annually	Grab
Barium	Annually	Grab

2. The permittee must submit monitoring results on DEQ-approved forms. The reporting period is the calendar month. The permittee must submit reports to DEQ by the 15th day of the following month. The permittee must also submit a copy of the report to DOGAMI.
3. The permittee must conduct a mechanical integrity test on each injection well approved for use at least once every five years. The permittee must assure that either DOGAMI or DEQ is represented during all mechanical integrity tests (MITs). The permittee must submit a report showing the MIT results to both agencies no later than 30 days after completing the MIT.
4. If injection pressure monitoring shows an increase or decrease of 10 percent or more, for a given injection volume, the permittee must cease injection activity immediately, notify DEQ and DOGAMI, and perform a mechanical integrity test (MIT). If the injection well passes the MIT, then the permittee must submit to DEQ and DOGAMI an explanation to account for the abrupt pressure change. DEQ and DOGAMI must be

satisfied with the explanation before injection activity can resume. If the injection well fails the MIT, then the permittee must perform corrective action on the injection well, and complete a successful MIT before injection activity can resume.

5. Blowout prevention and casing shoe pressure testing must meet the requirements of DOGAMI permit, ID No. G-224, Notification, conditions 10 through 19. The permittee must copy DEQ on all blowout prevent and casing shoe pressure test results (see DOGAMI permit I.D. No. G-224, Notification, conditions 22 and 23).
6. Annual chemical analysis reports are due July 1st of every year the permit is in effect.

SCHEDULE F
General Conditions

1. **Standard Conditions.**
   a. **Duty to Comply.** The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Safe Drinking Water Act, a violation of Oregon Revised Statutes (ORS) 468B.025, and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application; except that the permittee need not comply with the provisions of this permit to the extent and for the duration such noncompliance is authorized in an emergency permit under §144.34.
   b. **Penalties for Violations of Permit Conditions.** ORS 468.140 allows DEQ to impose civil penalties up to $25,000 per day for violation of a term, condition, or requirement of a permit. ORS 468.943 creates the criminal offense of unlawful water pollution in the second degree, for the criminally negligent violation of ORS chapter 468B or any rule, standard, license, permit or order adopted or issued under ORS chapter 468B. In some situations, violations of a term, condition or requirement of the permit may also be a criminal offense, specifically unlawful water pollution in the first degree (a felony) or unlawful water pollution in the second degree (a misdemeanor). [ORS 468.943 and 468.946].
   c. **Duty to Mitigate.** The permittee must take all reasonable steps to promptly minimize or correct any real or potentially adverse impact on the environment resulting from noncompliance with this permit. In the event of any adverse impact on the environment or human health or safety resulting from noncompliance with this permit, the permittee must perform accelerated or additional monitoring as necessary to determine the nature and impact of the non-complying discharge.
   d. **Duty to Reapply.** If the permittee wishes to continue an activity regulated by this permit after the permit expiration date of this permit, the permittee must apply for and obtain a new permit. In accordance with OAR 340-045-0040(1), the application must be submitted at least 60 days before the expiration date of this permit. DEQ may grant permission to submit an application less than 60 days in advance of the permit expiration date. DEQ will not grant permission for a renewal application to be submitted later than the expiration date of the existing permit.
   e. **Permit Actions.**
      i. This permit may be modified, revoked and reissued, or terminated for cause including, but not limited to, the following:
         (1) Violation. The violation of any term, condition, or requirement of this permit, or a related state rule or statute, or a federal regulation related to underground injection control for injection wells;
         (2) Misrepresentation. Obtaining this permit by misrepresentation or failure to disclose fully all material facts; or
         (3) Change of condition. A change of any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.
      ii. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any

permit condition.

f. **Reference to Federal Law.** The Underground Injection Control (UIC) Program is a federal program under the federal Safe Drinking Water Act (SDWA). Federal regulations governing or applicable to the UIC Program are covered in 40 CFR Parts 136, 141, 144, and 146. The SDWA provides for states to administer the federal program. The Environmental Protection Agency has authorized DEQ to administer the UIC Program in Oregon. DEQ administers the program through Oregon Revised Statutes (ORS) and Oregon Administrative Rules (OAR), which meet the requirements of federal code of regulations for the federal UIC program. This permit is issued pursuant to OAR Chapter 340, Division 44 (revised and adopted by the Environmental Quality Commission in September 2001), OAR Chapter 340, Division 40 and OAR Chapter 340, Division 45. In implementing the state UIC Program, DEQ requires compliance with applicable state statutes and administrative rules applicable to the UIC Program and DEQ-issued WPCF permits.

g. **Property Rights.** The issuance of this permit does not convey any property rights of any sort or any exclusive privileges.

h. **Permit Reference.** All rules and statutes referred to in this permit are those in effect on the date this permit is issued, or the date the permit has been modified as provided in OAR 340-045-0055 to incorporate the new provisions, whichever occurs later.

i. **Supplying False Information to Agency.** Under ORS 468.953, any person who supplies false information to DEQ commits a Class C felony. Under OAR 340-012-0053(1)(b), providing the department with false information, is a Class 1 violation. A person commits the crime of supplying false information to any agency if the person:

   i. Makes any false material statement, representation or certification knowing it to be false, in any application, notice, plan, record, report or other document required by any provision of ORS chapter 465, 466, 468, 468A or 468B or any rule adopted pursuant to ORS chapter 465, 466, 468, 468A or 468B;

   ii. Omits any material or required information, knowing it to be required, from any document described in paragraph i of this subsection;

   iii. Alters, conceals or fails to file or maintain any document described in paragraph I of this subsection in knowing violation of any provision of ORS chapter 465, 466, 468, 468A or 468B or any rule adopted pursuant to ORS chapter 465, 466, 468, 468A or 468B.

j. **Duty to Provide Information.** The permittee must furnish to DEQ, within a time specified, any information which DEQ may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with the permit. The permittee must also furnish to DEQ upon request, copies of records required to be kept by this permit.

k. **Retention of Records.** The permittee must retain records of all monitoring and maintenance information, including all field notes, calibration and maintenance records, and all original strip chart recordings for continuous monitoring instrumentation, all analyses of the data generated, all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least ten (10) years from the date of the sample, measurement, report, or application. The permittee must make the records available to DEQ upon request.

l. **Need to Halt or Reduce Activity not a Defense.** It is not a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of the permit.

m. **Requirements Prior to Commencing Injection.** Except for all new underground injection systems authorized by an area permit, the permittee must not commence injection into a new injection well until construction is complete, and one of the following conditions are met:

   i. The permittee has submitted a notice of completion of construction to DEQ, and DEQ has inspected or otherwise reviewed the new underground injection system and finds it is in compliance with the conditions of the permit; or

   ii. The permittee has included in its notice a 15-day time period in which DEQ will inspect the injection

system, but has not received notice from DEQ of its intent to inspect or otherwise review the new underground injection system within 15 days of the date of the notice of construction completion. In this circumstance, prior inspection or review is waived and the permittee may commence injection.

n. **Notice prior to and Reporting of Conversion, Abandonment or Decommissioning of an Underground Injection System and Plugging.**
   i. The permittee must provide prior notice of conversion, abandonment or decommissioning of any underground injection system owned or operated by the permittee in accordance with notification requirements set forth in OAR 340-044-0040.

   ii. The permittee must comply with the decommissioning (abandonment) and conversion requirements for underground injection systems, including reporting requirements, as specified in OAR 340-044-0040.
   iii. Fees, as authorized by Oregon Revised Statutes (ORS) 468B.196(1)(e), apply for any abandonment or decommissioning of any underground injection system.

o. **Permit Modifications.** The permittee may request, or the department may initiate, a permit modification. Any modification to the permit must be in accordance with the provisions of OAR 340-045-0055 and 40 CFR 144.41, as applicable.

2. **Operation and Maintenance.**
   a. **Proper Operation and Maintenance.** The permittee must at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of a back-up or auxiliary facilities or similar systems only when necessary to achieve compliance with permit conditions.
   b. **Removed Substances.** The permittee must dispose or otherwise manage any soil, gravel, sludge, liquids, or other materials removed from or adjacent to a UIC in accordance with 40 CFR 144.82(b).

3. **Monitoring and Records.** The permittee must comply with monitoring requirements of 40 CFR 144.51(j) and the following conditions:
   a. Samples and measurements taken for the purpose of monitoring must be representative of the monitored activity.
   b. Records of monitoring information must include:
      i. The date, exact place, time and methods of sampling or measurements;
      ii. The name(s) of the individual(s) who performed the sampling or measurements;
      iii. The date(s) analyses were performed;
      iv. The name(s) of the individual(s) who performed the analyses;
      v. The analytical techniques or methods used;
      vi. The results of such analyses;
      vii. Calibration and maintenance records and all original strip chart recordings for continuous monitoring instruments, copies of all reports required by this permit, and records of all data used to complete the application for this permit for a period of at least 10 years from the date of the sample, measurement, report, or application. This period may be extended by request of DEQ at any time; and
      viii. The nature and composition of all injected fluids until three year as after completion of any plugging and abandonment procedures.
   c. DEQ may require the owner or operator to deliver the records to DEQ at the conclusion of the retention period.
   d. The permittee must allow DEQ, or an authorized representative, upon the presentation of credentials and other documents as may be required by law, to:

i. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;
ii. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and
iii. Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the Safe Drinking Water Act or state law, any substances or parameters at any location.

4. **Reporting and Signatory Requirements.** The permittee must comply with the reporting requirements of 40 CFR 144.51(j) and the following conditions:
   b. **Planned changes.** The permittee must give notice to DEQ as soon as possible of any planned physical alterations or additions to the permitted facility.
   c. **Anticipated noncompliance.** The permittee must give DEQ advance notice of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.
   d. **Transfers.** This permit is not transferrable to any person except after notice to DEQ and the conditions of OAR 340-045-0045 are met. The department may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary under the federal Safe Drinking Water Act (see 40 CFR 144.38; in some cases, modification or revocation and reissuance is mandatory).
   e. **Compliance Schedule.** The permittee must make compliance reports on all interim and final requirements contained in any compliance or implementation schedule included in this permit. The reports must be submitted no later than 30 days following each schedule date. The reports must explain the cause of any noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirements.
   f. **Twenty-four Hour and Five Day Reporting.** Unless a different compliance schedule and reporting requirements are otherwise noted in this permit, the permittee must report to DEQ any non-compliance which endangers human health or the environment in accordance with 40 CFR 144.51(1)(6), including:
      i. Any monitoring or other information which indicates that any contaminant may cause an endangerment of the naturally existing background groundwater quality; or any non-compliance with a permit condition or malfunction of the injection system which may cause fluid migration into groundwater; or a spill of any hazardous or toxic fluid which enters into an underground injection system.
      ii. Any indication of non-compliance which endangers health or the environment must be provided orally within 24 hours from the time the permittee becomes aware of the circumstances.
      iii. The permittee must submit a written report within 5 days of the time the permittee becomes aware of the circumstances of noncompliance referred to above. The written report must contain a description of the non-compliance and its cause, the period of the non-compliance, including exact dates and times, and if the non-compliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and/or prevent reoccurrence of the non-compliance.
   g. **Other Compliance.** Annual reports must include all other instances of non-compliance, as required in 40 CFR 144.51 l(2), l(5), l(6), and l(7).
   h. **Other Violations.** The permittee must report all instances of exceedance of permit limits in the monitoring report for the period covering the exceedance, and report all permit violations, or non-compliance with permit conditions which occurred during a permit established reporting period in the annual UIC system management plan report for that period. The reports must contain:
      i. A description of the violation or noncompliance and its cause;
      ii. The period of violation or noncompliance;
      iii. The estimated time the violation or noncompliance is expected to continue if it has not been

corrected; and

iv. Steps taken or planned to reduce, eliminate, and/or prevent reoccurrence of the violation or noncompliance.

i. **Signatory Requirements.** All applications, reports or information submitted to the department must be signed and certified expressly as provided in of 40 CFR §144.32.

5. **Definitions.** Unless context clearly indicates otherwise, the terms used in this permit have the meanings set out below, and in OAR 340-040-0010, OAR 340-044-0010, or 40 CFR 144.3. In the event of a conflict, the definitions in the permit control over the definitions in state rules or federal regulations.

a. ***Background groundwater quality*** means the quality of the water immediately upgradient from a current or potential source of pollution that is unaffected by the source. For the purpose of groundwater monitoring under a WPCF permit of an underground injection system well, the site-specific background water quality is the concentration of the pollutant of concern in the upgradient monitoring well, provided that the pollutant concentration is not caused by other UICs owned or operated by the permittee.

b. ***Best Management Practices (BMPs)*** means institutional, structural and non-structural controls designed to prevent or reduce the concentration of pollutants in stormwater before discharge to the subsurface. BMPs include, but are not limited to:

i. Schedules of activities, prohibitions of practices, maintenance procedures, education or other management practices to prevent or reduce pollution of waters of the state;

ii. Operational and structural source controls that minimize or prevent contaminants from entering stormwater; and

iii. Pre-treatment controls that remove contaminants contained in stormwater runoff before infiltration into natural subsurface soils.

c. ***CFR*** means Code of Federal Regulations.

d. ***Compliance Response*** means applying BMPs, seeking new opportunities for improving program effectiveness, controlling stormwater pollution, protecting beneficial uses, and, where applicable, addressing pollutant concentrations that exceed the concentration limits established in this permit.

e. ***Compliance Point(s) or Point of Compliance*** means the point or points where groundwater quality parameters must be at or below the permit-specified concentration limits or concentration limit variance.

f. ***Concentration Limit*** means the maximum acceptable concentration of a contaminant allowed in groundwater at the Department specified compliance point.

g. ***Concentration Limit Variance*** means a groundwater quality concentration limit which is granted by DEQ or the EQC, on a case-by-case basis, as an alternative to a permit-specific concentration limit established under OAR 340-040-0030(3).

h. ***Contaminant*** means any physical, chemical, biological, or radiological substance or matter in water.

i. ***De minimis*** means an amount that either by low volume or low contaminant concentration will not significantly affect groundwater quality in accordance with OAR 340-040-0020(3).

j. ***DEQ*** *means* the Department of Environmental Quality.

k. ***Discharge or Disposal*** means the placement of waste, including stormwater runoff, on land or otherwise

into the environment in a manner that does or tends to affect quality of public waters.

l. ***Domestic well*** means a water supply well used to serve no more than three residences for the purpose of supplying water for drinking, culinary, or household uses. Domestic wells include irrigation wells because irrigation wells can be used as drinking water supply wells without well modification or notification to the Oregon Water Resources Department, unless the Permittee has adopted an enforceable regulatory mechanism that prevents the use of irrigation wells for domestic or public drinking water supply purposes.

m. ***Dry Season*** means the calendar period from June 1 through September 30.

n. ***Drywell or Sump*** means an injection well, other than a subsurface distribution system, completed so that its bottom and sides are typically dry except when receiving fluids.

o. ***EPA*** means U.S. Environmental Protection Agency.

p. ***EQC*** means Environmental Quality Commission.

q. ***Groundwater*** means water below land surface in a zone of saturation, which may fluctuate seasonally and includes perched groundwater.

r. ***Grab sample*** means an individual discrete sample collected over a period of time not to exceed 15 minutes.

s. ***Industrial or Commercial Activities*** for the purpose of underground stormwater injection control means, but is not limited to:
   i. Manufacturing, processing, material handling, retail or wholesale business and those areas of an industrial facility or commercial property associated with such activities.
   ii. Material handling activities include the storage, loading and unloading, transport or conveyance of any raw material, intermediate product, final product or waste product including hazardous substances, toxic materials and petroleum products.

t. ***Injection*** means the emplacement or discharge of fluids into the subsurface.

u. ***Injection Point or Point of Injection or End- of-Pipe Discharge*** means the last accessible sampling point prior to waste fluids being released into the subsurface environment. For purposes of this permit, the point of injection is the end-of-pipe discharge into the injection well.

v. ***Injection System or Underground Injection System*** means a well, improved sinkhole, sewage drainhole, subsurface fluid distribution system or groundwater point source used for the subsurface emplacement or discharge of fluids.

w. ***Injection Well*** means a well into which fluids are being discharged for the purpose of subsurface emplacement.

x. ***Irrigation well*** (See Domestic Well).

y. ***Method Reporting Limit (MRL)*** means the analytical method reporting limit to which the laboratory can confidently quantify the detected analyte concentration. The MRL is above the laboratory method detection limit.

z. ***mg/L*** means milligrams per liter.

aa. ***ml/L*** means milliliters per liter.

bb. ***MS4*** means a municipal separate storm sewer system.

cc. ***Natural water quality*** means the water quality that would exist as a result of conditions unaffected by human-caused pollution.

dd. ***New Facility*** means a facility or activity authorized to operate under a Department approved permit for the first time after the effective date of OAR 340-040-0030. A new facility or activity includes changes in facility operations, disposal technique, or other alterations which justify new conditions to, and necessitate major modifications of, an existing permit.

ee. ***NO_3*** means nitrate as nitrogen.

ff. ***OAR*** means Oregon Administrative Rule.

gg. ***ORS*** means Oregon Revised Statute.

hh. ***Owner or Operator*** means any person or agency, municipality, organization, or corporation who alone, or jointly, or severally with others:
   i. Owns, leases, operates, controls or exercises significant control over the operation of a facility; Owns, leases, operates, controls or exercises significant control over the operation of a facility;
   ii. Has care, charge, or control of any real property as agent, executor, executrix, administrator, administratix, trustee, lessee or guardian of the estate of the holder of legal title; or
   iii. Is the contract purchaser of real property.

ii. ***Permit*** means the Wastewater Pollution Control Facility permit specified herein, authorizing the Permittee listed on Page 1 of this permit to discharge to UICs.

jj. ***Permit action*** means the issuance, modification, renewal or revocation by the Department of a permit.

kk. ***Permittee*** Under OAR 340-045-0010(12) means a person, which is defined as the United States and agencies thereof, any state, any individual, public or private corporation, political subdivision, government agency, municipality, industry, co-partnership, association, form, trust, estate, or any legal entity whatsoever.

ll. ***Pollutant*** (see Contaminant).

mm. ***Pollution or water pollution*** means such alteration of the physical, chemical or biological properties of any waters of the state, including change in temperature, taste, color, turbidity, silt or odor of the waters, or such discharge of any liquid, gaseous, solid radioactive or other substance into any waters of the state, which will or tends to, either by itself or in connection with any other substance, create a public nuisance or which will or tends to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational or other legitimate beneficial uses of livestock, wildlife, fish or other aquatic life or habitat thereof.

nn. ***Potable*** means water that meets standards for drinking water set by OAR Chapter 333, Division 61, Public Water Systems.

oo. ***Public water system*** means a system for the provision of piped water for human consumption, if such system has more than 3 service connections or supplies water to a public or commercial establishment which operates for a total of at least 60 days per year, and which is used by 10 or more individuals per day. Public water system also means a system for the provision to the public of water through

constructed conveyances other than pipes to at least 15 service connections or regularly serves at least 25 people per day for at least 60 days per year. A public water system is a "community water system", a "transient non-community water system", a "non-transient non-community water system" or a "state regulated water system".

pp. ***Public water system well or public water well*** means a water supply well serving a public water system.

qq. ***Sanitary Waste*** means liquid or solid wastes originating solely from humans and human activities, such as wastes collected from toilets, showers, wash basins, sinks used for cleaning domestic areas, sinks used for food preparation, clothes washing operations and sinks or washing machines where food and beverage serving dishes, glasses and utensils are cleaned.

rr. ***Seasonally high groundwater level*** means the highest level of the permanent groundwater table or perched groundwater may reach on a seasonal basis.

ss. ***Separation Distance*** means the distance in the unsaturated zone, confinement barrier or engineered filtration medium between the bottom of the UIC and groundwater, and prevents contaminants from reaching groundwater. Under no circumstance must a separation distance between groundwater and the bottom of the UIC be less than 5 feet, unless specifically authorized in writing by DEQ, that protects groundwater to primary drinking water regulations under the federal Safe Drinking Water Act (SDWA), or complies with the groundwater protection requirements specified in Oregon Administrative Rules (OAR) 340-40, including Concentration Limit Variances (CLVs) established as a permit condition under OAR 340-040-0030, or may protect human health.

tt. ***Storm Water (or Stormwater)*** means water from precipitation or snow melt that collects on or runs off outdoor surfaces such as roofs, buildings, roads, or paved and unpaved land surfaces.

uu. ***Subsurface Fluid Distribution System*** means an assemblage of perforated pipes, drain tiles or other mechanism intended to distribute fluids below the ground surface.

vv. ***Surface Infiltration*** means fluid movement from the ground surface into underlying soil material without the use of a Subsurface Fluid Distribution System or injection system.

ww. ***Time-of-Travel (TOT)*** means the amount of time it takes groundwater to flow within an aquifer to a given well.

xx. ***Underground Injection Control (UIC)*** means the Underground Injection Control program under part C of the federal Safe Drinking Water Act, including an "approved State program." It also means an underground injection system regulated under the underground injection control program.

yy. ***Underground Injection System*** (see Injection System).

zz. ***Underground Source of Drinking Water*** means an aquifer or groundwater source that supplies or potentially could supply drinking water for human consumption.

aaa. ***U.S.C.*** means United States Code.

bbb. ***Waste*** means sewage, industrial wastes, and all other liquid, gaseous, solid, radioactive or other substances which will or may cause pollution or tend to cause pollution of any waters of the state.

ccc. ***Water or waters of the state*** include lakes, bays, ponds, impounding reservoirs, springs, wells, rivers, streams, creeks, estuaries, marshes, inlets, canals, the Pacific Ocean within the territorial limits of the State of Oregon and all other bodies of surface or underground waters, natural or artificial, inland or

ddd. coastal, fresh or salt, public or private (except those private waters which do not combine or effect a junction with natural surface or underground waters), which are wholly or partially within or bordering the state or within its jurisdiction.

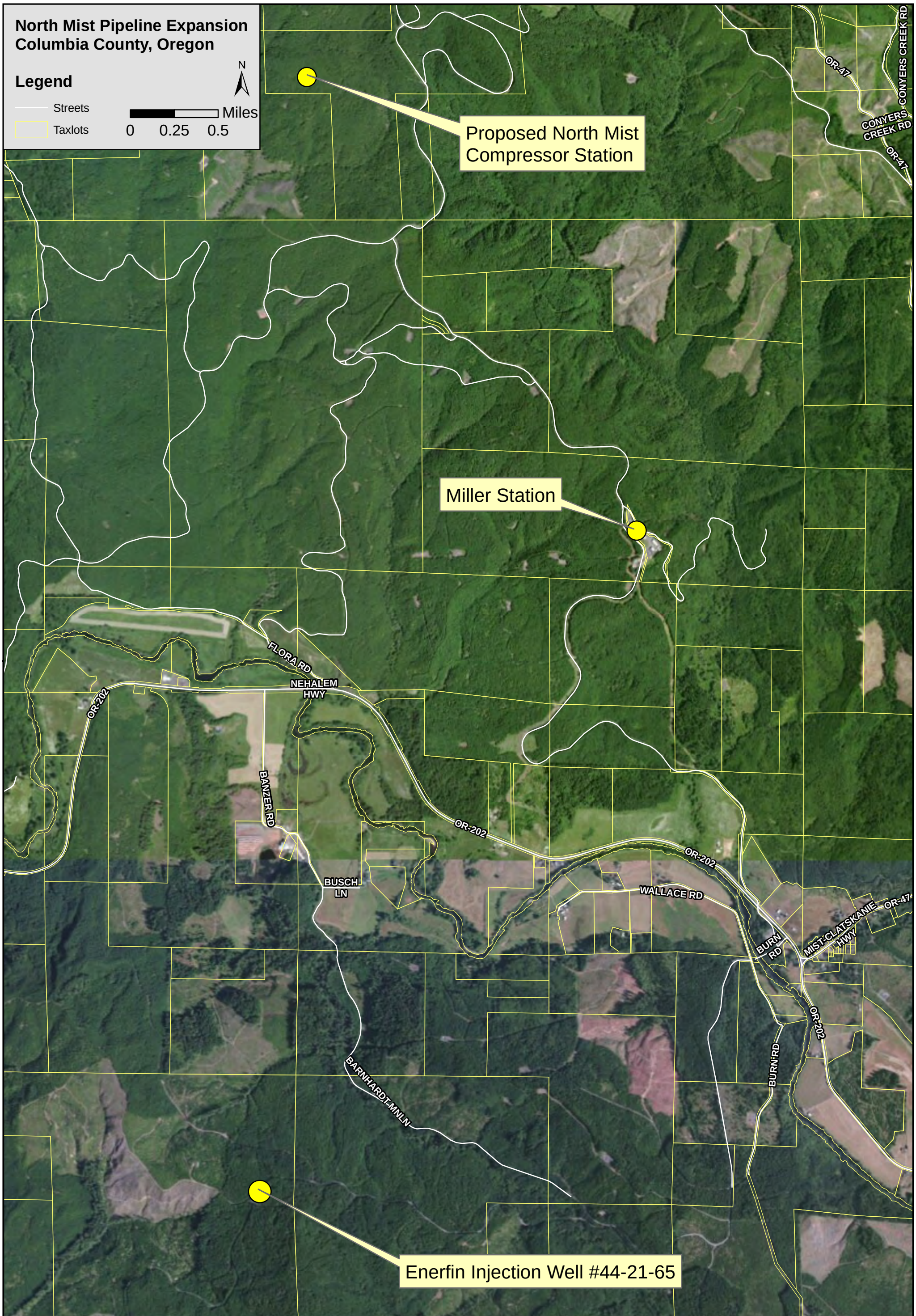
eee. ***Water Table*** means the upper surface of an unconfined water body, the surface of which is at atmospheric pressure and fluctuates seasonally. The water table is defined by the levels at which water stands in wells that penetrate the water body.

fff. ***Well*** means a bored, drilled, or driven shaft whose depth is greater than the largest dimension; or, a dug hole whose depth is greater than the largest surface dimension; or an improved sink hole; or a subsurface distribution system.

ggg. ***Wet season*** means the calendar period from October 1 through May 31.

hhh. ***WPCF*** means a Wastewater Pollution Control Facilities permit as defined in OAR 340-045 to construct and operate a disposal system with no discharge to navigable waters.

iii. ***Year*** means calendar year, except where otherwise defined in the permit.



Enerfin Injection Well #44-21-65
North Mist Pipeline Expansion Project
Columbia County, Oregon

NW Natural

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Plot Date: 4/16/2015 Created By: apb

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Oregon
Kate Brown, Governor

Department of Environmental Quality
Northwest Region
700 NE Multnomah Street, Suite 600
Portland, OR 97232
(503) 229-5263
FAX (503) 229-6957
TTY 711

June 30, 2015

Michael J. Hayward
Environmental Management & Sustainability Manager
NW Natural
220 NW Second Avenue
Portland, Oregon 97209

RE: Permit Modification No. 1, Enerfin Resources Northwest, Permit No. 101690

Dear Michael:

This letter acknowledges that the Department of Environmental Quality (DEQ) is in receipt of an application for modification of the Enerfin Resources Northwest Water Pollution Control Facilities (WPCF) permit (permit no. 101690). The application was received electronically on June 30, 2015. DEQ reviewed the permit application and concluded that the application is complete with the exception of fees that must be submitted for permit modification. DEQ may request additional information from the applicant at any time during the permit modification process.

Modification of Enerfin's WPCF permit will take approximately three months. DEQ plans to begin this process in November 2015, and complete the process in January 2016. Please note that this is a planning-level schedule, which may change based on the applicant's requests extensions, the volume of public comments that are received, and whether a public hearing is requested.

If you have any questions concerning the annual reporting, you may call me at (503) 229-6371 or email me at (kohlbecker.matt@deq.state.or.us).

Sincerely,

Matthew Kohlbecker, RG
UIC Hydrogeologist

ENERFIN RESOURCES

Houston · Tulsa · Bakersfield

May 5, 2015

Mr. Matt Kohlbecker
UIC Senior Hydrogeologist
DEQ Northwest Region
2020 SW 4th Avenue, STE 150
Portland, Oregon 97201

Subject: Major Permit Modification Request
Enerfin Resources Northwest,
Water Pollution Control Facilities Permit No. 101690

Dear Mr. Kohlbecker,

As you know, injection wells are regulated under the Safe Drinking Water Act by the U.S. Environmental Protection Agency (EPA). In Oregon, EPA has delegated the regulation of certain underground injection control (UIC) classes, including class II, to the Oregon Department of Environmental Quality (DEQ). Currently Enerfin Resources Northwest (Enerfin) owns and manages a Class II underground injection well at the Mist gas field (Mist, Oregon) under Water Pollution Control Facility *permit number 101690* issued by DEQ on November 8, 2011. This existing permit allows for salt water extracted from the Clark and Wilson Sandstone of the Cowlitz Formation to be re-injected into the same geologic formation at specified operating conditions.

NW Natural recently approached Enerfin requesting a permit modification that would allow for the re-injection of volumes of like-quality salt water produced from the Clark and Wilson Sandstone by NW Natural owned and operated wells.

NW Natural is the regional natural gas distributor for a large geographic area of western Oregon and southwestern Washington. NW Natural owns and operates several natural gas production and storage wells located within the Mist gas field. NW Natural is currently preparing an application for a State of Oregon Energy Siting Facility Council (EFSC) permit amendment to construct a natural gas storage facility with four new natural gas injection/withdrawal wells drilled into an existing production reservoir (*i.e.*, "Adams Reservoir"). Once constructed, natural gas would be injected into this naturally occurring reservoir via the newly installed wells and subsequently withdrawn to meet NW Natural customer demands.

49774 Road 426, Suite B, Oakhurst, CA 93644
(559) 683-3637

During the development and early withdrawal phases of NW Natural's facility, the new wells may produce limited volumes of salt water from the Adams Reservoir. The Adams Reservoir is geologically located within the Clark and Wilson Sandstone of the Cowlitz Formation, and encounters the same salt water aquifer that is in hydrogeologic continuity with the other natural gas reservoirs within the Mist gas field (including several permitted production and storage wells, and Enerfin's permitted salt water injection well). Once at the surface, this salt water will require disposal in an acceptable manner. Disposal options in this remote geographic location are limited due to the expected salinity, chloride, and total dissolved solids content of this ancestral salt water. The most practicable and responsible method for disposing of any produced saline water of like quality would be to re-inject the water into the original geological formation from which it was produced. At this time, Enerfin is the owner of the only permitted Class II injection well in this geographic area.

As such, Enerfin is proposing the following modifications to the existing permit:

1. Major Permit Modification - Modify permit language in Schedule A, section 4, from:

   "The permitted injection well must be used only for the injection of fluid produced in association with the Cowlitz Formation natural gas production in the Mist gas field, and produced only from wells that the permittee owns and operates."

   to:

   "The permitted injection well must be used only for the injection of fluid produced in association with the Cowlitz Formation natural gas production <u>or natural gas storage</u> in the Mist gas field and produced only from wells that <u>either</u> the permittee <u>or NW Natural</u> owns and operates."

Excluding the above language change, all other operational conditions would remain as originally specified.

Sincerely,

Peggy Morgan
Land Manager

cc: Gregory Geist, Oregon DEQ
Mike Hayward, NW Natural

49774 Road 426, Suite B, Oakhurst, CA 93644
(559) 683-3637

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ATTACHMENT E-4:

BEAVER GENERATING STATION NPDES PERMIT EXTENSION

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Portland General Electric Company
121 SW Salmon Street • Portland, Oregon 97204

April 3, 2015

ES-119-2015

Andrew Bauer
Environmental Specialist
NW Natural
220 NW Second Avenue
Portland, OR 97209

Dear Mr. Bauer:

Portland General Electric Company agrees to let NW Natural discharge hydrostatic testing water generated from the construction of natural gas transmission pipelines from the proposed Adams storage area to the Port Westward industrial area. In order for the hydrostatic testing water discharge to at the PGE Beaver Plant it must meet the following conditions:

1. A three month advance notification to the Beaver Plant Manager is required prior to discharge into the system. PGE will use this time to provide notification to DEQ of the non-routine discharge.
2. The location of the discharge point and the placement of any temporary piping or hoses will be approved by the Beaver plant manager.
3. Discharge flow rates and times will also have to be coordinated with Beaver plant personnel. The maximum discharge allowed will be 500,000 gallons/day.
4. There will be no chemicals added to the water (e.g. corrosion inhibitors, detergents, soaps and cleaners).
5. The characteristics for the water will be:
    a. A Total Suspended Solids (TSS) value of < 15 mg/l,
    b. pH between 6.5 and 8.5,
    c. Ambient or river temperature, and
    d. No visible oil sheen and oil and grease < 15 mg/l.

Please contact me at (503) 464-7109 if you require additional information about the proposed discharge requirements.

Sincerely,

Chip Bloomer

Chip Bloomer
Senior Project Specialist
Environmental Compliance & Licensing

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Expiration Date: November 30, 2012
Permit Number: 101209
File Number: 70805

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM WASTE DISCHARGE PERMIT

Northwest Region – Portland Office
2020 SW 4th Ave., Suite 400, Portland, OR 97201
Telephone: (503) 229-5263

Issued pursuant to ORS 468B.050 and The Federal Clean Water Act

ISSUED TO:

Portland General Electric
121 S.W. Salmon Street, 3WTCR05
Portland, OR 97204

SOURCES COVERED BY THIS PERMIT:

Outfall Number	Outfall Location
001	Columbia River RM 53

Type of Waste
Cooling water, demineralizer back-wash, neutralization tank effluent, oil/water separator effluent, and other miscellaneous waste streams.

FACILITY TYPE & LOCATION:

Beaver Generating Station
80997 Kallunki Road
Clatskanie, OR 97016

RECEIVING STREAM INFORMATION:

Basin: North Coast – Main Stem Columbia
Sub-Basin: Lower Columbia - Clatskanie

Receiving Stream: Columbia River
County: Columbia
LLID: 1228792423014-279840-D

Treatment System Class: *NA*
Collection System Class: *NA*

EPA REFERENCE NO: OR002743-0

Permit issued in response to Application No. 974648 received May 31, 2007.
This permit is issued based on the land use findings in the permit record.

Beth Moore

Beth Moore, Acting Manager, Water Quality Source Control
Northwest Region

12/27/07
Date

PERMITTED ACTIVITIES

Until this permit expires or is modified or revoked, the permittee is authorized to construct, install, modify, or operate a wastewater collection, treatment, control and disposal system and discharge to public waters adequately treated wastewaters only from the authorized discharge point or points established in Schedule A and only in conformance with all the requirements, limitations, and conditions set forth in the attached schedules as follows:

Page
Schedule A - Waste Discharge Limitations not to be Exceeded 3
Schedule B - Minimum Monitoring and Reporting Requirements 5
Schedule C - ***Not Applicable (No Compliance Conditions)***
Schedule D - Special Conditions 8
Schedule E – ***Not Applicable (Reserved for pretreatment at POTWs)***
Schedule F - General Conditions 9

Unless specifically authorized by this permit, by another NPDES or WPCF permit, or by Oregon Administrative Rule, any other direct or indirect discharge of waste is prohibited, including discharge to waters of the state or an underground injection control system.

SCHEDULE A

1. **Waste Discharge Limitations [Not to be exceeded after permit issuance].**

a. Outfall 001: Wastewater Discharged to the Columbia River.

PARAMETER	MONTHLY AVERAGE	DAILY MAXIMUM
Total Suspended Solids	15 mg/L	30 mg/L
Oil & Grease	10 mg/L	15 mg/L
Excess Thermal Load[1]	1.60 MW	3.95 MW

pH	Must not be outside the range of 6.0 – 9.0
Flow	Must not exceed 1.44 mgd

[1]The daily maximum excess thermal load was calculated using the design flow of 1.44 mgd and a maximum daily temperature of 95 °F (35 °C). The monthly average excess thermal load was calculated using a discharge flow of 0.72 mgd and a maximum monthly average temperature of 90 °F (32 °C). Upon approval of a Total Maximum Daily Load (TMDL) for temperature for this portion of the Columbia River, this permit may be re-opened and new temperature and/or thermal load limits assigned.

b. Outfall 101 (Internal Monitoring Point): Cooling Tower blow-down prior to mixing with other waste streams.

PARAMETER	MONTHLY AVERAGE	DAILY MAXIMUM
Free Available Chlorine[2]	0.2 mg/L	0.5 mg/L

[2]Chlorine must not be discharged for more than two hours on any day. Further, there must be no discharge of cooling tower blow-down during chlorination.

c. Outfall 201 (Internal Monitoring Point): Outfall 201 was established to monitor discharges from the six Heat Recovery Steam Generators (HRSGs). HRSG discharges are 100% boiler blow-down, which is defined as a ***low volume waste source***, per 40 CFR 423.11 (b). Beginning with this Renewal Permit, Outfall 201 discharges will be limited and monitored at Outfall 301 (Pond B).

d. Outfall 301 (Internal Monitoring Point): The Outfall 301 discharge is monitored at Pond B. This discharge is a collection of ***low volume waste sources***[3]. Discharge limits listed under 40 CFR 423.12 (b) (3) apply.

PARAMETER	MONTHLY AVERAGE	DAILY MAXIMUM
Total Suspended Solids	30 mg/L	100 mg/L
Oil & Grease	15 mg/L	20 mg/L

[3]***Low volume waste sources*** are collectively considered to be one source, per 40 CFR 423.11 (b); i.e. all waste water from sources not covered by specific limitations otherwise established in this part. Low volume waste sources include, but are not limited to waste water from:

- Wet scrubber air pollution control system,
- Ion exchange water treatment system,
- Water treatment evaporator blow-down,
- Laboratory and sampling streams,
- Boiler blow-down,
- Floor drains,
- Cooling tower basin cleaning wastes, and
- Re-circulating house service water systems.

Sanitary and air conditioning wastes are not included.

e. Outfall 401 (Internal Monitoring Point): Storm water discharge from the tank farm oil-water separator prior to mixing with other waste streams.

PARAMETER	MONTHLY AVERAGE	DAILY MAXIMUM
Total Suspended Solids	30 mg/L	100 mg/L
Oil & Grease	15 mg/L	20 mg/L

2. **Corrosion Inhibitors**. Zinc and chromates must not be used as corrosion inhibitors, except in closed systems.

3. **No PCB Discharge**. There must be no discharge of polychlorinated biphenyl compounds such as those used for transformer fluid.

4. **Mixing Zone**. Except as provided for in Oregon Administrative Rule (OAR) 340-045-0080, no wastes may be discharged and no activities may be conducted that violate Water Quality Standards as adopted in OAR 340-041-0104, except in the defined mixing zone:

   The allowable mixing zone (MZ) is that portion of the Columbia River within 200 feet of the point of discharge. The zone of immediate dilution (ZID) is defined as that portion of the Columbia River within 20 feet of the discharge point.

SCHEDULE B

1. **Minimum Monitoring and Reporting Requirements** (unless otherwise approved in writing by the Department).

The permittee must monitor the parameters as specified below at the locations indicated. The laboratory used by the permittee to analyze samples shall have a quality assurance/quality control (QA/QC) program to verify the accuracy of sample analysis. If QA/QC requirements are not met for any analysis, the results must be included in the report, but not used in calculations required by this permit. When possible, the permittee shall re-sample in a timely manner for parameters failing the QA/QC requirements, analyze the samples, and report the results.

a. Outfall 001: Wastewater Discharge to the Columbia River

ITEM OR PARAMETER	MINIMUM FREQUENCY[1]	TYPE OF SAMPLE
Flow	Continuous	Recording
Temperature	Continuous	Recording
Total Suspended Solids	1/Week	Grab
Oil & Grease	1/Week	Grab
pH	1/Week	Grab
Daily Maximum Temperature	1/Day	Reading
Daily Average Temperature	1/Day	Calculation
Daily Maximum Excess Thermal Load[2]	1/Day	Calculation
Monthly Average Excess Thermal Load[2]	1/Month	Calculation

[1]When discharging.

[2]Calculation of excess thermal loads

- Daily maximum temperature reading and daily average temperature calculation must be recorded on a daily basis.
- The daily maximum excess thermal load must be calculated using the daily maximum temperature and the corresponding flow rate when the maximum temperature was recorded.
- The monthly average excess thermal load must be calculated using the average of the daily average temperatures and the average of the daily average flows during the month.
- If the calculation results in a thermal load value less than zero, the results must be recorded as zero.

Daily maximum and monthly average excess thermal loads must be calculated using the formula below:

$$\mathbf{H = \rho\, C_p\, Q\, (\Delta T)} \left(1000\ \mathrm{L/m^3}\right) \left\{1\mathrm{W/1J/s}\right\} (1\ \mathrm{MW/10^6\ W}) = \mathrm{MW}$$

Where:
H = Excess thermal load {Megawatts (MW)}
ρ = Density of water (1.0 kg/L)
C_p = Specific heat of water (4182 Joules/kg-°C)
Q = Discharge flow (meters^3/sec)
ΔT = Daily maximum effluent temperature or average of daily average temperature (°C) minus criterion (20 °C) for calculation of daily maximum or monthly average excess thermal load, respectively.

b. Outfall 101 (Internal Monitoring Point): Cooling Tower blow-down prior to mixing with other waste streams.

ITEM OR PARAMETER	MINIMUM FREQUENCY	TYPE OF SAMPLE
Flow	Daily During Blow-down	Estimate
Free Available Chlorine	Prior to Initiating Blow-down After Chlorination	Grab

c. Outfall 201 (Internal Monitoring Point): Heat Recovery Steam Generator (HRSG) blow-down is combined with other ***low volume waste sources*** at Outfall 301 (see below).

d. Outfall 301 (Internal Monitoring Point): ***Low volume waste sources***.

ITEM OR PARAMETER	MINIMUM FREQUENCY[1]	TYPE OF SAMPLE
Oil & Grease	2/Month	Grab
TSS	2/Month	Grab

[1]When discharging.

e. Outfall 401 (Internal Monitoring Point): Storm water discharge from the tank farm oil-water separator prior to mixing with other waste streams.

ITEM OR PARAMETER	MINIMUM FREQUENCY[1]	TYPE OF SAMPLE
Oil & Grease	2/Month	Grab
TSS	2/Month	Grab

[1]When discharging.

2. **Reporting Requirements**

a. Reporting Monitoring Results. Monitoring results must be reported on approved forms. Since daily monitoring is required for some pollutants, the permittee must submit a spread sheet that contains the necessary data in addition to the USEPA discharge monitoring form. Reports must be submitted to the Department's Northwest Region - Portland Office by the 15th day of the following month.

b. Reporting of Non-detect Sample Results. For all pollutants, if a value is less than the permit limit and less than the minimum quantitative level (MQL), the permittee must report Non-Detect (ND) and detection level in mg/L for the parameter. For example, if the MQL for a pollutant is 10 µg/L and the value of the analytical result is below the MQL, the permittee must report ND (0.010 mg/L) on the Discharge Monitoring Report. For compliance purposes, one-half of the MQL may be used as the value for analytical results below the MQL.

c. Supervision. State monitoring reports must include the name and signature of the person assigned by the permittee to ensure compliance with the collection, testing, discharge, and reporting requirements listed in Schedules A and B of this permit.

d. Monitoring Records Prepared in Ink. All bench sheets, laboratory analysis sheets, and other records to support the data reported on the Discharge Monitoring Report (DMR) must be prepared in ink. Pencil entries or *liquid paper* corrections shall be prohibited by appropriate laboratory operating procedures. Changes to any supporting records that may be required to correct the original data must be made by lining through the original data. The date of the change and the initials of the individual making the change must be recorded in ink adjacent to the change.

SCHEDULE C
COMPLIANCE CONDITIONS AND SCHEDULES
(NOT APPLICABLE)

SCHEDULE D
SPECIAL CONDITIONS

1. **Re-Opening of Permit**. This permit may be reopened for the inclusion of additional limitations, monitoring requirements, or both. Upon completion of a Total Maximum Load (TMDL) for the Lower Columbia River, and the assignment of a Waste Load Allocation (WLA) to the permittee, the WLA shall be incorporated into this permit, or a subsequent permit renewal.

2. **Continue Effluent Temperature Reduction**. The permittee's effluent Temperature Management Plan and Alternatives Analysis (TMP/AA) document for the Beaver Plant was approved by the Department on October 14, 2003. Permittee must continue its current program for temperature management/reduction, as outlined in the TMP/AA.

3. **Solids Management**. Filter back-wash solids, sludge, dirt, sand, silt, or other pollutants separated from or resulting from the treatment of intake or supply water must not be discharged to surface waters without first receiving adequate treatment for removal of pollutants. Solids must be treated in accordance with the Solids Management Plan submitted to the Department. No substantial changes must be made to the Solids Management Plan without prior written approval from the Department.

4. **Storm Water Management**. Storm water discharge from areas where chemicals and oils are transferred and stored will be discharged in accordance with the limitations and monitoring requirements established in schedules A and B of this permit.

   Storm water from the tank farm is directed to the tank farm oil-water separator during normal storm events. During intense storm events, storm water from the tank farm may be directed directly to the holding ponds. When storm water from the tank farm is discharged directly to the holding ponds, the permittee must visually inspect the holding ponds to determine if there is oil sheen. If there is oil sheen, the permitted must take appropriate action to prevent the discharge of waste water containing oil sheen.

5. **Contingency Plan and Employee Education**. An adequate contingency plan for handling spills and unplanned discharges must be in place at all times. An employee education program must also be in place. A continuing program of employee orientation and education must be maintained to ensure that employees are aware of the need for good in-plant controls and quick and proper action in the event of a spill or an accident.

6. **Designated Personnel**. Properly qualified personnel must be designated to carry out the operation and maintenance of the waste collection, treatment, and disposal systems.

7. **Notification of Malfunctions**. The permittee shall notify the DEQ Northwest Region - Portland Office **[telephone: (503) 229-5263]** in accordance with the response times noted in the General Conditions of this permit (Schedule F), of any malfunction so that corrective action can be coordinated between the permittee and the Department.

SCHEDULE E
PRETREATMENT
(NOT APPLICABLE)

SCHEDULE F
NPDES GENERAL CONDITIONS – INDUSTRIAL FACILITIES

SECTION A. STANDARD CONDITIONS

1. Duty to Comply with Permit
The permittee must comply with all conditions of this permit. Failure to comply with any permit condition is a violation of the Clean Water Act, Oregon Revised Statutes (ORS) 468B.025, and 40 Code of Federal Regulations (CFR) Section 122.41(a), and grounds for an enforcement action. Failure to comply is also grounds for the Department to modify, revoke, or deny renewal of a permit.

2. Penalties for Water Pollution and Permit Condition Violations
ORS 468.140 allows the Department to impose civil penalties up to $10,000 per day for violation of a term, condition, or requirement of a permit. Additionally 40 CFR 122.41 (A) provides that any person who violates any permit condition, term, or requirement may be subject to a federal civil penalty not to exceed $25,000 per day for each violation.

   Under ORS 468.943 and 40 CFR 122.41(a), unlawful water pollution, if committed by a person with criminal negligence, is punishable by a fine of up to $25,000 imprisonment for not more than one year, or both. Each day on which a violation occurs or continues is a separately punishable offense.

   Under ORS 468.946, a person who knowingly discharges, places, or causes to be placed any waste into the waters of the state or in a location where the waste is likely to escape into the waters of the state is subject to a Class B felony punishable by a fine not to exceed $200,000 and up to 10 years in prison. Additionally, under 40 CFR 122.41(a) any person who knowingly discharges, places, or causes to be placed any waste into the waters of the state or in a location where the waste is likely to escape into the waters of the state is subject to a federal civil penalty not to exceed $100,000, and up to 6 years in prison.

3. Duty to Mitigate
The permittee must take all reasonable steps to minimize or prevent any discharge or sludge use or disposal in violation of this permit that has a reasonable likelihood of adversely affecting human health or the environment. In addition, upon request of the Department, the permittee must correct any adverse impact on the environment or human health resulting from noncompliance with this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

4. Duty to Reapply
If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must apply for and have the permit renewed. The application must be submitted at least 180 days before the expiration date of this permit.

   The Department may grant permission to submit an application less than 180 days in advance but no later than the permit expiration date.

5. Permit Actions

   This permit may be modified, revoked and reissued, or terminated for cause including, but not limited to, the following:

   a. Violation of any term, condition, or requirement of this permit, a rule, or a statute
   b. Obtaining this permit by misrepresentation or failure to disclose fully all material facts
   c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge
   d. The permittee is identified as a Designated Management Agency or allocated a wasteload under a Total Maximum Daily Load (TMDL)
   e. New information or regulations
   f. Modification of compliance schedules
   g. Requirements of permit reopener conditions

h. Correction of technical mistakes made in determining permit conditions
i. Determination that the permitted activity endangers human health or the environment
j. Other causes as specified in 40 CFR 122.62, 122.64, and 124.5

The filing of a request by the permittee for a permit modification, revocation or reissuance, termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

6. Toxic Pollutants
The permittee must comply with any applicable effluent standards or prohibitions established under Oregon Administrative Rules (OAR) 340-041-0033 for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

7. Property Rights and Other Legal Requirements
The issuance of this permit does not convey any property rights of any sort, or any exclusive privilege, or authorize any injury to persons or property or invasion of any other private rights, or any infringement of federal, tribal, state, or local laws or regulations.

8. Permit References
Except for effluent standards or prohibitions established under Section 307(a) of the Clean Water Act and OAR 340-041-0033for toxic pollutants, all rules and statutes referred to in this permit are those in effect on the date this permit is issued.

9. Permit Fees
The permittee must pay the fees required by Oregon Administrative Rules.

SECTION B. OPERATION AND MAINTENANCE OF POLLUTION CONTROLS

1. Proper Operation and Maintenance
The permittee must at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) that are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems that are installed by a permittee only when the operation is necessary to achieve compliance with the conditions of the permit.

2. Need to Halt or Reduce Activity Not a Defense
For industrial or commercial facilities, upon reduction, loss, or failure of the treatment facility, the permittee must, to the extent necessary to maintain compliance with its permit, control production or all discharges or both until the facility is restored or an alternative method of treatment is provided. This requirement applies, for example, when the primary source of power of the treatment facility fails or is reduced or lost. It is not a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

3. Bypass of Treatment Facilities

a. Definitions
(1) "Bypass" means intentional diversion of waste streams from any portion of the treatment facility. The term "bypass" does not apply if the diversion does not cause effluent limitations to be exceeded, provided the diversion is to allow essential maintenance to assure efficient operation or the diversion is due to nonuse of nonessential treatment units or processes at the treatment facility.
(2) "Severe property damage" means substantial physical damage to property, damage to the treatment facilities or treatment processes that causes them to become inoperable, or substantial and permanent loss of natural resources that can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

b. Prohibition of bypass.
(1) Bypass is prohibited unless:
(a) Bypass was necessary to prevent loss of life, personal injury, or severe property damage;
(b) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate backup equipment should have been

installed in the exercise of reasonable engineering judgment to prevent a bypass that occurred during normal periods of equipment downtime or preventative maintenance; and

(c) The permittee submitted notices and requests as required under General Condition B.3.c.

(2) The Department may approve an anticipated bypass, after considering its adverse effects and any alternatives to bypassing, when the Department determines that it will meet the three conditions listed above in General Condition B.3.b.(1).

c. Notice and request for bypass.

(1) Anticipated bypass. If the permittee knows in advance of the need for a bypass, a written notice must be submitted to the Department at least ten days before the date of the bypass.

(2) Unanticipated bypass. The permittee must submit notice of an unanticipated bypass as required in General Condition D.5.

4. Upset

a. Definition. "Upset" means an exceptional incident in which there is unintentional and temporary noncompliance with technology based permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operation error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventative maintenance, or careless or improper operation.

b. Effect of an upset. An upset constitutes an affirmative defense to an action brought for noncompliance with such technology-based permit effluent limitations if the requirements of General Condition B.4.c are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

c. Conditions necessary for a demonstration of upset. A permittee who wishes to establish the affirmative defense of upset must demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

(1) An upset occurred and that the permittee can identify the causes(s) of the upset;

(2) The permitted facility was at the time being properly operated;

(3) The permittee submitted notice of the upset as required in General Condition D.5, hereof (24-hour notice); and

(4) The permittee complied with any remedial measures required under General Condition A.3 hereof.

d. Burden of proof. In any enforcement proceeding the permittee seeking to establish the occurrence of an upset has the burden of proof.

5. Treatment of Single Operational Upset

For purposes of this permit, A Single Operational Upset that leads to simultaneous violations of more than one pollutant parameter will be treated as a single violation. A single operational upset is an exceptional incident that causes simultaneous, unintentional, unknowing (not the result of a knowing act or omission), temporary noncompliance with more than one Clean Water Act effluent discharge pollutant parameter. A single operational upset does not include Clean Water Act violations involving discharge without a NPDES permit or noncompliance to the extent caused by improperly designed or inadequate treatment facilities. Each day of a single operational upset is a violation.

6. Overflows from Wastewater Conveyance Systems

a. Definitions

(1) "Overflow" means the diversion and discharge of waste streams from any portion of the wastewater conveyance system through a designed overflow device or structure, other than discharges to the wastewater treatment facility.

(2) "Severe property damage" means substantial physical damage to property, damage to the conveyance system which causes it to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of an overflow.

(3) "Uncontrolled overflow" means the diversion of waste streams other than through a designed overflow device or structure.

b. Prohibition of overflows. Overflows are prohibited unless:

(1) Overflows were unavoidable to prevent an uncontrolled overflow, loss of life, personal injury, or severe property damage;

(2) There were no feasible alternatives to the overflows, such as the use of auxiliary conveyance systems, or maximization of conveyance system storage; and

(3) The overflows are the result of an upset as defined in General Condition B.4. and meeting all requirements of this condition.

c. Uncontrolled overflows are prohibited where wastewater is likely to escape or be carried into the waters of the State by any means.

d. Reporting required. Unless otherwise specified in writing by the Department, all overflows and uncontrolled overflows must be reported orally to the Department within 24 hours from the time the permittee becomes aware of the overflow. Reporting procedures are described in more detail in General Condition D.5.

7. Public Notification of Effluent Violation or Overflow
If effluent limitations specified in this permit are exceeded or an overflow occurs, upon request by the Department, the permittee must take such steps as are necessary to alert the public about the extent and nature of the discharge. Such steps may include, but are not limited to, posting of the river at access points and other places, news releases, and paid announcements on radio and television.

8. Removed Substances
Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters must be disposed of in such a manner as to prevent any pollutant from such materials from entering waters of the state, causing nuisance conditions, or creating a public health hazard.

SECTION C. MONITORING AND RECORDS

1. Representative Sampling
Sampling and measurements taken as required herein must be representative of the volume and nature of the monitored discharge. All samples must be taken at the monitoring points specified in this permit, and shall be taken, unless otherwise specified, before the effluent joins or is diluted by any other waste stream, body of water, or substance. Monitoring points may not be changed without notification to and the approval from the Department.

2. Flow Measurements
Appropriate flow measurement devices and methods consistent with accepted scientific practices must be selected and used to ensure the accuracy and reliability of measurements of the volume of monitored discharges. The devices must be installed, calibrated and maintained to insure that the accuracy of the measurements is consistent with the accepted capability of that type of device. Devices selected must be capable of measuring flows with a maximum deviation of less than ± 10 percent from true discharge rates throughout the range of expected discharge volumes.

3. Monitoring Procedures
Monitoring must be conducted according to test procedures approved under 40 CFR part 136, unless other test procedures have been specified in this permit.

4. Penalties of Tampering
The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit may, upon conviction, be punished by a fine of not more than $10,000 per violation, imprisonment for not more than two years, or both. If a conviction of a person is for a violation committed after a first conviction of such person, punishment is a fine not more than $20,000 per day of violation, or by imprisonment of not more than four years, or both.

5. Reporting of Monitoring Results

Monitoring results must be summarized each month on a Discharge Monitoring Report form approved by the Department. The reports must be submitted monthly and are to be mailed, delivered or otherwise transmitted by the 15th day of the following month unless specifically approved otherwise in Schedule B of this permit.

6. Additional Monitoring by the Permittee
If the permittee monitors any pollutant more frequently than required by this permit, using test procedures approved under 40 part CFR 136 or as specified in this permit, the results of this monitoring must be included in the calculation and reporting of the data submitted in the Discharge Monitoring Report. Such increased frequency must also be indicated. For a pollutant parameter that may be sampled more than once per day (e.g., Total Chlorine Residual), only the average daily value must be recorded unless otherwise specified in this permit.

7. Averaging of Measurements
Calculations for all limitations that require averaging of measurements must utilize an arithmetic mean, except for bacteria which shall be averaged as specified in this permit.

8. Retention of Records
The permittee must retain records of all monitoring information, including: all calibration, maintenance records, all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit for a period of at least 3 years from the date of the sample, measurement, report, or application. This period may be extended by request of the Department at any time.

9. Records Contents
Records of monitoring information must include:

a. The date, exact place, time, and methods of sampling or measurements;
b. The individual(s) who performed the sampling or measurements;
c. The date(s) analyses were performed;
d. The individual(s) who performed the analyses;
e. The analytical techniques or methods used; and
f. The results of such analyses.

10. Inspection and Entry
The permittee must allow the Department or an authorized representative upon the presentation of credentials to:

a. Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;
b. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;
c. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit, and
d. Sample or monitor at reasonable times, for the purpose of assuring permit compliance or as otherwise authorized by state law, any substances or parameters at any location.

SECTION D. REPORTING REQUIREMENTS

1. Planned Changes
The permittee must comply with OAR chapter 340, division 52, "Review of Plans and Specifications" and 40 CFR Section 122.41(l) (1). Except where exempted under OAR chapter 340, division 52, no construction, installation, or modification involving disposal systems, treatment works, sewerage systems, or common sewers may be commenced until the plans and specifications are submitted to and approved by the Department. The permittee must give notice to the Department as soon as possible of any planned physical alternations or additions to the permitted facility.

2. Anticipated Noncompliance
The permittee must give advance notice to the Department of any planned changes in the permitted facility or activity that may result in noncompliance with permit requirements.

3. Transfers
This permit may be transferred to a new permittee provided the transferee acquires a property interest in the permitted activity and agrees in writing to fully comply with all the terms and conditions of the permit and the rules of the Commission. No permit may be transferred to a third party without prior written approval from the Department. The Department may require modification, revocation, and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary under the Clean Water Act (see 40 CFR Section 122.61; in some cases, modification or revocation and reissuance is mandatory). The permittee must notify the Department when a transfer of property interest takes place.

4. Compliance Schedule
Reports of compliance or noncompliance with, or any progress reports on interim and final requirements contained in any compliance schedule of this permit must be submitted no later than 14 days following each schedule date. Any reports of noncompliance must include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirements.

5. Twenty-Four Hour Reporting
The permittee must report any noncompliance that may endanger health or the environment. Any information must be provided orally (by telephone) within 24 hours, unless otherwise specified in this permit, from the time the permittee becomes aware of the circumstances. During normal

business hours, the Department's Regional office must be called. Outside of normal business hours, the Department must be contacted at 1-800-452-0311 (Oregon Emergency Response System).

A written submission must also be provided within 5 days of the time the permittee becomes aware of the circumstances. Pursuant to ORS 468.959 (3) (a), if the permittee is establishing an affirmative defense of upset or bypass to any offense under ORS 468.922 to 468.946, delivered written notice must be made to the Department or other agency with regulatory jurisdiction within 4 (four) calendar days of the time the permittee becomes aware of the circumstances. The written submission must contain:

a. A description of the noncompliance and its cause;
b. The period of noncompliance, including exact dates and times;
c. The estimated time noncompliance is expected to continue if it has not been corrected;
d. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance; and
e. Public notification steps taken, pursuant to General Condition B.6

The following must be included as information that must be reported within 24 hours under this paragraph:

f. Any unanticipated bypass that exceeds any effluent limitation in this permit;
g. Any upset that exceeds any effluent limitation in this permit;
h. Violation of maximum daily discharge limitation for any of the pollutants listed by the Department in this permit; and
i. Any noncompliance that may endanger human health or the environment.

The Department may waive the written report on a case-by-case basis if the oral report has been received within 24 hours.

6. Other Noncompliance
The permittee must report all instances of noncompliance not reported under General Condition D.4 or D.5, at the time monitoring reports are submitted. The reports must contain:

a. A description of the noncompliance and its cause;
b. The period of noncompliance, including exact dates and times;
c. The estimated time noncompliance is expected to continue if it has not been corrected; and
d. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

7. Duty to Provide Information
The permittee must furnish to the Department within a reasonable time any information that the Department may request to determine compliance with this permit. The permittee must also furnish to the Department, upon request, copies of records required to be kept by this permit.

Other Information: When the permittee becomes aware that it has failed to submit any relevant facts or has submitted incorrect information in a permit application or any report to the Department, it must promptly submit such facts or information.

8. Signatory Requirements
All applications, reports or information submitted to the Department must be signed and certified in accordance with 40 CFR Section 122.22.

9. Falsification of Information
Under ORS 468.953, any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance, is subject to a Class C felony punishable by a fine not to exceed $100,000 per violation and up to 5 years in prison. Additionally, according to *40 CFR 122.41(k)(2)*, any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit including monitoring reports or reports of compliance or non-compliance shall, upon conviction, be punished by a federal civil penalty not to exceed $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

10. Changes to Discharges of Toxic Pollutant
The permittee must notify the Department as soon as it knows or have reason to believe of the following:

a. That any activity has occurred or will occur that would result in the discharge, on a routine or frequent basis, of any toxic pollutant that is not limited in the permit, if that discharge will exceed the highest of the following "notification levels:
   (1) One hundred micrograms per liter (100 □g/l);

(2) Two hundred micrograms per liter (200 □g/l) for acrolein and acrylonitrile; five hundred micrograms per liter (500 □g/l) for 2,4-dinitrophenol and for 2-methyl-4,6-dinitrophenol; and one milligram per liter (1 mg/l) for antimony;
(3) Five (5) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR Section 122.21(g)(7); or
(4) The level established by the Department in accordance with 40 CFR Section 122.44(f).

b. That any activity has occurred or will occur that would result in any discharge, on a non-routine or infrequent basis, of a toxic pollutant that is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":
(1) Five hundred micrograms per liter (500 □g/l);
(2) One milligram per liter (1 mg/l) for antimony;
(3) Ten (10) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR Section 122.21(g)(7); or
(4) The level established by the Department in accordance with 40 CFR Section 122.44(f).

SECTION E. DEFINITIONS

1. BOD means five-day biochemical oxygen demand.
2. TSS means total suspended solids.
3. "Bacteria" includes but is not limited to fecal coliform bacteria, total coliform bacteria, and E. coli bacteria.
4. FC means fecal coliform bacteria.
5. Total residual chlorine means combined chlorine forms plus free residual chlorine
6. Technology based permit effluent limitations means technology-based treatment requirements as defined in 40 CFR Section 125.3, and concentration and mass load effluent limitations that are based on minimum design criteria specified in OAR Chapter 340, Division 41.
7. mg/l means milligrams per liter.
8. kg means kilograms.
9. m^3/d means cubic meters per day.
10. MGD means million gallons per day.
11. 24-hour Composite sample means a combination of at least six discrete sample aliquots of at least 100 milliliters, collected at periodic intervals from the same location, during the operating hours of the facility over a 24 hour period. Four (rather than six) aliquots should be collected for volatile organics analyses. The composite must be flow or time proportional, whichever is more appropriate. The sample aliquots must be collected and stored in accordance with procedures prescribed in the most recent edition of Standard Methods for the Examination of Water and Wastewater.
12. Grab sample means an individual discrete sample collected over a period of time not to exceed 15 minutes.
13. Quarter means January through March, April through June, July through September, or October through December.
14. Month means calendar month.
15. Week means a calendar week of Sunday through Saturday.

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Portland General Electric Company
121 SW Salmon Street • Portland, Oregon 97204

May 21, 2012
ES-091-2012
GOV REL 9-1
Beaver NPDES

DEQ NWR Office
2020 SW 4th Ave, Suite 400
Portland, Oregon 97201
Attn: Annie Hill

Subject: Beaver Plant NPDES Permit Renewal

Dear Ms. Hill:

Enclosed is Portland General Electric's (PGE's) Beaver Plant NPDES permit renewal application (Permit # 101209, File # 70905). The current permit expires on 11/30/2012. This application includes the Beaver Generating Plant NPDES permit renewal summary, a water flow diagram for the Beaver Plant, EPA Form 2C, and the requested "environmental map" of the associated mixing zone.

If you have questions or need additional information, please contact Chip Bloomer at 503-464-7109 (chip.bloomer@pgn.com).

Sincerely,

Arya Behbehani, Manager
Environmental Services

Enclosures:
Beaver Generating Plant NPDES Renewal Summary
DEQ Form NPDES-R
Water Flow Diagram
EPA Form 2C
Environmental Map

cc: Bill Monroe

BEAVER GENERATING PLANT
NPDES RENEWAL SUMMARY 2012
NPDES PERMIT 101209
DEQ File # 70805

Facility Description

The Beaver Generating Plant is located on the northernmost border of Oregon, near the town of Clatskanie. The facility consists of six turbine generators (fueled either by natural gas or diesel oil), and complementary steam turbine generators (powered by exhaust steam from the turbine generators). In addition, there is a 24 MW natural gas fired turbine used to provide the plant with peaking power. The 520 MW generation facility is primarily a peak load power plant, operating intermittently whenever power generation is economically viable. When not in operation, the gas turbines are maintained in a standby mode, capable of being brought on line within 20 minutes.

The plant utilizes a holding pond system with approximately one million gallons capacity, into which cooling water and de-mineralized backwash are discharged. When necessary the ponds are used for cooling, neutralization, and retention time.

Neutralization tank effluent and oil-water separator effluent from the plant are discharged into the Columbia River through Outfall 001. A mixing zone study for the outfall, equipped with a submerged diffuser, was prepared in 1999 and submitted to DEQ.

The plant has three internal monitoring points:
Internal Outfall 101 – Cooling Tower Blowdown Prior to Mixing With Other Streams
Internal Outfall 301 – Low Volume Waste Sources Prior To Mixing With Other Streams
Internal Outfall 401 – Oily Water Separators Prior To Mixing With Other Streams

Requested Permit Changes

There are no requested changes to the permit at this time.

Changes Since Existing Permit Was Issued

Facility

PGE is in the process of evaluating the replacement of Beaver's existing raw water clarifier with a 4,500 MGD capacity clarifier that will also supply the Port Westward facility with demineralized, potable, and cooling tower makeup water. When installed, the discharge from the clarifier (estimated 120 GPM) will be treated as a low volume waste source. The discharge point will either be at outfall 301 or a new internal outfall will be established.

Stormwater

The facility's Standard Industrial Classification (SIC) code is specifically listed in the federal requirements for multi-sector general permitting (MSGP). DEQ has revised the NPDES General Permit Nos. 1200-Z to meet the MSGP requirements. It was determined during the 2002 and 2007 permit renewal process that a separate Stormwater permit is not required for this facility. There continues to be no requirement for a separate permit as there is no exposure at this site for industrial materials and activities aside from those areas which already discharge in accordance with the permit. Industrial materials or activities involving materials handling equipment and activities, raw materials, intermediate product and waste disposal are in storm resistant shelters or are incorporated into the current wastewater conveyance system for monitoring and treatment prior to discharge through outfall 001.

Discharge Monitoring Report Summary and Compliance history

This section provides a summary of the compliance history of the facility during this permit period. A detailed review of each permit condition is available upon request.

Since NPDES permit renewal in 2007, the Beaver facility has not received a Notice of Noncompliance (NON).

Schedule A - Waste Discharge Limitations

All waste water discharge to the Columbia River through Outfall 001 was within the limitations established in the permit.

All monitoring of waste water at internal Outfalls 101 and 301 demonstrated discharges that were within the limitations established by the permit.

Monitoring at internal Outfall 401 demonstrated discharges within permit limits for total suspended solids, except for one sample. In July of 2009 analyses indicated that the discharge to internal Outfall 401 exceeded the monthly average limit. The permit limit for the average TSS concentration is 30 mg/l and the reported value was 48.5 mg/l. The reported value was high due to a 90 mg/l concentration for sample taken on July 21st. The cause of these exceedences was either analytical error or caused by filter maintenance. To prevent reoccurrence PGE refurbished the oily water separator and increased the frequency of inspections and maintenance. There have been no exceedences since these changes were implemented.

Schedule B - Minimum Monitoring and Reporting

The plant met all of the Schedule B compliance conditions and schedules.

Schedule C – Compliance Condition and Schedules

The plant met all of the Schedule C compliance conditions and schedules.

Schedule D – Special Conditions

The plant met all of the Schedule D special conditions

Schedule F – NPDES General Conditions

The plant met all of the Schedule F general conditions

DEQ USE ONLY
Application #:
File #:
Mail ID #2/#9:
LLID/RM:
ACD Fee Paid:
DOC Conf.:
Notes:

RENEWAL APPLICATION NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT (NPDES-R)

Oregon Department of Environmental Quality

DEQ USE ONLY
Received:
Amount Received:
Check #:
Deposit #:
☐ IND ☐ DOM ☐ UIC:
Notes:

A. REFERENCE INFORMATION

1. Legal Name: Portland General Electric	2. Common Name: Beaver Generating Station
3. Permit #: 101209 DEQ Site ID#: 70805 Permit Expiration Date: 11/30/2012	4. Facility Physical Address: 80997 Kallunki Road City, State, Zip Code: Clatskanie, Oregon 97016 County: Columbia
5. Responsible Official: Arya Behbehani Mailing Address: 121 SW Salmon Street, 3WTCBR05	Telephone #: 503-464-8141 City, State, Zip Code: Portland, Oregon 97204
6. Facility Contact: Bill Monroe Facility Mailing Address: 80997 Kallunki Road	Telephone #: 503-728-7424 City, State, Zip Code: Clatskanie, OR 97016
7. Invoice to: Arya Behbehani Billing Address: 121 SW Salmon St., 3WTCBR05	Telephone #: 503-464-8141 City, State, Zip Code: Portland, Oregon 97204

B. REQUIRED INFORMATION

(EPA Form 2A, 2B, 2C, 2E, or 2F must also be submitted with this application)

1. Briefly describe the permitted facility, type of wastewater, and primary method of wastewater treatment and disposal:
   See attached Beaver Generating Plant NPDES Renewal Summary and water flow diagram.

2. Have the treatment or disposal methods employed, as indicated in previous applications, been altered in any way since the last application was submitted? ☐ YES ☒ NO If "YES," explain:

3. Has the quantity or quality of wastes discharged, as indicated in previous applications, been significantly changed in any way since the last application was submitted? ☐ YES ☒ NO If "YES," explain:

4. If there are any changes anticipated in the near future that would affect waste quantity or quality, attach an explanation or proposal.
5. Review each condition of your current permit and attach a brief report that indicates your progress in meeting the requirements, limitations, and compliance schedules of the permit.
6. If the permitted facility or operation is a domestic wastewater treatment plant, attach a copy of your Biosolids Management Plan.

C. SIGNATURE OF LEGALLY AUTHORIZED REPRESENTATIVE

I hereby certify that the information contained in this application is true and correct to the best of my knowledge and belief. In addition, I agree to pay all permit fees required by Oregon Administrative Rules 340-45. This includes a renewal application fee to renew the permit and a compliance determination fee invoiced annually by DEQ to maintain the permit.

Arya Behbehani	PGE Environmental Services Manager
Name of Legally Authorized Representative (Type or Print)	**Title**
Arya Behbehani	5/23/12
Signature of Legally Authorized Representative	**Date**

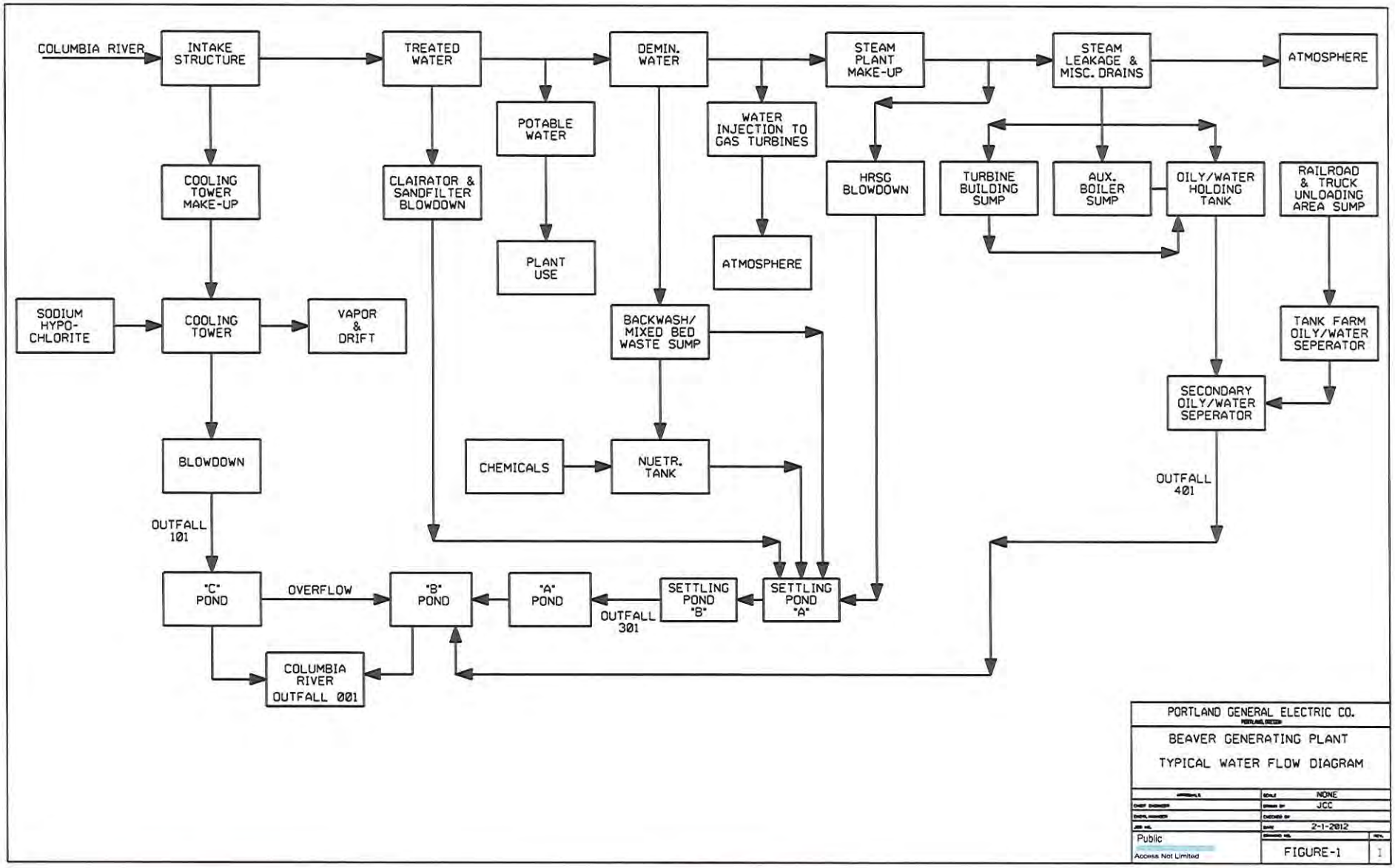


FIGURE-1.dgn 05/21/2012 3:24:29 PM

Please print or type in the unshaded areas only.

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)
OR002743-0

Form Approved.
OMB No. 2040-0086.
Approval expires 3-31-98.

FORM **2C** NPDES

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY
APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER
EXISTING MANUFACTURING, COMMERCIAL, MINING AND SILVICULTURE OPERATIONS
Consolidated Permits Program

I. OUTFALL LOCATION

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. OUTFALL NUMBER (*list*)	B. LATITUDE			C. LONGITUDE			D. RECEIVING WATER (*name*)
	1. DEG.	2. MIN.	3. SEC.	1. DEG.	2. MIN.	3. SEC.	
001	46	10	52	123	11	02	Columbia River

II. FLOWS, SOURCES OF POLLUTION, AND TREATMENT TECHNOLOGIES

A. Attach a line drawing showing the water flow through the facility. Indicate sources of intake water, operations contributing wastewater to the effluent, and treatment units labeled to correspond to the more detailed descriptions in Item B. Construct a water balance on the line drawing by showing average flows between intakes, operations, treatment units, and outfalls. If a water balance cannot be determined (*e.g., for certain mining activities*), provide a pictorial description of the nature and amount of any sources of water and any collection or treatment measures. Drawing Attached

B. For each outfall, provide a description of: (1) All operations contributing wastewater to the effluent, including process wastewater, sanitary wastewater, cooling water, and storm water runoff; (2) The average flow contributed by each operation; and (3) The treatment received by the wastewater. Continue on additional sheets if necessary.

1. OUTFALL NO. (*list*)	2. OPERATION(S) CONTRIBUTING FLOW		3. TREATMENT		
	a. OPERATION (*list*)	b. AVERAGE FLOW (*include units*)	a. DESCRIPTION	b. LIST CODES FROM TABLE 2C-1	
001	Cooling Water	600,000 GPD	Holding Ponds, Settling Ponds	1-U	S-P
	Demineralizer Backwash		Sludge is Land Applied	4-A	2-K
	Neutralizing Tank Water		Neutralization	2-F	1-F
	Stormwater runoff		oil/water Seperation		

OFFICIAL USE ONLY (*effluent guidelines sub-categories*)

CONTINUED FROM THE FRONT

C. Except for storm runoff, leaks, or spills, are any of the discharges described in Items II-A or B intermittent or seasonal?

☑ YES (*complete the following table*) ☐ NO (*go to Section III*)

1. OUTFALL NUMBER (*list*)	2. OPERATION(s) CONTRIBUTING FLOW (*list*)	3. FREQUENCY		4. FLOW				
		a. DAYS PER WEEK (*specify average*)	b. MONTHS PER YEAR (*specify average*)	a. FLOW RATE (*in mgd*)		B. TOTAL VOLUME (*specify with units*)		C. DURATION (*in days*)
				1. LONG TERM AVERAGE	2. MAXIMUM DAILY	1. LONG TERM AVERAGE	2. MAXIMUM DAILY	
001	Drainage from condenser during maintenance or shutdown. *Drainage may occur for approximately one or two days per year depending upon maintenance or shutdown requiremnts. Drainage is approximately 400,000 gallons.	*	*	*	*	*	*	*

III. PRODUCTION

A. Does an effluent guideline limitation promulgated by EPA under Section 304 of the Clean Water Act apply to your facility?

☑ YES (*complete Item III-B*) ☐ NO (*go to Section IV*)

B. Are the limitations in the applicable effluent guideline expressed in terms of production (*or other measure of operation*)?

☐ YES (*complete Item III-C*) ☑ NO (*go to Section IV*)

C. If you answered "yes" to item III-B, list the quantity which represents an actual measurement of your level of production, expressed in the terms and units used in the applicable effluent guideline, and indicate the affected outfalls.

1. AVERAGE DAILY PRODUCTION			2. AFFECTED OUTFALLS (*list outfall numbers*)
a. QUANTITY PER DAY	b. UNITS OF MEASURE	c. OPERATION, PRODUCT, MATERIAL, ETC. (*specify*)	

IV. IMPROVEMENTS

A. Are you now required by any Federal, State or local authority to meet any implementation schedule for the construction, upgrading or operations of wastewater treatment equipment or practices or any other environmental programs which may affect the discharges described in this application? This includes, but is not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant or loan conditions.

☐ YES (*complete the following table*) ☑ NO (*go to Item IV-B*)

1. IDENTIFICATION OF CONDITION, AGREEMENT, ETC.	2. AFFECTED OUTFALLS		3. BRIEF DESCRIPTION OF PROJECT	4. FINAL COMPLIANCE DATE	
	a. NO.	b. SOURCE OF DISCHARGE		a. REQUIRED	b. PROJECTED

B. OPTIONAL: You may attach additional sheets describing any additional water pollution control programs (*or other environmental projects which may affect your discharges*) you now have underway or which you plan. Indicate whether each program is now underway or planned, and indicate your actual or planned schedules for construction.

☐ MARK "X" IF DESCRIPTION OF ADDITIONAL CONTROL PROGRAMS IS ATTACHED

 CONTINUE ON PAGE 3

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)

OR002743-0

CONTINUED FROM PAGE 2

V. INTAKE AND EFFLUENT CHARACTERISTICS

A, B, & C: See instructions before proceeding – Complete one set of tables for each outfall – Annotate the outfall number in the space provided.
NOTE: Tables V-A, V-B, and V-C are included on separate sheets numbered V-1 through V-9.

D. Use the space below to list any of the pollutants listed in Table 2c-3 of the instructions, which you know or have reason to believe is discharged or may be discharged from any outfall. For every pollutant you list, briefly describe the reasons you believe it to be present and report any analytical data in your possession.

1. POLLUTANT	2. SOURCE	1. POLLUTANT	2. SOURCE

VI. POTENTIAL DISCHARGES NOT COVERED BY ANALYSIS

Is any pollutant listed in Item V-C a substance or a component of a substance which you currently use or manufacture as an intermediate or final product or byproduct?

☐ YES (*list all such pollutants below*) ☑ NO (*go to Item VI-B*)

 CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

VII. BIOLOGICAL TOXICITY TESTING DATA

Do you have any knowledge or reason to believe that any biological test for acute or chronic toxicity has been made on any of your discharges or on a receiving water in relation to your discharge within the last 3 years?

☐ YES (*identify the test(s) and describe their purposes below*) ☑ NO (*go to Section VIII*)

VIII. CONTRACT ANALYSIS INFORMATION

Were any of the analyses reported in Item V performed by a contract laboratory or consulting firm?

☑ YES (*list the name, address, and telephone number of, and pollutants analyzed by, each such laboratory or firm below*) ☐ NO (*go to Section IX*)

A. NAME	B. ADDRESS	C. TELEPHONE (*area code & no.*)	D. POLLUTANTS ANALYZED (*list*)
Columbia Analytical Services	1317 South 13th Avenue P.O. Box 479 Kelso, Washington 98626	(360) 577-7222	Copper Total Suspended Solids Oil & Grease Iron Analysis for Pollutants listed on Table V-B

IX. CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. NAME & OFFICIAL TITLE (*type or print*)	B. PHONE NO. (*area code & no.*)
Arya Behbehani, Manager - Environmental Services	(503) 464-8141
C. SIGNATURE	D. DATE SIGNED

PLEASE PRINT OR TYPE IN THE UNSHADED AREAS ONLY. You may report some or all of this information on separate sheets (*use the same format*) instead of completing these pages.
SEE INSTRUCTIONS.

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)
OR002743-0

V. INTAKE AND EFFLUENT CHARACTERISTICS *(continued from page 3 of Form 2-C)*

OUTFALL NO. 001

PART A –You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

1. POLLUTANT	2. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (*if available*) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (*if available*) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	3. UNITS (*specify if blank*) a. CONCEN-TRATION	b. MASS	4. INTAKE (*optional*) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
a. Biochemical Oxygen Demand (*BOD*)	0.5						1	mg/L				
b. Chemical Oxygen Demand (*COD*)	<2.5						2	mg/L				
c. Total Organic Carbon (*TOC*)	1.1						2	mg/L				
d. Total Suspended Solids (*TSS*)	13						204	mg/L				
e. Ammonia (*as N*)	<0.005						1	mg/L				
f. Flow	VALUE 0.06		VALUE 0.02		VALUE 0.01		35	m3/S		VALUE		
g. Temperature (*winter*)	VALUE 25		VALUE 19		VALUE 15		12	°C		VALUE		
h. Temperature (*summer*)	VALUE 34		VALUE 29		VALUE 25		12	°C		VALUE		
i. pH	MINIMUM 7.08	MAXIMUM 8.98	MINIMUM	MAXIMUM			52	STANDARD UNITS				

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1. POLLUTANT AND CAS NO. (*if available*)	2. MARK "X" a. BELIEVED PRESENT	b. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (*if available*) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (*if available*) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCEN-TRATION	b. MASS	5. INTAKE (*optional*) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
a. Bromide (24959-67-9)		X												
b. Chlorine, Total Residual		X	<0.06						209	mg/L				
c. Color		X												
d. Fecal Coliform		X												
e. Fluoride (16984-48-8)		X												
f. Nitrate-Nitrite (*as N*)		X												

CONTINUE ON REVERSE

ITEM V-B CONTINUED FROM FRONT

1. POLLUTANT AND CAS NO. (*if available*)	2. MARK "X"		3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. BELIEVED PRESENT	b. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
			(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
g. Nitrogen, Total Organic (*as N*)		X												
h. Oil and Grease	X		8.7						208	mg/L				
i. Phosphorus (as P), Total (7723-14-0)		X												
j. Radioactivity														
(1) Alpha, Total		X												
(2) Beta, Total		X												
(3) Radium, Total		X												
(4) Radium 226, Total		X												
k. Sulfate (*as SO_4*) (14808-79-8)	X		48.2						1	mg/L				
l. Sulfide (*as S*)		X												
m. Sulfite (*as SO_3*) (14265-45-3)		X												
n. Surfactants		X												
o. Aluminum, Total (7429-90-5)		X												
p. Barium, Total (7440-39-3)		X												
q. Boron, Total (7440-42-8)		X												
r. Cobalt, Total (7440-48-4)		X												
s. Iron, Total (7439-89-6)	X		262						1	ug/L				
t. Magnesium, Total (7439-95-4)		X												
u. Molybdenum, Total (7439-98-7)		X												
v. Manganese, Total (7439-96-5)		X												
w. Tin, Total (7440-31-5)		X												
x. Titanium, Total (7440-32-6)		X												

CONTINUE ON PAGE V-3

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	OUTFALL NUMBER
OR002743-0	001

CONTINUED FROM PAGE 3 OF FORM 2-C

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (*secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions*), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (*all 7 pages*) for each outfall. See instructions for additional details and requirements.

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X	<30						1	ug/L				
2M. Arsenic, Total (7440-38-2)			X	<30						1	ug/L				
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)			X	<3.0						1	ug/L				
5M. Chromium, Total (7440-47-3)			X	<2.0						1	ug/L				
6M. Copper, Total (7440-50-8)		X		<2.0						1	ug/L				
7M. Lead, Total (7439-92-1)			X	<30						1	ug/L				
8M. Mercury, Total (7439-97-6)			X	<0.02						1	ug/L				
9M. Nickel, Total (7440-02-0)			X	<20						1	ug/L				
10M. Selenium, Total (7782-49-2)			X	<30						1	ug/L				
11M. Silver, Total (7440-22-4)			X	<3.0						1	ug/L				
12M. Thallium, Total (7440-28-0)			X	<50						1	ug/L				
13M. Zinc, Total (7440-66-6)		X		34.4						1	ug/L				
14M. Cyanide, Total (57-12-5)			X	10						1	ug/L				
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetra-chlorodibenzo-P-Dioxin (1764-01-6)			X	DESCRIBE RESULTS											

CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X	<0.14						1	ug/L				
4V. Bis (*Chloro-methyl*) Ether (542-88-1)			X												
5V. Bromoform (75-25-2)			X	<0.28						1	ug/L				
6V. Carbon Tetrachloride (56-23-5)			X	<0.14						1	ug/L				
7V. Chlorobenzene (108-90-7)			X	<0.14						1	ug/L				
8V. Chlorodi-bromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X	<0.23						1	ug/L				
10V. 2-Chloro-ethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichloro-bromomethane (75-27-4)			X												
13V. Dichloro-difluoromethane (75-71-8)			X												
14V. 1,1-Dichloro-ethane (75-34-3)			X	<0.11						1	ug/L				
15V. 1,2-Dichloro-ethane (107-06-2)			X	<0.12						1	ug/L				
16V. 1,1-Dichloro-ethylene (75-35-4)			X												
17V. 1,2-Dichloro-propane (78-87-5)			X												
18V. 1,3-Dichloro-propylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X	<0.13						1	ug/L				
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X	<0.20						1	ug/L				

 CONTINUE ON PAGE V-5

CONTINUED FROM PAGE V-4

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – VOLATILE COMPOUNDS (*continued*)															
22V. Methylene Chloride (75-09-2)			X	<0.20						1	ug/L				
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X	<0.14						1	ug/L				
24V. Tetrachloro-ethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X	<0.11						1	ug/L				
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloro-ethane (71-55-6)			X	<0.12						1	ug/L				
28V. 1,1,2-Trichloro-ethane (79-00-5)			X	<0.14						1	ug/L				
29V Trichloro-ethylene (79-01-6)			X												
30V. Trichloro-fluoromethane (75-69-4)			X	<0.14						1	ug/L				
31V. Vinyl Chloride (75-01-4)			X	<0.042						1	ug/L				
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X	<0.32						1	ug/L				
2A. 2,4-Dichloro-phenol (120-83-2)			X	<0.30						1	ug/L				
3A. 2,4-Dimethyl-phenol (105-67-9)			X												
4A. 4,6-Dinitro-O-Cresol (534-52-1)			X												
5A. 2,4-Dinitro-phenol (51-28-5)			X	<2.3						1	ug/L				
6A. 2-Nitrophenol (88-75-5)			X	<0.38						1	ug/L				
7A. 4-Nitrophenol (100-02-7)			X	<2.0						1	ug/L				
8A. P-Chloro-M-Cresol (59-50-7)			X												
9A. Pentachloro-phenol (87-86-5)			X												
10A. Phenol (108-95-2)			X	<0.33						1	ug/L				
11A. 2,4,6-Trichloro-phenol (88-05-2)			X	<0.21						1	ug/L				

CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – BASE/NEUTRAL COMPOUNDS															
1B. Acenaphthene (83-32-9)			X	<0.29						1	ug/L				
2B. Acenaphtylene (208-96-8)			X	<0.24						1	ug/L				
3B. Anthracene (120-12-7)			X	<0.62						1	ug/L				
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X	<0.60						1	ug/L				
6B. Benzo (*a*) Pyrene (50-32-8)			X	<0.66						1	ug/L				
7B. 3,4-Benzo-fluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X	<0.83						1	ug/L				
10B. Bis (*2-Chloro-ethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloro-ethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												
13B. Bis (*2-Ethyl-hexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X	<0.28						1	ug/L				
15B. Butyl Benzyl Phthalate (85-68-7)			X	<0.47						1	ug/L				
16B. 2-Chloro-naphthalene (91-58-7)			X	<0.29						1	ug/L				
17B. 4-Chloro-phenyl Phenyl Ether (7005-72-3)			X	<0.28						1	ug/L				
18B. Chrysene (218-01-9)			X	<0.79						1	ug/L				
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichloro-benzene (95-50-1)			X	<0.44						1	ug/L				
21B. 1,3-Di-chloro-benzene (541-73-1)			X	<0.36						1	ug/L				

CONTINUE ON PAGE V-7

CONTINUED FROM PAGE V-6

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – BASE/NEUTRAL COMPOUNDS (*continued*)															
22B. 1,4-Dichloro-benzene (106-46-7)			X												
23B. 3,3-Dichloro-benzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131-11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitro-toluene (121-14-2)			X												
28B. 2,6-Dinitro-toluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B. 1,2-Diphenyl-hydrazine (*as Azo-benzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachloro-benzene (118-74-1)			X												
34B. Hexachloro-butadiene (87-68-3)			X	<0.30						1	ug/L				
35B. Hexachloro-cyclopentadiene (77-47-4)			X												
36B Hexachloro-ethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												
39B. Naphthalene (91-20-3)			X	<0.37						1	ug/L				
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitro-sodimethylamine (62-75-9)			X												
42B. N-Nitrosodi-N-Propylamine (621-64-7)			X												

CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

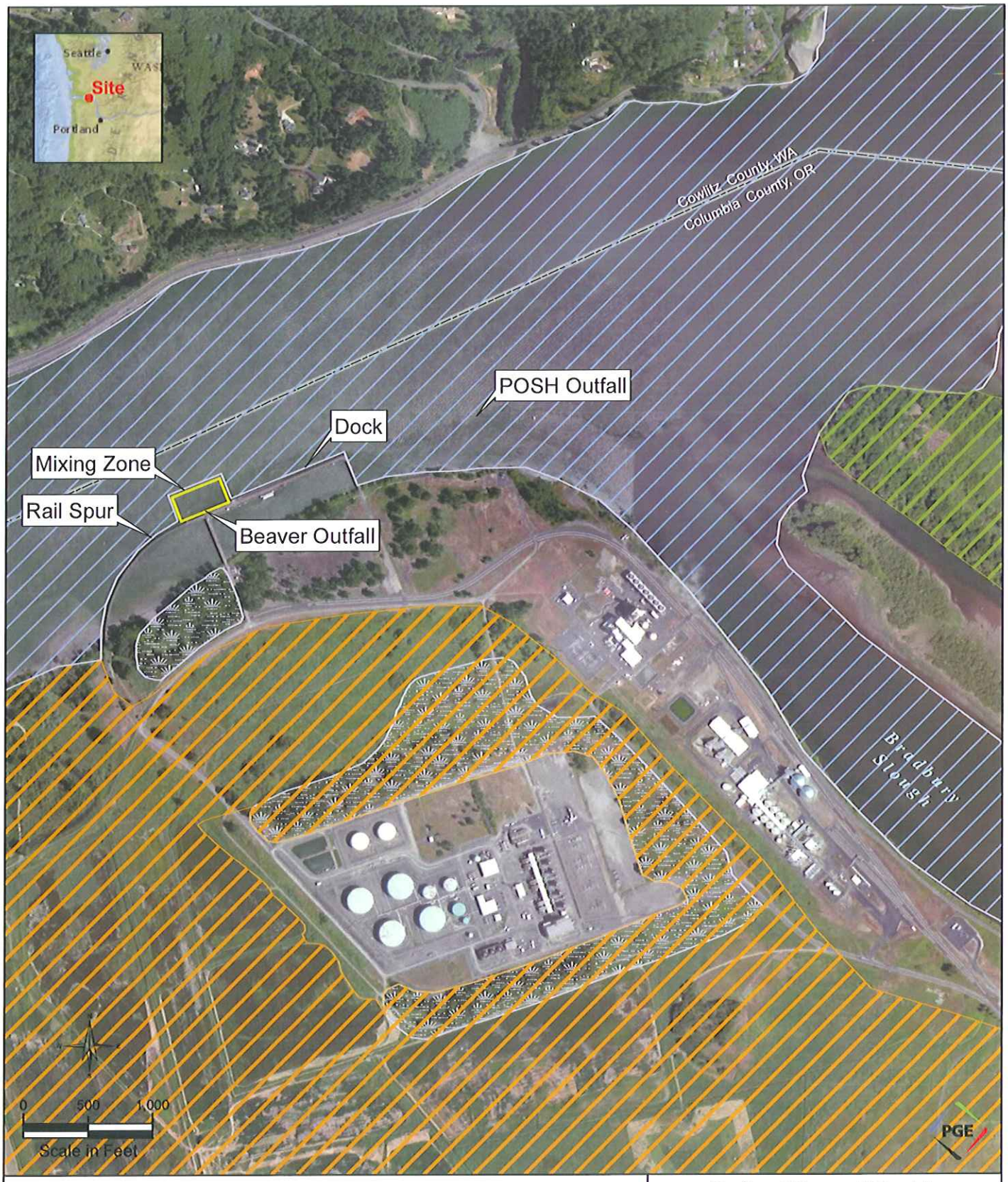
1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – BASE/NEUTRAL COMPOUNDS (*continued*)															
43B. N-Nitro-sodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X	<0.49						1	ug/L				
45B. Pyrene (129-00-0)			X	<0.74						1	ug/L				
46B. 1,2,4-Tri-chlorobenzene (120-82-1)			X	<0.36						1	ug/L				
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												

CONTINUE ON PAGE V-9

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	OUTFALL NUMBER
OR002743-0	001

CONTINUED FROM PAGE V-8

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – PESTICIDES (*continued*)															
17P. Heptachlor Epoxide (1024-57-3)			X												
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												



Map Features

- Bald Eagle Nesting Grounds
- Salmon/Trout Rearing and Migration
- Columbia White-Tailed Deer Habitat
- Wetlands

Portland General Electric
Portland, Oregon

Figure x

Beaver - Port Westward Generation Facilities

J:\Port_Westward\Maps\PW_Beaver_A.mxd

North Mist Pipeline Expansion
Columbia County, Oregon

Legend

Taxlot

NPDES Discharge Point

Proposed Hydrostatic Test Wastewater Discharge Point

8N4W1600 100

8N4W1500 100

Kallunki Rd

8N4W1500 200

8N4W1600 200

8N4W1500 500

8N4W1500 600

8N4W1600 400

8N4W1600 300

Portland & Western RR

8N4W2100 100 POYSKY GEORGE J & KAREN

Plot Date: 4/14/2015 Created By: apb

Beaver Generating Station Wastewater Discharge Points
North Mist Pipeline Expansion Project
Columbia County, Oregon

Feet
0 250 500

N

NW Natural

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DO NOT DUPLICATE or DISTRIBUTE
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Portland General Electric Company
121 SW Salmon Street • Portland, Oregon 97204

May 21, 2012
ES-091-2012
GOV REL 9-1
Beaver NPDES

DEQ NWR Office
2020 SW 4th Ave, Suite 400
Portland, Oregon 97201
Attn: Annie Hill

Subject: Beaver Plant NPDES Permit Renewal

Dear Ms. Hill:

Enclosed is Portland General Electric's (PGE's) Beaver Plant NPDES permit renewal application (Permit # 101209, File # 70905). The current permit expires on 11/30/2012. This application includes the Beaver Generating Plant NPDES permit renewal summary, a water flow diagram for the Beaver Plant, EPA Form 2C, and the requested "environmental map" of the associated mixing zone.

If you have questions or need additional information, please contact Chip Bloomer at 503-464-7109 (chip.bloomer@pgn.com).

Sincerely,

Arya Behbehani, Manager
Environmental Services

Enclosures:
Beaver Generating Plant NPDES Renewal Summary
DEQ Form NPDES-R
Water Flow Diagram
EPA Form 2C
Environmental Map

cc: Bill Monroe

BEAVER GENERATING PLANT
NPDES RENEWAL SUMMARY 2012
NPDES PERMIT 101209
DEQ File # 70805

Facility Description

The Beaver Generating Plant is located on the northernmost border of Oregon, near the town of Clatskanie. The facility consists of six turbine generators (fueled either by natural gas or diesel oil), and complementary steam turbine generators (powered by exhaust steam from the turbine generators). In addition, there is a 24 MW natural gas fired turbine used to provide the plant with peaking power. The 520 MW generation facility is primarily a peak load power plant, operating intermittently whenever power generation is economically viable. When not in operation, the gas turbines are maintained in a standby mode, capable of being brought on line within 20 minutes.

The plant utilizes a holding pond system with approximately one million gallons capacity, into which cooling water and de-mineralized backwash are discharged. When necessary the ponds are used for cooling, neutralization, and retention time.

Neutralization tank effluent and oil-water separator effluent from the plant are discharged into the Columbia River through Outfall 001. A mixing zone study for the outfall, equipped with a submerged diffuser, was prepared in 1999 and submitted to DEQ.

The plant has three internal monitoring points:
Internal Outfall 101 – Cooling Tower Blowdown Prior to Mixing With Other Streams
Internal Outfall 301 – Low Volume Waste Sources Prior To Mixing With Other Streams
Internal Outfall 401 – Oily Water Separators Prior To Mixing With Other Streams

Requested Permit Changes

There are no requested changes to the permit at this time.

Changes Since Existing Permit Was Issued

Facility

PGE is in the process of evaluating the replacement of Beaver's existing raw water clarifier with a 4,500 MGD capacity clarifier that will also supply the Port Westward facility with demineralized, potable, and cooling tower makeup water. When installed, the discharge from the clarifier (estimated 120 GPM) will be treated as a low volume waste source. The discharge point will either be at outfall 301 or a new internal outfall will be established.

Stormwater

The facility's Standard Industrial Classification (SIC) code is specifically listed in the federal requirements for multi-sector general permitting (MSGP). DEQ has revised the NPDES General Permit Nos. 1200-Z to meet the MSGP requirements. It was determined during the 2002 and 2007 permit renewal process that a separate Stormwater permit is not required for this facility. There continues to be no requirement for a separate permit as there is no exposure at this site for industrial materials and activities aside from those areas which already discharge in accordance with the permit. Industrial materials or activities involving materials handling equipment and activities, raw materials, intermediate product and waste disposal are in storm resistant shelters or are incorporated into the current wastewater conveyance system for monitoring and treatment prior to discharge through outfall 001.

Discharge Monitoring Report Summary and Compliance history

This section provides a summary of the compliance history of the facility during this permit period. A detailed review of each permit condition is available upon request.

Since NPDES permit renewal in 2007, the Beaver facility has not received a Notice of Noncompliance (NON).

Schedule A - Waste Discharge Limitations

All waste water discharge to the Columbia River through Outfall 001 was within the limitations established in the permit.

All monitoring of waste water at internal Outfalls 101 and 301 demonstrated discharges that were within the limitations established by the permit.

Monitoring at internal Outfall 401 demonstrated discharges within permit limits for total suspended solids, except for one sample. In July of 2009 analyses indicated that the discharge to internal Outfall 401 exceeded the monthly average limit. The permit limit for the average TSS concentration is 30 mg/l and the reported value was 48.5 mg/l. The reported value was high due to a 90 mg/l concentration for sample taken on July 21st. The cause of these exceedences was either analytical error or caused by filter maintenance. To prevent reoccurrence PGE refurbished the oily water separator and increased the frequency of inspections and maintenance. There have been no exceedences since these changes were implemented.

Schedule B - Minimum Monitoring and Reporting

The plant met all of the Schedule B compliance conditions and schedules.

Schedule C – Compliance Condition and Schedules

The plant met all of the Schedule C compliance conditions and schedules.

Schedule D – Special Conditions

The plant met all of the Schedule D special conditions

Schedule F – NPDES General Conditions

The plant met all of the Schedule F general conditions

DEQ USE ONLY
Application #:
File #:
Mail ID #2/#9:
LLID/RM:
ACD Fee Paid:
DOC Conf.:
Notes:

RENEWAL APPLICATION NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT (NPDES-R)

Oregon Department of Environmental Quality

DEQ USE ONLY
Received:
Amount Received:
Check #:
Deposit #:
☐ IND ☐ DOM ☐ UIC:
Notes:

A. REFERENCE INFORMATION

1. Legal Name: Portland General Electric	2. Common Name: Beaver Generating Station
3. Permit #: 101209 DEQ Site ID#: 70805 Permit Expiration Date: 11/30/2012	4. Facility Physical Address: 80997 Kallunki Road City, State, Zip Code: Clatskanie, Oregon 97016 County: Columbia
5. Responsible Official: Arya Behbehani Mailing Address: 121 SW Salmon Street, 3WTCBR05	Telephone #: 503-464-8141 City, State, Zip Code: Portland, Oregon 97204
6. Facility Contact: Bill Monroe Facility Mailing Address: 80997 Kallunki Road	Telephone #: 503-728-7424 City, State, Zip Code: Clatskanie, OR 97016
7. Invoice to: Arya Behbehani Billing Address: 121 SW Salmon St., 3WTCBR05	Telephone #: 503-464-8141 City, State, Zip Code: Portland, Oregon 97204

B. REQUIRED INFORMATION

(EPA Form 2A, 2B, 2C, 2E, or 2F must also be submitted with this application)

1. Briefly describe the permitted facility, type of wastewater, and primary method of wastewater treatment and disposal:
   See attached Beaver Generating Plant NPDES Renewal Summary and water flow diagram.

2. Have the treatment or disposal methods employed, as indicated in previous applications, been altered in any way since the last application was submitted? ☐ YES ☒ NO If "YES," explain:

3. Has the quantity or quality of wastes discharged, as indicated in previous applications, been significantly changed in any way since the last application was submitted? ☐ YES ☒ NO If "YES," explain:

4. If there are any changes anticipated in the near future that would affect waste quantity or quality, attach an explanation or proposal.
5. Review each condition of your current permit and attach a brief report that indicates your progress in meeting the requirements, limitations, and compliance schedules of the permit.
6. If the permitted facility or operation is a domestic wastewater treatment plant, attach a copy of your Biosolids Management Plan.

C. SIGNATURE OF LEGALLY AUTHORIZED REPRESENTATIVE

I hereby certify that the information contained in this application is true and correct to the best of my knowledge and belief. In addition, I agree to pay all permit fees required by Oregon Administrative Rules 340-45. This includes a renewal application fee to renew the permit and a compliance determination fee invoiced annually by DEQ to maintain the permit.

Arya Behbehani	PGE Environmental Services Manager
Name of Legally Authorized Representative (Type or Print)	**Title**
Arya Behbehani	5/23/12
Signature of Legally Authorized Representative	**Date**

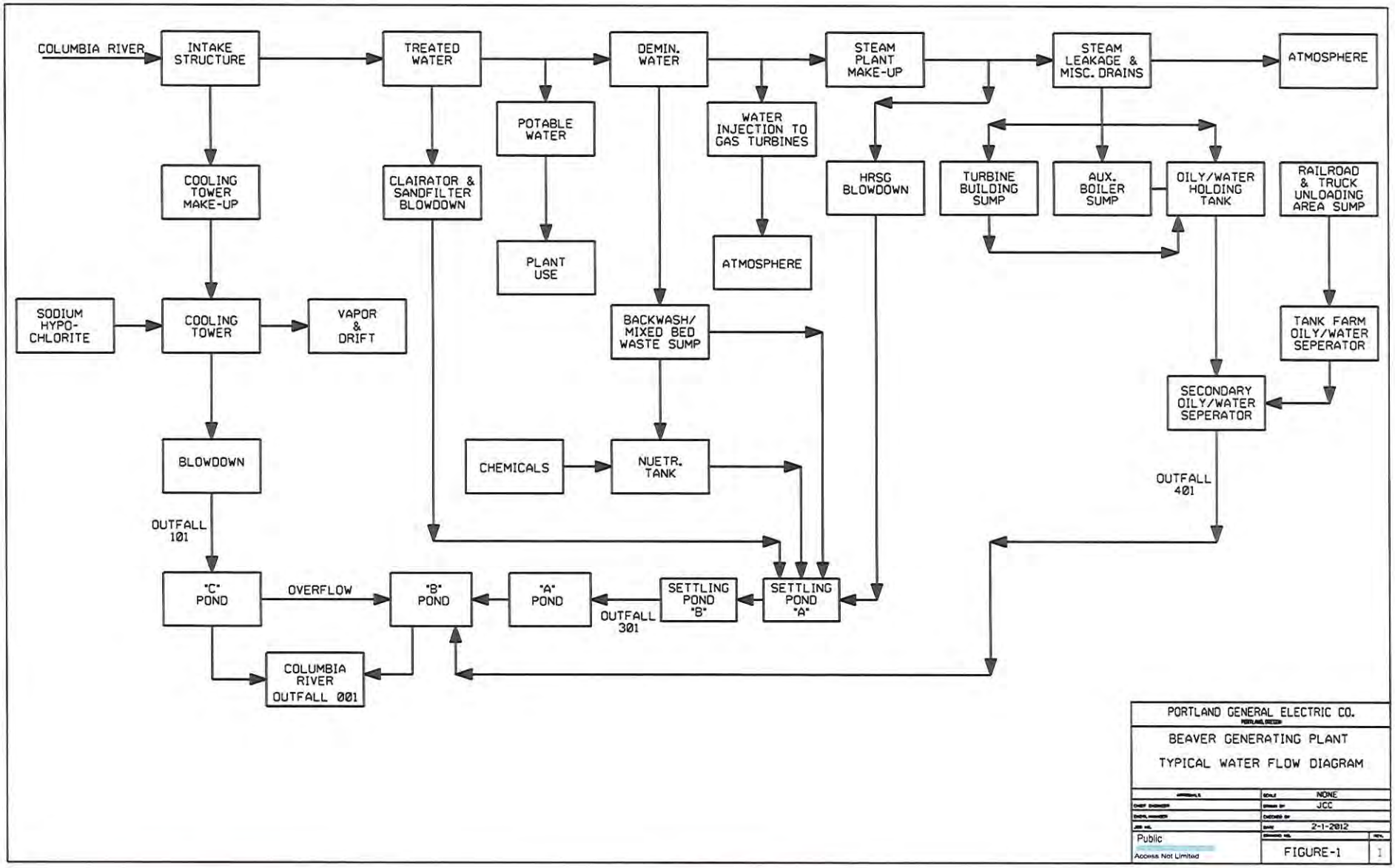


FIGURE-1.dgn 05/21/2012 3:24:29 PM

Please print or type in the unshaded areas only.

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)
OR002743-0

Form Approved.
OMB No. 2040-0086.
Approval expires 3-31-98.

FORM **2C** NPDES

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY
APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER
EXISTING MANUFACTURING, COMMERCIAL, MINING AND SILVICULTURE OPERATIONS
Consolidated Permits Program

I. OUTFALL LOCATION

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. OUTFALL NUMBER (*list*)	B. LATITUDE			C. LONGITUDE			D. RECEIVING WATER (*name*)
	1. DEG.	2. MIN.	3. SEC.	1. DEG.	2. MIN.	3. SEC.	
001	46	10	52	123	11	02	Columbia River

II. FLOWS, SOURCES OF POLLUTION, AND TREATMENT TECHNOLOGIES

A. Attach a line drawing showing the water flow through the facility. Indicate sources of intake water, operations contributing wastewater to the effluent, and treatment units labeled to correspond to the more detailed descriptions in Item B. Construct a water balance on the line drawing by showing average flows between intakes, operations, treatment units, and outfalls. If a water balance cannot be determined (*e.g., for certain mining activities*), provide a pictorial description of the nature and amount of any sources of water and any collection or treatment measures. Drawing Attached

B. For each outfall, provide a description of: (1) All operations contributing wastewater to the effluent, including process wastewater, sanitary wastewater, cooling water, and storm water runoff; (2) The average flow contributed by each operation; and (3) The treatment received by the wastewater. Continue on additional sheets if necessary.

1. OUTFALL NO. (*list*)	2. OPERATION(S) CONTRIBUTING FLOW		3. TREATMENT		
	a. OPERATION (*list*)	b. AVERAGE FLOW (*include units*)	a. DESCRIPTION	b. LIST CODES FROM TABLE 2C-1	
001	Cooling Water	600,000 GPD	Holding Ponds, Settling Ponds	1-U	S-P
	Demineralizer Backwash		Sludge is Land Applied	4-A	2-K
	Neutralizing Tank Water		Neutralization	2-F	1-F
	Stormwater runoff		oil/water Seperation		

OFFICIAL USE ONLY (*effluent guidelines sub-categories*)

CONTINUED FROM THE FRONT

C. Except for storm runoff, leaks, or spills, are any of the discharges described in Items II-A or B intermittent or seasonal?

☑ YES (*complete the following table*) ☐ NO (*go to Section III*)

1. OUTFALL NUMBER (*list*)	2. OPERATION(s) CONTRIBUTING FLOW (*list*)	3. FREQUENCY		4. FLOW				
		a. DAYS PER WEEK (*specify average*)	b. MONTHS PER YEAR (*specify average*)	a. FLOW RATE (*in mgd*)		B. TOTAL VOLUME (*specify with units*)		C. DURATION (*in days*)
				1. LONG TERM AVERAGE	2. MAXIMUM DAILY	1. LONG TERM AVERAGE	2. MAXIMUM DAILY	
001	Drainage from condenser during maintenance or shutdown. *Drainage may occur for approximately one or two days per year depending upon maintenance or shutdown requiremnts. Drainage is approximately 400,000 gallons.	*	*	*	*	*	*	*

III. PRODUCTION

A. Does an effluent guideline limitation promulgated by EPA under Section 304 of the Clean Water Act apply to your facility?

☑ YES (*complete Item III-B*) ☐ NO (*go to Section IV*)

B. Are the limitations in the applicable effluent guideline expressed in terms of production (*or other measure of operation*)?

☐ YES (*complete Item III-C*) ☑ NO (*go to Section IV*)

C. If you answered "yes" to item III-B, list the quantity which represents an actual measurement of your level of production, expressed in the terms and units used in the applicable effluent guideline, and indicate the affected outfalls.

1. AVERAGE DAILY PRODUCTION			2. AFFECTED OUTFALLS (*list outfall numbers*)
a. QUANTITY PER DAY	b. UNITS OF MEASURE	c. OPERATION, PRODUCT, MATERIAL, ETC. (*specify*)	

IV. IMPROVEMENTS

A. Are you now required by any Federal, State or local authority to meet any implementation schedule for the construction, upgrading or operations of wastewater treatment equipment or practices or any other environmental programs which may affect the discharges described in this application? This includes, but is not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant or loan conditions.

☐ YES (*complete the following table*) ☑ NO (*go to Item IV-B*)

1. IDENTIFICATION OF CONDITION, AGREEMENT, ETC.	2. AFFECTED OUTFALLS		3. BRIEF DESCRIPTION OF PROJECT	4. FINAL COMPLIANCE DATE	
	a. NO.	b. SOURCE OF DISCHARGE		a. REQUIRED	b. PROJECTED

B. OPTIONAL: You may attach additional sheets describing any additional water pollution control programs (*or other environmental projects which may affect your discharges*) you now have underway or which you plan. Indicate whether each program is now underway or planned, and indicate your actual or planned schedules for construction.

☐ MARK "X" IF DESCRIPTION OF ADDITIONAL CONTROL PROGRAMS IS ATTACHED

 CONTINUE ON PAGE 3

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)

OR002743-0

CONTINUED FROM PAGE 2

V. INTAKE AND EFFLUENT CHARACTERISTICS

A, B, & C: See instructions before proceeding – Complete one set of tables for each outfall – Annotate the outfall number in the space provided.
NOTE: Tables V-A, V-B, and V-C are included on separate sheets numbered V-1 through V-9.

D. Use the space below to list any of the pollutants listed in Table 2c-3 of the instructions, which you know or have reason to believe is discharged or may be discharged from any outfall. For every pollutant you list, briefly describe the reasons you believe it to be present and report any analytical data in your possession.

1. POLLUTANT	2. SOURCE	1. POLLUTANT	2. SOURCE

VI. POTENTIAL DISCHARGES NOT COVERED BY ANALYSIS

Is any pollutant listed in Item V-C a substance or a component of a substance which you currently use or manufacture as an intermediate or final product or byproduct?

☐ YES (*list all such pollutants below*) ☑ NO (*go to Item VI-B*)

 CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

VII. BIOLOGICAL TOXICITY TESTING DATA

Do you have any knowledge or reason to believe that any biological test for acute or chronic toxicity has been made on any of your discharges or on a receiving water in relation to your discharge within the last 3 years?

☐ YES (*identify the test(s) and describe their purposes below*) ☑ NO (*go to Section VIII*)

VIII. CONTRACT ANALYSIS INFORMATION

Were any of the analyses reported in Item V performed by a contract laboratory or consulting firm?

☑ YES (*list the name, address, and telephone number of, and pollutants analyzed by, each such laboratory or firm below*) ☐ NO (*go to Section IX*)

A. NAME	B. ADDRESS	C. TELEPHONE (*area code & no.*)	D. POLLUTANTS ANALYZED (*list*)
Columbia Analytical Services	1317 South 13th Avenue P.O. Box 479 Kelso, Washington 98626	(360) 577-7222	Copper Total Suspended Solids Oil & Grease Iron Analysis for Pollutants listed on Table V-B

IX. CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. NAME & OFFICIAL TITLE (*type or print*)	B. PHONE NO. (*area code & no.*)
Arya Behbehani, Manager - Environmental Services	(503) 464-8141
C. SIGNATURE	D. DATE SIGNED

PLEASE PRINT OR TYPE IN THE UNSHADED AREAS ONLY. You may report some or all of this information on separate sheets (*use the same format*) instead of completing these pages.
SEE INSTRUCTIONS.

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)
OR002743-0

V. INTAKE AND EFFLUENT CHARACTERISTICS *(continued from page 3 of Form 2-C)*

OUTFALL NO. 001

PART A –You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

1. POLLUTANT	2. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (*if available*) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (*if available*) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	3. UNITS (*specify if blank*) a. CONCEN-TRATION	b. MASS	4. INTAKE (*optional*) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
a. Biochemical Oxygen Demand (*BOD*)	0.5						1	mg/L				
b. Chemical Oxygen Demand (*COD*)	<2.5						2	mg/L				
c. Total Organic Carbon (*TOC*)	1.1						2	mg/L				
d. Total Suspended Solids (*TSS*)	13						204	mg/L				
e. Ammonia (*as N*)	<0.005						1	mg/L				
f. Flow	VALUE 0.06		VALUE 0.02		VALUE 0.01		35	m3/S		VALUE		
g. Temperature (*winter*)	VALUE 25		VALUE 19		VALUE 15		12	°C		VALUE		
h. Temperature (*summer*)	VALUE 34		VALUE 29		VALUE 25		12	°C		VALUE		
i. pH	MINIMUM 7.08	MAXIMUM 8.98	MINIMUM	MAXIMUM			52	STANDARD UNITS				

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1. POLLUTANT AND CAS NO. (*if available*)	2. MARK "X" a. BELIEVED PRESENT	b. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (*if available*) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (*if available*) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCEN-TRATION	b. MASS	5. INTAKE (*optional*) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
a. Bromide (24959-67-9)		X												
b. Chlorine, Total Residual		X	<0.06						209	mg/L				
c. Color		X												
d. Fecal Coliform		X												
e. Fluoride (16984-48-8)		X												
f. Nitrate-Nitrite (*as N*)		X												

CONTINUE ON REVERSE

ITEM V-B CONTINUED FROM FRONT

1. POLLUTANT AND CAS NO. (*if available*)	2. MARK "X"		3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. BELIEVED PRESENT	b. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
			(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
g. Nitrogen, Total Organic (*as N*)		X												
h. Oil and Grease	X		8.7						208	mg/L				
i. Phosphorus (as P), Total (7723-14-0)		X												
j. Radioactivity														
(1) Alpha, Total		X												
(2) Beta, Total		X												
(3) Radium, Total		X												
(4) Radium 226, Total		X												
k. Sulfate (*as SO_4*) (14808-79-8)	X		48.2						1	mg/L				
l. Sulfide (*as S*)		X												
m. Sulfite (*as SO_3*) (14265-45-3)		X												
n. Surfactants		X												
o. Aluminum, Total (7429-90-5)		X												
p. Barium, Total (7440-39-3)		X												
q. Boron, Total (7440-42-8)		X												
r. Cobalt, Total (7440-48-4)		X												
s. Iron, Total (7439-89-6)	X		262						1	ug/L				
t. Magnesium, Total (7439-95-4)		X												
u. Molybdenum, Total (7439-98-7)		X												
v. Manganese, Total (7439-96-5)		X												
w. Tin, Total (7440-31-5)		X												
x. Titanium, Total (7440-32-6)		X												

CONTINUE ON PAGE V-3

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	OUTFALL NUMBER
OR002743-0	001

CONTINUED FROM PAGE 3 OF FORM 2-C

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (*secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions*), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (*all 7 pages*) for each outfall. See instructions for additional details and requirements.

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X	<30						1	ug/L				
2M. Arsenic, Total (7440-38-2)			X	<30						1	ug/L				
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)			X	<3.0						1	ug/L				
5M. Chromium, Total (7440-47-3)			X	<2.0						1	ug/L				
6M. Copper, Total (7440-50-8)		X		<2.0						1	ug/L				
7M. Lead, Total (7439-92-1)			X	<30						1	ug/L				
8M. Mercury, Total (7439-97-6)			X	<0.02						1	ug/L				
9M. Nickel, Total (7440-02-0)			X	<20						1	ug/L				
10M. Selenium, Total (7782-49-2)			X	<30						1	ug/L				
11M. Silver, Total (7440-22-4)			X	<3.0						1	ug/L				
12M. Thallium, Total (7440-28-0)			X	<50						1	ug/L				
13M. Zinc, Total (7440-66-6)		X		34.4						1	ug/L				
14M. Cyanide, Total (57-12-5)			X	10						1	ug/L				
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetra-chlorodibenzo-P-Dioxin (1764-01-6)			X	DESCRIBE RESULTS											

CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X	<0.14						1	ug/L				
4V. Bis (*Chloro-methyl*) Ether (542-88-1)			X												
5V. Bromoform (75-25-2)			X	<0.28						1	ug/L				
6V. Carbon Tetrachloride (56-23-5)			X	<0.14						1	ug/L				
7V. Chlorobenzene (108-90-7)			X	<0.14						1	ug/L				
8V. Chlorodi-bromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X	<0.23						1	ug/L				
10V. 2-Chloro-ethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichloro-bromomethane (75-27-4)			X												
13V. Dichloro-difluoromethane (75-71-8)			X												
14V. 1,1-Dichloro-ethane (75-34-3)			X	<0.11						1	ug/L				
15V. 1,2-Dichloro-ethane (107-06-2)			X	<0.12						1	ug/L				
16V. 1,1-Dichloro-ethylene (75-35-4)			X												
17V. 1,2-Dichloro-propane (78-87-5)			X												
18V. 1,3-Dichloro-propylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X	<0.13						1	ug/L				
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X	<0.20						1	ug/L				

 CONTINUE ON PAGE V-5

CONTINUED FROM PAGE V-4

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – VOLATILE COMPOUNDS (*continued*)															
22V. Methylene Chloride (75-09-2)			X	<0.20						1	ug/L				
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X	<0.14						1	ug/L				
24V. Tetrachloro-ethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X	<0.11						1	ug/L				
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloro-ethane (71-55-6)			X	<0.12						1	ug/L				
28V. 1,1,2-Trichloro-ethane (79-00-5)			X	<0.14						1	ug/L				
29V Trichloro-ethylene (79-01-6)			X												
30V. Trichloro-fluoromethane (75-69-4)			X	<0.14						1	ug/L				
31V. Vinyl Chloride (75-01-4)			X	<0.042						1	ug/L				
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X	<0.32						1	ug/L				
2A. 2,4-Dichloro-phenol (120-83-2)			X	<0.30						1	ug/L				
3A. 2,4-Dimethyl-phenol (105-67-9)			X												
4A. 4,6-Dinitro-O-Cresol (534-52-1)			X												
5A. 2,4-Dinitro-phenol (51-28-5)			X	<2.3						1	ug/L				
6A. 2-Nitrophenol (88-75-5)			X	<0.38						1	ug/L				
7A. 4-Nitrophenol (100-02-7)			X	<2.0						1	ug/L				
8A. P-Chloro-M-Cresol (59-50-7)			X												
9A. Pentachloro-phenol (87-86-5)			X												
10A. Phenol (108-95-2)			X	<0.33						1	ug/L				
11A. 2,4,6-Trichloro-phenol (88-05-2)			X	<0.21						1	ug/L				

CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – BASE/NEUTRAL COMPOUNDS															
1B. Acenaphthene (83-32-9)			X	<0.29						1	ug/L				
2B. Acenaphtylene (208-96-8)			X	<0.24						1	ug/L				
3B. Anthracene (120-12-7)			X	<0.62						1	ug/L				
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X	<0.60						1	ug/L				
6B. Benzo (*a*) Pyrene (50-32-8)			X	<0.66						1	ug/L				
7B. 3,4-Benzo-fluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X	<0.83						1	ug/L				
10B. Bis (*2-Chloro-ethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloro-ethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												
13B. Bis (*2-Ethyl-hexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X	<0.28						1	ug/L				
15B. Butyl Benzyl Phthalate (85-68-7)			X	<0.47						1	ug/L				
16B. 2-Chloro-naphthalene (91-58-7)			X	<0.29						1	ug/L				
17B. 4-Chloro-phenyl Phenyl Ether (7005-72-3)			X	<0.28						1	ug/L				
18B. Chrysene (218-01-9)			X	<0.79						1	ug/L				
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichloro-benzene (95-50-1)			X	<0.44						1	ug/L				
21B. 1,3-Di-chloro-benzene (541-73-1)			X	<0.36						1	ug/L				

CONTINUE ON PAGE V-7

CONTINUED FROM PAGE V-6

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – BASE/NEUTRAL COMPOUNDS (*continued*)															
22B. 1,4-Dichloro-benzene (106-46-7)			X												
23B. 3,3-Dichloro-benzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131-11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitro-toluene (121-14-2)			X												
28B. 2,6-Dinitro-toluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B. 1,2-Diphenyl-hydrazine (*as Azo-benzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachloro-benzene (118-74-1)			X												
34B. Hexachloro-butadiene (87-68-3)			X	<0.30						1	ug/L				
35B. Hexachloro-cyclopentadiene (77-47-4)			X												
36B Hexachloro-ethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												
39B. Naphthalene (91-20-3)			X	<0.37						1	ug/L				
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitro-sodimethylamine (62-75-9)			X												
42B. N-Nitrosodi-N-Propylamine (621-64-7)			X												

CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

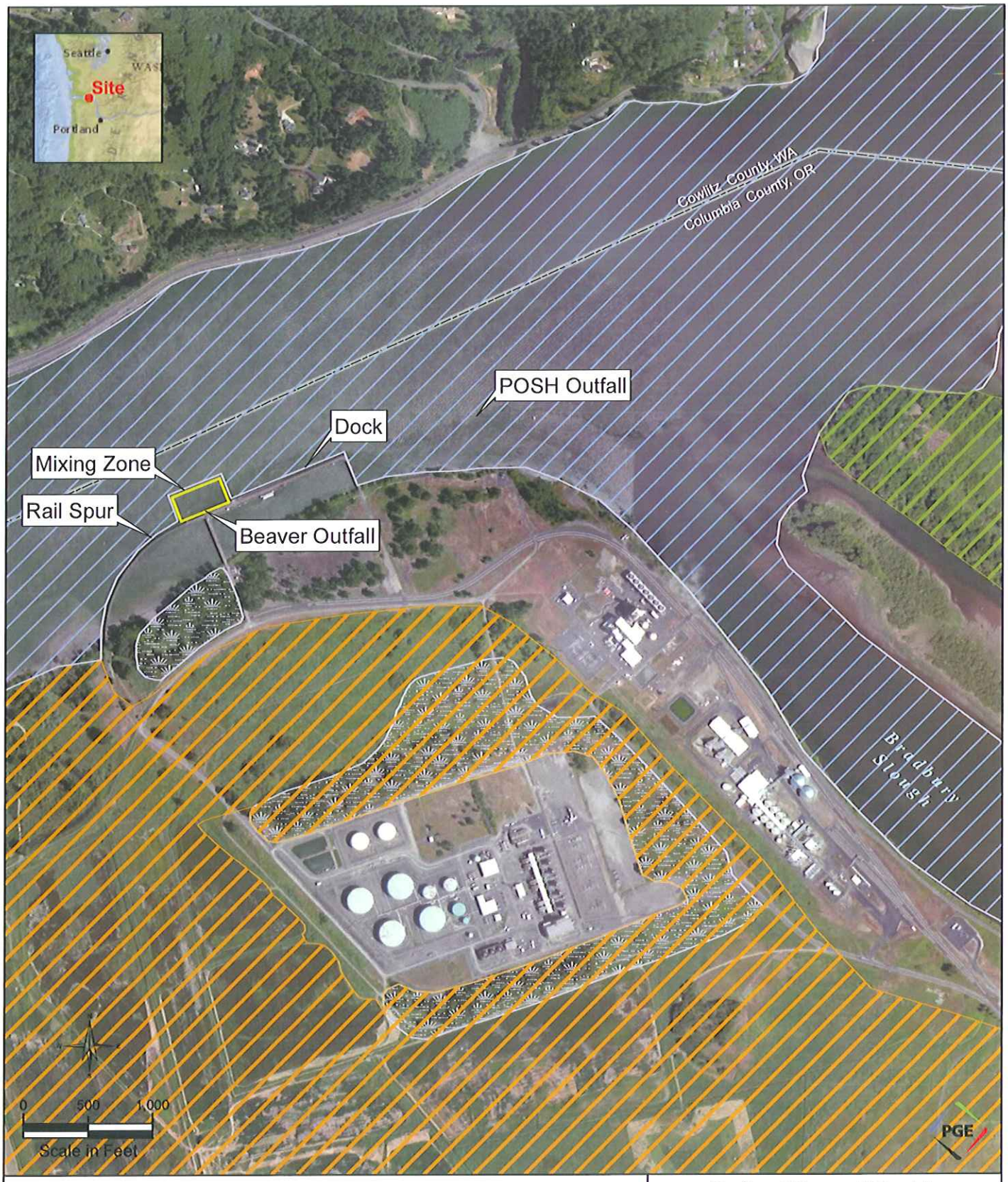
1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – BASE/NEUTRAL COMPOUNDS (*continued*)															
43B. N-Nitro-sodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X	<0.49						1	ug/L				
45B. Pyrene (129-00-0)			X	<0.74						1	ug/L				
46B. 1,2,4-Tri-chlorobenzene (120-82-1)			X	<0.36						1	ug/L				
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												

CONTINUE ON PAGE V-9

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	OUTFALL NUMBER
OR002743-0	001

CONTINUED FROM PAGE V-8

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – PESTICIDES (*continued*)															
17P. Heptachlor Epoxide (1024-57-3)			X												
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												



Map Features

- Bald Eagle Nesting Grounds
- Salmon/Trout Rearing and Migration
- Columbia White-Tailed Deer Habitat
- Wetlands

Portland General Electric
Portland, Oregon

Figure x

Beaver - Port Westward Generation Facilities

J:\Port_Westward\Maps\PW_Beaver_A.mxd

ATTACHMENT E-5:

FEDERAL CONCURRENCE LETTERS

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Oregon

John A. Kitzhaber, Governor

Department of Environmental Quality
Northwest Region
2020 SW 4th Ave, Suite 400
Portland, OR 97201
(503) 229-5263
FAX (503) 229-6945
TTY 711

April 22, 2015

Michael Hayward
Northwest Natural Gas Company
220 NW 2nd AVE
Portland, OR 97209

Re: AQ-Columbia Co.
NW Natural
File no. TBD

Dear Michael:

In accordance with OAR 345-021-0000(7), the Department of Environmental Quality (DEQ) is providing the following information with respect to Northwest Natural Gas Mist Compressor Station.

Federally-delegated air permit program (ACDP):

- The application was received on April 20, 2015.
- DEQ has not identified any additional information needs at this time, but we may request additional information at any time during the permit process.
- The time to issue this type of permit ranges from 10 to 18 months from the time the application was received. DEQ's best estimate at this time is February, 2016; however, there are many factors which may affect the actual issuance date and the permit may be issued earlier or later.

If you have any questions regarding the air quality permit, please contact me at 503-229-6333.

Sincerely,

Louis Bivins
Natural Resource Specialist

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, PORTLAND DISTRICT
P.O. BOX 2946
PORTLAND, OREGON 97208-2946

April 27, 2015

REPLY TO:
ATTENTION OF:
Operations Division
Regulatory Branch
Corps No. NWP-2015-167

Michael J Hayward
NW Natural
220 NW 2nd Ave
Portland, OR 97217

Dear Mr. Hayward:

The U.S. Army Corps of Engineers (Corps) has received your permit application, received April 24, 2015, requesting authorization to construct the North Mist Expansion Pipeline Project. The proposed project is located within palustrine wetlands south of and adjacent to the Columbia River, near the city of Clatskanie, Columbia County, Oregon. Your project has been assigned Corps No. NWP-2015-167. Please refer to this number in all correspondence.

I will be the Corps project manager responsible for reviewing your permit application. The Corps plans to review this project under our Nationwide Permit No. 12, for Utility Line Activities. In response to the receipt of a complete permit application, the Corps targets a decision being issued to the applicant within 60 days. The Corps will not issue a permit until all necessary Federal obligations have been met, including coordination as required under Section 7 of the Endangered Species Act, National Historic Preservation Act, etc.

You are cautioned that commencement of the proposed work prior to obtaining a Department of the Army (DA) permit would constitute a violation of Federal laws and subject you to possible enforcement action. Receipt of a permit from the Oregon Department of State Lands (DSL) does not obviate the requirement for obtaining a DA permit prior to commencing the proposed work.

If you have any questions regarding your application, please contact me at the letterhead address, by telephone at (503) 808-4384, or E-mail Richard.Chong@usace.army.mil.

Sincerely,

Richard Chong
Project Manager, Regulatory Branch

Exhibit F:

Property Ownership

North Mist Expansion Project

November 2015

Northwest Natural Gas

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1.0 Introduction

OAR 345-021-0010(1)(f)

A list of the names and mailing addresses of all owners of record, as shown on the most recent property tax assessment roll, of property located within or adjacent to the site boundary as defined in OAR 345-001-0010. The applicant shall submit an updated list of property owners as requested by the Department before the Department issues notice of any public hearing on the application for a site certificate as described in OAR 345-015-0220. In addition to incorporating the list in the application for a site certificate, the applicant shall submit the list to the Department in an electronic format approved by the Department. Property adjacent to the proposed site of the facility or corridor means property that is:

OAR 345-021-0010(1)(f)(C) Within 500 feet of the site boundary where the site, corridor or micrositing corridor is within a farm or forest zone.

Response: OAR 345-001-0010(55) defines "site boundary" as "the perimeter of the site of a proposed energy facility, its related or supporting facilities, all temporary laydown and staging areas and all corridors and micrositing corridors proposed by the applicant." Under this definition, the Site Boundary shown in **Figure A-1** of the **Project Description and OAR Division 27 Compliance** is the perimeter of the facility property (including both the existing Site Boundary and the Site Boundary expansion proposed in this Request, including the corridor for the proposed NMTP). As described in **Exhibit K**, the Project is located within Columbia County's farm and forest zones. Pursuant to OAR 345-021-0011(1)(f)(C), landowner notification is required for properties within 500 feet of the facility Site Boundary. The following list includes the names and mailing addresses of all owners of record within 500 feet of the facility Site Boundary.

Campbell Global
PO BOX 99,
Cathlamet, WA 98612

Weyerhaeuser Columbia
Timberlands, LLC
10 International Way,
Longview, WA 98632

Northwest Natural Gas Co.
220 2nd Ave NW,
Portland, OR 97209

Kristin M Bergseng &
Christine M Ruch
77870 Erickson Dike Rd,
Clatskanie, OR 97016

Lower Columbia Tree Farm
1500 SW First Ave, 1150
Portland, OR 97201

Russell and April Spaulding
PO Box 1459
Clatskanie, OR 97016

Gary and Heidi Bailey
PO Box 361
Clatskanie, OR 97016

OR DOT HWY DIV
6000 SW Raab Rd.
Portland, OR 97221

Jim and Lawanna Castle
77322 Palm Hill Rd.
Clatskanie, OR 97016

Mary E Heronimus
69143 Diamond T Ranch
Mist, OR 97016

Evenson Logging Co.
PO Box 127
Clatskanie, OR 97016

Lillian H Palm
76886 Palm Hill Rd,
Clatskanie, OR 97016

Mark and Katrina Kynsi
15694 Luxford Rd,
Clatskanie, OR 97016

Ralph J. and Helen L Kleger
Revocable Living Trust
9658 SW Denney Rd,
Beaverton, OR 97008

Claruth Inc, Willna Inc,
Franbea Inc, Ea 1/3
PO Box 127,
Clatskanie, OR 97016

Patricia Ann Cink
6105 Rexroth Ave,
Bakersfield, CA 93306

Judith Bergman
15910 Elliott Rd,
Clatskanie, OR 97016

Portland General Electric
121 SW Salmon St
#1WTC0510
Portland, OR 97204

Ray J Grimsbo and Debra A
1525 Glacier Ridge Rd NE
Bend, OR 97701

Arthur Lee Johnson and
Diane P
15914 Colvin Rd
Clatskanie, OR 97016

Bessie M Savage
15773 Colvin Rd
Clatskanie, OR 97016

Anthony A Mittone
PO Box 629
Clatskanie, OR 97016

Midland Water Association
Inc
PO Box 922
Clatskanie, OR 97016

USA – Fish and Wildlife
Service
911 11th Ave NE
Portland, OR 97232

Beaver Drainage
Improvement Company
PO Box 1078
Clatskanie, OR 97016

Cascade Kelly Holdings LLC
81200 Kallunki Rd,
Clatskanie, OR 97016

George and Karen Poysky
PO Box 158
Clatskanie, OR 97016

Lawrence and Wanda
Derby
81036 Erickson Dike Rd.
Clatskanie, OR 97016

Port of St. Helens
PO BOX 190
Columbia, OR 97018
Hopville Farms, LLC
PO Box 361
Terrebonne, OR 97760

Collins Road Clatskanie, LLC
1521 Westbranch Dr, Ste 200
McLean, VA 22102

John & Rose Castle
77434 Palm Hill Rd.
Clatskanie, OR 97016

Ronald and Julie Webster
16127 Highway 30
Clatskanie, OR 97016

Eric S and Julie Haney
1419 Hwy 202
Mist, OR 97016

Charles Lagle and Ana Lee Mcburney-Lagle
2587 E Bart St
Gilbert, AZ 85295

Jan Patrick Nelson and Cindy Darlene
14998 Hwy 202
Mist, OR 97016

Michael Galassi
14431 Wallace Rd
Mist, OR 97016

James E Woods
68760 Burn Rd
Clatskanie, OR 97016

Bruce McFadden
3305 Voltaire St.
San Diego, CA 92106

Glen D Sweeden and Gloria Sweeden
PO Box 1374
Clatskanie, OR 97016

Jeffrey P Saunders
15388 Luxford Rd
Clatskanie, OR 97016

Table 1. Map Taxlots by Owner

MAP TAXLOT	OWNER
7N4W 600 300	BAILEY GARY M & HEIDI L
8N4W3200 1200	BEAVER DRAINAGE IMPROVEMENT COMPANY
7N5W1200 500	BERGMAN JUDITH
7N4W 500 800	BERGSENG CHRISTINE M
6N5W00 600	CAMPBELL GLOBAL LLC
6N5W00 300	CAMPBELL GLOBAL LLC
7N4W 600 1000	CAMPBELL GLOBAL LLC
8N4W1600 400	CASCADE KELLY HOLDINGS LLC
7N4W 600 1100	CASTLE JIM R & LAWANNA L
7N4W 600 1101	CASTLE JOHN L & ROSE M
7N5W1200 300	CINK FAMILY TRUST
7N5W1200 300	CINK FAMILY TRUST
7N5W00 5000	CLARUTH INC WILLNA INC FRANBEA INC EA1/3
7N5W00 4500	CLARUTH INC WILLNA INC FRANBEA INC EA1/3
7N5W1200 200	CLARUTH INC WILLNA INC FRANBEA INC EA1/3
7N5W1100 600	CLARUTH INC WILLNA INC FRANBEA INC EA1/3
8N4W3200 600	COLLINS ROAD CLATSKANIE LLC
8N4W3200 900	COLLINS ROAD CLATSKANIE LLC
8N4W2100 200	DERBY LAWRENCE N & WANDA B
7N4W 700 1000	EVENSON LOGGING CO
7N4W 700 1000	EVENSON LOGGING CO
7N4W 700 1000	EVENSON LOGGING CO
7N4W 700 1000	EVENSON LOGGING CO
7N4W 700 1000	EVENSON LOGGING CO
6N5W1400 700	GALASSI MICHAEL
6N5W1400 700	GALASSI MICHAEL
7N5W 100 1201	GRIMSBO J RAY & DEBRA A
7N5W 100 1201	GRIMSBO J RAY & DEBRA A
7N5W 100 1200	GRIMSBO J RAY & DEBRA A
7N5W 100 1201	GRIMSBO J RAY & DEBRA A

MAP TAXLOT	OWNER
6N5W1400 502	HANEY ERIC S & JULIE
6N5W13C0 100	HIERONIMUS MARY E
8N4W3200 1000	HOPVILLE FARMS LLC
8N4W3100 100	HOPVILLE FARMS LLC
7N5W 100 1300	JOHNSON ARTHUR LEE & DIANE P
7N5W 100 2702	KLEGER RALPH J & HELEN L REV LIV TRUST
7N5W 100 1100	KYNSI MARK P & KATRINA J
6N5W1400 503	LAGLE CHARLES & MCBURNEY-LAGLE LEE ANA
8N4W2800 101	LOWER COLUMBIA TREE FARM LLC
8N4W2800 200	LOWER COLUMBIA TREE FARM LLC
8N4W2900 200	LOWER COLUMBIA TREE FARM LLC
8N4W2900 300	LOWER COLUMBIA TREE FARM LLC
8N4W3200 1100	LOWER COLUMBIA TREE FARM LLC
8N4W3100 500	LOWER COLUMBIA TREE FARM LLC
7N4W 600 100	LOWER COLUMBIA TREE FARM LLC
7N4W 500 900	MCFADDEN BRUCE
7N4W 500 900	MCFADDEN BRUCE
7N5W1100 800	MIDLAND WATER ASSOCIATION INC
7N5W 100 1500	MITTONE ANTHONY A
6N5W1400 600	NELSON JAN PATRICK & CINDY DARLENE
7N4W 600 599	OR DOT HWY DIV
7N4W 700 1001	PALM LILLIAN H
8N4W2000 300	PORT OF ST HELENS
8N4W2100 400	PORT OF ST HELENS
8N4W2100 700	PORT OF ST HELENS
8N4W1500 500	PORT OF ST HELENS
8N4W1600 200	PORT OF ST HELENS
8N4W2100 500	PORT OF ST HELENS
8N4W2100 700	PORT OF ST HELENS
8N4W2200 1100	PORT OF ST HELENS
8N4W1500 500	PORT OF ST HELENS

MAP TAXLOT	OWNER
8N4W2200 1100	PORT OF ST HELENS
8N4W1600 300	PORTLAND GENERAL ELECTRIC COMPANY
8N4W1500 600	PORTLAND GENERAL ELECTRIC COMPANY
8N4W2100 100	POYSKY GEORGE J & KAREN
7N5W 100 1400	SAVAGE BESSIE M
7N4W 600 200	SPAULDING RUSSELL R & APRIL
7N4W 500 1000	SWEEDEN GLEN D 1/2 & SWEEDEN GLORIA 1/2
8N4W3100 400	USA -FISH & WILDLIFE SERVICE
7N4W 600 500	WEBSTER RONALD N & JULIE B
6N5W00 500	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
6N5W00 501	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
6N5W00 500	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
6N5W00 700	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W00 2200	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W00 3100	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W00 4800	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W00 4700	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W00 4600	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W00 1400	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
6N5W2300 400	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
6N5W1400 100	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W1200 201	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W1200 400	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W00 1500	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N4W 700 1100	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W1200 100	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N4W 600 1400	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N4W 600 1400	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N4W 700 1100	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W1200 401	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W1200 100	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC

MAP TAXLOT	OWNER
7N5W1100 601	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
7N5W00 1300	WEYERHAEUSER COLUMBIA TIMBERLANDS LLC
6N5W2300 200	WOODS JAMES E
7N5W 100 1000	SAUNDERS JEFFREY P

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Exhibit G

Materials Analysis

North Mist Expansion Project

November 2015

Northwest Natural Gas

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Acronyms and Abbreviations

NWN	Northwest Natural Gas
OAR	Oregon Administrative Rule
Project	North Mist Expansion Project

1.0 Introduction

Exhibit G provides an analysis of construction materials for the Project, as required to meet the submittal requirements of Oregon Administrative Rule (OAR) 345-021-0010(1)(g) paragraphs (A) through (C). OAR 345 Division 22 does not provide an approval standard specific to Exhibit G.

2.0 Construction Materials Inventory: OAR 345-021-0010(1)(g)(A)

The typical materials needed for construction of the Project are as follows:

North Mist Compressor Station:
Materials: Aggregate, sand, cement, rebar, structural steel, electrical wire, paint, pipeline coating, water, etc.

Equipment: Dump trucks, vacuum trucks, scrapers, excavators, dozers, compaction equipment, graders, water trucks, service trucks, personnel vehicles, crane, welders, etc.

North Mist Transmission Pipeline:

Materials: Steel pipe, bedding sand, HDD drilling fluid, water, crane mats, welding rod, paint, pipeline coating, water, etc.

Equipment: HDD equipment, dump trucks, vacuum trucks, sweeper trucks, scrapers, excavators, dozers, side booms, compaction equipment, graders, water trucks, service trucks, personnel vehicles, crane, welders, etc.

Table G-1 provides an inventory of industrial materials that would be used during construction of the Project. Solid wastes generated and flowing out of the facility during construction are outlined in Table V-1.

Table G-1. Inventory of Materials to be Used During Construction of the Project

Material	Quantity/Units	Ultimate Disposition
Rock/gravel	Approximately 58,000 tons or 42,000 cubic yards for the compressor station and access road	Maintained as on-site roadbed or graveled area associated with the compressor station and access road.
Concrete foundation materials	Approximately 3,000 cubic yards of concrete for equipment and building foundations, including the small communications tower.	Incorporated into equipment pads, tower foundations, and building foundations.
Structural Steel	Approximately 28 tons of structural steel used at the compressor station in buildings and foundations plus an additional approximately 5 tons of structural steel in the communications tower	Incorporated into buildings, foundations, communications tower and other internal components.

Table G-1. Inventory of Materials to be Used During Construction of the Project		
Material	Quantity/Units	Ultimate Disposition
Temporary use of bentonite	152 cubic yards of bentonite	It is expected that the used bentonite will be recycled using land farming techniques, which would result in zero solid waste.

3.0 Operational Materials Inventory

No substantial quantities of industrial materials will be stored on the Project during operation. Lubricating oils and antifreeze will be present at the North Mist Compressor Station, and will be fully contained within the compressors. Lubricating oils and antifreeze are drained and replaced periodically; new oil will be brought in on an as-needed basis and used oil will be stored in the waste oil tank waiting removal for recycling by a licensed vendor. If heavy equipment is necessary for major maintenance issues, such as the replacement of a compressor, its use would be similar to the construction stage: fuel or oils needed for maintenance would be delivered by a licensed maintenance contractor on an as-needed basis, and no substantial quantities will be stored on-site.

It is possible that major equipment may need to be replaced during the lifetime of the Project; however, due to the unpredictable nature of major maintenance problems, no estimate has been provided for the amount of major components that may be needed. Minor maintenance may also require the replacement and removal of smaller components, which are not expected to constitute substantial amounts of industrial materials. Minor and potentially hazardous materials could include oily rags or similar materials related to equipment lubrication and other maintenance.

Small quantities of lubricating oils, cleaners, or antifreeze may be stored at the North Mist Station for use during Project operations. None would be present in substantial reportable quantities; the amounts present (if any) would be no greater than household quantities.

Table G-2 provides an inventory of industrial materials that would be used during operation of the Project. No industrial materials will be stored in association with the operation of the North Mist Transmission Pipeline itself.

Table G-2. Inventory of Materials to be Used During Operation of the Project		
Oils (compressor and engine lubricants, gear oil and transformer coolant)	Estimated at up to 400 gallons per year, dependent on maintenance schedule.	Small quantity stored in buildings for minor maintenance; full oil change done as-needed by a specialized contractor or appropriately trained company personnel and used oils removed for recycling.
Simple Green (general cleaner)	Estimated at up to 5 gallons per year, dependent on need.	Small quantity stored in buildings for minor maintenance.
WD-40; grease (general lubricant)	Estimated at up to 1 gallon per year, dependent on need.	Small quantity stored in buildings for minor maintenance.
Ethylene glycol (anti-freeze)	Estimated at up to 250 gallons every four years per anticipated maintenance schedule.	Small quantity stored in buildings for minor maintenance.
Triethylene glycol (TEG) (dehydration fluid)	Anticipated replacement every three to ten years depending on operating conditions. Dehydration units hold 2500 gallons each (2 units).	Fresh TEG is brought in as needed for change out with used TEG being removed for recycling.

4.0 Hazardous Materials Handling and Management OAR 345-021-0010(1)(g)(B)

During the construction and/or operational phases of the Project it may be necessary to use minor quantities of hazardous substances (materials requiring Safety Data Sheets). These materials would include small, but necessary, quantities of fuels, lubricants, oils, greases, antifreeze, tri-ethylene glycol, and hydraulic fluids. All potentially hazardous substances, during both phases, will be used in a manner that is protective of human health, protective of the environment, and that complies with all applicable local, state, and federal environmental laws and regulations. For any necessary potentially hazardous substance used during either the construction or operational phase, Safety Data Sheets (SDS) will be made available and located at the construction area or the Facility.

Extremely Hazardous Substances (EHS) in excess of Threshold Planning Quantities, highly toxic, and/or explosive materials will not be necessary to support either the construction or the operational phase. Additionally, materials used during the construction and operation of the Facility will be selected such that they minimize the potential for producing "hazardous waste" as defined by the Resource Conservation and Recovery Act (RCRA).

NWN's Waste Minimization and Recycling Plan is presented in **Attachment G-1** of this **Exhibit.**

4.1 Construction Phase

Potentially hazardous substances used during the construction phase may include gasoline, diesel, hydraulic oil, lubricants, paints, pipe coating, etc. It is anticipated that only minor quantities of

potentially hazardous substances will be necessary to complete construction, and that when potentially hazardous substance are necessary they will only be present in quantities similar to household levels. No potentially hazardous substances will be permanently present within the construction yards at quantities which exceed OSFM Reportable Quantities. When not in use, all potentially hazardous substances will be stored in a covered and lockable location with appropriate secondary containment that is staged within or nearby the construction yard.

Fuel for construction equipment would be delivered to the site via a specialized mobile vehicle by a licensed service contractor on an as-needed basis. Following the completion of fueling activities these vehicles would not be staged within any construction yard or at the Facility. Fueling for smaller mobile vehicles will be completed off site at nearby privately owned fueling stations. Construction based equipment will be regularly inspected to detect potential leaks or other issues which may require maintenance. Potentially hazardous substances related to the maintenance of the construction equipment will only be brought to the construction site by a maintenance technician on an as-needed basis, and any unused or waste substances would be removed during the same service call.

The prevention and minimization of accidental releases of these materials will be accomplished through proper containment during use and transportation to the project site, and the observance of appropriate handling procedures during the transferring of any fuels from the delivery vehicles to the construction equipment. All fueling and vehicle maintenance operations will be conducted a sufficient distance, 100 feet, from any sensitive ecosystems (i.e. riparian, wetland, potential nesting areas) to avoid the potential for impacting those areas.

In the unlikely event that an accidental spill occurs, any spilled or released substances will be cleaned up and any contaminated media impacted by the spill will be managed in accordance with all applicable regulations. Larger spill kits with absorbents, absorbent pads, spill socks, and disposable bags will be maintained at the construction yard in close proximity to construction activities. In addition, to reduce the response time to a spill, smaller spill kits containing absorbent pads will be located on key pieces of construction equipment. All employees will be instructed in the location, handling, and usage of the spill kits. All spills will be reported to a designated qualified person who will make an assessment of the cleanup activities and a determination if further actions or notifications are required.

4.2 Operation Phase

Potentially hazardous substances used during the operational phase of the Facility may include lubricating oils, dehydration fluid, and antifreeze. Operation of the Project will produce small amounts of compressor crankcase oil, occasional oil-contaminated triethylene glycol, antifreeze, oil/water separator oils, oily rags, oil filters and granular activated carbon (a filtering media). In accordance with NWN's existing recycling program, the crankcase oil, triethylene glycol and oil/water separator oils will be collected, transported and recycled by a vendor. Oily rags and oil filters will be disposed of by a permitted facility. The granular activated carbon will be collected and sent to a permitted facility for regeneration and returned for later use.

It is anticipated that the types, amounts, and usage of potentially hazardous substances will be limited based on the operational nature of the Facility and the limited need for these substances. Any potentially hazardous substances necessary to support the long term operation of the Facility will either be limited to quantities of less than Oregon State Fire Marshall (OSFM) Reportable Quantities, or disclosed annually as part of the Community Right to Know Act managed by the OSFM. When such substances are not in use, the substances will be either stored in a secure building or stored in appropriate structures specifically designed for the substance which will meet all applicable regulatory requirements. Substances will be selected in such a manner to minimize the potential for producing RCRA defined hazardous wastes. **Table G-2** provides an inventory of industrial materials that would be used during operation of the Facility.

In the unlikely event that an accidental spill occurs during the operational phase at the Facility, any spilled or released substances will be cleaned up and any contaminated media will be managed in accordance with all applicable RCRA regulations. Spill kits with absorbents, absorbent pads, spill socks, and disposable bags will be located in within the Facility and in close proximity to any structure which may contain potentially hazardous substances. All employees associated with the operation of the Facility will be trained on the location and usage of the spill kits, and an emergency contact list will be maintained at the Facility.

5.0 Non-Hazardous Waste Management: OAR 345-021-0010(1)(g)(C)

5.1 Construction Phase

NWN will fully comply with all applicable waste handling and disposal regulations on all lands associated with the Project, during both construction and operation. Solid waste will be stored in a manner that does not constitute a fire, health, or safety hazard until such time as it can be hauled off for recycling or disposal, as appropriate. **Exhibit V-1** provides an estimate of solid waste quantities.

Solid waste materials, such as excess construction materials or scrap steel, will be generated during construction. When feasible, the waste generated during construction will be recycled. Steel scraps and copper wiring scraps will be separated and recycled to the extent feasible. Wood from concrete forms will be reused when possible and then recycled. Excess excavated material will be used to restore ground contours after construction.

5.1.1 North Mist Compressor Station

Construction wastes from the North Mist Compressor Station will consist of nonhazardous equipment packaging and general construction debris. The material will consist of concrete, fiber board, wood, plastic, conduit, scrap wire and scrap steel. The waste materials will be transported to an appropriate recycling facility, utilizing NWN's established recycling program, or to a nearby landfill for non-recyclable goods. NWN's Waste Minimization and Recycling Plan is presented in **Attachment G-1** of this **Exhibit.**

5.1.2 North Mist Transmission Pipeline

The wastes generated from the installation of the North Mist Transmission Pipeline will consist of nonhazardous construction materials. The solid materials will consist of scrap steel, welding rod and erosion control materials such as silt fencing and bio-bags. The scrap steel and welding rod will be collected and transported to a recycling facility. The silt fence material and bio-bags will be transported to a local landfill.

The use of Horizontal Directional Drilling technology to cross water bodies, streams, wetlands, and agricultural fields minimizes the amount of erosion control materials needed for the pipeline construction. All drilling fluids will be disposed of in accordance with state and federal regulations.

HDD drilling fluid is recycled during the drilling process. However, spent drilling fluids and associated solids (cuttings) will be stored on site in stock piles and liquid tight containers during construction prior to disposal. Final disposal will be at a local landfill or via land application at the Columbia Tree Farm property. NW Natural is currently in discussions with Columbia Tree Farm for land application of spent drilling fluids and cuttings. A written agreement will be in place prior to any land application. In the event inadvertent returns are encountered during construction, management of those returns will be in accordance with the Inadvertent Return Response Plan presented as Attachment F to the JPA in Exhibit J.

5.2 Operational Phase

During operations, little to no solid waste will be generated by the Project.

ATTACHMENT G-1:

NW NATURAL WASTE MINIMIZATION AND RECYCLING PLAN

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NW Natural

Waste Minimization & Recycling Plan

NW Natural is committed to excellence in environmental stewardship. In all activities, from office to field we work to encourage and accomplish waste minimization and recycling of materials. All employees have a role in reducing waste as we work to safely and effectively deliver natural gas to our customers throughout the region. In addition to practical application of this plan, NW Natural's senior management has been demonstrating leadership in stewardship for many years, even recognizing Environmental Stewardship as a core value.

Waste audits are conducted every 3-5 years in the Portland office to benchmark success of waste diversion and reduction processes. Additionally, programs and education are offered to all employees on the topic of waste reduction with regularity through intranet posts, special waste reduction challenges and sustainability lunch brownbag events.

Scope

This plan details practices for reduction and disposal of all waste streams (hazardous and non-hazardous) produced by NW Natural in all business operations and applies to all employees and contractors.

This plan covers both standard office operations and gas delivery as well as construction work managed by the Company. NW Natural works to reduce waste associated with processes whenever possible. Some limiting factors to further reduction include best practices in the areas of environmental management, health and safety. NW Natural will always prioritize operation in the manner that is most safe- this includes the use of one time use protective wear, site security and erosion prevention materials.

Waste Streams, Sources & Minimization/Disposal Strategy

NW Natural operates with best practices to produce the least waste possible without compromising quality and safety. Initiatives and policies support responsible purchasing, waste and resource use reduction. The company also works to responsibly dispose of or recycle those wastes which are produced necessarily. The annual waste footprint of NW Natural varies with the company's operational needs.

Non-hazardous Waste

The vast majority of NW Natural's waste streams fall under the category of Non-Hazardous. The types, sources and handling procedures of these waste streams are outlined in the table below.

Waste Type	Source(s)	Handling Procedure
Cardboard & Paper Products	• Office and print shop: generate paper waste and packaging waste. • Field Operations and Construction Packaging generate paper and cardboard waste.	• The company has Policies in place to reduce paper use through behavioral guidelines and default printer settings on all office computers. • Clean Paper and Cardboard is recycled at all NW Natural offices. This includes traditional office generated waste as well as construction packaging. • All NW Natural offices participate in paper and cardboard collection and recycling programs in standard operations
Metals	• Construction and Maintenance: Steel pipe, and other metal equipment or construction debris. • Field Services: retired meter sets Depressurized spray paint vessels • Offices: Aluminum and Tin can collection	• Pipe, meters and other scrap metals are collected, for recycling, at all office and construction sites in marked boxes and/or bins. Once full, NW Natural contacts hauler for collection. • Aluminum and tin cans are collected at all office sites in traditional municipal recycling. This stream is collected weekly by the contracted recycling hauler.
Plastics	• Polyethylene pipe • Equipment • Packaging • Plastic food and beverage containers	• Scrap and retired polyethylene piping is collected at construction sites and service centers in marked containers. When containers are full vendor is contacted to coordinate recycling. • All plastic equipment and packaging that is recyclable in the local municipality is separated and recycle pickup is coordinated weekly

		• Plastic food and beverage containers are collected and recycled at all NW Natural offices as part of single or mixed stream recycling programs.
Wood	• Pallets- used in bulk and equipment delivery • Construction & Demolition Surplus	• Pallets are collected and returned for reuse by vendor. • Wood not eligible for reuse will be transported to a facility for recycling.
Glass	• Facilities • Catering and break room - glass bottles and food containers	• Collect florescent light bulbs in centralized collection containers for recycling- (hazardous mercury collected-see next table). • Recycle glass bottles locally through municipal waste collection programs- regular hauler pick-up at all offices.
Liquids (non-hazardous)	• Automotive and equipment Paint (latex & oil based paints) • Automotive Oil • Pipeline Oil • Anti-Freeze	• Best practice is to use chemical products completely so no waste is generated. • Used paint thinner is collected and distilled for reuse. • Remaining chemical waste is classified and disposed of using certified vendor and landfill/ incinerator facility. • Used oil is collected and recycled using certified vendor • Used anti-freeze is recycled by vendor
Electronics	• Office & Field Equipment use of small and large electronic equipment for regular operations (computers, handheld data devices, GPS, printers, cellular phones, etc.)	• NW Natural collects and returns to vendor or certified recycler.
Organic Food & Plant associated	• Office Kitchen & Break-room wastes and Catering Wastes. • Greenspace clearing debris- limited.	• NW Natural participates in composting programs available in metro Portland. • Organic waste generated in areas without municipal compost are disposed of in the traditional solid waste stream.

Hazardous Waste

NW Natural's Environmental Management, Safety and Purchasing department have prioritized the purchase of nonhazardous and water based solvents and solutions whenever possible for more than 20 years.

The Chemical Safety Evaluation Committee (CSEC), chaired by Environmental Management staff and incuding members from both the Safety and Purchasing departments, determines if a proposed new

chemical is acceptable and beneficial for use in NW Natural operations. Chemicals are assessed based on the potential ecologial toxicity, worker health and safety critera, safety of storage and end of life disposal considerations.

The CSEC meets as needed to evaluate requests for new chemical use. It employs an online program for managing Saftey Data Sheets. Additionally, CSEC conducts periodic audits and inventories chemicals used in company facilities, in conjuction with a third party firm, to ensure the catalog of active chemicals in use at NWN is accurate and up to date.

Market availability is the limiting factor in almost all of our remaining hazardous waste streams. As new products become available, it may be possible to move toward the eventual goal of zero.

Waste Type	Source(s)	Handling Procedure
Chemical	• Automotive • Cleaning • Mercury containing items	• Best practice is to use chemical products completely so no waste is generated. • Used paint thinner is collected and distilled for reuse. • Remaining chemical waste is classified and disposed of using certified vendor and landfill/ incinerator facility.
Battery	• Facilities • Operations	• Batteries are collected at each facility and then recycled through a certified vendor.
Fluorescent Lamps	• Facilities	• Collect spent lamps and crush bulbs for glass recycling; Residual mercury is captured and disposed of as listed hazardous waste.
Liquids (Hazardous)	• Aerosol marking paint	• Collect residual waste paint from aerosol marking paint cans. • Waste paint is disposed of using certified vendor incinerator facility
Solid Waste (Hazardous)	• Liquefied Natural Gas (LNG) Plant(s) • Pipeline Contaminants	• Gas filters (Molecular Sieve Media) utilized at LNG Plants is replaced on an as-needed basis resulting in hazardous waste generation. Sieve media is disposed of at a certified waste disposal facility. • Pipeline Oil sludge and carbon black generated from pipeline maintenance is analyzed. If determined hazardous it is disposed of using a certified waste disposal facility.

Other Impact Reductions

Water Management Plan

Responsible water use is a priority in all construction and operational use.

Construction

NWN actively coordinates construction water use and sourcing with local water districts to ensure water is utilized with the least impact to both the environment and customers. This is especially key in dry and drought seasons.

When water is used on construction sites, NWN works to optimize water collection, reuse and recycling throughout the project whenever possible.

Automotive & Equipment Maintenance

All NW Natural auto garages comply with DEQ's EcoBiz Certification program. The EcoBiz program is composed of environmentally sustainable practices that are codified into legal requirements, best practices, and elective actions that support a sustainable workplace. Some of the compliance measures outlined in the EcoBiz program include waste minimization, waste collection, waste recycling, chemical storage, chemical reduction practices, sustainable purchasing protocols, waste water collection, and employee training.

Special Programs & Certifications

Eco-Biz Certification

All NW Natural Automotive Service Centers have attained Eco-Biz certification. The EcoBiz Maintenance Certification Program recognizes mechanical shops that reach the highest standards in minimizing their environmental impact. The goal of the program is to prevent and minimize pollution.

EPA Gas Star Program

NW Natural participates in the EPA Gas Star Program. This voluntary program applies to all sectors of the natural gas industry and provides industry best practices which NW Natural follows.

Sustainability at Work Gold Certification

NW Natural has been recognized by the City of Portland's Bureau of Planning and Sustainability as a Sustainable Workplace at the gold level. This certification is awarded to companies that achieve excellence in waste reduction, environmentally responsible practices, and employee programs.

Waste Minimization Responsibilities

Leadership

NW Natural officers are committed to Environmental Stewardship. The all-employee corporate expectations document is distributed to all staff (see attachment).

Environmental Management

In all areas of environmental compliance and voluntary management actions the Environmental Management department monitors and manages behaviors in construction, waste disposal, water use, erosion control, right of way maintenance, and other situational environmental issues.

All Employees: Best Practices

All NW Natural Employees are expected to operate with the core value of Environmental Stewardship in all work they do from office to field.

Green Team & Challenges

A volunteer group of employees, NW Natural's green team, implement voluntary programs including initiatives around waste stream management and resource utilization. All employees have the opportunity to participate in challenges to reduce their footprints.

NW Natural Environmental Stewardship

NW Natural's Sustainability Guidelines

NW Natural has been a regional leader on environmental policy for many years – from promoting energy efficiency to creation of the Smart Energy Program to advocacy on behalf of livability in the Pacific Northwest. As we help our customers use less energy and reduce their carbon footprint, we are setting sustainability expectations for ourselves, as well.

In the daily operation of our company, we have substantially cut back our use of toxic materials, and we are a regional utility leader in reducing our fleet's carbon emissions. Every facility remodel helps us better manage our energy use; every pipeline improvement reduces the potential for methane emissions, as well as safety hazards; and every construction project applies the best environmental practices we know of.

As with every aspect of our business, we comply with all laws and regulations governing environmental protection. But we don't stop at compliance – we constantly look for ways to do more than meet the requirements.

The ongoing challenge is to continuously find better methods to reduce the impact of our operations on the environment.

Environmental Stewardship is one of the company's core values. While company-wide policies, procedures and investments support this value, the steps you take each day at work can also make a great contribution to environmental protection.

The Green Team suggests these actions you can incorporate into your daily activities.

REDUCE, REUSE, RECYCLE at NW Natural.

Actions to reduce resource use, reuse materials and dispose of waste responsibly benefit more than the environment. Most sustainable practices are accompanied by cost savings and community benefits, so they are good for business from many perspectives. That's why it's valuable to apply these guidelines in all aspects of our work.

REDUCE. Of the "three R's," Reduce is the most important:

Be paper smart: Before you print, think about it. A digital file may be all you need. If you need a hard copy, use double-sided printing whenever possible, according to company policy. Many printers are set to use two sides of the paper automatically – set your computer to print on those printers. Also, make two-sided copies whenever possible. For more ways to reduce your paper use, check out NW Natural's **Paper and Printing Policies**. Find it on the Hub at **OurNWN>Culture & Community>Sustainability** and click on **Waste Reduction**.

Drive Mindfully: You have the opportunity to make environmentally responsible choices whenever you're in a vehicle. Every gallon of gasoline burned creates 20 pounds of carbon emissions. One easy way to use less fuel is to reduce the amount of time you spend idling in your car, truck or van. Learn more about the 2014 launch of the **idling reduction initiative** for our vehicle fleet. Find it on the Hub by visiting **OurNWN>Culture & Community>Sustainability**, then, click on **Field Operations**.

REUSE

Office Supply Collection & Reuse: Surplus and used office supplies can have a second life beyond your desk. Starting this summer, NW Natural's Green Team will set up collection stations for reusable office supplies. From staplers and scissors to file folders and binders, reuse can add up to savings.

Drink and eat responsibly: Avoid single-use beverage and food containers. Instead, grab a glass or mug from your break room. This summer, the ***Reduce, Reuse, Recaffienate*** initiative will focus on reducing the paper cup waste that happens in our coffee-crazed part of the world.

RECYCLE

Recycle and dispose of waste with care. We're fortunate to be in a region that values recycling and smart waste management. Recycling services are available everywhere NW Natural has operations. The City of Portland has the most extensive options for waste disposal in our service area, including compost collection. Use the resources available in your office and try to keep waste out of landfills. The company is rolling out **clearer signage** in 2014 to make the process even easier. Read more about this on the Hub at **OurNWN>Culture & Community>Sustainability** and click on **Waste Reduction**.

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Revised Exhibit H—Geologic Hazards Evaluation

North Mist Expansion Project
Columbia County, Oregon

for
NW Natural

November 6, 2015

GeoEngineers
Earth Science + Technology

Revised Exhibit H – Geologic Hazards Evaluation

North Mist Expansion Project
Columbia County, Oregon

for
NW Natural

November 6, 2015

GeoEngineers

1200 NW Naito Parkway, Suite 180
Portland, Oregon 97209
503.624.9274

Revised Exhibit H – Geologic Hazards Evaluation

North Mist Expansion Project
Columbia County, Oregon

File No. 6024-157-03

November 6, 2015

Prepared for:

NW Natural
220 NW 2nd Avenue, Suite 300
Portland, Oregon 97209

Attention: Michael Hayward

Prepared by:

GeoEngineers, Inc.
1200 NW Naito Parkway, Suite 180
Portland, Oregon 97209
503.624.9274

Brian C. Ranney, CEG
Senior Engineering Geologist

Expires 11/30/15

Douglas R. Schwarm, PE
Senior Engineer

Trevor N. Hoyles, PE
Principal

BCR:TNH:cje

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GLOSSARY OF ACRONYMS

ASCE: American Society of Civil Engineers

bgs: below ground surface

CEG: Certified Engineering Geologist

CRBG: Columbia River Basalt Group

CSZ: Cascadia Subduction Zone

DEM: Digital Elevation Model

DOGAMI: Oregon Department of Geology and Mineral Industries

EFSC: Energy Facility Siting Council

GIS: Geographic Information System

HDD: Horizontal Directional Drilling

LEG: Licensed Engineering Geologist

LiDAR: Light Detection and Ranging

mb: Body Wave Seismic Magnitude Scale

MCE: Maximum Considered Earthquake

Md: During Magnitude Seismic Scale

ML: Local Richter Magnitude Seismic Scale

MSL: above Mean Sea Level

MP: Mile Post

Ms: Surface Wave Seismic Magnitude Scale

NRCS: Natural Resources Conservation Survey

ODOE: Oregon Department of Energy

ORWD: Oregon Water Resources Department

OSSC: Oregon Structural Specialty Code

PE: Professional Engineer

PE: Probability of Exceedance

PGA: Peak Ground Acceleration

PGE: Portland General Electric

PSHM: Probabilistic Seismic Hazard Model

ROW: Right-of-Way

SLIDO: State Landslide Inventory Database

USGS: United States Geological Survey

H.1 INTRODUCTION

As described in Request for Amendment No. 11, NW Natural proposes to amend the Mist Facility's Site Certificate to expand the site boundary to develop new underground gas storage capacity through the development of the Adams reservoir, including construction of a new compressor station facility and new pipeline capacity. An approximately 12-mile-long, 24-inch-diameter natural gas pipeline and an approximately 2-mile-long utility conduit that will house power and communication cables will also be constructed as part of the project.

TABLE H-1. PROPOSED PIPELINE LENGTHS

Name	Length (feet)
North Mist Expansion Pipeline	**68,753 (total)**
North Mist Expansion 24-inch Pipeline, HDD Installation	24,498
North Mist Expansion 24-inch Pipeline, Open Trench Installation	44,255
Utility Conduit Trench	**11,564 (total)**
8-inch Utility Conduit installed in non-shared open trench	9,118
8-inch Utility Conduit installed in open trench shared with the 24-inch pipeline	2,446

In order to minimize impacts to natural resources and agricultural lands, a significant portion of the transmission pipeline will be installed utilizing horizontal directional drilling (HDD) methods. Approximately 35 percent of the pipeline is proposed to be installed by HDD method, with a total of nine bore pads within the Columbia River flood plain area. As the pipeline emerges from the agricultural area near the Columbia River, the final bore pad is proposed for location within PGE's PWIP property. The proposed pipeline, utility conduit and compressor station site are shown with respect to topography and the surrounding area in the attached Vicinity Map, Figure H-1.

GeoEngineers, Inc. (GeoEngineers) performed this evaluation to meet the Energy Facility Siting Council (EFSC) certificate application requirements for Exhibit H, as presented in Oregon Administrative Rule (OAR) 345-021-0010 (h)(1)(h) and OAR 345-022-020(1). Specifically, this exhibit satisfies subheading "A" of OAR 345-021-0010(1)(h), which requires a geologic report meeting the guidance of the Oregon Department of Geology and Mineral Industries (DOGAMI) Open File Report 00-04 (OFR 0-00-04, 2000). Where specific sections of this exhibit pertain to a sub heading of OAR 345-021-0010(1)(h), the administrative rule is listed in the section header. In addition, this revised exhibit addresses review comments provided by the Oregon Department of Energy (ODOE), and DOGAMI.

Pipeline route and compressor station site selection began in 2009. At that time, NW Natural was considering several options for pipeline routing, the main option being the installation of a pipeline between a well pad site and the compressor station, which included a proposed HDD installation beneath the headwaters of the Lindgren Creek Drainage. After investigation by GeoEngineers, Inc., it was determined that the proposed HDD was marginally feasible. NW Natural then identified a route that passed through the headwaters of the Graham Creek Drainage. NW Natural was initially considering crossing the Graham Creek drainage by installing the pipeline using HDD construction methods. However, it was determined that an HDD installation across the Graham Creek drainage was also not feasible. GeoEngineers, Inc. then evaluated an overland pipeline route across the Graham Creek drainage in 2013

and recommended re-routing the pipeline to avoid the Graham Creek drainage because the slopes within the drainage were very steep, and potentially unstable. GeoEngineers, Inc. continued to work with NW Natural in selecting the currently preferred route based on constructability and long-term stability.

H.2 GEOLOGICAL AND TOPOGRAPHIC FEATURES

Geologic and topographic conditions within the project area were initially evaluated using the following reference materials:

- Publications, including oil and gas investigations, published state of Oregon geological literature, DOGAMI and United States Geological Survey (USGS) bulletins and special papers, unpublished masters theses and doctoral dissertations and the applicable county soil survey.
- State water well logs.
- Geologic and topographic maps, including the State of Oregon Geological Map, oil and gas investigation mapping, unpublished mapping completed with doctoral dissertations and masters theses and the applicable topographic quadrangle for the project area.
- Stereo pairs of aerial photographs taken in 2001, provided by NW Natural.
- Light Detection and Ranging (LiDAR) based digital elevation models (DEM) of the site.

Detailed citations of these reference materials are included in the reference Section H.11 of this exhibit.

H.2.1 Geologic Conditions

H.2.1.1 Geologic Setting

The project is located within mountainous terrain of the Oregon Coast Range, and a relatively flat valley associated with the Columbia River. In Oregon, the Coast Range is a belt of moderately high mountains, extending along a north-south axis between the Columbia River and the Klamath Mountains. The core of this anticlinal structural chain is underlain by early Tertiary aged pillow basalts, lavas, and basalt breccias that were erupted underwater as oceanic islands. The flanks of the coast range are composed of marine sedimentary rocks that accumulated around the underwater oceanic islands. The volcanic and sedimentary rocks were later accreted onto the western edge of the North American continent by the subduction of the Juan de Fuca tectonic plate (Orr and Orr, 1999). During and after this accretion, the Columbia River cut through the Oregon and Washington Coast Range forming a river valley and associated broad alluvial plain that forms the northern border of the Oregon Coast Range Mountains.

Because of the presence of natural gas in economic quantities, Columbia County has been subject to several generations of geologic research. The understanding of rock units and structures has progressed from the earlier work of Warren and Norbisrath (1946); to more intensive study in the 1970s by Van Atta (1971), Niem and Van Atta (1973), and Newton and Van Atta (1976); through the master's theses of Kelty (1981), Kadri (1982), and Ketrenos (1986); and most recently to the compilations of Niem and others (1990, 1994). Geologic mapping has been aided by the large number of wells drilled and geophysical surveys conducted in support of natural gas exploration.

H.2.1.2 Stratigraphy

In the Mist area, basement rocks of the Tillamook Volcanics (upper to middle Eocene (which are chemically equivalent to the Grays River Volcanics in the site area [Niem, Snavely and Niem, 1990]), remnants of a large mid-ocean volcanic complex, are overlain by several thousand feet of marine sedimentary rocks deposited on the emerging continental shelf. Deep in that sequence, shallow-marine to deltaic sandstones of the Cowlitz Formation (upper Eocene) are the primary hydrocarbon reservoir rocks. Fine-grained sediment layers in the upper Cowlitz and the overlying Keasey Formation form the cap to the reservoir rocks. These sediments are in turn overlain by the Grays River Volcanics. Shallow marine sedimentary rocks of the Pittsburg Bluff Formation and Scappoose Formations overlie the Grays River Volcanics. Basalts belonging to the Columbia River Basalt Group (CRBG) and the Grays River Volcanics overlie and are interfingered with the marine sedimentary rocks.

A geologic map of the site is provided in Figures H-2 through H-8. We utilized geologic mapping produced by the DOGAMI Oregon Geologic Mapping compilation, Version 5 (DOGAMI, 2009) to evaluate and describe geologic materials in the near vicinity of the project.

The project area is underlain chiefly by six major geologic units:

- Quaternary Alluvium (Qal)
- Quaternary Landslide Debris (QLS)
- CRBG (Tco, Twfs, Tgr1, Tgr2)
- Scappoose Formation (Tso, Ts1, Ta)
- Pittsburg Bluff Formation (Tc, Tpb, Tpbcc, Tps)
- Grays River Volcanics (Tgrv)

In general, the oldest mapped rocks of the site area are the Grays River Volcanics. These volcanic rocks are overlain by the Pittsburg Bluff Formation rocks. The younger Scappoose Formation rocks are valley fill sediments cut into the older Pittsburg Bluff Formation. The CRBG overlies, and in some cases are interfingered with these sedimentary rocks. Quaternary-aged landslide debris is mapped capping the CRBG in a portion of the uplands area of the proposed pipeline alignment and proposed compressor station site. Quaternary-aged alluvium derived from deposition by the Columbia River is the youngest mapped formation in the area. These geologic materials are described in more detail in the “Site Geology” Section H.2.1.4 of this exhibit.

H.2.1.3 Geologic Structure

The Mist area, including the project site, is located on the Nehalem Arch, a high area formed in the basement Tillamook Volcanics connecting the Willapa Hills and Northern Coast Range uplifts (north and south, respectively), and separating the sediment-filled Nehalem and Astoria forearc basins (east and west, respectively) (Niem and others, 1994). The Mist area is a relatively low saddle in the Nehalem Arch. In the Miocene epoch flood basalts of the CRBG, sandstone and siltstone sediments were transported west and the Mist Saddle area was still low enough to receive these Scappoose sediments and flood basalts. The latest uplift of the Coast Range occurred in the late Neogene period.

Numerous faults have been identified in the Mist area; many are older faults dating from a late Eocene (pre-Keasey Formation) period of tectonism and not exposed at the surface. The closest active fault mapped by the USGS (2009) is the Gales Creek Fault Zone, which is located approximately 20 miles south of the site. A series of mostly northwest-southeast and west-east normal faults cut across the Nehalem Arch, forming the Nehalem graben, generally coincident with the Nehalem River valley between the cities of Mist and Birkenfeld (Niem and others, 1990). Disruption of rock layers along faults causes zones of weakness that are exploited by erosion, commonly becoming stream valleys; a fault seems to be responsible for the valley of Lindgren Creek near the project area (Ketrenos, 1986).

In general, major strata in the area are only gently deformed. Ketrenos (1986) stated that dips in bedding planes in the younger rocks are generally about 5 to 10 degrees to the northwest, whereas mapped dips in the older strata can be up to about 30 degrees (e.g., Newton and Van Atta, 1976; Kelty, 1981). But attitudes can change within short distances, particularly around faults. The extensive old faulting in the area has also probably contributed to local fault-zone deformation.

H.2.1.4 Site Geology

The following paragraphs describe the major geologic units and their mapped locations relative to the proposed compressor station site, pipeline and utility conduit alignments.

QUATERNARY ALLUVIUM

Quaternary-aged alluvium (Qal) fills the Columbia River valley, north of Highway 30, between approximate pipeline mileposts (MP) 7.5 and MP 12.2, the northern terminus of the pipeline. The Quaternary alluvium consists of unconsolidated silt, sand and gravel deposited by the Columbia River.

LANDSLIDE DEBRIS (QUATERNARY)

Quaternary aged landslide debris (Qls) is mapped extensively in the mountainous terrain south of Highway 30. The proposed compressor station and Adams well pad are situated on this unit. The proposed pipeline crosses this unit approximately between MP 0 and MP 1.35, as shown in Figures H-2 and H-3. The proposed utility conduit crosses this unit between MP 0 and MP 0.9, and approximately between MP 1.1 and MP 1.35. The landslide debris is described as mixed grain sediments derived from landslide deposition (DOGAMI, 2009). Based on interpretation of LiDAR generated hillshade model of the area, the mapped extent of the landslide debris does not accurately represent discrete landslide boundaries. Discrete landslides identified in this study (based on site-specific aerial photograph and LiDAR DEM interpretation) are shown in Figures H-2 through H-5 and discussed in more detail in Section H.7.4 of this exhibit.

COLUMBIA RIVER BASALT GROUP (MIDDLE MIOCENE)

Basalts belonging to the CRBG (Tco, Twfs, Tgr1, Tgr2) are mapped approximately between MP 1.35 and MP 1.8, and MP 5.75 and MP 6.95 of the proposed pipeline alignment. The CRBG includes several sub-aerial basalt flows erupted from fissures near the Oregon-Idaho-Washington border. The individual flows within the group have been differentiated by many geologic studies and mapping projects in the Pacific Northwest. To be consistent with the mapped geology obtained from DOGAMI (DOGAMI, 2009) we did not attempt to differentiate individual flows further than DOGAMI's compilation mapping. In general, the CRBG rocks consist of dark-gray to black, aphanitic basalt with some localized breccias and pyroclastics. The CRBG overlie and are interbedded with sandstone and siltstone of the Scappoose and Pittsburg Bluff Formations. Ketrenos (1986) notes that on the east side of the Mainline Road in the project area, the

CRBG rocks overlie and are interbedded with Scappoose Formation sediments; to the west of the Mainline Road, the basalts lie directly on Pittsburg Bluff rocks (Ketrenos, 1986).

SCAPPOOSE FORMATION (EARLY TO MIDDLE MIOCENE)

The Astoria Group of the Scappoose Formation (TA, Tso, Ts1,) is mapped between MP 1.8 and MP 3.2, and MP 4.05 and MP 5.75 of the proposed pipeline, and between MP 0.9 and MP 1.0, and MP 1.35 and MP 2.2 of the proposed utility conduit. The Astoria Group includes shallow marine micaceous sandstone and carbonaceous siltstone that have been mapped and described in various geologic maps and texts (Schlicker et al., 1972; Niem and others, 1990). The Scappoose Formation includes fluvial, lacustrine, deltaic, and estuarine facies that generally represent a large valley fill deposited on an eroded surface cut into Pittsburg Bluff and older rocks.

PITTSBURG BLUFF FORMATION (OLIGOCENE)

The Pittsburg Bluff Formation (Tps, Tpbcc, Tpb, Tc) is mapped approximately between MP 3.2 and MP 4.05, and MP 6.95 and MP 7.02 of the proposed pipeline alignment, and between approximately MP 1.0 and MP 1.1 of the proposed utility conduit. The Pittsburg Bluff rocks are typically tuffaceous and arkosic sandstones, locally glauconitic and fossiliferous, with lesser tuffaceous siltstone, claystone, and coal. They were deposited in marine to deltaic waters that appear to have been becoming shallower with time; ultimately, the area rose above sea level, and there is an erosional unconformity between the top of the Pittsburg Bluff Formation and overlying strata.

GRAYS RIVER VOLCANICS (LATE EOCENE TO EARLY OLIGOCENE)

The Grays River Volcanics (Tgrv) are mapped approximately between MP 7.02 and MP 7.5 along the proposed pipeline alignment. These volcanic rocks form a prominent cliff adjacent to the south side of Highway 30 where the proposed pipeline crosses Highway 30. The Grays River Volcanics are an assemblage of volcanic units that were erupted within the Cascadia forearc basin. They generally consist of greater than 3,500 meters of submarine and subaerial basalt flows and volcanoclastic rocks. In the vicinity of the project area, the Grays River volcanics consist of blocky to columnar jointed dark gray to black basalt.

H.2.1.5 Geologic Unit Stability

In general, geologic units within the project area appear to be relatively stable but are prone to landsliding, as is typical in the northern Oregon Coast Range. Based on the distribution of mapped landslides in the area (See Figures H-2 through H-15), the sedimentary units (Pittsburg Bluff Formation, Scappoose Formation) appear to be less stable than the volcanic geologic units (Grays River Volcanics, CRBG). Most of the landslides mapped in the project area are associated with drainage slopes greater than 50 percent, or occur at the contact of sedimentary units and the overlying volcanic units, where differential erosion leads to the over-steepening of slopes within the sedimentary units. Areas where slope gradients are less than 50 percent, ridge tops and the volcanic geologic units appear to be the most stable areas within the project area.

H.2.1.6 Soil

Shallow subsurface soil conditions in the project vicinity are identified by the U.S. Department of Agriculture Natural Resources Conservation Survey (NRCS) web soil maps (NRCS, 2014) and the Soil Conservation Service (SCS) Soil Survey of Columbia County (Smythe, 1986). The survey describes soil conditions in the upper 5 feet of the subsurface profile and classifies land use. Thirteen soil units were

identified by the SCS within the North Mist Expansion Project area. Soils defined as "protected" are protected against flooding by either a dike or dredge material. A general description of each soil unit is provided in Table H-2 below. Exhibit I provides a more detailed assessment of soil conditions within the project area.

TABLE H-2. SOIL UNIT DESCRIPTIONS

Soil Unit	Setting Within Project Location	Approximate Thickness	Formation Setting	Permeability	Runoff	Hazard for Erosion
Alstony Gravelly Loam	Moderate to steep slopes at higher elevations near ridge tops	2 feet	Colluvium derived from volcanic rocks and ash	Moderate	Very Rapid	High
Anunde Silt Loam	Gentle to moderate, stable, convex slopes	At least 5 feet	Colluvium derived from siltstone mixed with volcanic ash	Moderate	Rapid	High
Braun-Scaponia Silt Loam	Gentle to steep, active and stable, convex slopes	2.5 feet	Colluvium derived from siltstone	Moderate	Medium to rapid	High
Caterl Gravelly Silt	Moderate slopes	3.5 feet	Colluvium derived from igneous rock mixed with volcanic ash	Moderate	Rapid	High
Crims Silt Loam, Protected	Concave areas of low flood plains of the Columbia River	At least 5 feet	Partially decomposed plant material	Moderate	Slow	Slight
Locoda Silt Loam, Protected	Flood plains of the Columbia River	1 foot	Alluvium from mixed sources	Moderately slow	Slow	Slight
Murnen Silt Loam	Gentle to moderate, ridge tops and side slopes	4 feet	Colluvium and residuum derived from basalt mixed with volcanic ash	Moderate to high	Medium to rapid	Moderate to high
Scaponia-Braun Silt Loam	Active north and south convex slopes	3 to 5 feet	Colluvium derived dominantly from siltstone	Moderate	Very rapid	High

Soil Unit	Setting Within Project Location	Approximate Thickness	Formation Setting	Permeability	Runoff	Hazard for Erosion
Tolke Silt Loam	Broad stable ridge tops and on gentle to moderate side slopes	5 feet	Volcanic ash and colluvium derived from siltstone and shale	Moderate	Medium to rapid	Moderate to high
Udipsamments, Protected	Flood plains of the Columbia River	At least 5 feet	Sandy dredge material	Rapid to very rapid	Slow	Slight to moderate
Wauld Very Gravelly Loam	Moderate to steep active side slopes	3 feet	Colluvium derived from basalt	Moderate	Rapid	High
Wauna Silt Loam, Protected	On flood plains of the Columbia River	At least 5 feet	Alluvium from mixed sources	Moderately slow	Slow to ponded	Slight
Wauna-Locoda Silt Loam	Flood plains of the Columbia River	At least 5 feet	Alluvium from mixed sources	Moderately slow	Slow to ponded	Slight

H.2.1.7 Groundwater

Regional groundwater is located from fewer than 10 feet below the ground surface (bgs) in the Columbia River valley north of Highway 30 to hundreds of feet bgs in mountainous terrain south of Highway 30 in the project area. Elevations within the project area range between about Elevations 0 feet above mean sea level (MSL) and 1,850 feet MSL. A well log obtained from the Oregon Water Resources Department (OWRD) for a water well drilled at the Miller Station compressor station indicated a static groundwater level of 188 feet beneath the surface (OWRD, 2009). Miller Station is located roughly 3 miles south of southern end of the project area, at an elevation of roughly 1,050 feet MSL. Localized perched groundwater may exist in the upland area of the project site.

Groundwater levels were interpreted within borings completed in the Columbia River valley at depths ranging from approximately 2 to 14 feet bgs, which generally correlates with an elevation of the nearby Columbia River. However, during flooding conditions on the Columbia River, or during heavy prolonged precipitation, groundwater will be located at the ground surface within the low-lying valley north of Highway 30. Static groundwater was not encountered in borings completed at the proposed compressor station site. Groundwater levels will fluctuate with precipitation, site utilization and other factors.

H.2.2 Topography

H.2.2.1 General

Regional topographic conditions along the proposed pipeline and utility conduit routes are shown in Figure H-1. Slope gradients in the project area are shown in Figures H-16 through H-22. The proposed North Mist Pipeline route starts at the proposed compressor station at the south end of the project, traverses mountainous terrain northward to the Columbia River valley north of Highway 30, and then traverses the relatively flat Columbia River valley to an existing PGE power facility in Port Westward,

Oregon. The proposed utility conduit route starts at the proposed compressor station and continues southward along mostly existing gravel roads through rugged terrain to an existing utility junction box.

H.2.2.2 North Mist Pipeline

Beginning at the proposed compressor station site, at an elevation of roughly 1,300 feet MSL, the proposed pipeline alignment climbs moderate to steep slopes cross country between MP 0 and MP 0.5 to an elevation of 1,580 feet MSL. At MP 0.5 the alignment follows an existing gravel road and pipeline right-of-way (ROW) traversing moderately steep side-slopes to a maximum elevation of about 1,800 feet MSL at MP 1.65, where it then leaves the road, climbs a moderate slope to an elevation of about 1,840 feet MSL and then traverses a west facing slope to about MP 2.0. The alignment then descends moderately steep slopes to an existing road at MP 2.4. Between MP 2.4 and MP 2.8, the pipeline follows a gravel road traversing moderately steep side slopes, crossing a drainage, which is a tributary of Graham Creek. At this point, the alignment leaves the gravel road, but continues to traverse moderate steep side slopes just west of the gravel road to an elevation of about 1,440 feet MSL at about MP 3.0. The alignment then descends cross country between MP 3.0 and MP 3.4 along moderate slopes, predominately along the crest of a ridge to an elevation of about 1,060 feet MSL. From MP 3.4 to MP 7.0, the alignment generally follows an existing gravel road around the headwall of a tributary of Graham Creek, and then gradually descends gentle slopes along a broad ridge top, mostly following existing gravel and paved roadways, before descending the southern Columbia River Valley wall along Palm Hill Road to about MP 7.47, at an elevation of about 200 feet MSL. Between MP 7.47 and roughly MP 7.5, the pipeline alignment descends a cliff (by way of an HDD) adjacent to Highway 30. The proposed HDD exits on the relatively flat Columbia River valley at an elevation of about 0 feet MSL at about MP 7.5. Between MP 7.5 and the end of the pipeline at MP 12.2, the pipeline traverses cross-country across the relatively flat Columbia River valley, crossing the Clatskanie River and several sloughs within the valley to the existing PGE power generation facility near the southwest bank of the Columbia River.

H.2.2.3 North Mist Pipeline Compressor Station

The proposed North Mist Pipeline Compressor Station site is located on gentle slopes along a broad mid-slope bench with elevations ranging from approximately 1,285 feet above MSL in the southwest corner of the site to approximately 1,320 feet above MSL on the eastern border of the site.

H.2.2.4 Utility Conduit

The proposed utility conduit leaves the proposed compressor station site (approximate elevation 1,300 feet MSL) and is co-located with the proposed pipeline alignment to approximate MP 0.52. From MP 0.0 to MP 0.52, the utility conduit route climbs cross country through densely vegetated mountainous terrain to an existing gravel road at an elevation of approximately 1,500 feet MSL. The proposed utility conduit route then turns southwest and follows an existing road to about MP 0.75, where the route then follows a power line corridor along a ridgeline to about MP 0.98 where it again meets up with an existing gravel road at an elevation of about 1,320 feet MSL. The proposed utility conduit route then traverses steep mountainous terrain as it follows a gravel road to the southern end of the proposed utility conduit route at an elevation of about 1,280 feet MSL. Between MP 1.0 and the southern terminus of the route at approximately MP 2.2, the gravel road and utility conduit route generally traverses steep, west to southwest facing slopes.

H.3 DESCRIPTION OF SITE-SPECIFIC GEOTECHNICAL WORK [OAR 345-021-0010 (h) (1) (h) (B)]

GeoEngineers, Inc. completed site-specific geotechnical work for the project, including a subsurface exploration program for the proposed compressor station and HDD alignments, a site reconnaissance of proposed pipeline and utility conduit routes, HDD alignments and facility locations, and laboratory testing and geotechnical analysis. Borings completed along the proposed alignment are shown in Figures H-2 through H-8. The results of geotechnical work associated with the proposed North Mist Expansion Project Compressor Station site are presented in a geotechnical report titled, "Revised Preliminary Geotechnical Evaluation, North Mist Compressor Station," dated September 18, 2015.

GeoEngineers, Inc. completed a final HDD design report for the eight proposed HDD installations titled "Geotechnical Engineering and HDD Design, North Mist Pipeline, Columbia County, Oregon," dated September 18, 2015.

The preliminary geotechnical report for the proposed compressor station site and the final HDD design report are included in Appendices H-C and H-D, respectively.

H.4 EVIDENCE OF CONSULTATION [OAR 345-021-0010 (h) (1) (h) (C)]

In preparing this Exhibit, GeoEngineers consulted with the Oregon DOGAMI and reviewed DOGAMI publications and guidance documents, as listed in the reference section of this exhibit.

Bill Burns, RG, CEG of DOGAMI, (Personal Communication, 2015) was contacted regarding this geologic hazard study, as required by OAR 345-021-0010(1)(h)(C). During the discussion with Mr. Burns, GeoEngineers, Inc. reported the general approach to evaluating geologic hazards for the project, including LiDAR interpretation to identify/evaluate landslides and the site-specific hazard study that was conducted for the project. Site-specific geotechnical work that has been completed thus far for the project was also discussed. Although Mr. Burns concurred with the proposed approach, he requested that recommendations for future landslide evaluations, if necessary, be included in this exhibit. Mr. Burns also requested that NW Natural forward future geotechnical studies that are completed for the project, particularly for landslide evaluations, to DOGAMI. NW Natural will continue engaging with DOGAMI prior to and/or after submittal of the Request for Amendment No. 11. A copy of an email confirming the discussions with Bill Burns of DOGAMI is provided in Appendix A of this exhibit.

H.5 PROPOSED SITE-SPECIFIC GEOTECHNICAL WORK FOR PIPELINES [OAR 345-021-0010 (h)(1) (h) (E)]

As summarized in this Exhibit, geologic hazards were not identified along the proposed pipeline route that would require further geotechnical study for the purposes of evaluating or mitigating risk to the utility conduit or the pipeline. However, as summarized in the potential adverse impacts to Slope Stability Section H.7.4.3 in this exhibit, there may be areas where grading may require cuts and fills along the utility conduit or the pipeline ROW in order to install these facilities adjacent to existing roads.

Based on the results of the evaluations and analyses supporting this Exhibit H, the following geotechnical work will be completed prior to construction of the compressor station, pipeline and utility conduit. NW

Natural proposes that the final scope of these studies will be determined by NW Natural's geotechnical consultants and confirmed by ODOE in consultation with DOGAMI. The studies will address the following:

- Production of civil site plans for the proposed compressor station, and the utility conduit and pipeline alignments ROW. The civil site plans will include existing topography, proposed grading (cuts and fills), alignment of the utility conduit and pipeline, existing utilities, culverts or other site features within the ROWs, and final positioning of equipment within the compressor station.
- Site-specific geotechnical studies will be conducted for proposed cut and fill slopes along the pipeline and utility conduit alignments once civil site plans have been developed and site grading has been delineated. The site-specific geotechnical studies will include slope stability analyses (as needed) to provide recommendations to mitigate potential adverse impacts to slope stability that may result from cutting into hillsides adjacent to the existing roadways. The study will include recommendations for restoring site grades to pre-construction conditions. Recommendations for engineered fill slopes will include specifications for materials to be used, adequacy of native soils to be used as fill, lift thickness, and compaction criteria for wet and dry weather conditions.
- A site-specific geotechnical evaluation will be prepared for development of the compressor station site once site grading and final facility locations are determined. Additional borings will be completed to define geotechnical conditions at the proposed equipment locations at the site once the final layout of equipment is known. In addition, if cuts and fills greater than 5 feet are anticipated, additional borings will be completed in cut and fill slope locations to evaluate the stability of cut and fill slopes. The final geotechnical engineering report will include:
    - Additional mapping and characterization of the landslide deposit identified at the compressor station site. The landslide deposit characterization will define the vertical limits of the landslide deposits within the compressor station site (based on subsurface investigation and interpretation by an engineering geologist);
    - Slope stability analyses for cut and fill slopes, and the effect cut and fill slopes may have on the stability of the larger landslide deposit that the compressor station will be sited on;
    - Conclusions and recommendations for cut and fill slope stability;
    - Foundation settlement conclusions (particularly in the vicinity of borings ACSB-2 and ACSB-4 where low standard penetration test (SPT) blow count loose sands were documented);
    - Discussion of the high soil moisture contents observed in borings completed at the site; and
    - Conclusions/recommendations for utilization of on-site materials as structural fill, recommendations for imported structural fill, placement of fill on slopes, erosion protection of cut and fill slopes, excavation considerations, compaction of fill materials, gravel and/or paved roadways and surface, drainage considerations, seismic design criteria.
- Evaluation of the two landslides identified along the utility conduit alignment (Landslides 3-042-030-A and 3-042-031-A) will be completed in order to better define risk to the adjacent logging road and utility conduit, and to evaluate potential road stabilization options to be discussed with the road owner. NW Natural will provide a report of this evaluation to ODOE prior to construction.

H.6 ASSESSMENT OF SITE-SPECIFIC SEISMIC HAZARDS [OAR 345-021-0010 (h)(1) (h) (F)]

H.6.1 Historical Seismicity [OAR 345-021-0010 (h) (1) (h) (F) (iii)]

Tables H-B.1 and H-B.2 in Appendix B provide a list of recorded earthquakes that have epicenters within 50 miles of the compressor station and pipeline alignment. Also in the list are observed earthquakes that caused ground shaking along the alignment that exceeded Modified Mercalli Intensity III (USGS, 2009). Table H-B.3 in Appendix B provides an additional list of recorded earthquakes within 50 miles of the site with a reported magnitude greater than 3.0 that occurred between July 1974 and September 2015, excluding events associated with volcanic activity near Mount Saint Helens (USGS, 2015).

Reported magnitudes use a variety of scales including surface waves (Ms), body waves (mb), duration magnitude (Md), or local Richter magnitude (ML). The location of earthquakes with reported magnitude values listed in Tables H-B.1, H-B.2 and H-B.3 are shown with respect to the compressor station site and pipeline alignment in Figure H-23.

During site reconnaissance, general observations were conducted by GeoEngineers, Inc. to evaluate the presence of structural features such as faulting and other discontinuities that may be indicative of historical seismicity at the compressor station site or along the pipeline and utility conduit alignments. Faults in outcrops, distinct topographic lineations, vegetation patterns or surface water patterns that would indicate historical seismicity at the compressor station site or along the pipeline or utility conduit alignments were not identified. In addition, indications of tsunami activity along the pipeline alignment within the Columbia River flood plain north of Highway 30 were not identified.

H.6.2 Contributing Earthquake Sources [OAR 345-021-0010 (h) (1) (h) (F) (ii)]

Seismic hazard deaggregations were performed for the 4,975-year, 2,475-year and 475-year hazard levels for rock outcrop condition (i.e. Vs30 = 760 m/s) using the 2008 USGS Probabilistic Seismic Hazard Model (PSHM) at the compressor station site, pipeline MP 6.1 and milepost 12.1. Figures H-24 through H-32 show the deaggregations obtained from the USGS. The 475-year motion corresponds to a 10 percent probability of exceedance (PE) in 50 years. The 2,475-year motion has a 2 percent PE in 50 years, and the 4,975-year motion has a 1 percent PE in 50 years. Deaggregations were also performed for the 2,475-year hazard level at half-mile increments along the full 12.5-mile-long alignment to evaluate changes in fault influence and ground motion in support of the liquefaction triggering analyses described in a subsequent section of this exhibit.

The 2014 USGS probabilistic seismic hazard mapping, which maps the expected 475-year and 2,475-year peak ground acceleration (PGA) throughout the United States, was reviewed for a comparison to the 2008 model. As explained later in this section, the 2014 mapping provides similar probabilistic PGA results as the 2008 model. Because the 2008 model can be utilized to provide probabilistic results for a specific site by latitude and longitude rather than a general area like the 2014 hazard mapping, the evaluation below was performed utilizing the 2008 probabilistic seismic hazard model.

The seismic deaggregation results show that the dominant seismic hazard sources for the 475-year, 2,475-year and 4,975-year earthquake levels are the magnitude (M)8.0 to M9.0 Cascadia Subduction Zone (CSZ) interface events, M6.8 to M6.9 deep intraplate earthquakes, and M6.0 to M6.2 crustal earthquakes from background seismicity that is associated with gridded crustal fault sources of non-discrete origin. In general, fault distances for CSZ and deep intraplate fault sources identified by the

PSHM were closest to the compressor station site and became more distant as the analysis moved northward along the pipeline alignment to PGE's PWIP property near the Columbia River. The distance to gridded crustal sources remains essentially constant across the alignment for each hazard level, as would be expected for a deliberately distributed seismic source. The calculated distance of gridded crustal sources is placed closer to the site as the hazard level increases.

An overview of the range of distance-magnitude pairs and percent contribution to the seismic hazard described within the seismic deaggregation at the southern and northern extremities of the alignment for all principal sources of seismicity is presented in Tables H-3 through H-6.

TABLE H-3. SUMMARY OF USGS SEISMIC HAZARD DEAGGREGATION FOR 475-YEAR HAZARD LEVEL

Fault Source	Distance Range From Site (miles)	Magnitude	Percent Contribution to Hazard[1]
Cascadia M8.0 – M8.2 Floating	39.7 – 43.8	8.10	5.75 – 5.02
Cascadia M8.3 – M8.7 Floating	38.3 – 42.56	8.50 – 8.51	23.21 – 20.81
Cascadia Megathrust	19.5 – 21.0	9.00	33.73 – 31.44
Western US Gridded Crustal	10.1 – 10.0	6.01 – 6.03	8.79 – 8.59
50-kilometers (km) Deep Intraplate	48.5 – 49.3	6.81 – 6.76	27.26 – 31.41

Note:

[1] The percent contribution to hazard describes the relative contribution of the predicted ground motion from an individual fault source to the total seismic hazard for a given return period.

TABLE H-4. SUMMARY OF USGS SEISMIC HAZARD DEAGGREGATION FOR 2,475-YEAR HAZARD LEVEL

Fault Source	Distance Range From Site (miles)	Magnitude	Percent Contribution to Hazard[1]
Cascadia M8.0 – M8.2 Floating	32.8 – 37.7	8.11	4.47 – 3.89
Cascadia M8.3 – M8.7 Floating	33.0 – 37.8	8.52	25.64 – 23.15
Cascadia Megathrust	32.4 – 37.1	9.01	51.94 – 49.27
Western US Gridded Crustal	5.7	6.15 – 6.13	4.96 – 5.74
50-km Deep Intraplate	39.3 – 40.8	6.89 – 6.86	12.46 – 16.20

Note:

[1] The percent contribution to hazard describes the relative contribution of the predicted ground motion from an individual fault source to the total seismic hazard for a given return period.

TABLE H-5. SUMMARY OF USGS SEISMIC HAZARD DEAGGREGATION FOR 4,975-YEAR HAZARD LEVEL

Fault Source	Distance From Site (miles)	Magnitude	Percent Contribution to Hazard[1]
Cascadia M8.0 – M8.2 Floating	31.3 – 36.2	8.11	3.85 – 3.32
Cascadia M8.3 – M8.7 Floating	31.8 – 36.6	8.53	25.36 – 22.96
Cascadia Megathrust	31.6 – 36.4	9.01	57.96 – 55.63
Western US Gridded Crustal	5.0 – 4.8	6.20 – 6.18	3.92 – 4.95
50-km Deep Intraplate	37.2 – 38.4	6.91 – 6.89	8.49 – 11.58

Note:

[1] The percent contribution to hazard describes the relative contribution of the predicted ground motion from an individual fault source to the total seismic hazard for a given return period

In addition to fault hazards returned by the seismic deaggregation results, eleven crustal faults capable of generating strong ground motion were identified by the USGS Quaternary Fault and Fold Database (USGS, 2012) within 50 miles of the compressor station site and pipeline alignment. Many of these faults are considered within the PSHM. A summary of Quaternary faults within 50 miles of the compressor station site and pipeline alignment is provided in Table H-6 and shown with respect to the site in Figure H-24. Fault source parameters were obtained from the documentation for the 2008 Update of the United States Seismic Maps (Petersen and others, 2008), or are otherwise referenced below Table H-6.

As shown in the table below, the closest mapped active fault to the site is the Gales Creek Fault Zone. DOGAMI representatives requested that GeoEngineers, Inc. contact Dr. Ray E. Wells of the USGS who has been conducting research on the fault for over 20 years to determine if any relevant unpublished hazard information is available. GeoEngineers, Inc. attempted to contact Dr. Wells via telephone on September 9, 2015 and September 11, 2015 (personal communication, 2015a) and via email on September 15, 2015 (personal communication, 2015b); however, Dr. Wells was not reached by the time of issuance of this exhibit.

TABLE H-6. QUATERNARY FAULTS WITHIN 50 MILES OF SITE

Fault Source	Nearest Distance to Site (miles)	Fault Length (km)	Maximum Magnitude	Vertical or Horizontal Slip Rate (mm/year)
Gales Creek Fault Zone	18.7	27	6.75	0.016
Portland Hills Fault	27.4	50	7.05	0.1
Helvetia Fault	33.5	14	6.4	0.014
East Bank Fault[1]	36.5	29	N/A	< 0.2
Oatfield Fault[2]	38.5	29	N/A	< 0.2
Willapa Bay Fault Zone[3]	38.7	37	N/A	0.2 – 1.0
Newberg Fault	41.0	34	6.85	0.016
Beaverton Fault Zone[4]	41.5	15	N/A	< 0.2
Lacamas Lake Fault	44.3	24	6.67	0.026
Tillamook Bay Fault Zone[5]	44.4	32	N/A	< 0.2
Nehalem Bank Fault[6]	48.8	101	N/A	1.0 – 5.0

Notes:

[1] Personius, S.F., compiler, 2002, Fault number 876, East Bank fault, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 09/10/2015.

[2] Personius, S.F., compiler, 2002, Fault number 875, Oatfield fault, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 09/10/2015.

[3] McCrory, P.A., compiler, 2003, Fault number 592, Willapa Bay fault zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 09/10/2015.

[4] Personius, S.F., compiler, 2002, Fault number 715, Beaverton fault zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 09/10/2015.

[5] Personius, S.F., compiler, 2002, Fault number 881, Tillamook Bay fault zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 09/10/2015.

[6] Personius, S.F., compiler, 2002, Fault number 789, Nehalem Bank fault, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 09/10/2015 06:36 PM.

mm = millimiters

H.6.2.1 Crustal Seismicity

Comparison of the distance of Quaternary faults and gridded crustal faults provided by the PSSM to the compressor station site and pipeline alignment suggests that fault sources provided by the PSHM are generally closer and yields more conservative estimate of the crustal seismic hazard. Gridded crustal seismicity presented within the PSHM provides distance-magnitude pairs of (10.0 miles, M6.01)

(5.7 miles, M6.15) and (4.8 miles, M6.20) for the 475-year, 2475-year and 4975-year hazard levels respectively. While the Gales Creek Fault Zone and Portland Hills Fault are estimated as capable of delivering maximum earthquake magnitudes of M6.75 and M7.05, both faults range from approximately 2 to 5 times farther from the site than the PSHM derived crustal seismicity from the 475-year to 4,975-year hazard level.

H.6.2.2 Cascadia Subduction Zone (CSZ) Seismicity

Most of the seismic hazard is from potential CSZ interface events and deep intraplate earthquakes. At the 475-year hazard level, deep intraplate events pose up approximately 30-percent of the hazard described by the PSHM, whereas combined CSZ interface events presents approximately 60 percent of the described hazard. The influence of the CSZ becomes even more dominant at the 2,475-year and 4,975-year hazard levels. As the USGS PSHM provides spectral acceleration parameters based on the most severe ground motion, the PSHM provides a reasonable and conservative description of contributing earthquake sources and ground motion parameters. Past comparisons of crustal, intraplate and CSZ interface estimated PGAs at Astoria, Oregon and Portland, Oregon agree well with the conclusion that CSZ interface events will likely dominate deep intraplate seismicity (Geomatrix, 1995).

H.6.3 Median Ground Response Spectrum [OAR 345-021-0010 (h) (1) (h) (F) (i) and (iv)]

Site response is only necessary for design of structures, which for this project is limited to equipment installed on shallow pads at the compressor station. Pipeline design does not use acceleration response spectra. For this reason, analysis of dynamic site response parameters is limited to the compressor station at the south end of the pipeline.

Table H-7 presents the parameters for the median ground response spectrum from the MCE_R as defined by the American Society of Civil Engineers (ASCE) 7-10. The parameters provided in Table H-7 are based on the conditions encountered in the borings drilled at the compressor station. Site Class D was determined using penetration resistances measured in the borings and the procedure in ASCE 7-10 Chapter 20.

TABLE H-7. COMPRESSOR STATION SEISMIC DESIGN PARAMETERS

Parameter	Short Period (T_s = 0.2 sec.)	1 Second Period (T_1 = 1.0 sec.)
Mapped Spectral Acceleration Parameter	S_s = 1.058 g	S_1 = 0.512 g
Site Class	D	
Site Coefficient, F	F_a = 1.077	F_v = 1.500
MCE_R Site Spectral Acceleration Parameter	S_{MS} = 1.139 g	S_{M1} = 0.768 g
Design Spectral Acceleration Parameter	S_{DS} = 0.760 g	S_{D1} = 0.512 g
PGA_M	0.497 g	

H.6.4 Site Seismic Hazards [OAR 345-021-0010 (h) (1) (h) (F) (v)]

The following sections address the potential for seismic hazards to affect the site.

H.6.4.1 Ground Shaking

Ground shaking for the 475-year, 2,475-year, and 4,975-year hazard level was assessed at the compressor station site and at the approximate midpoint and end of the pipeline alignment (MP 6.1 and MP 12.1, respectively) using the PSHM for rock outcrop conditions as described in Section H.6.2. To characterize ground motion amplification effects along the pipeline alignment, a site class was assigned in accordance with methods outlined in Chapter 20 of ASCE 7-10 (with March 2013 errata) based on boring log data and geologic interpretation. The USGS Seismic Design Maps application (USGS, 2014) was then used to collect mapped acceleration parameters along the length of the alignment at half-mile intervals.

H.6.4.1.1 ROCK OUTCROP PGA

Table H-8 summarizes peak ground accelerations for rock outcrop conditions as determined by the USGS PSHM at the compressor station site, pipeline milepost 6.1 and pipeline milepost 12.1 for the 475-year, 2,475-year and 4,975-year hazard levels. Bedrock PGA's vary by up to 6 percent between the two ends of the 12-mile alignment.

TABLE H-8. USGS 2008 ROCK OUTCROP PEAK GROUND ACCELERATION (PGA)

Location	475-year PGA	2,475-year PGA	4,975-year PGA
Compressor Station Site	0.2057	0.5010	0.6743
MP 6.1	0.2052	0.4881	0.6539
MP 12.1	0.2060	0.4768	0.6347

The USGS 2014 probabilistic seismic hazard mapping indicates that PGAs associated the 475-year and 2,475-year recurrence interval earthquakes would range between 0.15g – 0.2g and 0.4g – 0.8g, respectively. Comparison of Seismic-Hazard Maps for the Conterminous United States, 2014 (Petersen and others, 2014) with the 2008 rock outcrop ground motions presented in Table H-8 above indicates that the PGA values are fairly similar, but suggests that future revisions to ground motions used by ASCE codes and the International Building Codes (IBC) will likely be similar, if not slightly lower than ground motions found within current codes.

H.6.4.1.2 SITE CLASS ADJUSTED PGA_M

Site class was determined using geologic interpretation supplemented by borings completed at the compressor station site and the pipeline alignment north of Highway 30. Where borings were available site soils class was determined according to the penetration resistance method in ASCE 7-10, Table 20.3-1. Table H-9 summarizes the interpreted site class along the pipeline alignment, and mapped maximum considered geometric mean (MCE_G) PGA, site coefficient F_{PGA} and the site class adjusted

mapped MCE_G PGA (PGA_M). Mapped acceleration parameters were determined starting at the compressor station and at half-mile intervals along the pipeline alignment, obtained from the USGS Seismic Design Maps application (USGS, 2014) for ASCE 7-10 (with March 2013 errata).

TABLE H-9. ASCE 7-10 SITE CLASS, PGA AND PGA_M

Mile Post	Site Class	PGA	F_{PGA}	PGA_M
0.0 – 2.6	D	0.494 – 0.491	1.006 – 1.009	0.497 – 0.496
2.6 – 5.1	D	0.491 – 0.483	1.009 – 1.017	0.496 – 0.491
5.1 – 7.6	D	0.483 – 0.478	1.017 – 1.022	0.491 – 0.488
7.6 – 9.1	E	0.477 – 0.472	0.9	0.430 – 0.425
9.1 – 10.6	E	0.472 – 0.470	0.9	0.425 – 0.423
11.1 – 11.6	E	0.469 – 0.467	0.9	0.422 – 0.421
11.6 – 12.1	E	0.467 – 0.466	0.9	0.421 – 0.419
12.1	E	0.466	0.9	0.419

Modern buried pipes with welded joints have low vulnerability to ground shaking without permanent ground deformation. A detailed study of the Southern California Gas Company's transmission and distribution system found that there are no reported cases of damage to steel pipelines with arc-welded joints due to ground shaking (O'Rourke, 1996). A study commissioned by the USGS (Ballantyne, 2008) reports that "…pipelines can readily accommodate wave propagation moving the pipe tangential to its alignment." Ballantyne also states that historically, steel pipelines with high quality arc welded joints perform very well in ground shaking environment, whereas pipelines with joints using oxy-acetylene welds can have failure rates nearly 100 times greater than those with electric arc welded joints. Based on this information, and the fact that all modern natural gas pipelines utilize arc-welded butt joints, there is a low risk of ground shaking in the absence of other deformation adversely affecting the pipeline.

H.6.4.2 Fault Rupture

The Gales Creek Fault Zone is the closest fault structure to the site that has been mapped by the USGS Quaternary Fault and Fold Database (USGS, 2012). The closest expression of the Gales Creek Fault Zone is located approximately 18.7 miles south of the site. In addition, the lack of small earthquakes in the recent historical record in the immediate vicinity of the site also indicates a low probability of a future earthquake large enough to cause ground rupture. During site reconnaissance, surface evidence of fault rupture (recent faulting related escarpments, weathered fault related escarpments) at the compressor station site or along the proposed pipeline or utility conduit alignments was not identified. Nor were lineaments identified in the LiDAR hillshade model, vegetation patterns or soil contrasts in aerial photographs that may indicate previously identified faults at the compressor station site or crossing the pipeline and utility conduit alignments. Therefore, fault rupture is not considered a credible hazard at the compressor station site, or along the pipeline and utility conduit alignments.

H.6.4.3 Seismically Induced Landslides

Earthquake forces can cause slope failures and movement of sloping ground. Existing landslides are most susceptible to seismic slope failure, but very steep slopes and jointed rock outcrops are also vulnerable. The pipeline was routed to avoid very steep slopes (greater than 70 percent) and existing landslides to the extent practical. However, the proposed compressor station is situated on a landform that is interpreted as a landslide deposit (based on subsurface materials observed in borings completed at the site), and the proposed pipeline crosses two ancient landslides. Otherwise, the proposed pipeline follows adjacent to existing gravel roads where adjacent slopes are generally gentle to moderate, or traverses cross country along gentle to moderate slopes predominately along or near ridge tops (see figures H-16 through H-22) . In the absence of landslide reactivation (discussed below), there is a relatively low risk of seismically induced landsliding affecting the proposed compressor station, pipeline and utility conduit.

There is a risk that the existing landslides could be reactivated during a seismic event. Seismically reactivated landslides present a low to moderate risk to the pipeline and compressor station site, depending on the location of the earthquake and the magnitude of landslide movement. However, if existing landslides are reactivated during a seismic event, and the landslides damage the pipeline or compressor station, there is a low risk to public safety because the known landslides that are in close proximity are located in unpopulated areas.

H.6.4.4 Liquefaction and Liquefaction-Induced Hazards

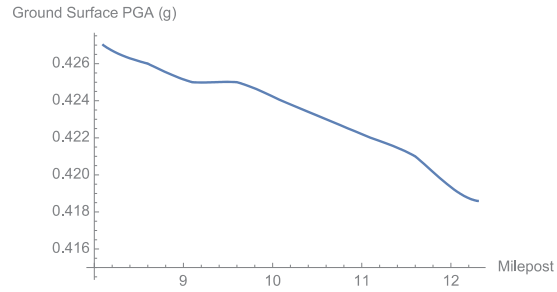
Liquefaction is not typically associated with mountainous terrain where static groundwater is located tens to hundreds of feet below the surface; rather it is associated with thick deposits of saturated, loose to medium dense granular alluvium, typically in low-lying alluvial plains with high groundwater conditions. The preliminary geotechnical work at the compressor station site, which is located in the mountainous terrain at an elevation of 1,285 feet MSL, found an isolated pocket of loose granular soils with relatively high moisture contents in borings ACSB-2 and ACSB-3. The loose granular soil is interpreted to be derived from a landslide deposit, rather than alluvial deposition. Although relatively loose granular soils with relatively high moistures contents were observed in these two borings, the loose granular soils are laterally discontinuous, and groundwater is likely located tens to hundreds of feet below the site. Therefore, there is no liquefaction hazard at the compressor site and as a result, detailed liquefaction analyses were not conducted for the compressor station site.

The utility conduit and pipeline alignments south of Highway 30 are located in the mountainous terrain that is not associated with liquefaction. Therefore, a detailed analysis of liquefaction hazard was focused along the 4.7 miles of the alignment that crosses the Columbia River floodplain, from the Highway 30 crossing near MP 7.5 to the pipeline termination near MP 12.2. Figure H-33 shows this part of the alignment relative to topographic features and geotechnical boring locations. Figures H-34 through H-37 show a geologic cross section, including plan and profile views of the eight deep HDD segments that will be used to install the pipeline 60 to 110 feet deep along the majority of the low-lying segment.

Topography along this part of the alignment is very flat. Aside from the roads that cross the low-lying lands and the dikes that contain the meandering streams and sloughs (which often are the same), the majority of the alignment has ground surface elevation 0 feet. There are some stretches of the alignment with topographic contours more than a mile apart.

Subsurface conditions along the alignment were characterized by 20 geotechnical borings and two cone penetration soundings at the locations shown in Figure H-33. The two westernmost borings are in the mountainous pipeline segment and encountered formational materials that are not liquefiable. Subsurface conditions used in the liquefaction hazard evaluation are described by the remaining 18 borings.

The CSZ Interplate seismic source controls the seismic hazard along the alignment; all of the liquefaciton triggering and lateral spreading computations use Mw=9.01. Ground-surface PGAs for the liquefaction triggering computations were obtained from the USGS probabilistic seismic hazard application at coordinates spaced ½-mile along the 12-mile-long alignment. The seismic hazard profile plotted to the right (for the low-lying segment of the pipeline north of Highway 30) shows the estimated ground surface PGA relative to pipeline milepost. The PGA used in the 18 liquefaction triggering analyses was evaluated by interpolating off of the line for each boring location.



Seismic Hazard Profile

H.6.4.4.1 LIQUEFACTION POTENTIAL

The potential for liquefaction under MCE ground shaking was evaluated for each of the 18 logged soil profiles. The borings encountered highly variable alluvium ranging from silty sands to highly plastic clays. Figures H-33 through H-37 show the interpreted distribution of the variable alluvium encountered by the borings along the pipeline alignment within the Columbia River valley north of Highway 30.

Three separate methods[1] were used at each soil profile, for a total of 54 liquefaction-triggering computations. Generally, the methods gave results within 5 percent of each other; differences were not significant enough to lead to disparate conclusions. Overall, the analyses indicate that:

1. Loose to medium dense sandy and silty-sandy alluvial soil layers are susceptible to liquefaction during MCE ground shaking. Even the sand deposit 40 to 70 feet deep in boring B-18, with uncorrected N of about 20 blows/foot (meaning a medium dense sand), has a safety factor of about 0.25 because the ground shaking has PGA>0.4 g and the M9 shaking has such long duration.
2. Fine-grained deposits are prevalent and generally have high plasticity. Aside from isolated zones of thick fine-grained deposits, and a hard material more than 170 feet deep in boring B-10, plasticity indices are 12 or higher. The elastic silt soils and other fine-grained soils are not susceptible to liquefaction.
3. The medium-dense to dense sands encountered deeper than 100 feet in B-10, B-11, and B-20 are not liquefiable according to the two methods that have regression coefficients capable of considering such depths.

[1] Methods are: Boulanger and Idriss (2014), Youd et al (2001), and Seed et al (2003). Youd's method is sometimes called the "Consensus" method, because of how it was developed, and Seed's method is sometimes called the "Queen Mary" method because of the venue where it was presented.

H.6.4.4.2 LIQUEFACTION SETTLEMENT

Volumetric strain of 1.5 percent to 2 percent is expected to occur in liquefied soils that had initial (corrected) penetration resistance of 10 to 20 blows per foot (Tokimatsu & Seed, 1987). This strain manifests as settlement of the ground surface after excess pore water pressures drain and liquefied sands reconsolidate. Different amounts of volumetric strain or different sand layer thicknesses, therefore, can cause differential settlement under the pipeline.

Differential settlement of the ground under the pipeline can cause bending stresses in the pipe wall. For the most part, the HDD alignments are deep and the liquefiable sandy layers are above the pipeline. For the short segments where the pipeline is shallow, such as locations in between HDD installations, the alignment crosses from beneath to above some of the discontinuous layers of potentially liquefiable alluvium, creating the potential for differential settlement along the pipe.

Table H-10 summarizes the liquefiable thicknesses and computed differential settlement magnitudes at the 18 boring profiles. Differential settlement considers both settlement magnitude and the pipeline segment length over which that settlement occurs. The analyses computed settlement magnitudes using the logged soil profiles and the volumetric strain correlations in Tokimatsu & Seed. Distances from non-settling points to the maximum settlement locations were evaluated using the interpreted cross sections in Sheets 2 through 5 supplemented by judgment to account for variability between borings.

TABLE H-10. LIQUEFACTION DIFFERENTIAL SETTLEMENT

Boring No.	Liquefiable Thickness (ft)		Differential Settlement (inches)
	Above Pipe	Below Pipe	
B-01	10	30	7
B-02	25	0	--
B-03	5	0	--
B-04	0	0	--
B-05	0	0	--
B-06	0	0	--
B-07	10	20	2
B-08	0	40	8
B-09	0	60	9
B-10	5	0	--
B-11	20	0	--
B-12	0	10	--
B-13	0	45	7
B-14	20	0	--
B-15	18	50	12
B-16	20	0	--

Boring No.	Liquefiable Thickness (ft)		Differential Settlement (inches)
	Above Pipe	Below Pipe	
B-18	18	20	2
B-20	25	0	--

The maximum vertical differential settlement of 12 inches is expected to occur along a 700-foot-long segment between Station 434+00 and Station 441+00, near boring B-15. The deflection angle for this settlement would be only about 0.08°, which is not the most severe on the alignment. Rather, the most severe differential settlement is expected to occur as HDD-4 rises through about 50 feet of potentially liquefiable sand between Stations 510+00 and 514+00, near boring B-9. This segment may experience as much as 9 inches of differential vertical settlement over a run of 400 feet. The deflection angle caused by falling 9 inches in 400 feet is about 0.1° and the radius of curvature for that deflection is approximately 106,700 feet.

The typical HDD design radius for curves in 24-inch pipe is about 2,400 feet. The most severe liquefaction settlement appears capable of imposing a radius of curvature about 1/44th as tight as a normal design curve. This deflection is effectively in the same category as construction layout tolerances. On this basis, it was concluded that the most severe differential settlement caused by the maximum credible earthquake, while sufficient to cause noticeable ground-surface settlement, is not abrupt enough to cause measurable effect on the planned pipeline. Differential settlement of liquefied soils is not a credible hazard to the pipeline.

H.6.4.4.3 LATERAL SPREADING

The potential lateral spread magnitude was computed for two cases: (a) the gently sloping ground where pipeline segments will be installed in shallow trenches, and (b) for the ground between shallow pipeline and free faces created by the stream and river channels. The likely lateral ground displacement for both cases was computed using the regression equations developed by Youd and others (Youd, 2002) which, though dated, remain the preferred lateral spread regression relationship (Franke, 2014).

For the gently sloping case, the maximum lateral spread hazard is located along the trenched segment between MP 8.8 and MP 9.1 (pipeline Stations 462+50 to 478+00), the connecting segment between HDD-3 and HDD-4. Thirty-five feet of liquefiable medium-grained sand is estimated to underlie the pipeline at this segment based on the conditions logged in boring B-13. The computations predict 6.3 feet of lateral spread.

Assuming that the deep parts of HDD-3 and HDD-4 anchor the pipe so that the lateral spread pulls the straight pipeline into an arc, the radius of curvature on a 1,500-foot-long segment that moves laterally a maximum of 6.3 feet is about 44,600 feet. Assuming a certain amount of unavoidable irregularity creates localized areas that curve twice as sharply, the lateral spreading curvature radius for gently sloping ground is about 10 times longer than a typical design radius in 24-inch pipe. Lateral spreading in the gently sloping parts of the low-lying alignment has negligible potential to cause inelastic strain in the pipe and essentially no potential to cause pipeline rupture.

Table H-11 summarizes the free face geometries for the four channels capable of affecting the pipe.

TABLE H-11. FREE FACE LATERAL SPREAD POTENTIAL

Channel Name	Pipeline Station	Slope Height (ft)	Setback Distance (ft)	Lateral Spread Magnitude (ft)
Clatskanie River	438+00	8	350	1.8
Beaver Slough 1	460+00	12	250	2.3
Beaver Slough 2	478+50	12	135	2.7
Columbia River Channel	664+00	35	2,850	1.6

The analyses indicate that the greatest lateral spread hazard occurs where the shallow parts of the pipeline are closest to the river channel. For the critical case, lateral spreading could affect the shallow segment at the end of HDD-3 (boring B-13). Spreading would be toward Beaver Slough, generally transverse to the pipeline, with the ends restrained by the deep part of HDD-3 down-station and the long trenched section up-station. The arc length would be approximately 300 feet, and the height from the original alignment (which makes a chord on the arc) is 2.7 feet for an arc length of 4,200 feet. The lateral spread magnitude is not sufficient to yield the pipe (meaning to cause permanent deformation) and has negligible potential to cause pipeline rupture.

It is interesting to note that the critical gently sloping ground segment is at one end of the critical free face lateral spread areas. The effect, should both areas spread during the MCE earthquake, would be to soften the restraint on both segments, lengthening the arc lengths for the same lateral displacement, which increases the radius of curvature and reduces the already small pipeline stresses.

One note about the Columbia River Channel analysis should be included in this discussion. Borings up-station from Larson Slough (about MP 10.1) encountered no liquefiable sands in the upper 50 feet. A free face lateral spread analysis of the fine-grained soils yields a 4-inch potential lateral spread, effectively a null-answer except for some loose regression coefficients. However, it is suggested that this conclusion is not reasonable considering the potential for variability in alluvial deposits. A second analysis of the Columbia River free face was performed assuming a hypothetical 20-foot-thick zone of medium dense silty sand. This analysis yields lateral spread of about 1.6 feet, indicating that the pipeline is simply too far from the Columbia River to be adversely affected by potential lateral spread despite the much higher riverbank slope.

H.6.5.5 Cyclic Strain Softening

The fine-grained layers of alluvium along the low-lying alignment segment (north of Highway 30) are likely to soften significantly during the MCE earthquake. The pipeline is insensitive to cyclic soil softening, though, because there are no loads capable of causing large displacements in the softened ground around the pipeline.

Initial static shear stresses occur in soil that supports loads imposed by building foundations, slopes, embankments, and other above ground structures. The extent of strain softening case histories is comprised entirely of earthquake-related deformations around multistory buildings (1999 Chi-Chi

earthquake), natural slopes in sensitive clays (1964 Alaska earthquake) and a well-instrumented preconsolidation embankment at the Carrefour Shopping Center (1999 Kokaeli earthquake). Boulanger and Idriss' 2007 procedure relies greatly on the displacements measured beneath the edge of that Carrefour preload, where the shear strength of underlying soft natural soils resisted slope instability failure around the embankment edges. Without the embankment (or building foundations, or roadway embankment, etc.) there are no shear stresses and no possibility of displacement should soil strength decrease.

Without a driving force, significant displacements cannot develop in the softened soils. Small-scale evidence of the softening could include localized lurching failures and ground cracks. These types of local displacements are at least an order of magnitude too small to damage a welded-joint pipeline.

There is no topographic relief, no building foundations, and no other source of initial shear stress along the pipeline alignment north of Highway 30. Where the ground does have slopes, such as at the flood control berms, the pipeline is installed 70 to 110 feet deep. Because there is no driving force, cyclic strain softening will not cause ground displacement. Cyclic strain softening is not a credible hazard to the pipeline.

H.6.5.6 Tsunami Inundation

The northern portion of the project, north of Highway 30, is located approximately 40 miles from the mouth of the Columbia River and is outside the tsunami inundation mapping for the state of Oregon. A "Workshop on Tsunami Hydrodynamics in a Large River" and associated paper (Yeh, et al., 2012) examined the tsunami penetration into the Columbia River. Yeh et al.'s study found that tsunami inundation would result in a wave height between 0 and 1 meters at the site, and that the wave would be completely contained within existing channels of the Columbia River. A model developed during the workshop and presented in Yeh et al.'s 2012 paper showed that no tsunami inundation would occur along the portion of the pipeline alignment within the Columbia River flood plain north of Highway 30. Based on the aforementioned mapping and research, tsunami inundation is not considered to be a seismic hazard at this site. Evidence that the site was impacted by past tsunamis was not identified during site reconnaissance conducted for the project.

H.6.5.7 Coseismic Subsidence

Discussions of subsidence associated with M9.0 CSZ events are typically limited to areas in close proximity to the coastline in the Northwest. Coseismic Subsidence Map for Simulated Magnitude 9 Cascadia Earthquake: Clatsop County, Oregon (Madin and Burns, 2013) and associated geographic information system (GIS) data depicting modeled coseismic subsidence developed as part the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes were reviewed to provide a qualitative assessment of the potential for subsidence at the site, particularly along the northern portion of the pipeline alignment located within the flood plain of the Columbia River.

Mapping of subsidence presented by Burns and Madin includes a stretch of the Columbia River that begins at the northwestern tip of the Clatsop Spit and reaches east to the community of Brownsmead, Oregon approximately 24-miles inland. However, GIS data included with the report reaching approximately 15 miles east beyond the Clatsop County map's published boundary suggests that maximum subsidence across the entire pipeline alignment may range between zero and 1 foot. While the GIS data reviewed falls outside of Burns and Madin's published coseismic subsidence mapping, it could

be inferred that a relatively small amount of subsidence associated with a M9.0 CSZ event may impact surface elevations as far east as the project site.

H.6.5.8 Seismically Induced Seiche Potential

Seismically induced seiche is a phenomena whereby an oscillation of a body of water in an enclosed or semi-enclosed basin creates a sudden rise in water height. The rise in water height can have a duration of a few minutes to several hours and a change in water height of a few centimeters to a few meters, depending on basin size, and in the case of earthquakes, the duration of shaking. Seiche can be caused by changes in atmospheric pressure, aided by winds, tidal currents and earthquakes (Bates and Jackson, 1984). For the purposes of this discussion, seiche is only considered as a result of earthquake shaking. Seiche in the project area could occur within the Columbia River near the northern end of the project, and within the Clatskanie River, Beaver Slough, Beaver Dredge and Larson Slough. Research has indicated that seismic seiche may occur on water bodies with a wide range in depth, width and rate of flow, and is more dependent on geologic and seismic factors than on hydrodynamic factors. For example, seismic seiche distribution appears to be controlled by variations of thickness of low rigidity sediments, seismic wave period, major tectonic features such as thrust faults, basins, arches and domes (McGarr and Vorhis, 1968). McGarr and Vorhis report that the greatest distribution of seiche in the United States related to the March 1964 Alaska earthquake was in the states bordering the Gulf of Mexico. The proposed pipeline alignment north of Highway 30 is located in an area with relatively thick accumulations of low rigidity sediments, and is not located in an enclosed or semi-enclosed basin. As such, although seiche may occur within water bodies adjacent to the pipeline alignment, the seiche would be relatively minor and would present a low risk to the buried pipeline.

H.7 ASSESSMENT OF SOIL RELATED HAZARDS [OAR 345-021-0010 (h) (1) (h) (G)]

GeoEngineers, Inc. completed an assessment of soil related hazards, including landsliding, erosion, flooding and groundwater. The assessment of these hazards is based on a desktop review of topography, geologic mapping, stream pattern observations, groundwater well logs, as well as site-specific reconnaissance that were conducted for the project. The sections below provide an assessment of each of these hazards as required by the OARs.

A geologic site reconnaissance of the compressor station and pipeline routing alternatives (including that which is currently proposed) was conducted at various dates and stages of the project. The reconnaissance were conducted in order to evaluate geologic hazards identified in the geologic map review, to map structural features, and to observe topography and indicators of seismic activity such as vegetative and surface water patterns that may be indicative of past seismic activity at the compressor station site or along the pipeline/utility conduit alignments. A reconnaissance of the first proposed pipeline route between the proposed Adams Well Pad and the previously proposed compressor station site was conducted in August 2009 by Trevor Hoyles, PE, LEG and Brian Ranney, RG, CEG (both of GeoEngineers, Inc.). A reconnaissance of a revised pipeline route was conducted on May 13, 2013 by Brian Ranney, RG, CEG, Trevor Hoyles, PE, LEG, and members of NW Natural staff. The results of that evaluation were presented in a report titled "*Revised Preliminary Geotechnical Evaluation, Emerald Storage Project, Columbia County, Oregon*" dated June 18, 2013 (GeoEngineers, 2013). After the 2013 site reconnaissance, NW Natural made changes to the pipeline route based on GeoEngineers' recommendations to avoid the potentially hazardous steep, rugged terrain of the Graham Creek drainage.

Additional pipeline routing and compressor station site changes were made between 2013 and 2015. In early to mid-year 2014, the currently proposed pipeline route and compressor station site were selected. Subsequent site reconnaissance were conducted along the upland portion of the pipeline route (and the compressor station site) south of Highway 30 on September 17 and 18, 2014 by Trevor Hoyles, PE, LEG and on February 18, 2015 by Brian Ranney, RG, CEG. Site reconnaissance of the route along the Columbia River flood plain north of Highway 30 were conducted on May 15, 2013, and February 20, 2015 by Brian Ranney, RG, CEG. Additional site reconnaissance of the compressor station site and pipeline route was conducted by Brian Ranney, RG, CEG, and Andrew Bauer, RG of NW Natural on September 3, 2015. Site specific observations described in the following paragraphs were based on these site visits.

H.7.1 General Surface Reconnaissance Observations

H.7.1.1 Compressor Station Site

The compressor station site topography consists of a relatively flat to slightly hummocky ground surface that is densely vegetated with straight mature conifer trees and forest understory species such as fern, moss, vine maple and salal. Surficial soils were observed within temporary access roads constructed to complete subsurface explorations at the site. Grading of the temporary access roads exposed sandy clay soils. Because of dense vegetation, no surficial soils could be observed in other areas of the site. No rock outcrops were observed at the compressor station site. Soils observed in a road cut adjacent to the southeast corner of the compressor station site appeared to be weathered basalt consisting of brownish-red clay with sand and some gravel. Indications of previous grading or fill soils placed at the compressor station site were not identified. Seeps, springs or streams within the compressor station site were not identified. Recent landsliding within the compressor station site or indications of recent slope movement such as bowed or bent conifer trees was not identified.

H.7.1.2 Pipeline and Utility Conduit Route South of Highway 30

Surficial deposits along the proposed pipeline and utility conduit routes in the mountainous segment south of Highway 30 were observed in road cuts where the alignments follows existing roads. In general, the surficial deposits consist of clay to sandy clay with occasional gravel derived from the in-place weathering of the underlying sedimentary and volcanic bedrock, or clayey gravel colluvium. As is typical with mountainous road construction, fill soils were placed across drainages and on the outboard edge of most of the roads. In general, fills placed during road construction appeared to be stable, although two road fill failures were observed as discussed in Section H.7.4.2.2 of this exhibit. Springs or seeps along the proposed pipeline or utility conduit alignment south of Highway 30 were not identified.

Landslide deposits were observed in two drainages west of the utility conduit alignment. The landslide deposits were derived from road fill failure initiated landslides discussed in the paragraph above. The landslides are identified as landslide 3-042-030-A and 3-042-031-A (see Figure H-9). The deposits were densely vegetated with brush, which precluded direct observation of the landslide deposit material type.

The proposed pipeline alignment and utility conduit alignment sections within roadways south of Highway 30 cross several small unnamed drainages that house ephemeral and perennial streams. The pipeline and the utility conduit will be installed within the road fill that crosses these drainages. The fill slopes were densely vegetated which precluded the identification of the fill soils. Surface indications of road fill instability at the drainage crossings were not observed. Existing culverts allow water to pass beneath the

roadways (and under or over the proposed elevation of the pipeline and utility conduit) at the stream crossings. Areas of deposition above the culverts, or areas of significant erosion at the culvert outlets were not observed. Because the culverts will not be disturbed during construction and operation of the proposed pipeline and utility conduit, these drainages will not likely impact the project. However, if the culverts and road fill fail at the crossings, there is a high risk that the pipeline and utility conduit will become exposed.

H.7.1.3 Pipeline Route North of Highway 30

Observations of surficial soils along the pipeline alignment north of Highway 30 were restricted by the heavily vegetated nature of the flood plain's agricultural use. However, where surficial soils could be observed they generally consist of organic silt, sandy silt and clay. The surface soils were generally saturated at the time of the reconnaissance, with localized ponds of surface water present in the lower lying areas of the alignment. This portion of the alignment crosses one river (the Clatskanie River), two sloughs (Beaver Slough and Larson Slough) and several drainage ditches as shown in Figures H-33 through H-37. Because these waterways are crossed by HDD installations, the waterways have no effect on the pipeline and the proposed construction does not affect the waterways.

H.7.2 Erosion

Erosion can be caused by air or water. Wind erosion is not a significant concern because of the fine-grained surface soils, tree cover along and adjacent to much of the pipeline and utility conduit alignments, planned post-construction revegetation of the pipeline corridors, and the subgrade protection measures that will be implemented to provide equipment access.

The soils at the project area are susceptible to water erosion as indicated in the soil assessment section of this exhibit (Section H.2.1.6). However, where the pipeline alignment follows the existing roadways, water erosion will be minimal because of existing surface water drainage systems and crushed rock road surfacing.

H.7.3 Flooding and Groundwater

The northern half of the pipeline alignment, north of Highway 30, will be located in the Columbia River flood plain. However, this area is protected from flooding of the Columbia River by a dike system. Moreover, the proposed development within the Columbia River flood plain is limited to a buried pipeline. As such there is a low risk of flooding from the Columbia River adversely affecting the project. However, flooding could result from a dike breach. Dike breach could occur during a seismic event (likely a CSZ rupture) or during extreme flooding. The pipeline within the Columbia River flood plain for the most part will be installed by means of HDD methods, and therefore, there is a low risk of flooding related to dike breach affecting the pipeline. However, where the pipeline will be installed in open trench segments, flooding and high groundwater can create buoyancy conditions that could result in floating of the pipeline. In addition, dike breach could possibly result in high velocity flows that may erode the ground surface at the open trench installed segments of the pipeline. If the soils were eroded at the open trench installed portions of the pipeline, the pipeline may become exposed. The risk posed to the pipeline as a result of flooding has been reduced to the extent practical by installing the pipeline by means of HDD methods below flood scour depth along as much of the alignment as generally allowed by HDD technology.

Groundwater levels are near the ground surface within the flood plain regions of the project site. HDD methods will be used for pipeline installation in most of the flood plain region. However, there are three relatively short open trench segments within the Columbia River flood plain where groundwater may be a temporary construction consideration. Dewatering may be necessary to install the pipeline in the open trench segment within the flood plain depending on the time of year construction is completed, and precipitation conditions at the time of construction. However, groundwater does not present a long-term hazard to the pipeline within the Columbia River flood plain provided the open trench pipeline segments are designed with buoyancy control.

Mitigation for hazards related to flooding and groundwater is discussed in Section H.9.2.

H.7.4 Landslide and Slope Stability

H.7.4.1 General

During the route selection process as described in the introduction section of this exhibit, GeoEngineers completed a desktop study to identify landslide hazards at the project site by reviewing the state landslide inventory database (SLIDO v3.2, 2014) and by interpreting historical aerial photographs and LiDAR generated hillshade DEMs. A site reconnaissance of the project area was conducted focusing on landslides identified in the desktop study and observing conditions along the proposed pipeline and utility conduit alignments. The proposed pipeline and utility conduit corridors were generally routed to avoid existing landslides and/or unstable slopes to the extent practical.

The compilation landslide mapping by Oregon DOGAMI (SLIDO v3.2) shows numerous landslides within the project area as shown in Figures H-9 through H-15. Most of these landslides are not in close proximity to the proposed pipeline alignment such that they are unlikely to affect the proposed project. However, the proposed pipeline alignment crosses two mapped landslides (thus the pipeline crosses four landslide margins) and is within 1,500 feet of several others. The following sections of this exhibit summarizes assessment of these mapped landslides along with additional landslides mapped by GeoEngineers in the project area.

H.7.4.2 Site-Specific Mapping and Evaluation

H.7.4.2.1 PIPELINE ALIGNMENT

The pipeline alignment crosses a mapped landslide (Marshland 13) included in the SLIDO database from MP 1.4 to MP 1.68 as shown in Figure H-10. Indications of recent movement such as bowed conifer trees, or recent ground cracks and scarps that would suggest this mapped feature is active were not observed during site reconnaissance. In addition, Indications of distress or damage to the logging road where it crosses the landslide area were not observed. Based on surface morphology and weathering of the topographic features, such as drainage patterns observed during the site reconnaissance and LiDAR hillshade review, this landslide is a dormant-mature or a relict landslide (Keaton and DeGraff, 1996). As such, the Marshland 13 landslide presents a low risk to the proposed pipeline in accordance with NW Natural's Landslide Risk Ranking and Monitoring Schedule, which is included in Section H.9.3.2.

The proposed pipeline alignment crosses a previously identified ancient deep-seated landslide near the Graham Creek drainage from about MP 2.75 to MP 3.15 and from approximate MP 3.48 to MP 3.72. This landslide is shown with respect to the proposed pipeline alignment in Figure H-11, and is identified as Landslide 3-048-029-A. The portion of the proposed pipeline route that crosses the landslide is co-

located with an existing 12-inch-diameter North Mist transmission pipeline. This landslide has been monitored for over 10 years as part of NW Natural's landslide monitoring program, and no indications of movement have been observed during that timeframe. In addition, a reconnaissance of the landslide was performed as part of this evaluation. Indications of recent movement such as bowed conifer trees, or ground cracks and scarps, or distress or damage to the logging road where it crosses the landslide area were not observed. Based on the historical monitoring data and interpretation of the landslide morphology, this landslide classifies as a dormant-mature or likely a relict landslide and presents a low risk to the proposed pipeline in accordance with NW Natural's Landslide Risk Ranking and Monitoring Schedule (Section H.9.3.2).

Landslide 3-50-029-A, which is located near MP 4.3, is located at its closest point approximately 100 feet west of the pipeline. The scarp of the landslide forms the ridgeline to the west of the pipeline alignment. The landslide was identified in LiDAR hillshade imagery. Indications of recent or historical movement of this landslide during were not identified during the site reconnaissance. The landslide is interpreted as a relict, inactive landslide that presents a low risk to the proposed pipeline in accordance with NW Natural's Landslide Risk Ranking and Monitoring Schedule (Section H.9.3.2).

The portions of the proposed pipeline route that follow existing logging roads may be subject to small and localized slumps related to the logging road cuts and fills. However, in general, the logging roads along the proposed route appear to be in good condition and well maintained.

H.7.4.2.2 CONDUIT ALIGNMENT

Landslides identified as Marshland 1507 and Marshland 1841 are mapped by SLIDO in close proximity to the conduit alignment as shown in Figure H-9. Marshland 1507 is mapped on the opposite side of the drainage from the conduit route. The conduit route is situated on the top of a narrow ridge that is considered to be stable and at low risk of being affected by this identified landslide. Therefore, Marshland 1507 is not considered a risk to the pipeline and was not evaluated further. Marshland 1841 is located approximately 100 feet downslope of the conduit alignment on a moderately steep west facing slope. Based on its proximity and position relative to the utility conduit, Marshland 1841 could pose a potential risk to the conduit. Therefore, Marshland 1841 was evaluated further. Topographic indicators of a landslide in the LiDAR hillshade model at the location of Marshland 1841 were not observed. Moreover, we did not observe indications of landsliding at that location during the site reconnaissance. Lacking topographic indications of landsliding, it is concluded that the Marshland 1841 landslide mapped by others is a either not a landslide or a relict, inactive landslide that presents a low risk to the proposed pipeline in accordance with NW Natural's Landslide Risk Ranking and Monitoring Schedule.

Two shallow debris slides were identified near the proposed utility conduit route, as shown in Figure H-9. These landslides are identified as Landslide 3-042-030-A and Landslide 3-042-031-A. Based on reconnaissance, each of these landslides resulted from failure of road fill that was placed on steep headwall swales. The landslides are approximately 80 feet wide by 120 feet long. The road fill failures mobilized into debris flows that traveled downslope. Soils were deposited in low gradient areas of the drainages downslope of the scarps. The landslide debris is now vegetated with 60-foot tall deciduous trees, fern, salal and other forest understory species. Most of the scarps of the landslides are inclined at gradients ranging between approximately 40 and 60 percent, and are vegetated with short grasses, ferns and alder trees ranging from about 15 to 50 feet high. However, there are areas on the edges of the scarp of both landslides that are vertical and unvegetated indicating more recent landsliding has occurred. These more recent areas of sliding are generally approximately 20 to 30 feet wide and about

30 feet long. Road cuts on the opposite side of the road from the landslides (cut side of the road) expose closely fractured weathered basalt.

Although the landslides occurred on the fill slope below the logging road, there is potential for the over steepened sections of the scarps to retrogress upslope into the road, particularly where it is underlain by fill. Because the proposed utility conduit was located on the outboard edge of the road where it is underlain by fill, GeoEngineers, Inc. recommended that the proposed pipeline location be moved to the in-board, cut side of the logging road where it will be installed within weathered bedrock that is less likely to be affected by upslope retrogression of the landslide scarp. This recommendation has been incorporated into the project plans.

H.7.4.2.3 COMPRESSOR STATION

A landslide and associated landslide deposits were mapped at the proposed compressor station site as shown in Figure H-9 (Landslide ID 3-043-031-B). This landslide was identified based on features observed in the LIDAR hillshade DEM, and also based on interpretation of subsurface conditions encountered in borings completed at the site for the geotechnical evaluation. GeoEngineers, Inc. observed this landslide during site reconnaissance as reported in Section H.7.1 of this exhibit. Based on landslide morphology, LiDAR data and boring logs the compressor station site is likely situated on landslide deposits derived from a rapidly moving shallow landslide that initiated upslope of the compressor station site, and that the landslide deposits are likely ancient and stable.

H.7.4.2.4 SUMMARY

The following table summarizes the landslides mapped by GeoEngineers for this project that are within 1,500 feet of the facilities.

TABLE H-12. LANDSLIDES

Site ID	Location	Proximity to Project Facilities	Landslide Classification	Description	Potential Risk
Marshland 13	MP 1.4 to MP 1.67	Crosses Feature	Earth Flow	Observed through desktop study and site reconnaissance. Well vegetated with no signs of recent movement in either existing vegetation or existing logging roads. Ancient	Low
Marshland 1841	Utility conduit MP 2.1	Approximately 100 feet west and downslope of the alignment.	Earth Flow	Observed through desktop study and site reconnaissance. Well vegetated with no signs of recent movement in either existing vegetation or existing logging roads. Ancient	Low
3-042-031-A	Utility conduit MP 1.8: West-facing headwall of stream.	Approximately 40 feet west of the utility conduit alignment.	Road Fill Failure resulting in shallow rapid debris slide and debris flow.	Approximately 25-year old road fill failure with recent sloughing observed on north end of slide scarp.	Low to Moderate

Site ID	Location	Proximity to Project Facilities	Landslide Classification	Description	Potential Risk
3-042-030-A	Utility conduit MP 1.65: Northwest facing headwall of stream.	Approximately 30 feet west of the utility conduit alignment.	Road Fill Failure resulting in shallow rapid debris slide and debris flow.	Approximately 25-year old road fill failure with recent sloughing observed on central portion of scarp. Recent ground cracks observed on south side of scarp.	Low to Moderate
3-048-029-A	MP 2.77 to MP 3.15 and MP 3.48 to MP 3.72	Crosses Feature	Earth Flow	Observed through desktop study and site reconnaissance. Well vegetated with no signs of movement in either existing vegetation or existing logging roads. Ancient.	Low
3-050-29-A	Pipeline MP 4.3: west-facing slope, west of North Mist Expansion Pipeline.	Approximately 100 feet west of North Mist Expansion Pipeline.	Earth Flow	Densely vegetated landslide (based on air photographs), best identified from LiDAR data. No recent indications of movement identified during site reconnaissance.	Low
3-043-031-A	Compressor Station Site	Approximately 850 feet south of the compressor station site.	Earth Flow	Densely vegetated landslide. Observed through desktop study. Drainage patterns suggest dormant-mature landslide. Unlikely to retrogress beyond ridgetop and affect Compressor station site	Low
3-043-031-B	Compressor Station Site	The proposed compressor station is located within this feature.	Earth Flow	Densely vegetated landslide with straight conifer trees. Observed through desktop study, site reconnaissance and subsurface investigation. No signs of movement in either existing vegetation or existing logging roads. Ancient.	Low

H.7.4.3 Potential Adverse Impacts to/from Slope Stability

The proposed pipeline generally follows adjacent to existing roads, or relatively gently sloping cross-country terrain. However, some portions of the pipeline and utility conduit alignments traverse slopes that are in excess of 65 percent, as shown in the slope gradient maps, Figures H-16 through H-22. However, there may be localized areas where excavation into steep slopes may be required to install the pipeline adjacent to existing logging roads. These areas have not been delineated at this time. Cutting and/or filling for on slopes in excess of 50 percent could create localized slope instability and should be evaluated on a site-specific basis prior to construction.

The following measures will be included in the final design of construction corridors along overland segments to minimize the potential to adversely affect slope stability:

- Permanent cut and fill slopes will be inclined at a maximum gradient of 2H:1V (horizontal to vertical).
- Fill slopes (not anticipated) will be keyed into undisturbed, firm native material.
- Corridors on sloping ground will be constructed with waterbars to prevent capturing, concentrating and rerouting surface water runoff. Waterbar spacing will be based on the slope gradient of the corridor as outlined in NW Natural's standard construction procedures.

Unstable slopes can impact the utility conduit, pipeline and compressor station site (the project). Adverse impacts to the project may include slow constant slope movement bending and over stressing the pipeline and utility conduit, sudden slope movements shearing the pipeline or utility conduit, and slope movements at the compressor station site cracking foundations constructed for equipment or buildings. As previously discussed, the known landslides crossed by the pipeline, and the compressor station site landslide, are ancient, inactive landslides that present a relatively low risk to the project, and an even lower risk to public safety because they are located in unpopulated areas.

H.7.5 Stream Channel Migration and Avulsion

The pipeline alignment north of Highway 30 crosses one river, two sloughs and several drainage ditches. In addition, the northern most portion of the alignment, where the pipeline terminates within PGE's existing facility, is located as close as approximately 1,750 feet the south bank of the Columbia River. The Clatskanie River, Beaver Slough, Larson Slough and the drainage ditches will be crossed by installing the pipeline using HDD installation methods. Where the pipeline crosses these waterways, it will be located approximately 65 feet beneath the Clatskanie River, between 77 and 93 feet beneath Beaver Slough, approximately 53 feet beneath Larson Slough, and generally between 52 and 104 feet below the drainage ditches. Where the pipeline crosses drainage ditches adjacent to Collins Road 2, it will be located 19 feet below the drainage ditch.

The Clatskanie River, Larson Slough and Beaver Slough are the major waterways crossed by the proposed pipeline. All of these waterways are low gradient waterways bounded by dike systems to protect adjacent agricultural farmland from flooding. Because of the low energy stream environment within the flood plain north of Highway 30 and the fact that the waterways are controlled by dike systems, there is a low risk of channel migration, in the absence of a catastrophic dike system failure. There is also a low risk of avulsion (in the absence of a catastrophic dike system failure) because the Clatskanie River, Larson Slough and Beaver slough cannot abandon their channels as the channels of these waterways in the project area are bounded by dike systems to control the location of the stream channels as well as flooding.

H.8 SEISMIC HAZARD MITIGATION [OAR 345-021-0010 (H) (1) (H H), (I H)]

NW Natural will design, engineer and construct the compressor station in accordance with the Oregon Structural Specialty Code (OSSC), which uses the 2012 IBC, with current amendments by the state of Oregon and local agencies. Pertinent design codes as they relate to geology, seismicity, and near-surface soil, are contained in IBC Section 1613, with slight modifications by the current amendments of the state of Oregon and local agencies. The project will be designed to meet these minimum standards

The liquefaction and lateral spreading analyses conducted for the project, as discussed in Section H.6.4.4 above, indicate that the estimated liquefaction and lateral spreading displacements will not result in rupture or overstress conditions of the pipeline and thus will not threaten public safety. Therefore, no specific mitigation for these hazards is required.

There is a risk that existing landslides could be reactivated during a seismic event. However, if existing landslides are reactivated during a seismic event, and the landslides damage the pipeline, there is a very low risk to public safety because the known landslides are located in unpopulated areas. Pipeline pressures are monitored and valves on each side of the pipeline will be remotely shut off in the event of a sudden loss of gas pressure, which will also mitigate risk related to the seismic reactivation of a landslide. Lastly, NW Natural's landslide hazards risk and monitoring plan presented in Section H.9.3.2 below provides actions to be taken in the case of a seismic event, which further help reduce risk to the public.

H.9 NON-SEISMIC HAZARD MITIGATION [OAR 345-021-0010 (H) (1) (HH) (I)]

NW Natural proposes to design, engineer and construct the compressor station, utility conduit and pipeline to avoid dangers to human safety related to non-seismic hazards in many ways, including:

- The proposed pipeline has been routed to avoid very steep slopes and active landslides.
- The proposed pipeline will be installed between 52 and 93 feet below the lowest points of waterways to mitigate potential environmental disturbance, and reduce the risk of groundwater flooding related hazards affecting the pipeline to the extent practical.
- The proposed pipeline north of Highway 30 will be installed almost entirely using HDD installation methods. Utilizing this construction method not only reduces environmental impacts, it mitigates potential hazards due to groundwater, flooding, stream channel migration, avulsion and dike breach to the extent practical.
- Site-specific geotechnical evaluations will be conducted for the compressor station site and for proposed grading along the utility conduit and pipeline alignments. These evaluations will be completed to reduce the risk of slope stability and foundation settlement adversely affecting the proposed facilities.

The paragraphs below provide discussion and recommended or anticipated mitigation measures for non-seismic hazards identified in this study.

H.9.1 Erosion

Where the proposed pipeline and utility conduit follows existing gravel roads, erosion is expected to be minimal and no special mitigation will be required. In overland segments, the pipeline and the utility conduit corridors will be protected from erosion during and after construction using current erosion control best management practices (BMPs). BMPs will also be used during and after construction of the proposed compressor station. A detailed erosion and sediment control plan will be completed to fulfill requirements of the National Pollutant Discharge Elimination System (NPDES) Permit 1200-C. Erosion control measures that may be employed during construction include:

- Installing sediment fence or other approved BMPs at downslope side of excavations and disturbed areas.

- Straw mulching within disturbed cross country segments of the corridor and locations adjacent to the road that have been affected during construction.
- Planting designated seed mixes within disturbed cross country segments of the corridor at affected areas adjacent to the road.

Exposed soil areas that are affected by the construction will be seeded after construction when there is adequate soil moisture. They will be reseeded in the spring if a healthy cover crop does not grow. The sediment fences will remain in place until the affected areas are well vegetated.

Whenever feasible, overland corridors will be constructed with waterbars so that surface drainage continues to natural drainage patterns, with minimal diversions through ditches and culverts. Regular maintenance of drainage facilities will ensure continued proper operation.

H.9.2 Flooding and Groundwater

Groundwater might be a concern in entry and exit pits for HDD installations and the trenched section of the pipeline within the Columbia River valley. Localized areas will be dewatered if necessary and the effluent will be treated, if necessary, and discharged on site through filter bags or other similar water discharge structures.

High groundwater conditions and flooding could result in positive buoyancy conditions (floating) of the pipeline within open trench segments within the flood plain north of Highway 30. In addition, if a dike breach should occur, wide spread flooding and high velocity waters from multiple dike breach locations is possible. Positive buoyancy conditions will be mitigated within the open trench segments of the pipeline north of Highway 30 by utilizing concrete coated pipe or concrete pipe weights that will counteract buoyancy conditions that may result from flooding or high groundwater.

Where the pipeline crosses streams north of Highway 30 (Clatskanie River, Beaver Slough and Larson Slough), it will be installed using HDD installation methods and will be between approximately 50 and 90 feet beneath the waterways. The HDD entry and exit points, where the HDD installed pipeline will be relatively shallow, will be a minimum of 225 feet away from dikes adjacent to the waterways, and in most cases much further. This setback from the dike system, coupled with the deeply installed pipeline, mitigates most of the risk associated with potential scour that could result from high velocity water flow if a dike breach were to occur. However, because of the limitations in HDD lengths, there will be short sections of pipeline between HDD installations that will be installed in a shallow open trench. These shallow open trench areas are located in a rural, relatively unpopulated area with the nearest residence more than 800 feet away. For these reasons, there is a low risk of scour due to dike breach presenting a hazard to public safety and therefore no additional mitigation is required.

No mitigation is deemed necessary for the southern half of the pipeline alignment or at all other proposed construction since these will be located in upland areas and ridge tops.

H.9.3 Landslides

H.9.3.1 Landslide Hazard Mitigation Discussion

Three ancient, inactive landslides were identified along the proposed pipeline alignment. These landslides are the SLIDO mapped landslide Marshland 13 along the proposed pipeline route between MP

1.45 and MP 1.75, Landslide 3-048-029 identified along the proposed pipeline alignment from MP 2.85 to 3.25 and from approximate MP 3.57 to 3.82, and Landslide 3-050-029-A located approximately 100 feet west of the pipeline alignment near MP 4.3. As previously discussed, these landslides pose a low risk to the pipeline. However, if these landslides were to re-activate in the future and affect the pipeline, there is a low risk to public safety because there are no structures, public facilities, or paved arterial roadways within several miles of the location where the pipeline crosses the landslides. Mitigation for potential risk will include monitoring this landslide in accordance with NW Natural's existing monitoring schedule for a low risk landslide, which is described in Section H.9.3.2 below. Because of the low risk to the pipeline and public safety, no other evaluation or mitigation of these landslides will be conducted.

Two recently active landslides were identified along the proposed utility conduit alignment (Landslides 3-042-031-A and 3-042-030-A along the utility conduit alignment, Figure H-9). To reduce the risk of the landslide scarps retrogressing and adversely affecting the proposed utility conduit, NW Natural has reduced the risk by moving the utility conduit location towards the inboard edge of the road away from the landslide scarps and so that the conduit will be buried in weathered bedrock. Additional mitigation will include monitoring the landslides in accordance with NW Natural's Landslide Risk Ranking and Monitoring Schedule, which is described in section H.9.3.2 below. Because the utility conduit does not house flammable gas or liquid, there is a no risk to public safety if the landslide scarps were to retrogress and adversely affect the utility conduit. Because of the low risk to public safety if these landslides were to retrogress and involve the utility conduit, no further mitigation is required to protect public safety. However, NW Natural intends to further investigate these two landslides to evaluate risk to the adjacent logging road and utility conduit and to road stabilization options to discuss with the landowner.

Landslide Marshfield 1841 is located within approximately 100 feet of the proposed utility conduit alignment. This landslide presents a low risk to the utility conduit alignment. Mitigation of the risk will include monitoring the landslides in accordance with NW Natural's Landslide Risk Ranking and Monitoring Schedule, which is described in Section H.9.3.2 below. Because the utility conduit does not house flammable gas or liquid, there is a no risk to public safety if the landslide scarps were to retrogress and adversely affect the utility conduit. Because of the low risk to public safety if these landslides were to retrogress and involve the utility conduit, no further mitigation is required to protect public safety.

The proposed compressor station site is situated on landslide deposits derived from a rapidly moving shallow landslide that initiated upslope of the compressor station site (3-043-031-B). The Evaluation presented in this Exhibit suggests that the landslide deposits at the compressor station site have remained stable since deposition. Additional evaluation of the landslide will be conducted as part of future work as described in Section H.5. The additional investigation will be completed to more accurately define the limits of the landslide and to provide geotechnical engineering recommendations for grading of the compressor station site and placement of foundations associated with structures. To mitigate the risk posed by the mapped landslide, this landslide will be included in NW Natural's landslide management system database and be monitored annually in accordance with the criteria for low risk landslides, as discussed in Section H.9.3.2 below.

Landslides could be reactivated due to extensive grading on the landslide, logging, precipitation and during or after a seismic event. There is a low to moderate risk that the landslides identified in this study would be reactivated by these processes. However, if the landslides were to be reactivated, there is a low risk to public safety because the known landslides are located in unpopulated areas. NW Natural

maintains a landslide-monitoring program into which each of the landslides identified by Table H-9 below will be placed (Section H.9.3.2 below). NW Natural has mitigated the risk of the reactivation of landslides adversely affecting the pipeline by routing the pipeline to avoid active landslides, and monitoring inactive landslides crossed by or in the near vicinity of the proposed pipeline as identified in Table H-9 at least once yearly (unless otherwise specified by the monitoring program) and after rain events or seismic events that exceed specified thresholds.

Although the logging roads followed by the proposed pipeline and the utility conduit alignment are well maintained and appear to be in good condition, smaller road slumps predominately along fills might occur along existing roads that the pipeline/utility conduit routes will follow. In order to reduce the potential for the pipeline to be affected by road related fill slumps, the pipeline and the utility conduit will be installed within the inside (bar ditch) edge of the roads where possible.

H.9.3.2 NW Natural's Landslide Hazard Monitoring Program

NW Natural developed a landslide risk ranking and monitoring schedule program for landslides that may affect their pipelines, and manages those landslides in a management system database. In general, the program classifies landslide risk to NW Natural's pipelines into categories of high, moderate and low, and then establishes a monitoring schedule for landslides placed into those categories. This monitoring program is completed in addition to quarterly monitoring of all NW Natural's transmission pipelines that are required by various utility commissions. NW Natural's landslide risk and monitoring schedule is presented below.

Landslide Risk

HIGH RISK

- Pipeline crosses landslide mass or is within 50 feet of slide margin;
- Surficial, geomorphic and vegetative features suggest that the landslide is active or recently active; and
- If the landslide is instrumented with inclinometers and/or strain gauges on the pipeline:
    - Movement was measured within the last two winters; or
    - The landslide has not been monitored through at least two winters.

MODERATE RISK

- Pipeline crosses landslide mass or is within 50 feet of margin; and
- Surficial, geomorphic and vegetative features suggest that the landslide is dormant; or
- Surficial, geomorphic and vegetative features suggest that the landslide moves at a very slow rate (<1 inch/year) and rapid movement is unlikely; or
- The landslide is instrumented with inclinometers and/or strain gauges on the pipeline; no movement was measured within two winters.

LOW RISK

- Pipeline is greater than 50 feet from margin of potentially active landslide; or
- Pipeline crosses landslide that has a low potential for reactivation based on one or all of the following criteria:

- Surficial, geomorphic and vegetative features suggest the landslide is dormant-mature; or
- The apparent cause of the landslide has been removed or the landslide has been stabilized (i.e., drainage improvements, grading); or
- Instrumentation and/or observations confirm that no movement has occurred for at least two winters of above-average rainfall.

Monitoring Schedule:

Monitoring includes visual surface observation of the pipeline ROW and adjacent areas, and reading of instrumentation (inclinometers, strain gauges), if installed within a known landslide. If during a monitoring event surface conditions suggest that movement may have occurred within the pipeline ROW, NW Natural will evaluate the newly reported surface indications of landslide movement, or obtain a consultant to evaluate the reported movement further.

(F) FREQUENTLY (HIGH RISK LANDSLIDES)

- At least once per month from October* through April.
- Immediately after 4 or more inches in 48 hours.
- Immediately after 6 or more inches in 7 days.
- Immediately after a rain on snow event.
- Immediately after an earthquake that generates PGAs in excess of 0.1g along the corridor.

*An initial fall reading should be taken earlier if precipitation conditions warrant.

(P) PERIODICALLY (MODERATE RISK LANDSLIDES)

- At least twice from October* through April.
- Immediately after 4 or more inches in 48 hours.
- Immediately after 6 or more inches in 7 days.
- Immediately after a rain on snow event.
- Immediately after an earthquake that generates PGAs in excess of 0.1g along the corridor.

*An initial fall reading should be taken earlier if precipitation conditions warrant.

(A) ANNUALLY (LOW RISK LANDSLIDES)

- At least once per year during the winter.
- Immediately after 25 or more inches in 30 days.
- Immediately after an earthquake that generates PGAs in excess of 0.1g along the corridor.

The table below summarizes how the landslides identified by this study will be incorporated into NW Natural's landslide risk ranging and monitoring program.

TABLE H-13. LANDSLIDE RISK RAKING AND MONITORING

Site ID	Risk Ranking	Monitoring Schedule
Marshland 13	Low	Annually
Marshland 1841	Low	Annually
3-042-031-A	Moderate	Periodically
3-042-030-A	Moderate	Periodically
3-048-029-A	Low	Annually
3-050-29-A	Low	Annually
3-043-031-A	Low	Annually
3-043-031-B	Low	Annually

H.10 LIMITATIONS

GeoEngineers, Inc. has collaborated with NW Natural to prepare this Exhibit H for use by NW Natural in support of the proposed North Mist Expansion Project Request for Site Certificate Amendment. This Exhibit is not intended to be a design document and should not be utilized for design or bidding purposes.

Within the limitations of scope, schedule and budget, the geologic and geotechnical services provided to prepare this Exhibit H have been executed in accordance with generally accepted practices in this area at the time the exhibit was prepared. While NW Natural intends that the Energy Facility Siting Council rely on all information in this Exhibit to satisfy the Council's Structural Standard, GeoEngineers, Inc. makes no warranty or other conditions, expressed or implied.

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FIGURES

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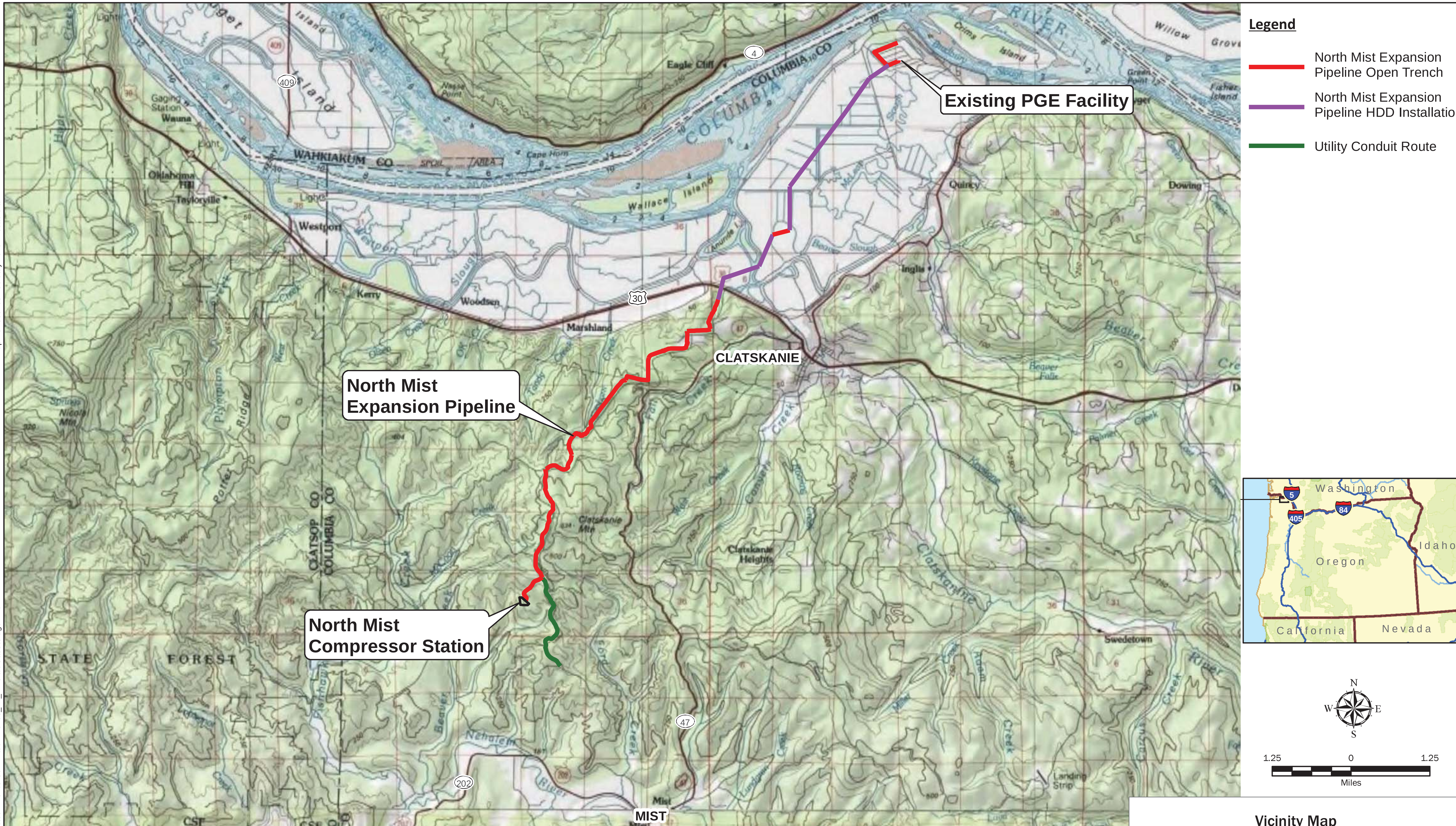

Map Revised: 05 February 2015 ccabrera

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Topo map obtained from NGS_Topo_US_2D, http://server.arcgisonline.com/arcgis/services

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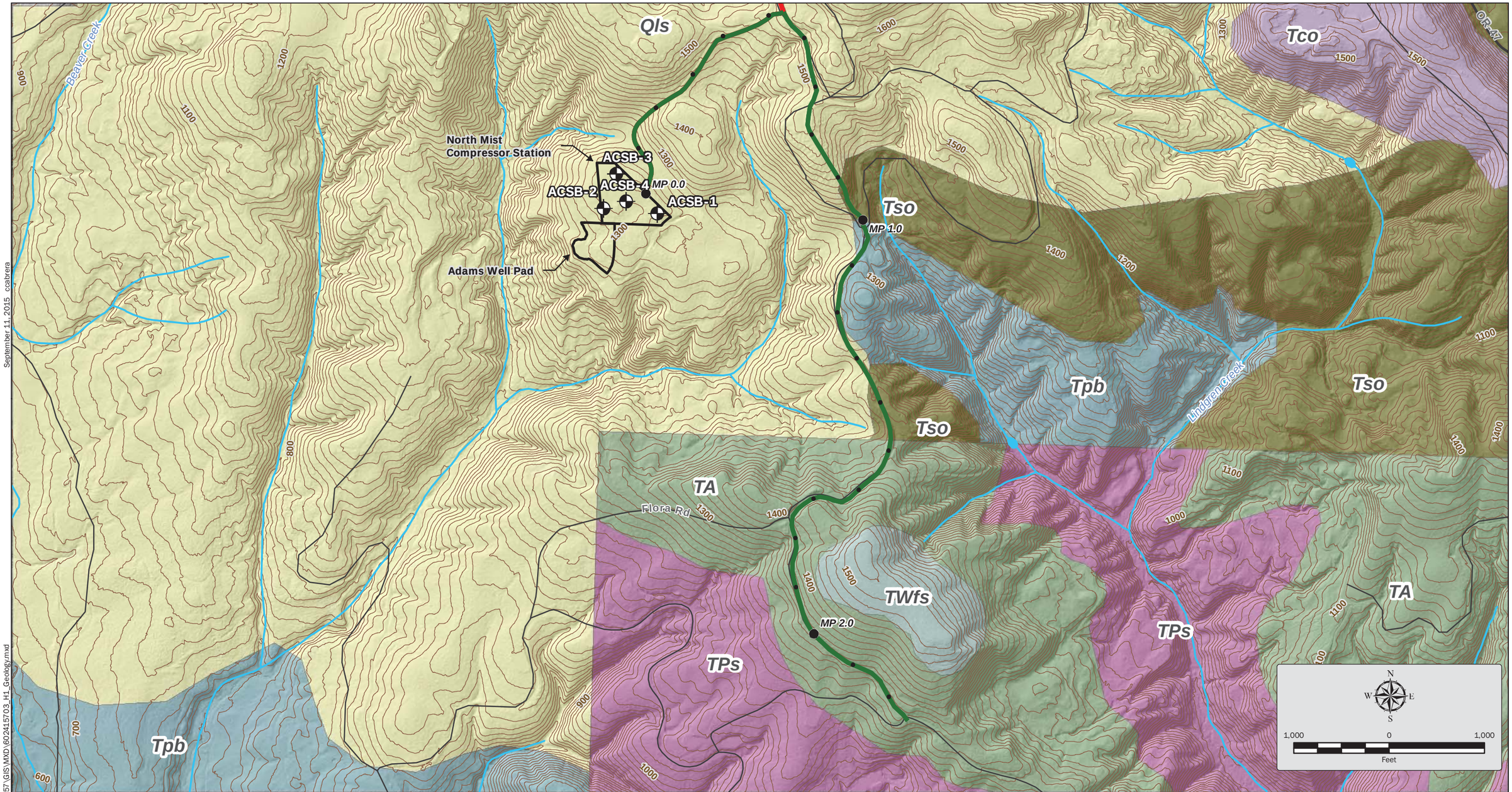
Vicinity Map

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-1



Data Source:
Geology from DOGAMI's Oregon Geologic Data Compilation, (OGDC-5, May 2009). 2014 ESRI Street Map and ArcGIS Online, Streets Basemap .
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
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Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- Approximate Boring Location
- Contours (20 foot)

Surficial Geology
- Qal: Alluvium
- Qls: Landslide debris

Columbia River Basalt Group (CRBG)
- Twfs: Wanapum Basalt
- Tco: Undifferentiated CRBs
- Tgr1: Grande Ronde Basalt Wapshilla Ridge Member
- Tgr2: Grande Ronde Basalt Grouse Creek Member

Scappoose Formation
- TA: Astoria Group
- Ts1: Astoria Group
- Tso: Astoria Group

Pittsburg Bluff Formation
- Tps: siltstone member
- Tpbcc: Conyers Creek Member
- Tpb: East Fork Member
- Tc: Clatskanie Conglomerate

Grays River Volcanics
- Tgrv: Yachats - Tillamook Group

Geology Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-2

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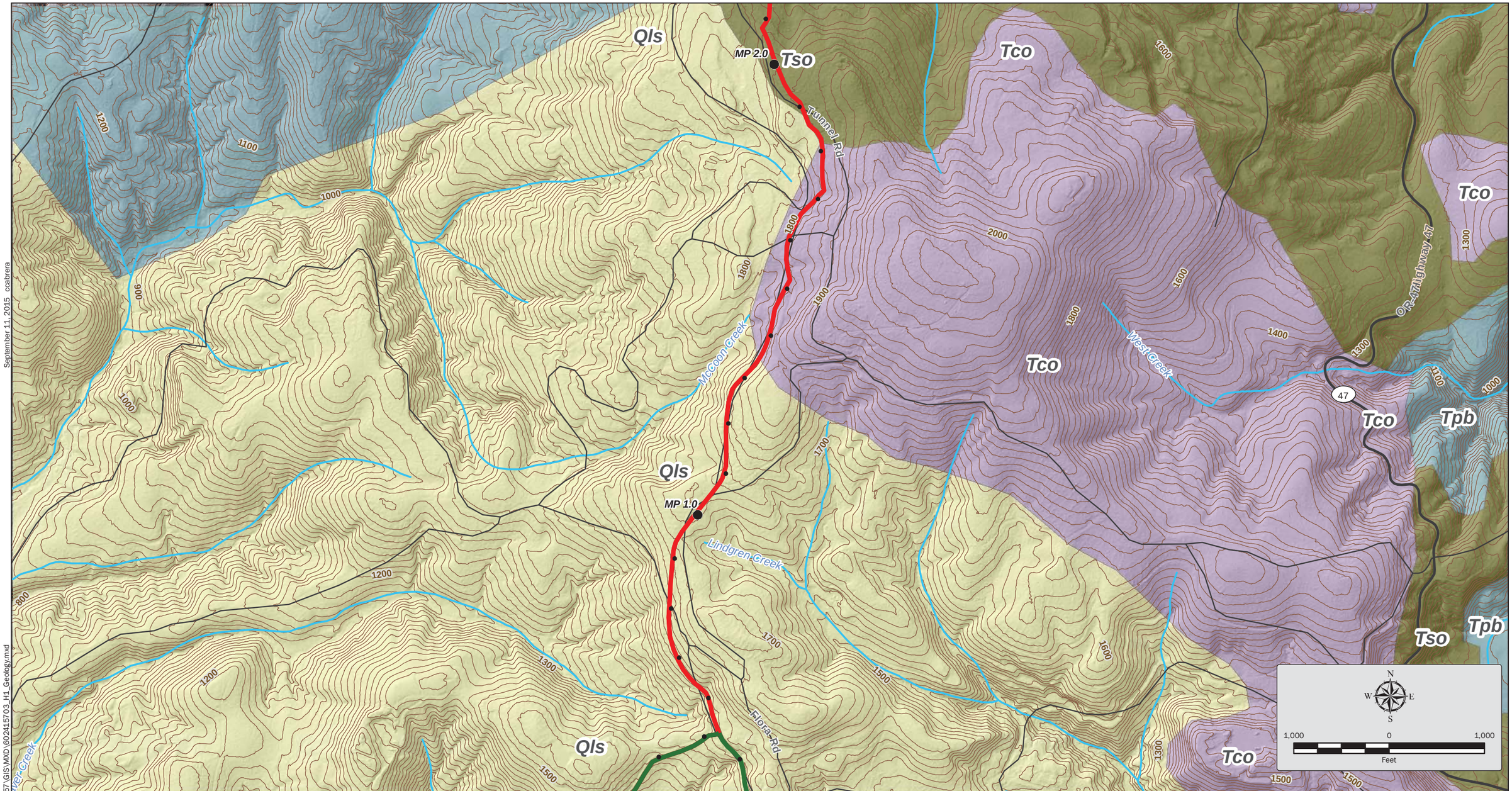

Data Source:
Geology from DOGAMI's Oregon Geologic Data Compilation, (OGDC-5, May 2009). 2014 ESRI Street Map and ArcGIS Online, Streets Basemap .
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- Approximate Boring Location
- Contours (20 foot)

Surficial Geology
- Qal: Alluvium
- Qls: Landslide debris

Columbia River Basalt Group (CRBG)
- Twfs: Wanapum Basalt
- Tco: Undifferentiated CRBs
- Tgr1: Grande Ronde Basalt Wapshilla Ridge Member
- Tgr2: Grande Ronde Basalt Grouse Creek Member

Scappoose Formation
- TA: Astoria Group
- Ts1: Astoria Group
- Tso: Astoria Group

Pittsburg Bluff Formation
- Tps: siltstone member
- Tpbcc: Conyers Creek Member
- Tpb: East Fork Member
- Tc: Clatskanie Conglomerate

Grays River Volcanics
- Tgrv: Yachats - Tillamook Group

Geology Map

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-3

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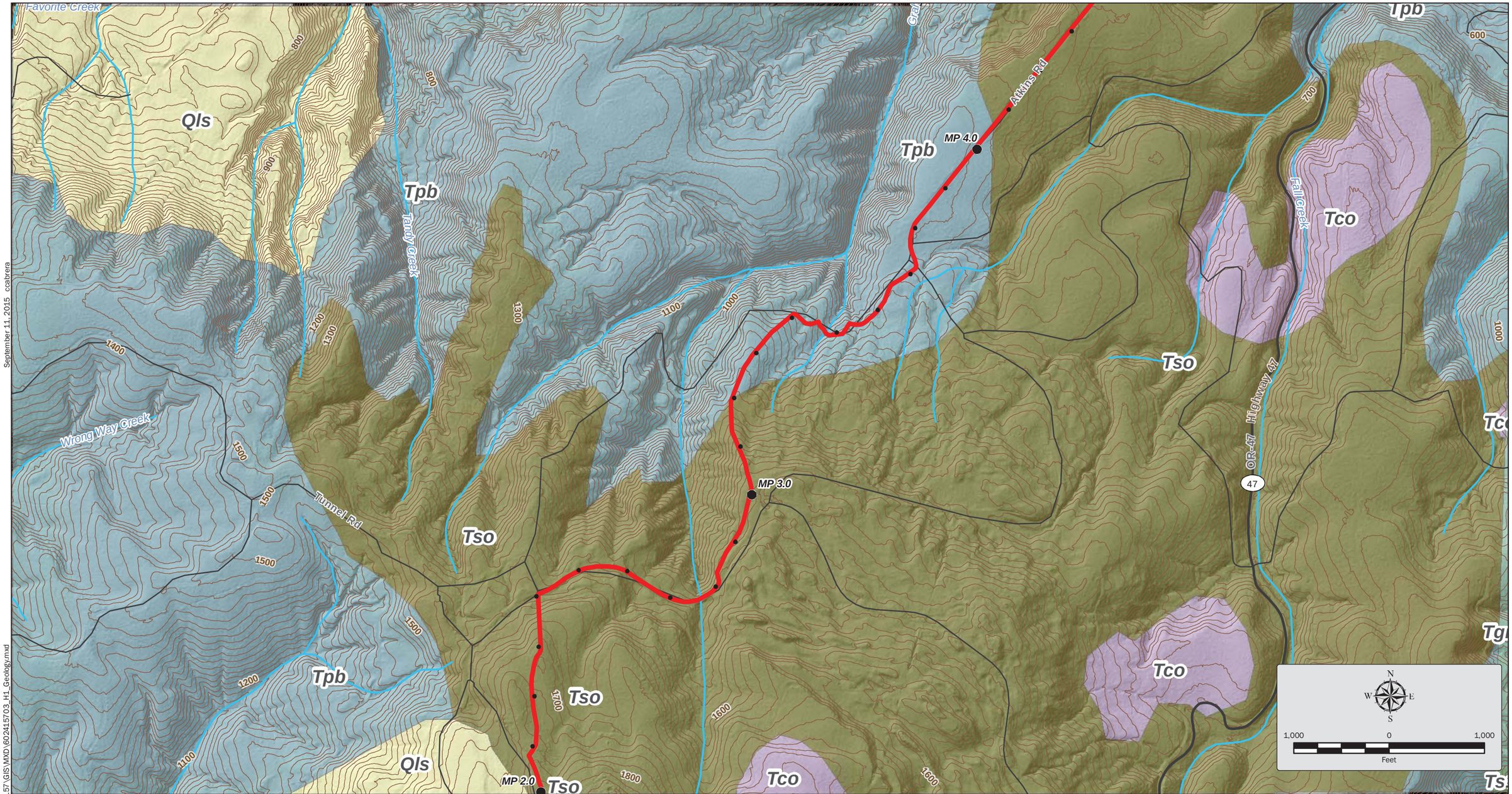

Data Source:
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LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- Approximate Boring Location
- Contours (20 foot)

Surficial Geology
- Qal: Alluvium
- Qls: Landslide debris

Columbia River Basalt Group (CRBG)
- Twfs: Wanapum Basalt
- Tco: Undifferentiated CRBs
- Tgr1: Grande Ronde Basalt Wapshilla Ridge Member
- Tgr2: Grande Ronde Basalt Grouse Creek Member

Scappoose Formation
- TA: Astoria Group
- Ts1: Astoria Group
- Tso: Astoria Group

Pittsburg Bluff Formation
- Tps: siltstone member
- Tpbcc: Conyers Creek Member
- Tpb: East Fork Member
- Tc: Clatskanie Conglomerate

Grays River Volcanics
- Tgrv: Yachats - Tillamook Group

Geology Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-4

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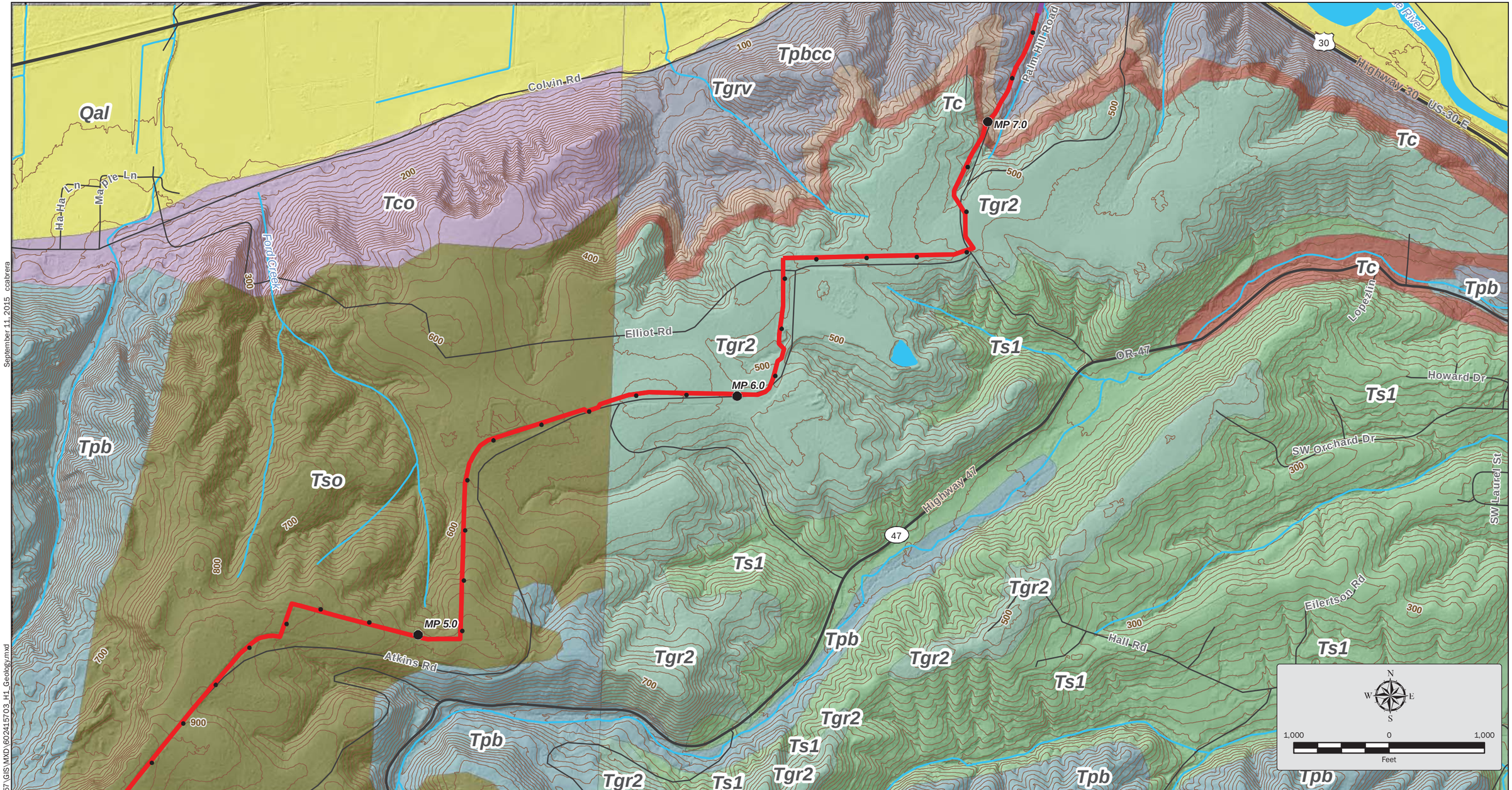

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Geology from DOGAMI's Oregon Geologic Data Compilation, (OGDC-5, May 2009). 2014 ESRI Street Map and ArcGIS Online, Streets Basemap .
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- Approximate Boring Location
- Contours (20 foot)

Surficial Geology
- Qal: Alluvium
- Qls: Landslide debris

Columbia River Basalt Group (CRBG)
- Twfs: Wanapum Basalt
- Tco: Undifferentiated CRBs
- Tgr1: Grande Ronde Basalt Wapshilla Ridge Member
- Tgr2: Grande Ronde Basalt Grouse Creek Member

Scappoose Formation
- TA: Astoria Group
- Ts1: Astoria Group
- Tso: Astoria Group

Pittsburg Bluff Formation
- Tps: siltstone member
- Tpbcc: Conyers Creek Member
- Tpb: East Fork Member
- Tc: Clatskanie Conglomerate

Grays River Volcanics
- Tgrv: Yachats - Tillamook Group

Geology Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-5

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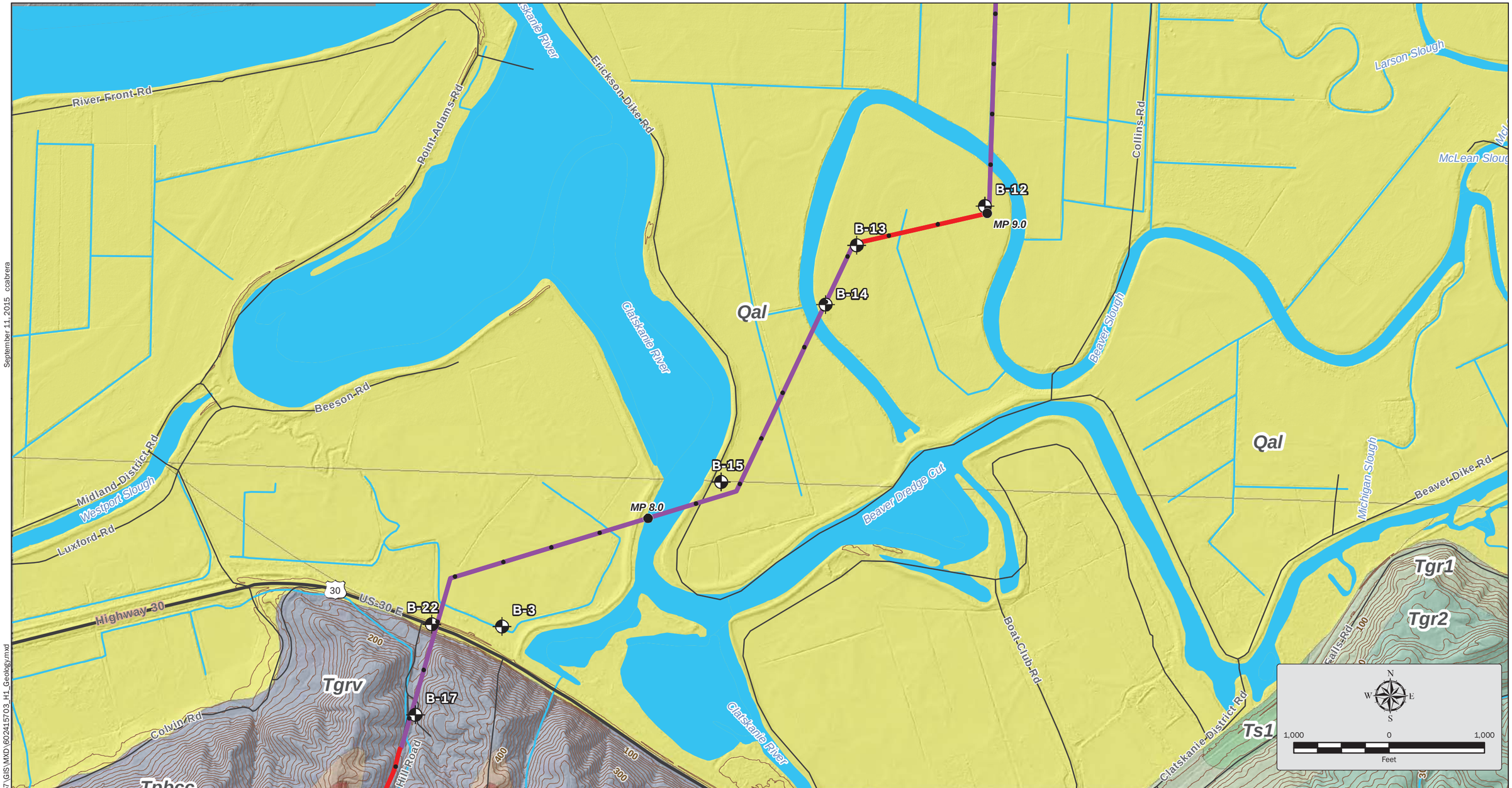

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Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- Approximate Boring Location
- Contours (20 foot)

Surficial Geology
- Qal: Alluvium
- Qls: Landslide debris

Columbia River Basalt Group (CRBG)
- Twfs: Wanapum Basalt
- Tco: Undifferentiated CRBs
- Tgr1: Grande Ronde Basalt Wapshilla Ridge Member
- Tgr2: Grande Ronde Basalt Grouse Creek Member

Scappoose Formation
- TA: Astoria Group
- Ts1: Astoria Group
- Tso: Astoria Group

Pittsburg Bluff Formation
- Tps: siltstone member
- Tpbcc: Conyers Creek Member
- Tpb: East Fork Member
- Tc: Clatskanie Conglomerate

Grays River Volcanics
- Tgrv: Yachats - Tillamook Group

Geology Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-6

Office: PORT Path: \\pdx\projects\6\60241.57\GIS\MXD\602415703_H1_Geology.mxd September 11, 2015 ccabrera

Data Source:
Geology from DOGAMI's Oregon Geologic Data Compilation, (OGDC-5, May 2009). 2014 ESRI Street Map and ArcGIS Online, Streets Basemap .
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- Approximate Boring Location
- Contours (20 foot)

Surficial Geology
- Qal: Alluvium
- Qls: Landslide debris

Columbia River Basalt Group (CRBG)
- Twfs: Wanapum Basalt
- Tco: Undifferentiated CRBs
- Tgr1: Grande Ronde Basalt Wapshilla Ridge Member
- Tgr2: Grande Ronde Basalt Grouse Creek Member

Scappoose Formation
- TA: Astoria Group
- Ts1: Astoria Group
- Tso: Astoria Group

Pittsburg Bluff Formation
- Tps: siltstone member
- Tpbcc: Conyers Creek Member
- Tpb: East Fork Member
- Tc: Clatskanie Conglomerate

Grays River Volcanics
- Tgrv: Yachats - Tillamook Group

Geology Map

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-7

Office: PORT Path: \\pdx\projects\6\60241.57\GIS\MXD\60241.5703_H1_Geology.mxd September 11, 2015 ccabrera

Data Source:
Geology from DOGAMI's Oregon Geologic Data Compilation, (OGDC-5, May 2009). 2014 ESRI Street Map and ArcGIS Online, Streets Basemap .
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- Approximate Boring Location
- Contours (20 foot)

Surficial Geology
- Qal: Alluvium
- Qls: Landslide debris

Columbia River Basalt Group (CRBG)
- Twfs: Wanapum Basalt
- Tco: Undifferentiated CRBs
- Tgr1: Grande Ronde Basalt Wapshilla Ridge Member
- Tgr2: Grande Ronde Basalt Grouse Creek Member

Scappoose Formation
- TA: Astoria Group
- Ts1: Astoria Group
- Tso: Astoria Group

Pittsburg Bluff Formation
- Tps: siltstone member
- Tpbcc: Conyers Creek Member
- Tpb: East Fork Member
- Tc: Clatskanie Conglomerate

Grays River Volcanics
- Tgrv: Yachats - Tillamook Group

Geology Map

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-8

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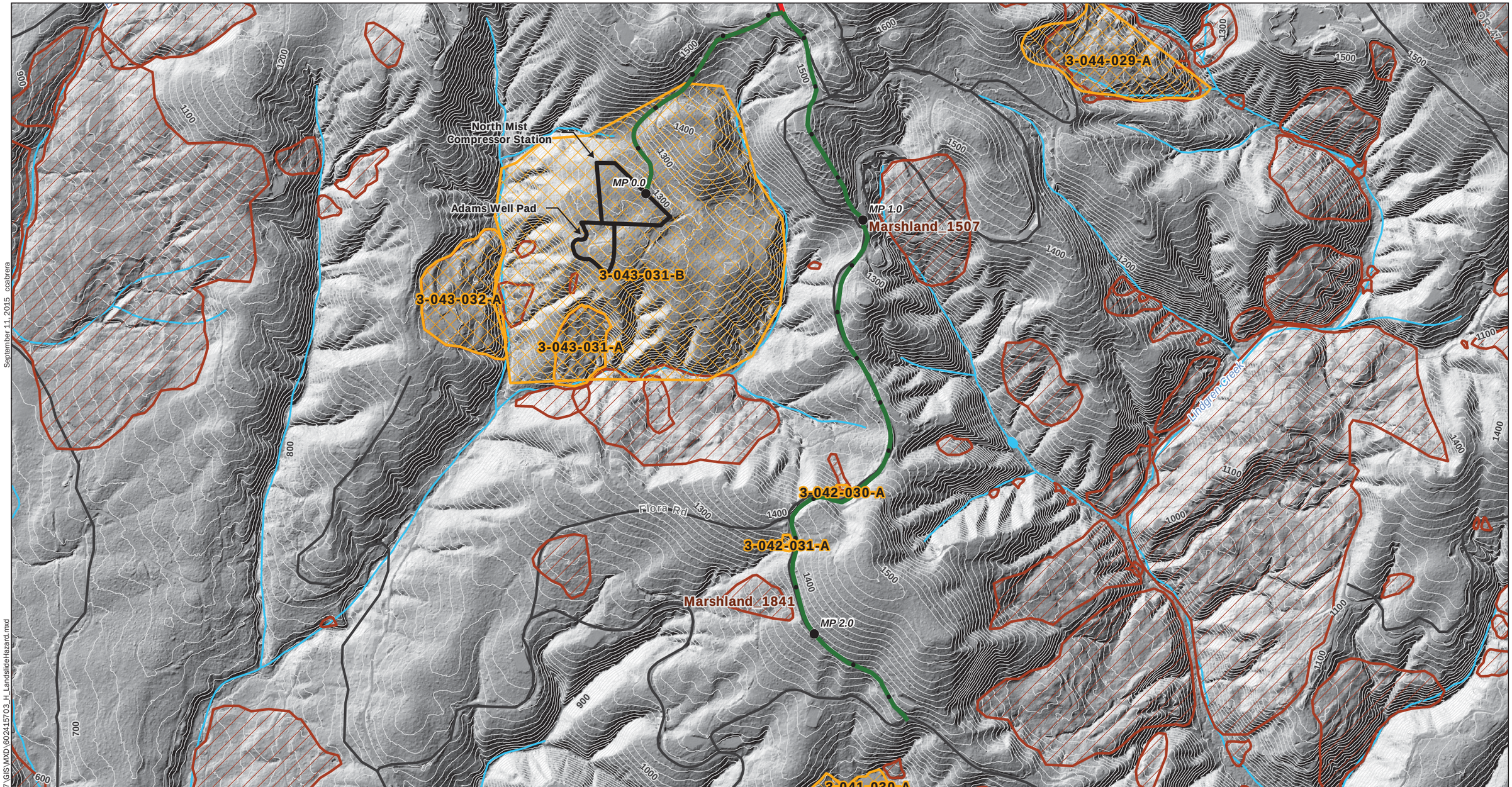

Data Source:
SLIDO 3.2 landslides from DOGAMI. 2014 ESRI Street Map
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN Lambert Conformal Conic

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- GeoEngineers Identified Landslides and Identification Number
- Slido Identified Landslides (DOGAMI)

N W E S

1,000 0 1,000
Feet

Landslide Hazard Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-9

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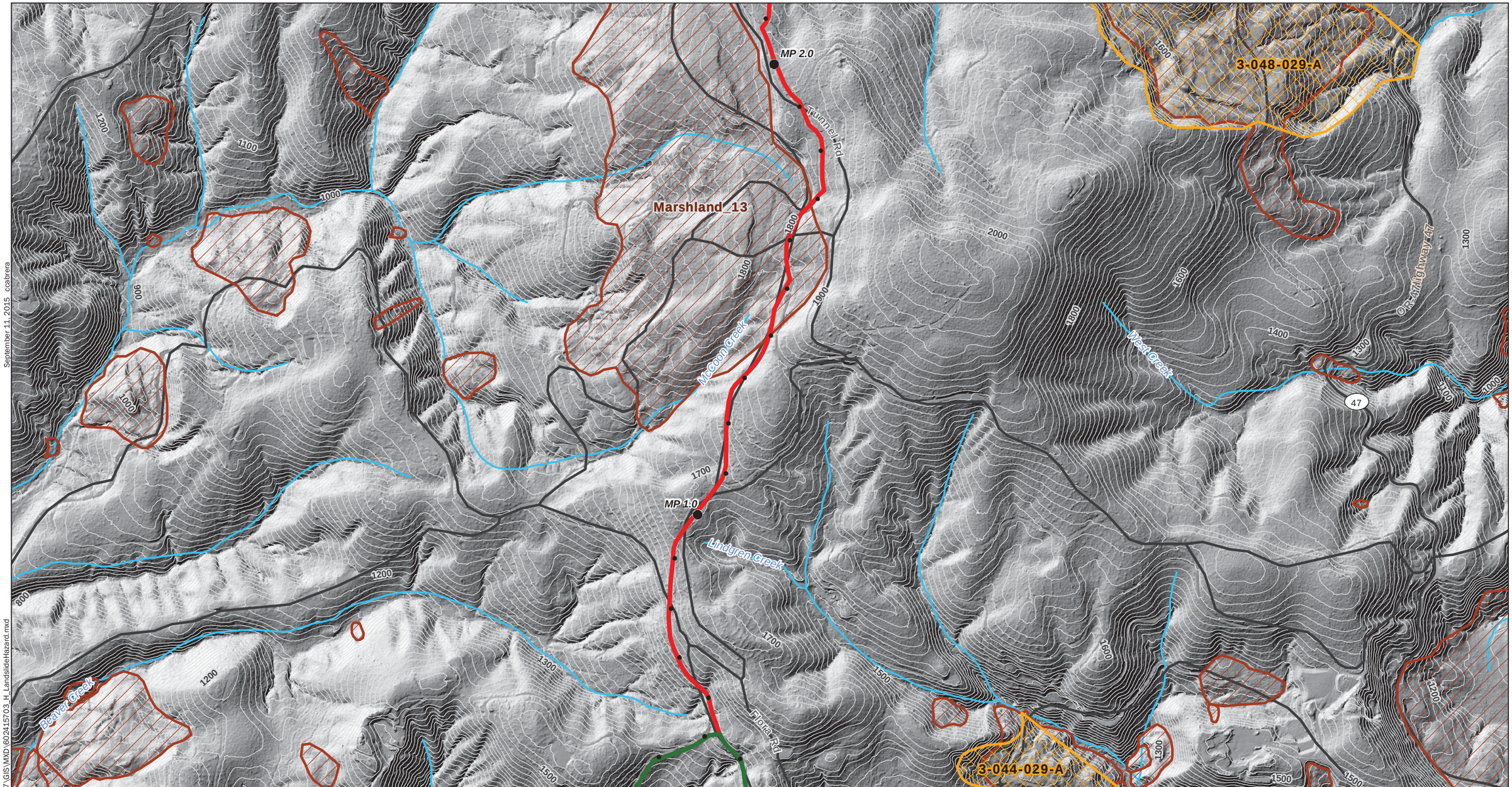

Data Source:
SLIDO 3.2 landslides from DOGAMI. 2014 ESRI Street Map
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
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Projection: NAD 1983 HARN Lambert Conformal Conic

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- GeoEngineers Identified Landslides and Identification Number
- Slido Identified Landslides (DOGAMI)

N W E S

1,000 0 1,000
Feet

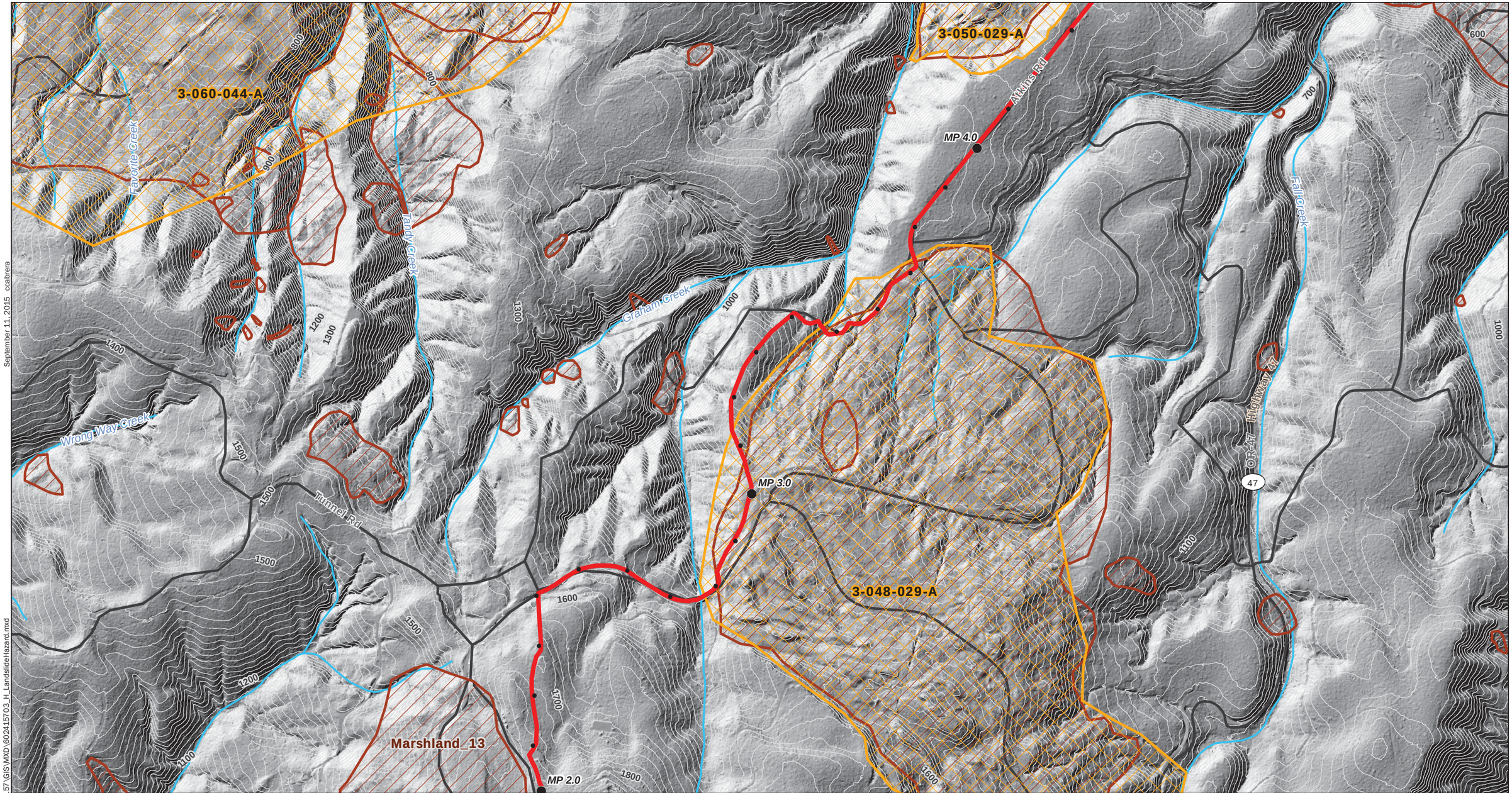
Landslide Hazard Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-10

Office: PORT Path: \\pdx\projects\6\6024157\GIS\MXD\6024157\03_H_LandslideHazard.mxd September 11, 2015 ccabrera



Data Source:
SLIDO 3.2 landslides from DOGAMI. 2014 ESRI Street Map
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN Lambert Conformal Conic

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- GeoEngineers Identified Landslides and Identification Number
- Slido Identified Landslides (DOGAMI)

N W E S

1,000 0 1,000
Feet

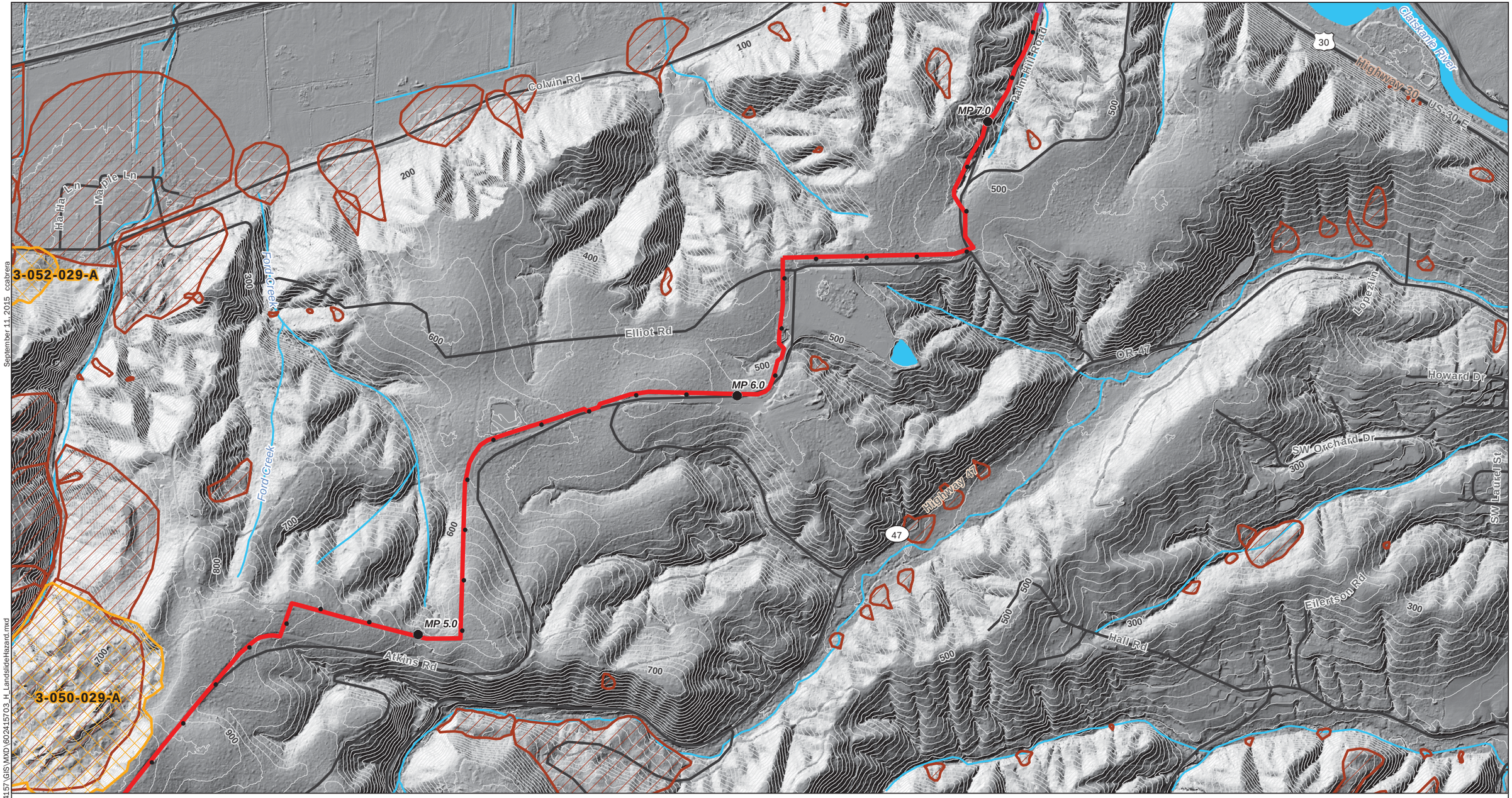
Landslide Hazard Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-11

Office: PORT Path: \\pdx\projects\6\6024157\GIS\MXD\6024157\03_H_LandslideHazard.mxd September 11, 2015 ccabrera



Data Source:
SLIDO 3.2 landslides from DOGAMI. 2014 ESRI Street Map
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN Lambert Conformal Conic

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- GeoEngineers Identified Landslides and Identification Number
- Slido Identified Landslides (DOGAMI)

N W E S

1,000 0 1,000
Feet

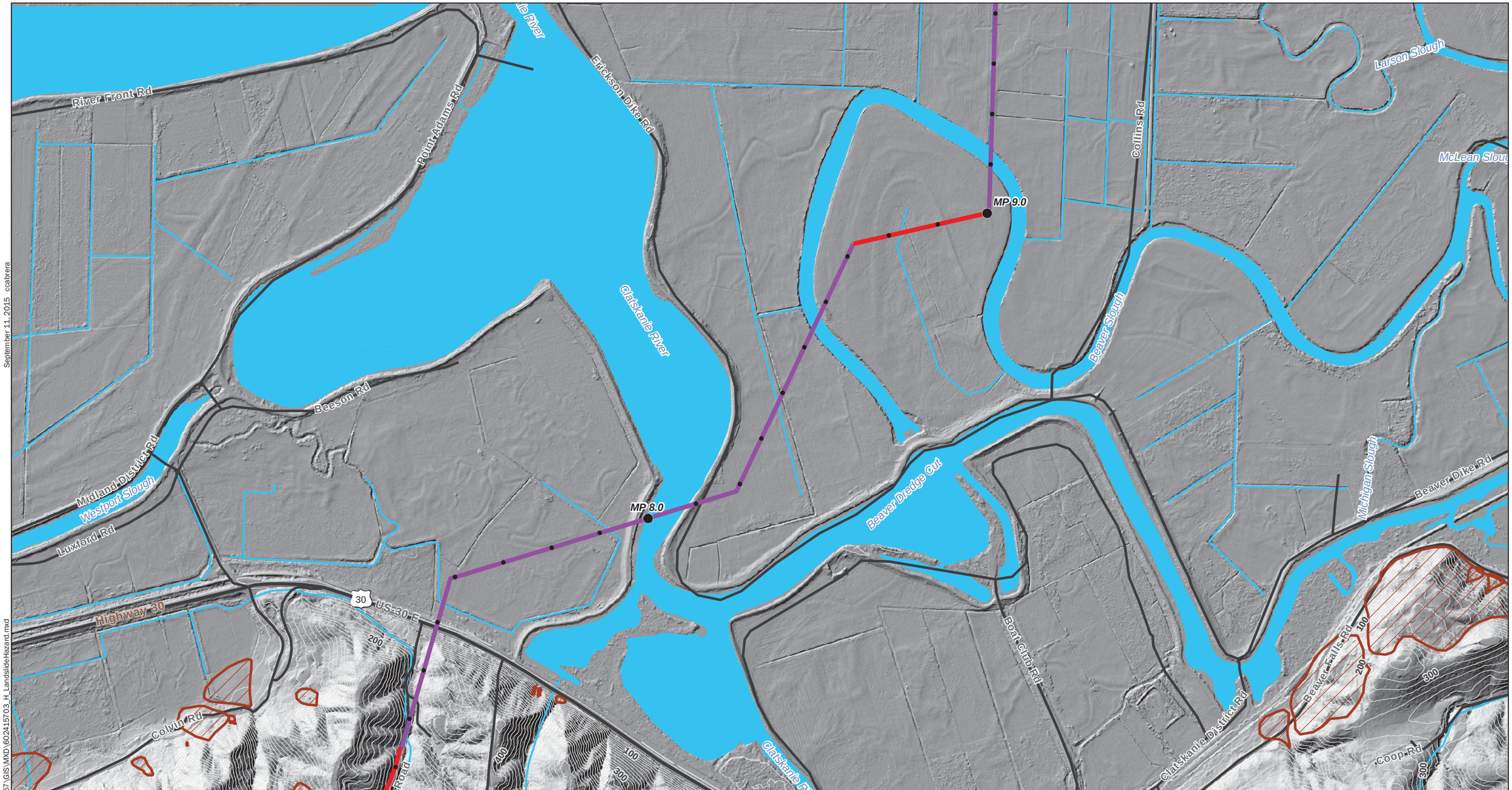
Landslide Hazard Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-12

Office: PORT Path: \\pdx\projects\6\6024157\GIS\MXD\6024157\03_H_LandslideHazard.mxd September 11, 2015 ccabrera



September 11, 2015 ccabrera

Path: \\pdx\projects\6\60241.57\GIS\MXD\60241.5703_H_LandslideHazard.mxd

Office: PORT

Data Source:
SLIDO 3.2 landslides from DOGAMI. 2014 ESRI Street Map
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN Lambert Conformal Conic

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- GeoEngineers Identified Landslides and Identification Number
- Slido Identified Landslides (DOGAMI)

N W E S

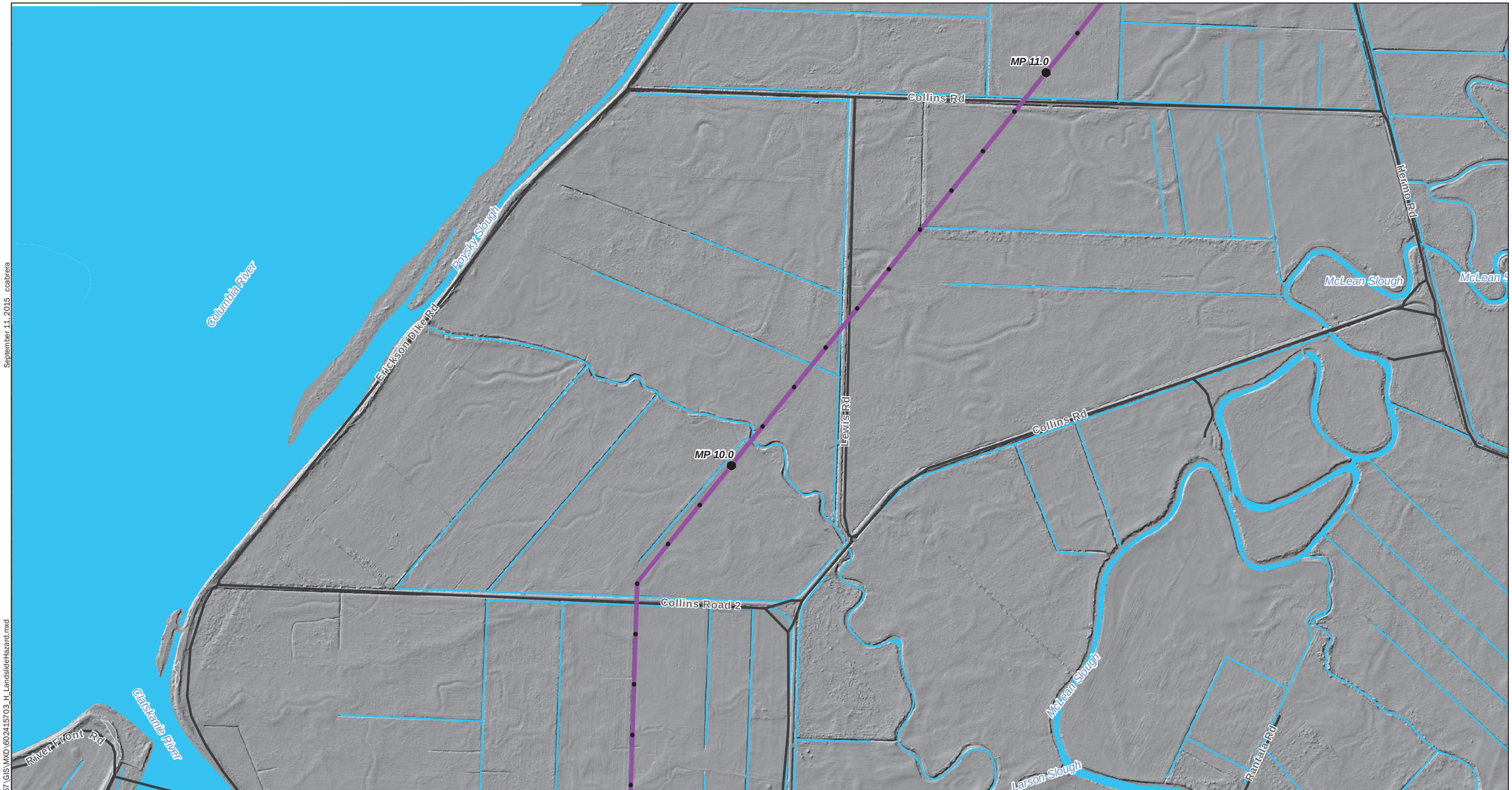
1,000 0 1,000
Feet

Landslide Hazard Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-13



Data Source:
SLIDO 3.2 landslides from DOGAMI. 2014 ESRI Street Map
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN Lambert Conformal Conic

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- GeoEngineers Identified Landslides and Identification Number
- Slido Identified Landslides (DOGAMI)

N W E S

1,000 0 1,000
Feet

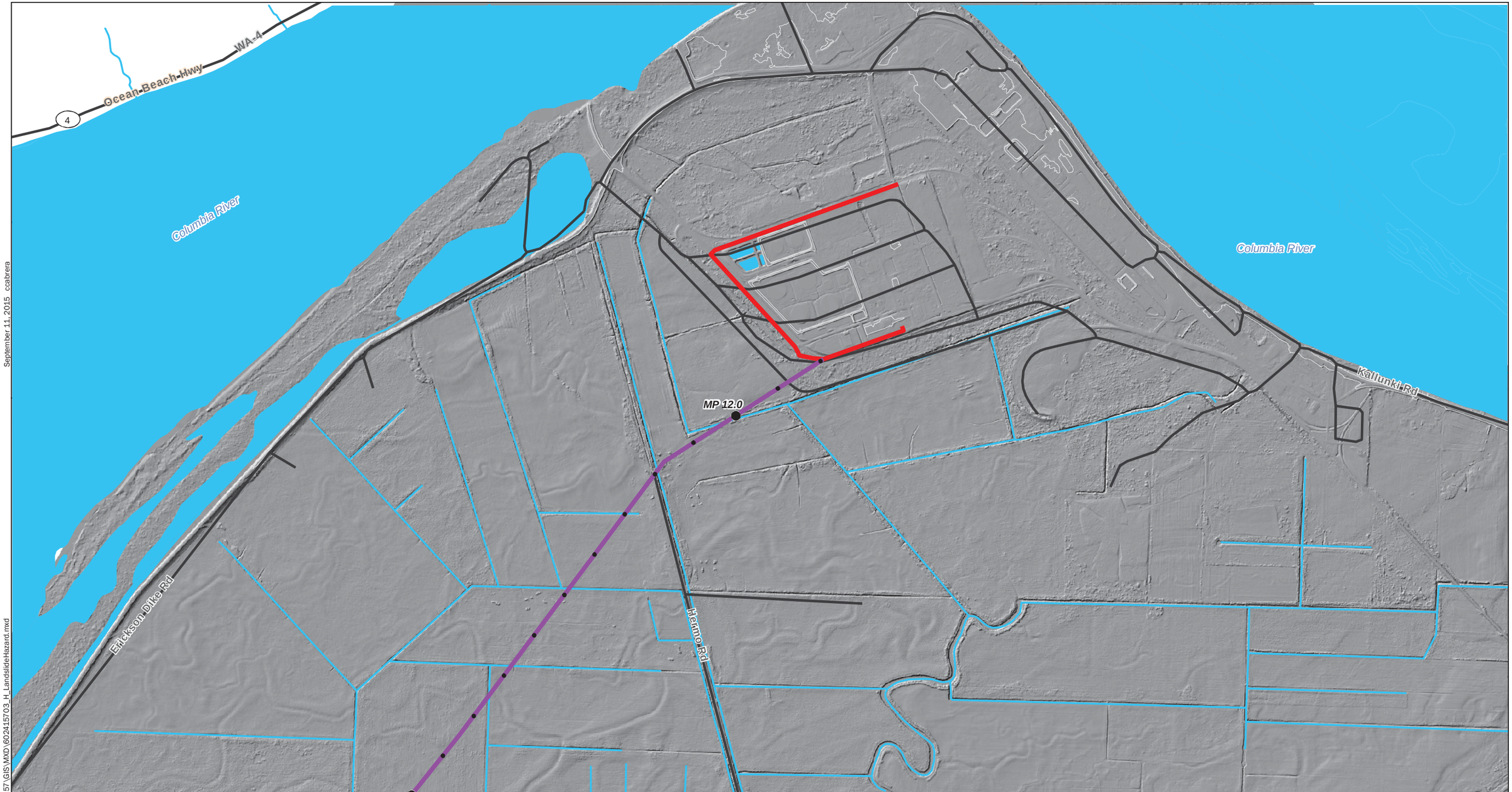
Landslide Hazard Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-14

Office: PORT Path: \\pdx\projects\6\60241.57\GIS\MXD\60241.57\03_H_LandslideHazard.mxd September 11, 2015 ccabrera



Data Source:
SLIDO 3.2 landslides from DOGAMI. 2014 ESRI Street Map
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
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Projection: NAD 1983 HARN Lambert Conformal Conic

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost
- GeoEngineers Identified Landslides and Identification Number
- Slido Identified Landslides (DOGAMI)

N W E S

1,000 0 1,000
Feet

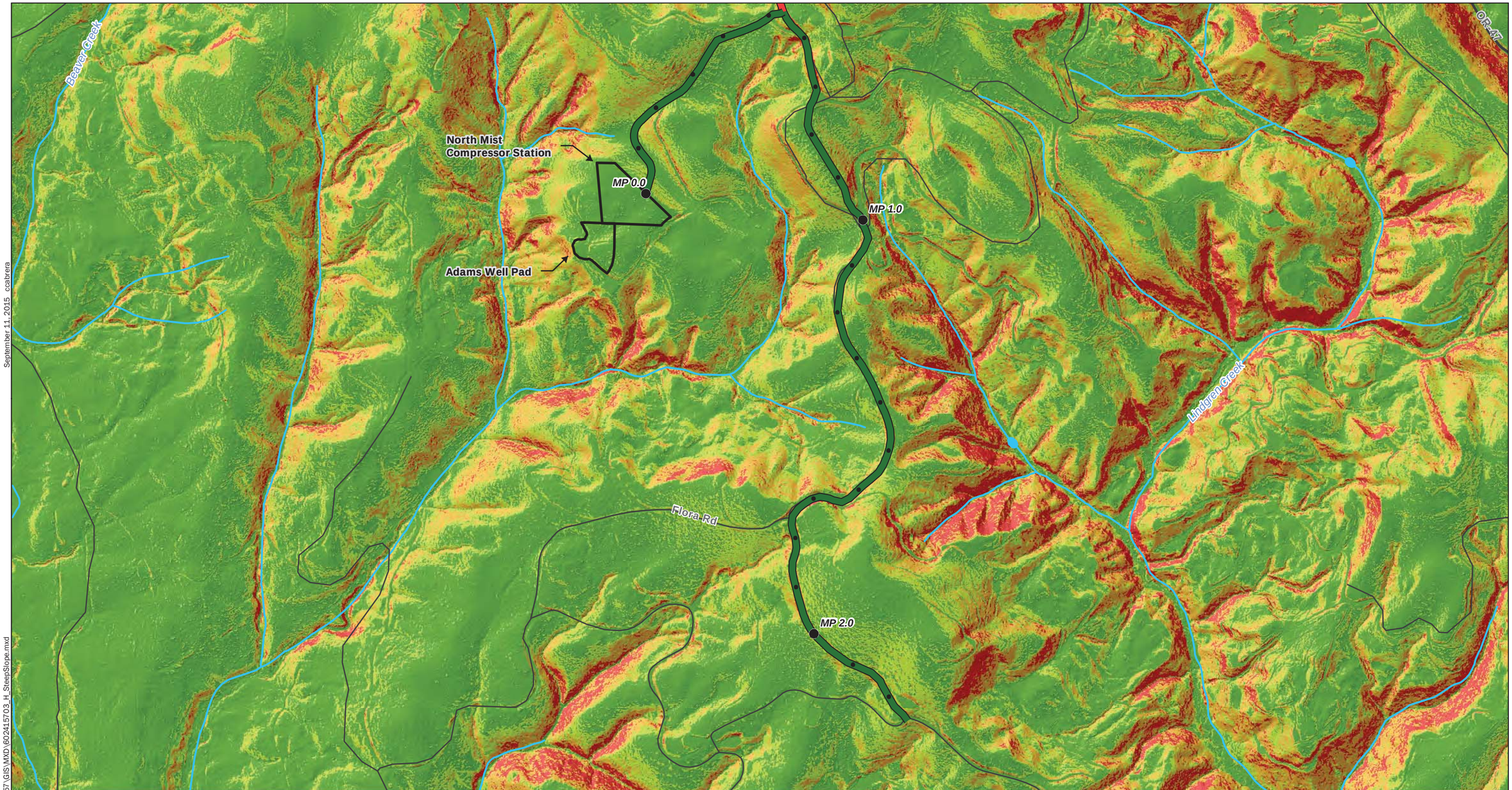
Landslide Hazard Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-15

September 11, 2015 ccabrera
Path: \\pdx\projects\6\6024157\GIS\MXD\6024157\03_H_LandslideHazard.mxd
Office: PORT



Data Source: ESRI Data Online, ESRI Base Map.
Steep slopes derived from LiDAR DEM from NW Natural.
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

Slope

- 0 - 30%
- 30 - 50%
- 50 - 80%
- >80%

N W E S

1,000 0 1,000
Feet

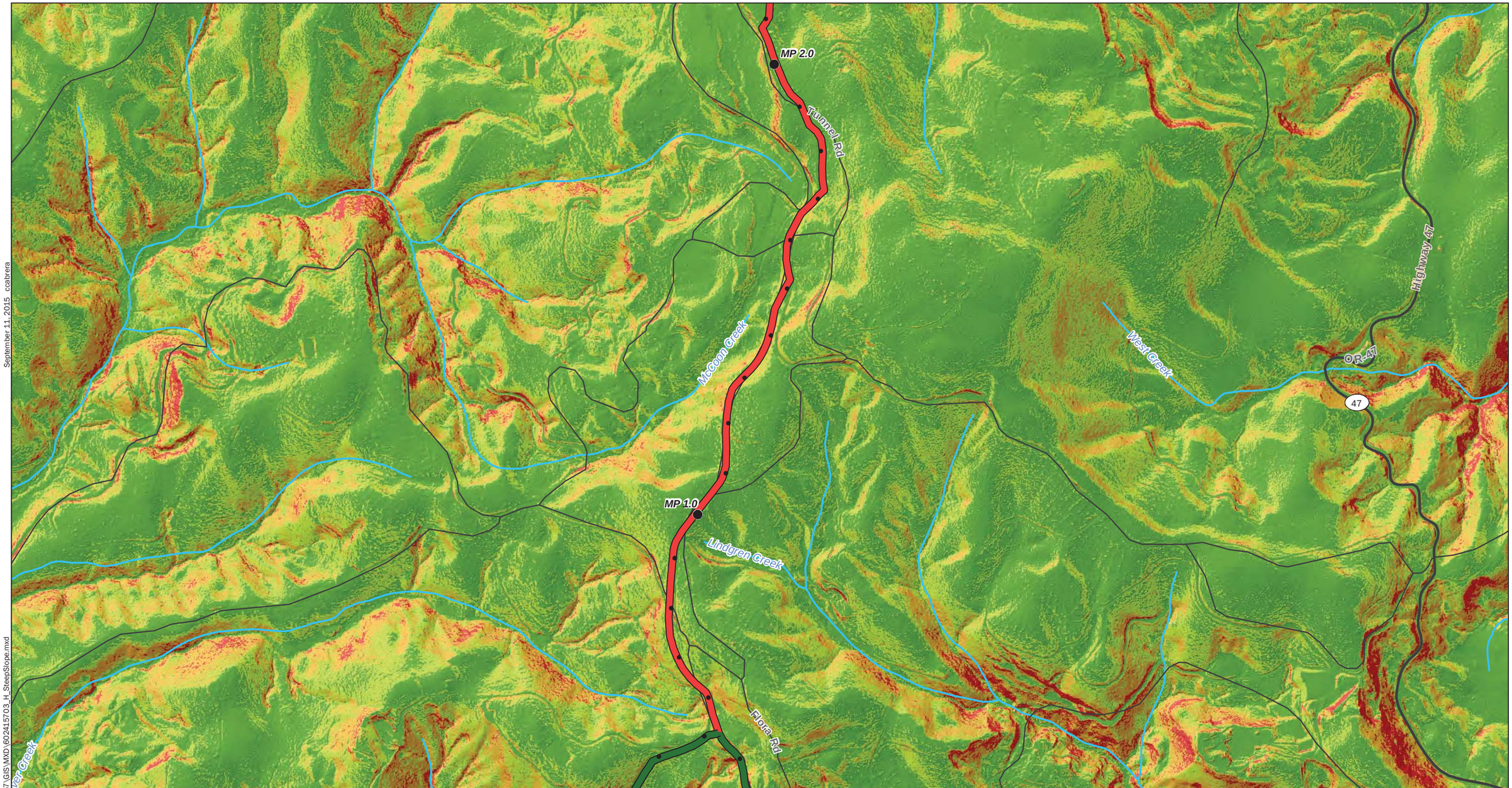
Slope Gradient Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-16

Office:PORT Path: \\pdx\projects\6\6024157\GIS\MXD\6024157G3_H_SteepSlope.mxd September 11, 2015 ccabrera



Data Source: ESRI Data Online, ESRI Base Map.
Steep slopes derived from LiDAR DEM from NW Natural.
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

Slope

- 0 - 30%
- 30 - 50%
- 50 - 80%
- >80%

N W E S

1,000 0 1,000
Feet

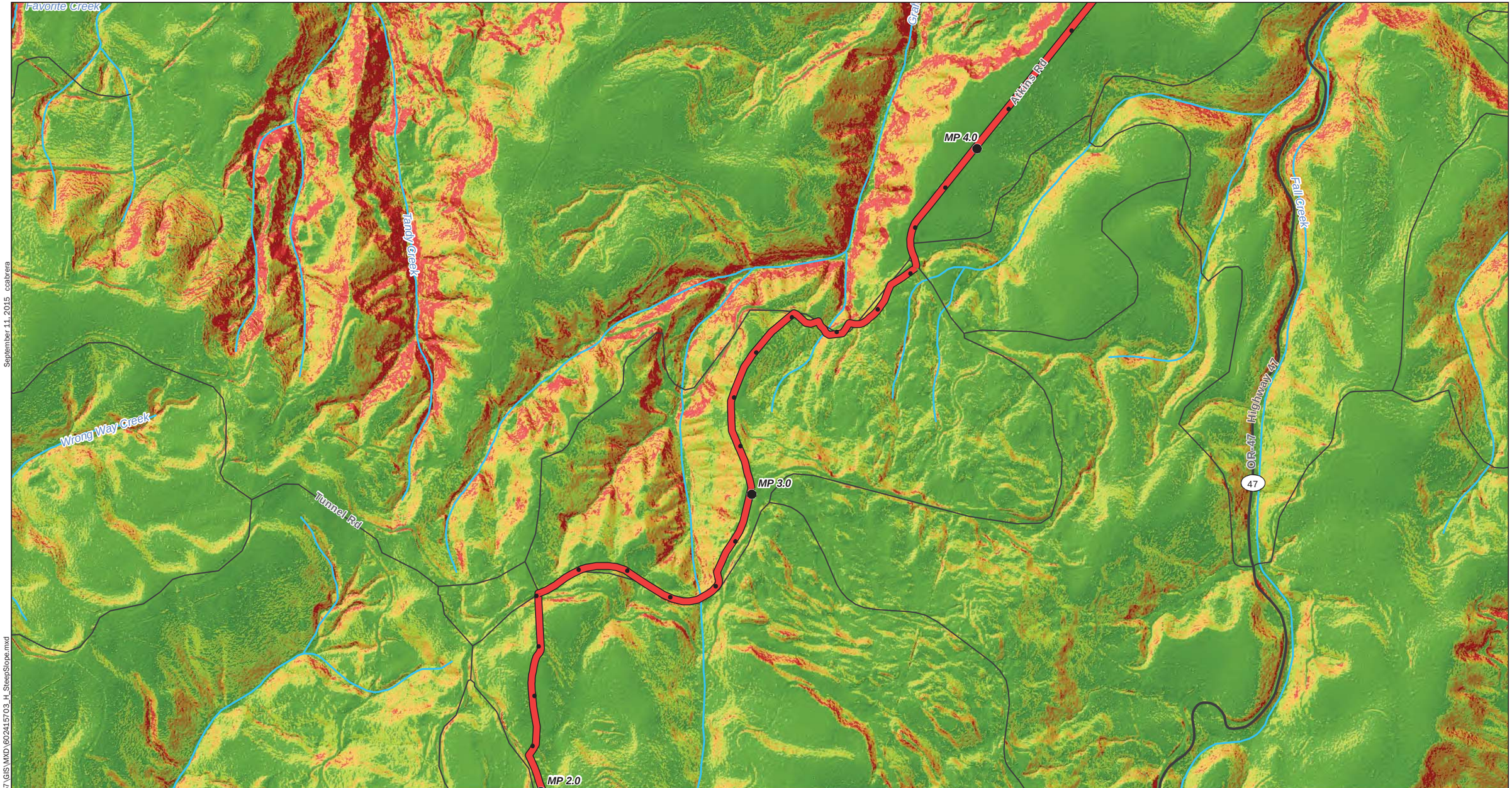
Slope Gradient Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-17

Office:PORT Path: \\prdx\projects\6\0024157\GIS\MXD\0024157\03_H_SteepSlope.mxd September 11, 2015 ccabrera



Data Source: ESRI Data Online, ESRI Base Map.
Steep slopes derived from LiDAR DEM from NW Natural.
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

Slope
- 0 - 30%
- 30 - 50%
- 50 - 80%
- >80%

N W E S

1,000 0 1,000
Feet

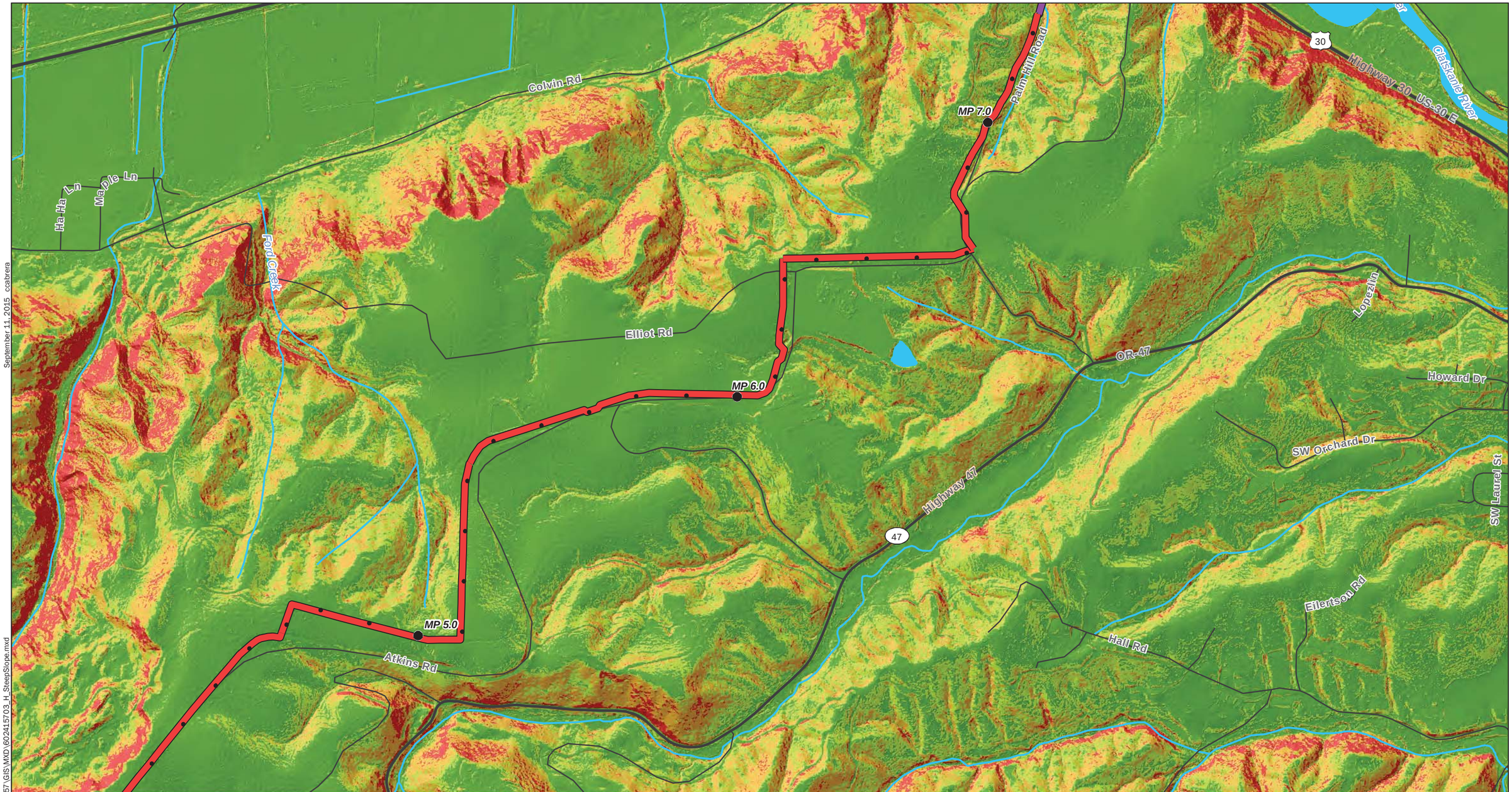
Slope Gradient Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-18

Office:PORT Path: \\pdx\projects\6\6024157\GIS\MXD\6024157\03_H_SteepSlope.mxd September 11, 2015 ccabrera



Data Source: ESRI Data Online, ESRI Base Map.
Steep slopes derived from LiDAR DEM from NW Natural.
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

Slope
- 0 - 30%
- 30 - 50%
- 50 - 80%
- >80%

N W E S

1,000 0 1,000
Feet

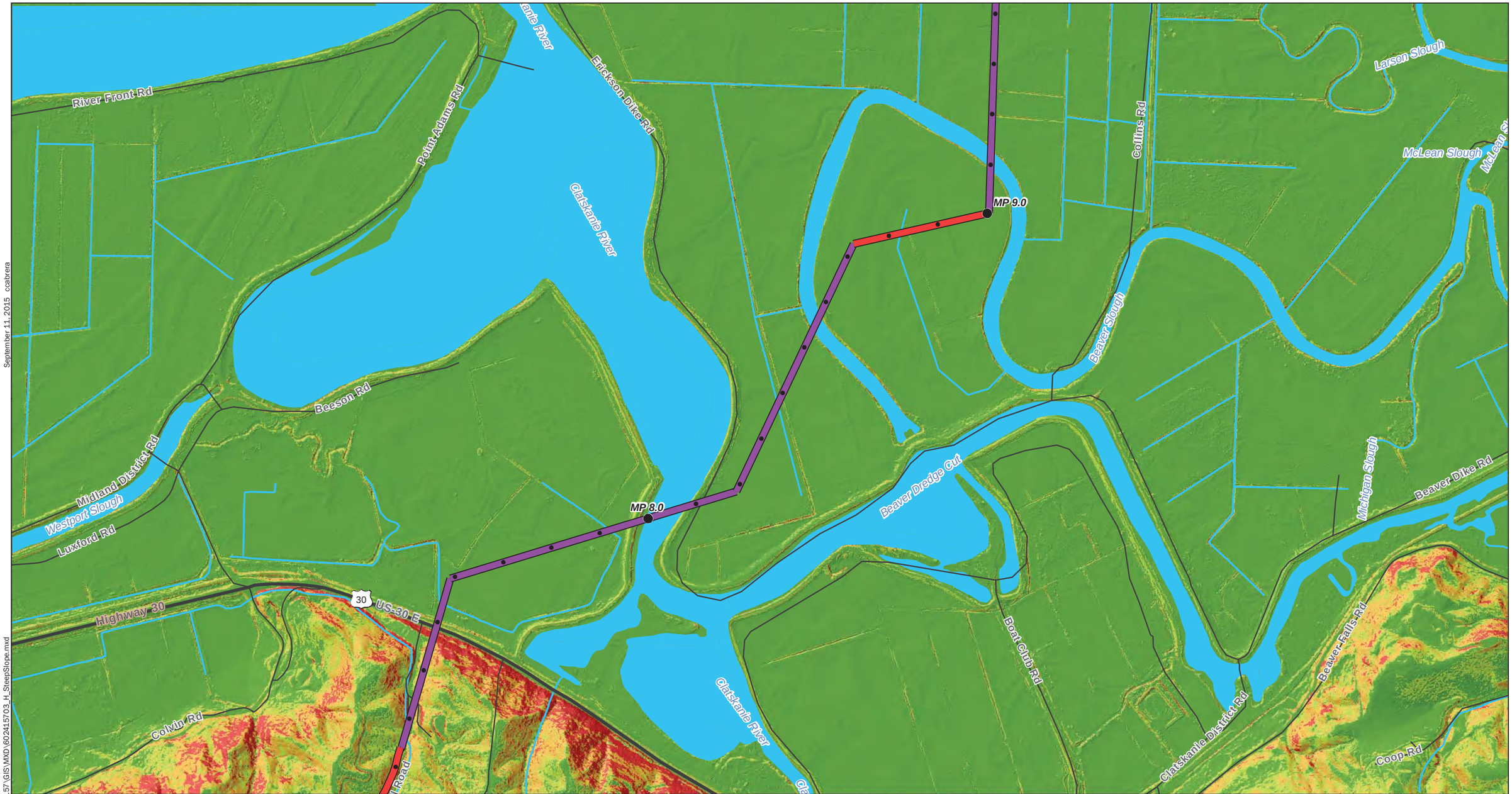
Slope Gradient Map

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-19

Office:PORT Path: \\pdx\projects\6\60241.57\GIS\MXD\602415703_H_SteepSlope.mxd September 11, 2015 ccabrera



Data Source: ESRI Data Online, ESRI Base Map.
Steep slopes derived from LiDAR DEM from NW Natural.
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

Slope
- 0 - 30%
- 30 - 50%
- 50 - 80%
- >80%

N W E S

1,000 0 1,000
Feet

Slope Gradient Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-20

September 11, 2015 ccabrera

Path: \\pdx\projects\6\6024157\GIS\MXD\6024157 03_H_SteepSlope.mxd

Office:PORT

Data Source: ESRI Data Online, ESRI Base Map.
Steep slopes derived from LiDAR DEM from NW Natural.
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

Slope
- 0 - 30%
- 30 - 50%
- 50 - 80%
- >80%

N W E S

1,000 0 1,000
Feet

Slope Gradient Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-21

Office:PORT Path: \\pdx\projects\6\6024157\GIS\MXD\602415703_H_SteepSlope.mxd September 11, 2015 ccabrera

Data Source: ESRI Data Online, ESRI Base Map.
Steep slopes derived from LiDAR DEM from NW Natural.
LiDAR from NW Natural, flown April 26, 2009 - June 23, 2009.
Water features from USGS, National Hydrography Dataset.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

Slope

- 0 - 30%
- 30 - 50%
- 50 - 80%
- >80%

N W E S

1,000 0 1,000
Feet

Slope Gradient Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-22

September 11, 2015 ccabrera
Path: \\pdx\projects\6\60241.57\GIS\MXD\60241.5703_H_SteepSlope.mxd
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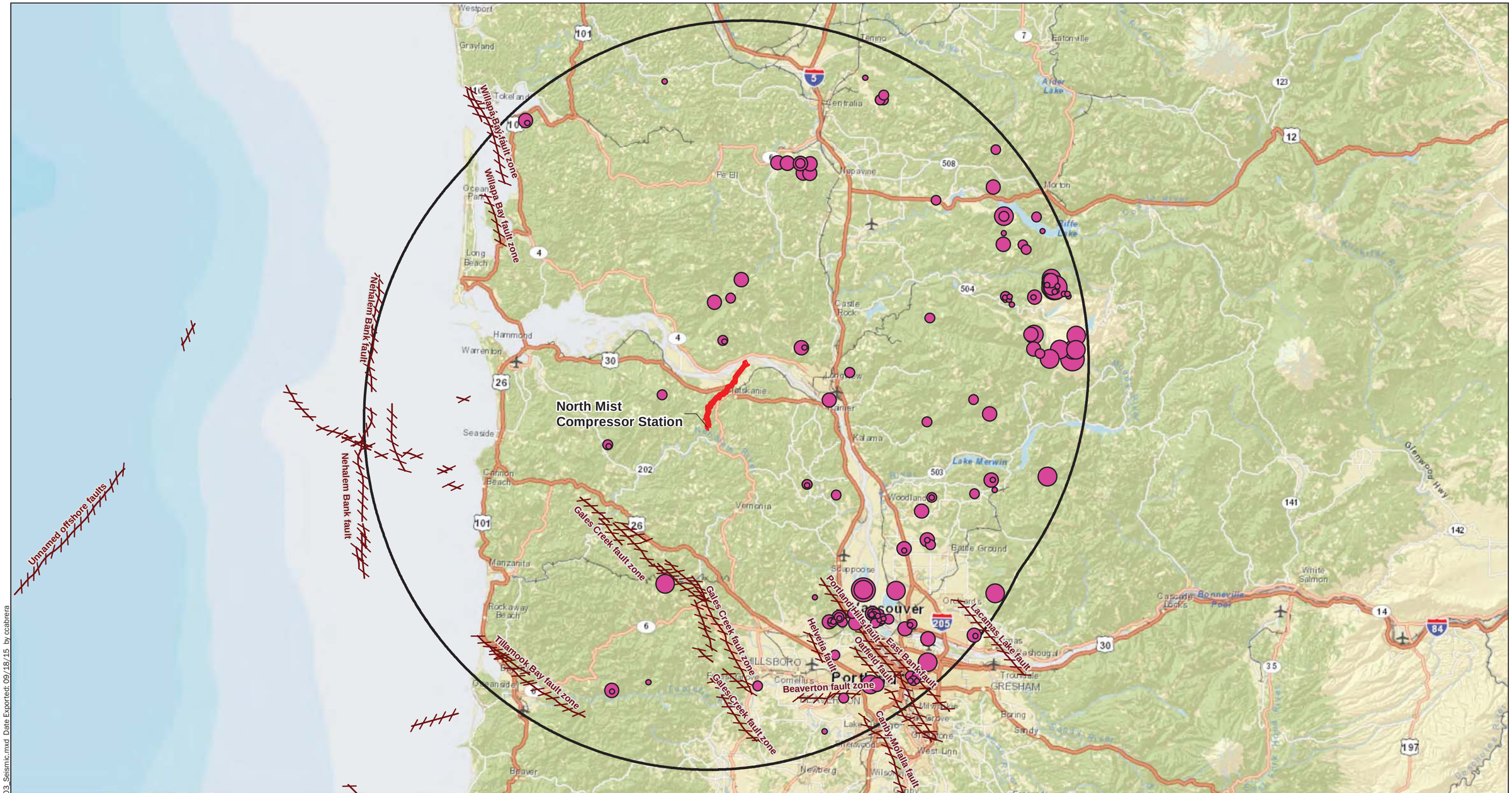


Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Faults (2010) and earthquake (2009 and 2015) locations from United States Geological Survey (USGS)

Projection: NAD 1983 HARN Oregon Statewide Lambert Feet Intl

Legend

- North Mist Expansion Pipeline
- North Mist 50 Mile Buffer
- USGS Quaternary Faults

USGS Historic Earthquakes (Magnitude)

- > 2
- 2 - 3
- 3 - 4
- 4 - 5
- < 5

N W E S

14 0 14
Miles

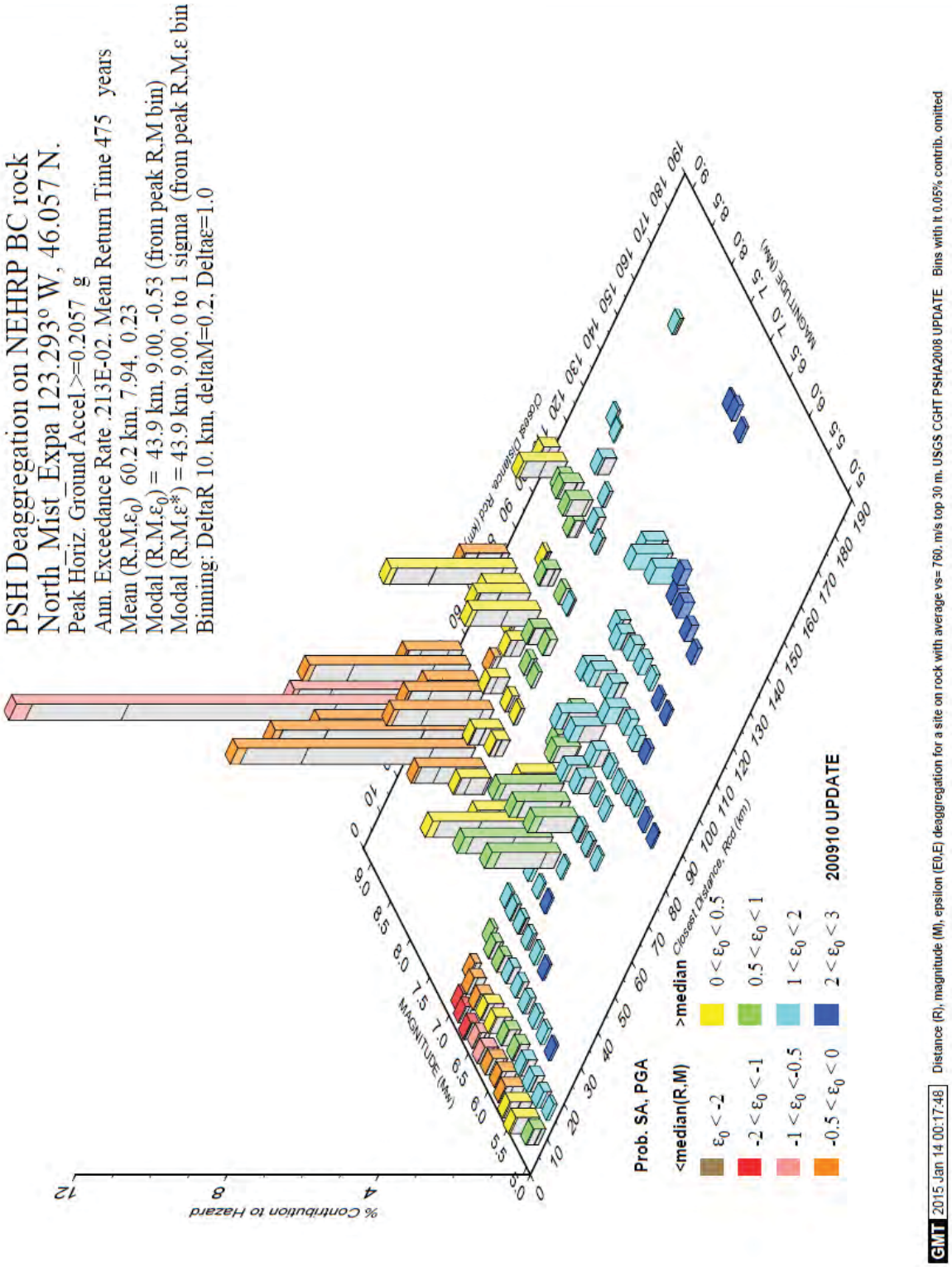
Historical Earthquake and Quaternary Fault Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-23

\\pdx\Projects\6\6024157\GIS\MXD\602415703_Seismic.mxd Date Exported: 09/18/15 by ccabrera

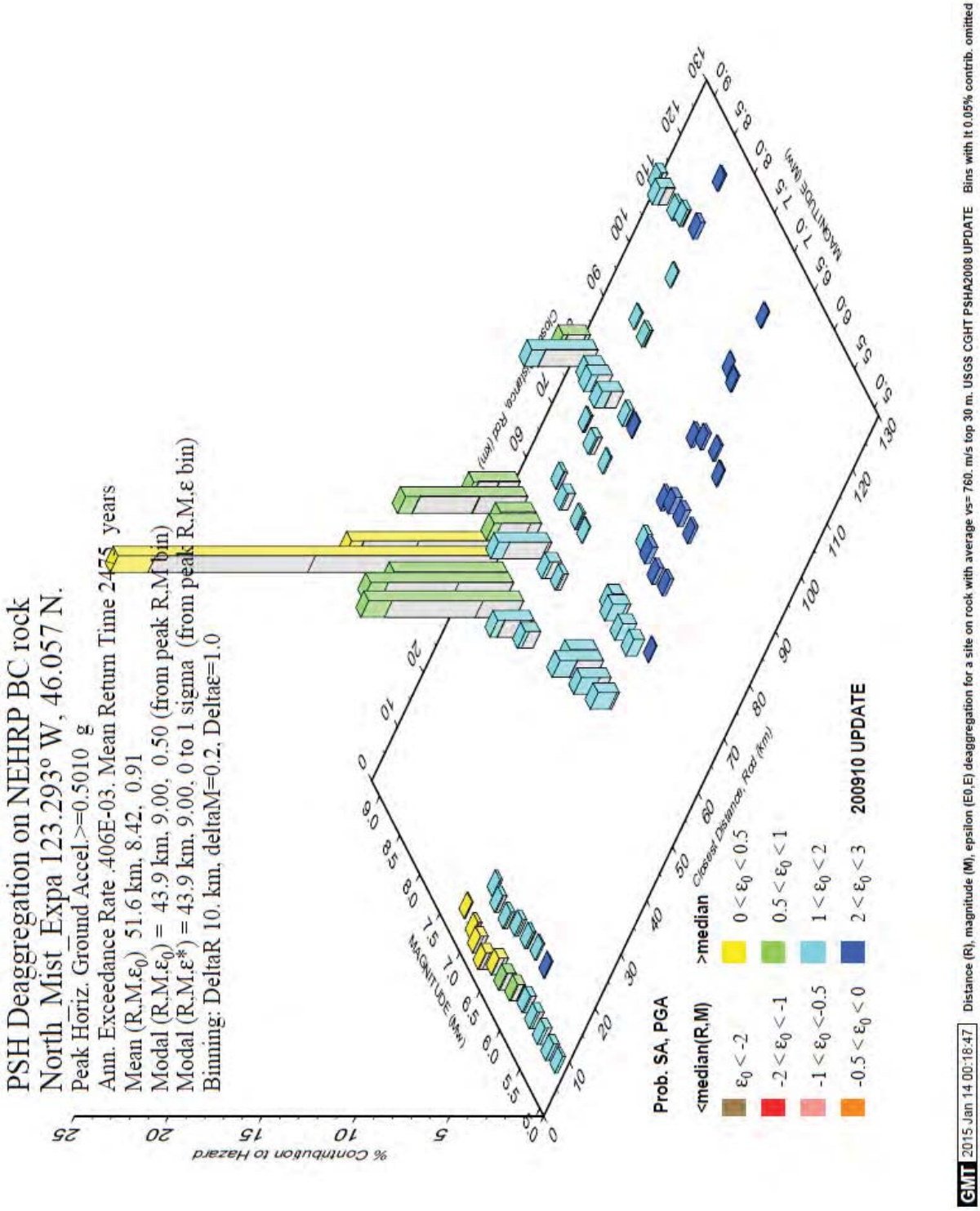


Compressor Station - Seismic Hazard Deaggregation (Rock Outcrop Condition, 475-Yr EQ Level)

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-24

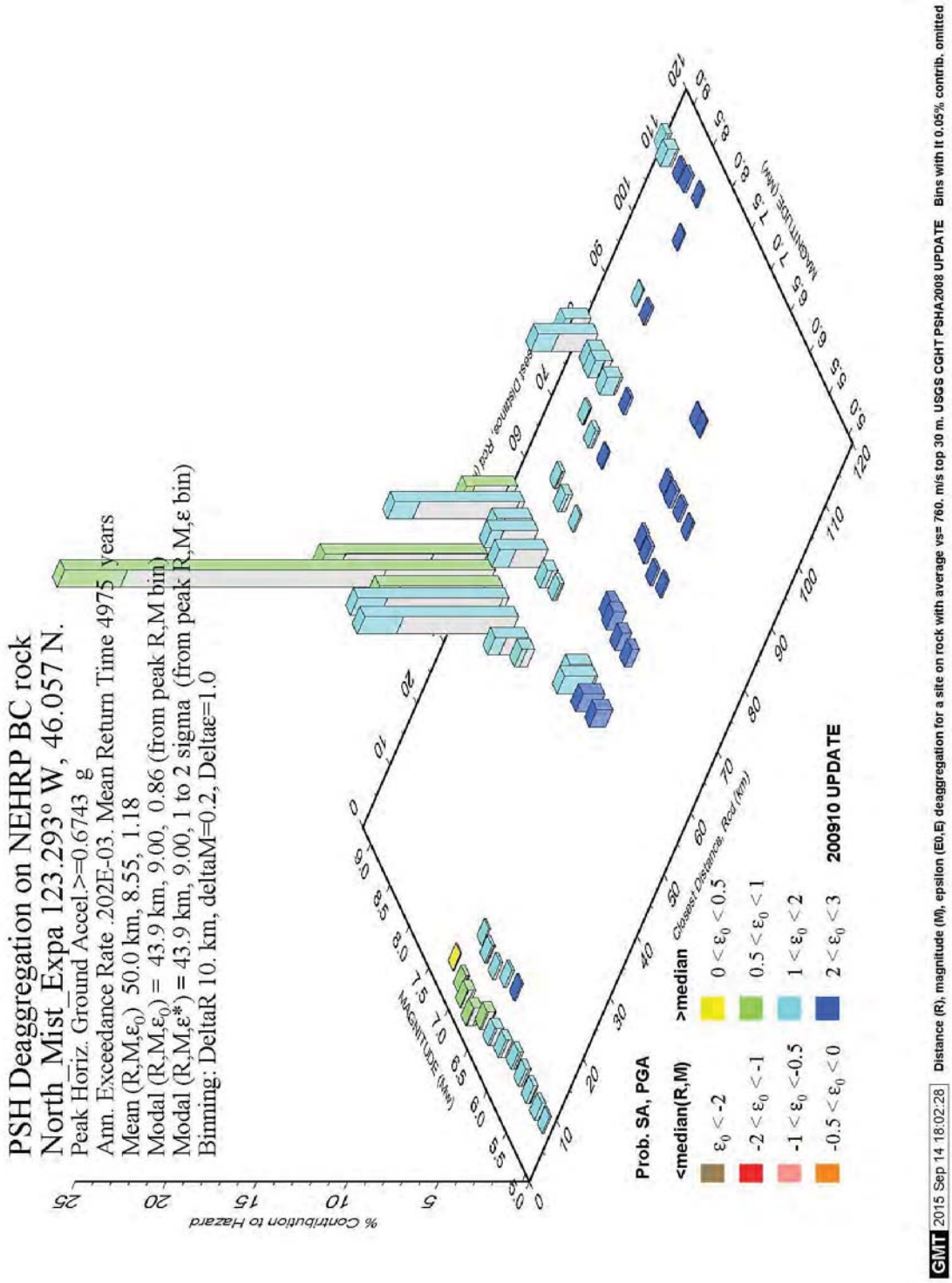


Compressor Station - Seismic Hazard Deaggregation (Rock Outcrop Condition, 2,475-Yr EQ Level)

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-25

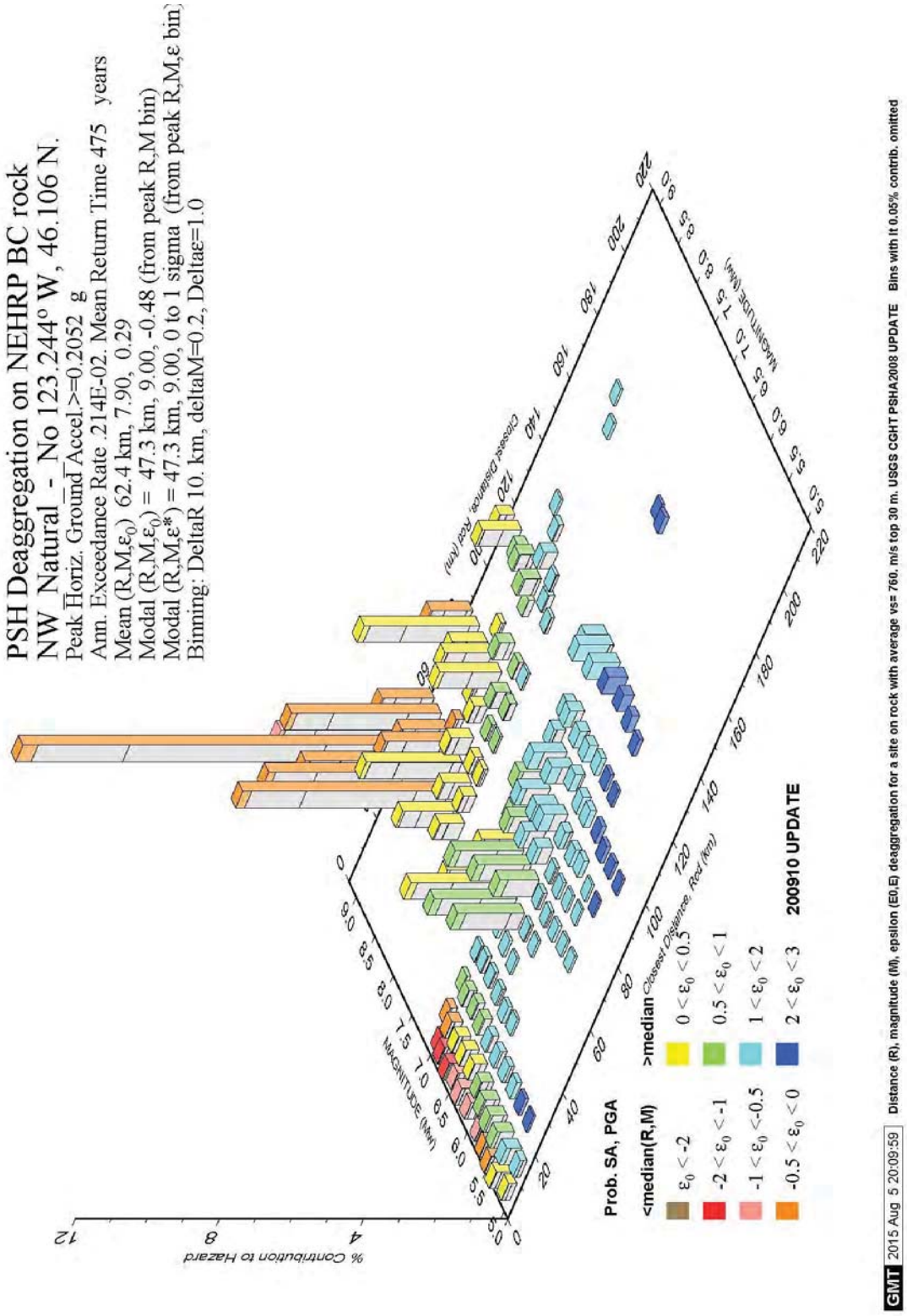


Compressor Station - Seismic Hazard Deaggregation (Rock Outcrop Condition, 4,975-Yr EQ Level)

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-26

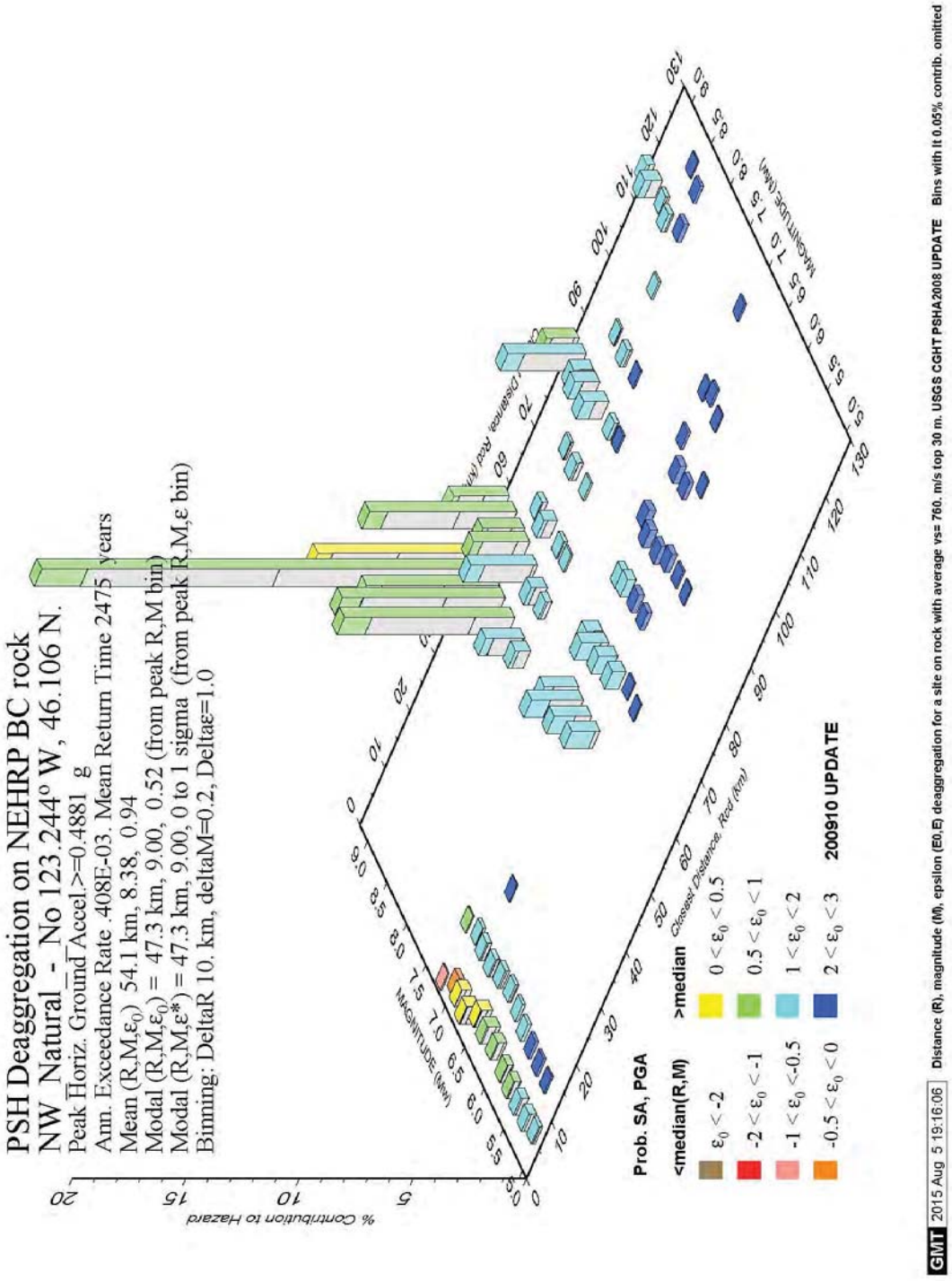


Pipeline Milepost 6.1 - Seismic Hazard Deaggregation (Rock Outcrop Condition, 475-Yr EQ Level)

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-27

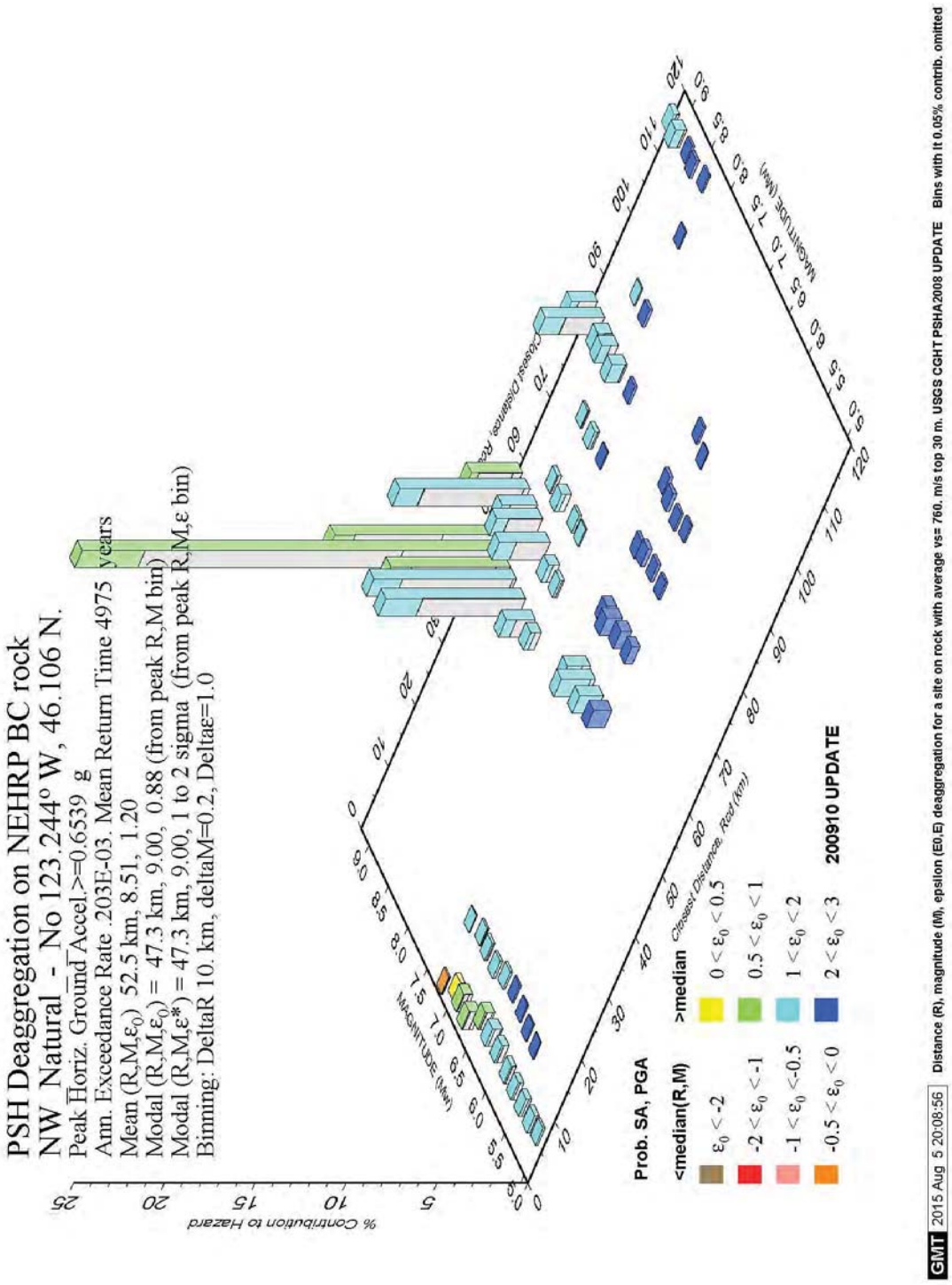


Pipeline Milepost 6.1 - Seismic Hazard Deaggregation (Rock Outcrop Condition, 2,475-Yr EQ Level)

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-28

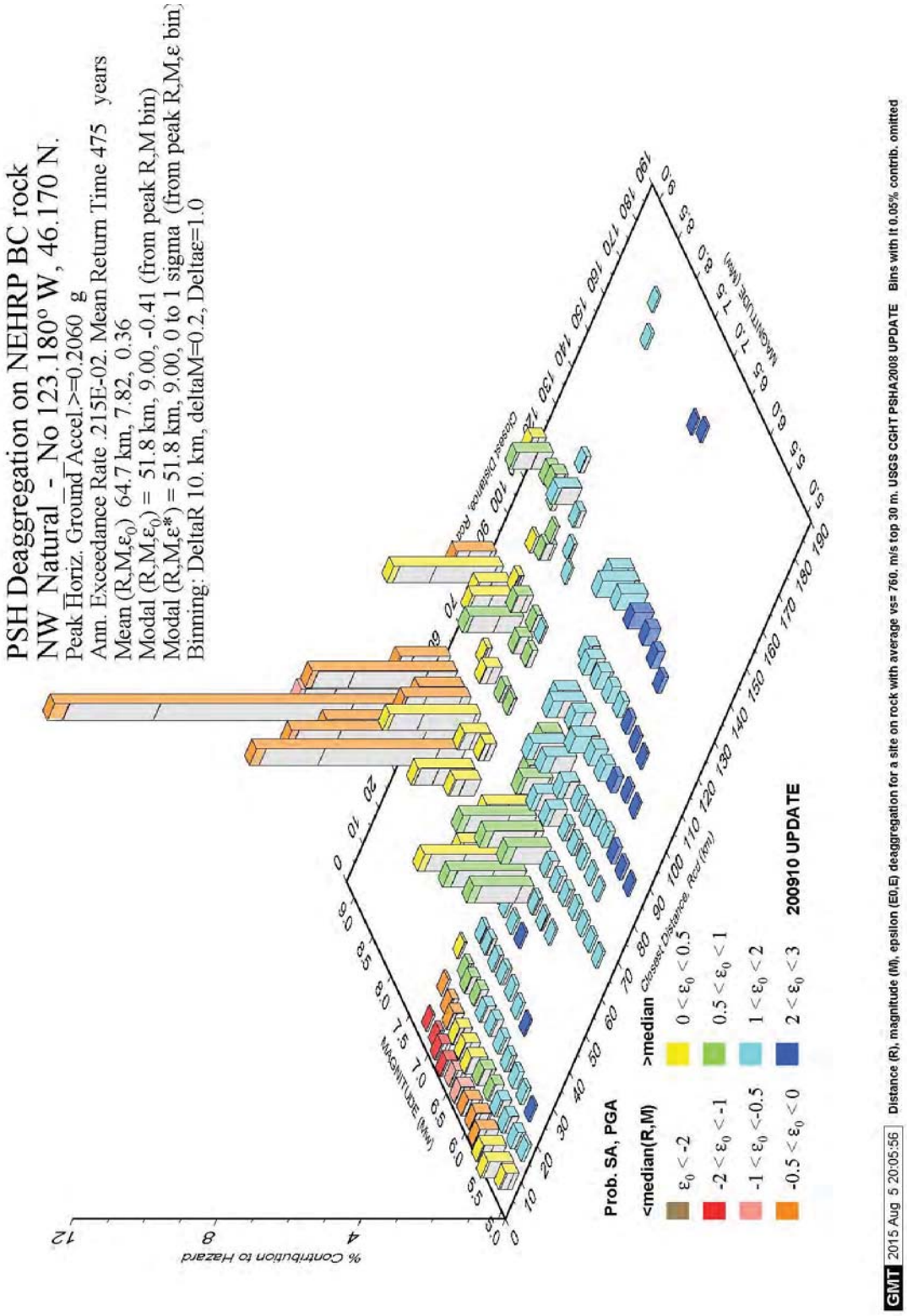


Pipeline Milepost 6.1 - Seismic Hazard Deaggregation (Rock Outcrop Condition, 4,975-Yr EQ Level)

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-29

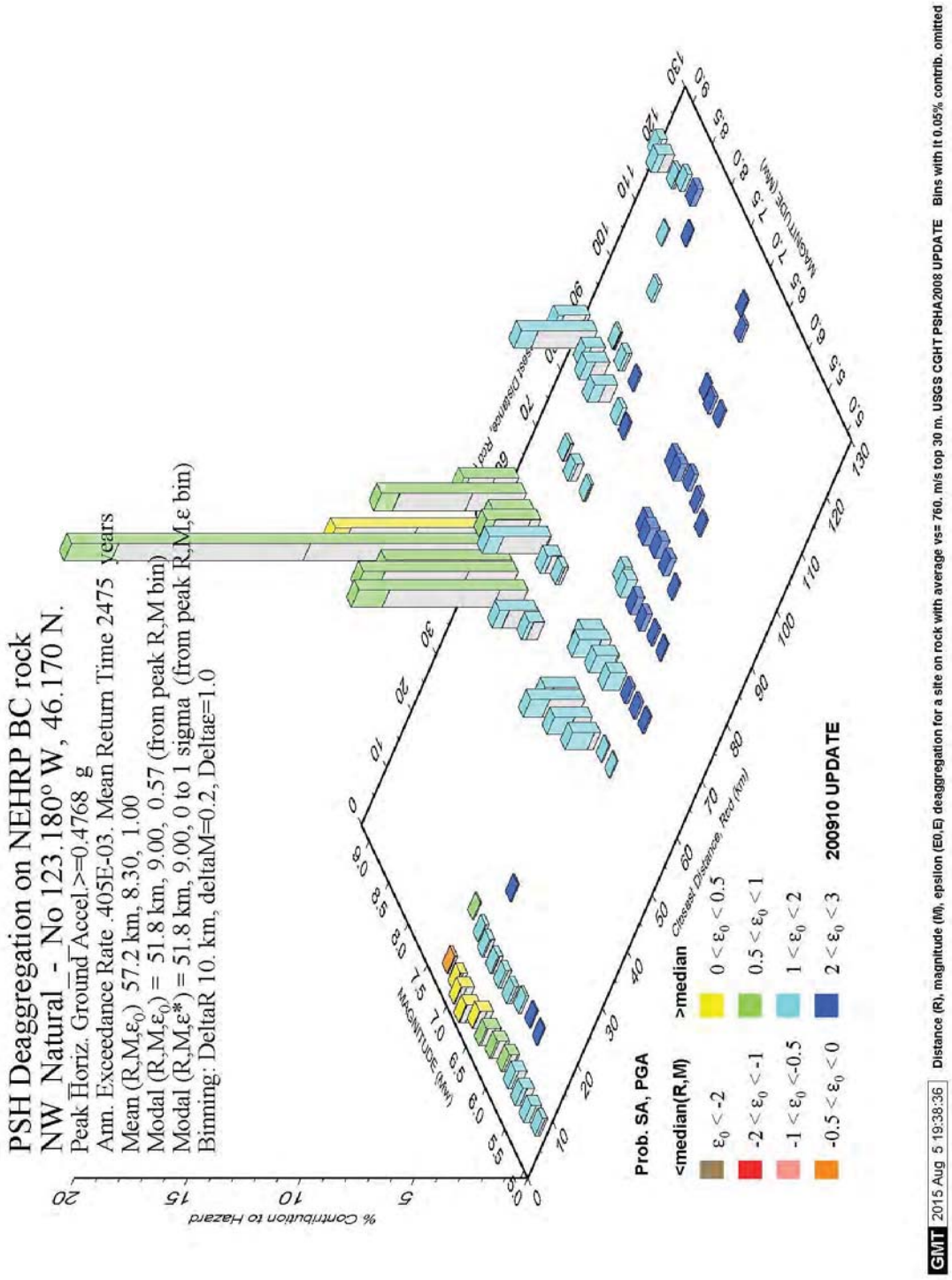


Pipeline Milepost 12.1 - Seismic Hazard Deaggregation (Rock Outcrop Condition, 475-Yr EQ Level)

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure H-30

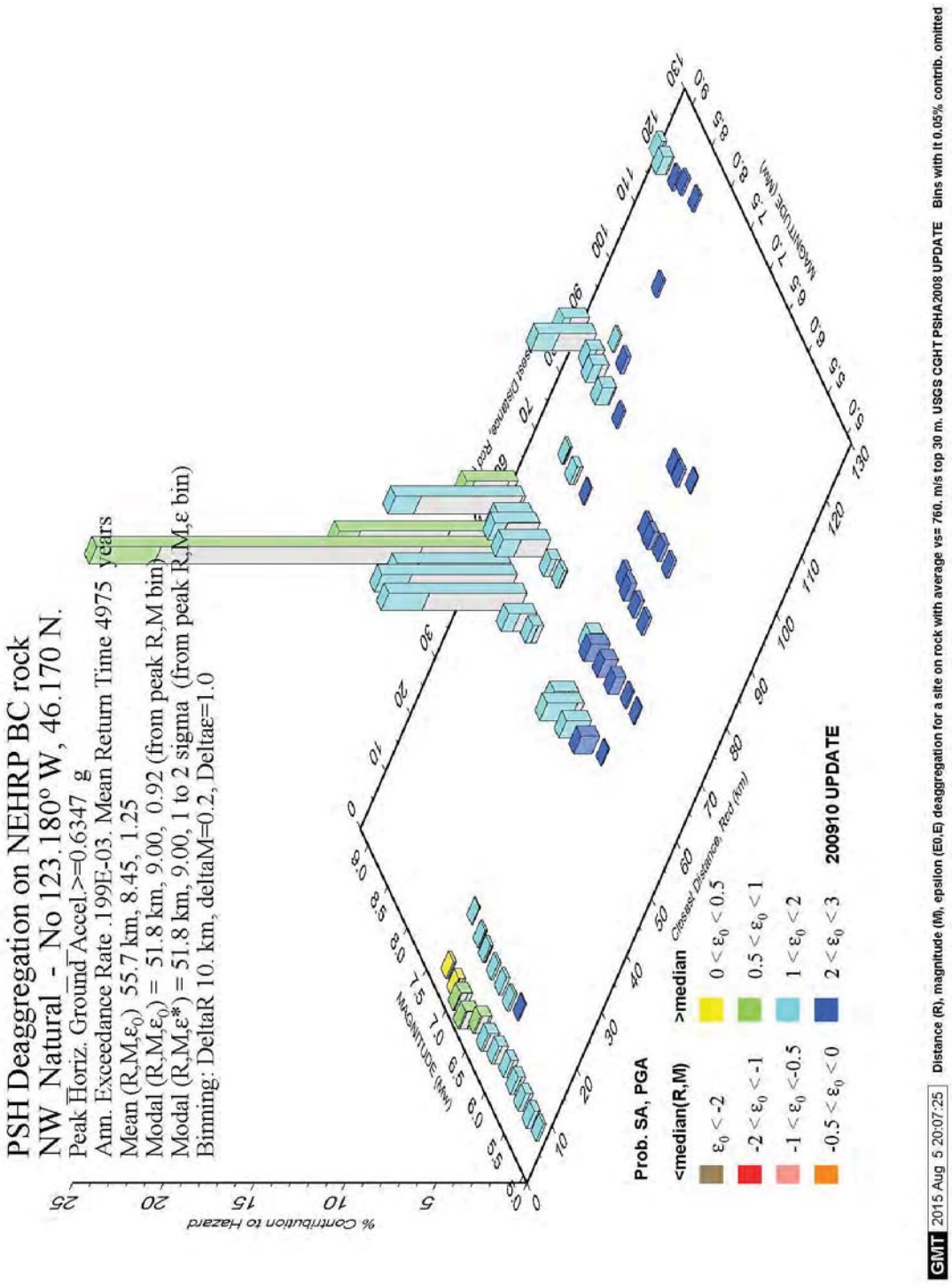


Pipeline Milepost 12.1 - Seismic Hazard Deaggregation (Rock Outcrop Condition, 2,475-Yr EQ Level)

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-31

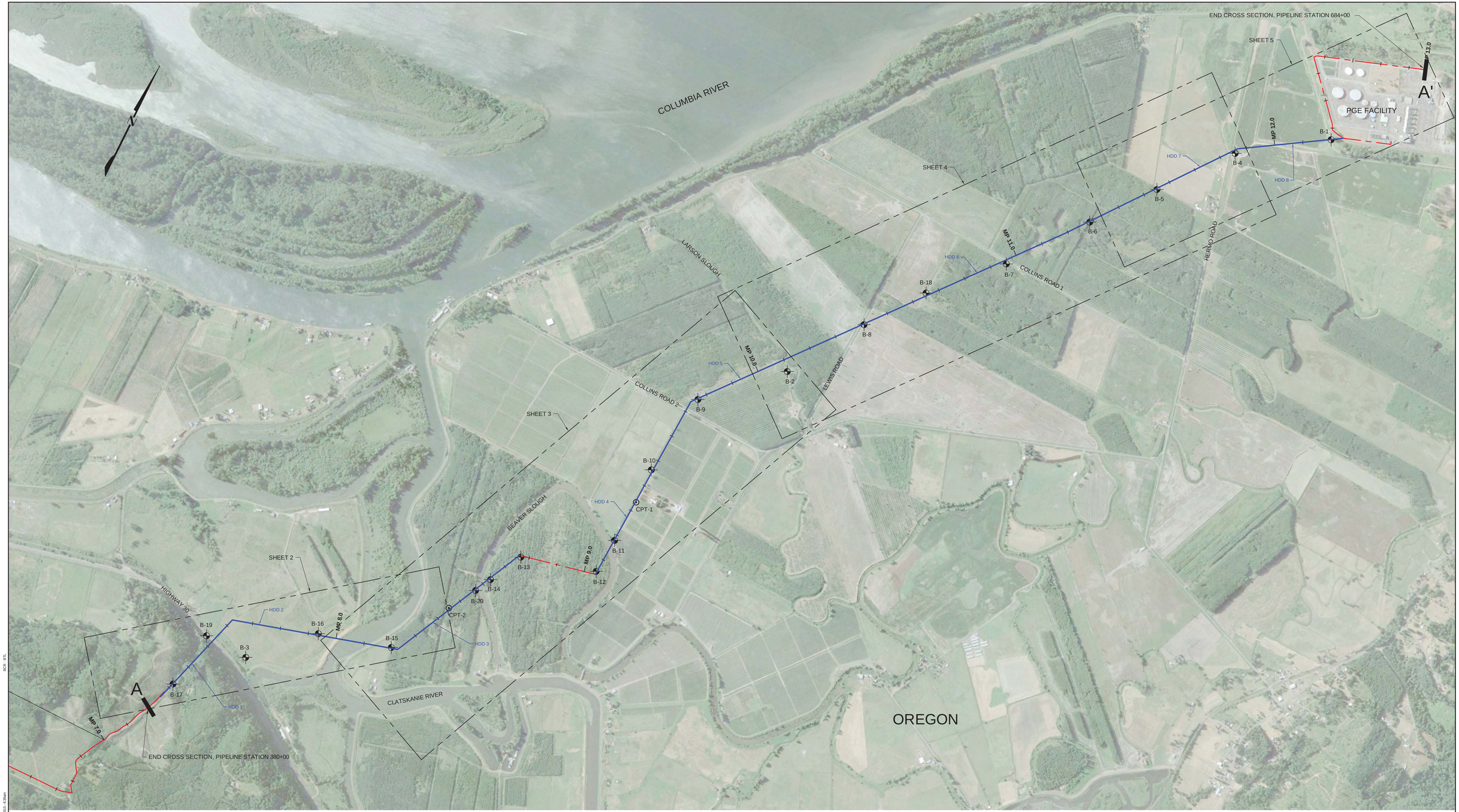


Pipeline Milepost 12.1 - Seismic Hazard Deaggregation (Rock Outcrop Condition, 4,975-Yr EQ Level)

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure H-32



PLAN

800' 0 800'

SCALE IN FEET

LEGEND:

- BORING LOCATION
- CPT LOCATION
- HDD INSTALLATION ALIGNMENT (SUBSURFACE)
- OPEN TRENCH INSTALLATION ALIGNMENT

Notes:
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3. GeoEngineers, Inc. has not verified the field location of the existing utilities.

Reference: Aerial image taken from Google Earth Pro © 2015, Licensed to Geoengineers, Inc., date July 16, 2014.

Projection: NAD83 Oregon State Plane, North Zone, International Foot.

GEOLOGIC CROSS SECTION SITE PLAN

NW NATURAL - NORTH MIST PROJECT
COLUMBIA COUNTY, OREGON

GEOENGINEERS

FIGURE H-33

ISSUED DATE: SEPTEMBER 15, 2015

P:\0950\41\704\Northwest Study\SHEET 1 LOWO\TAB SHEET 1 modified on Sep 15, 2015 - 8:29am

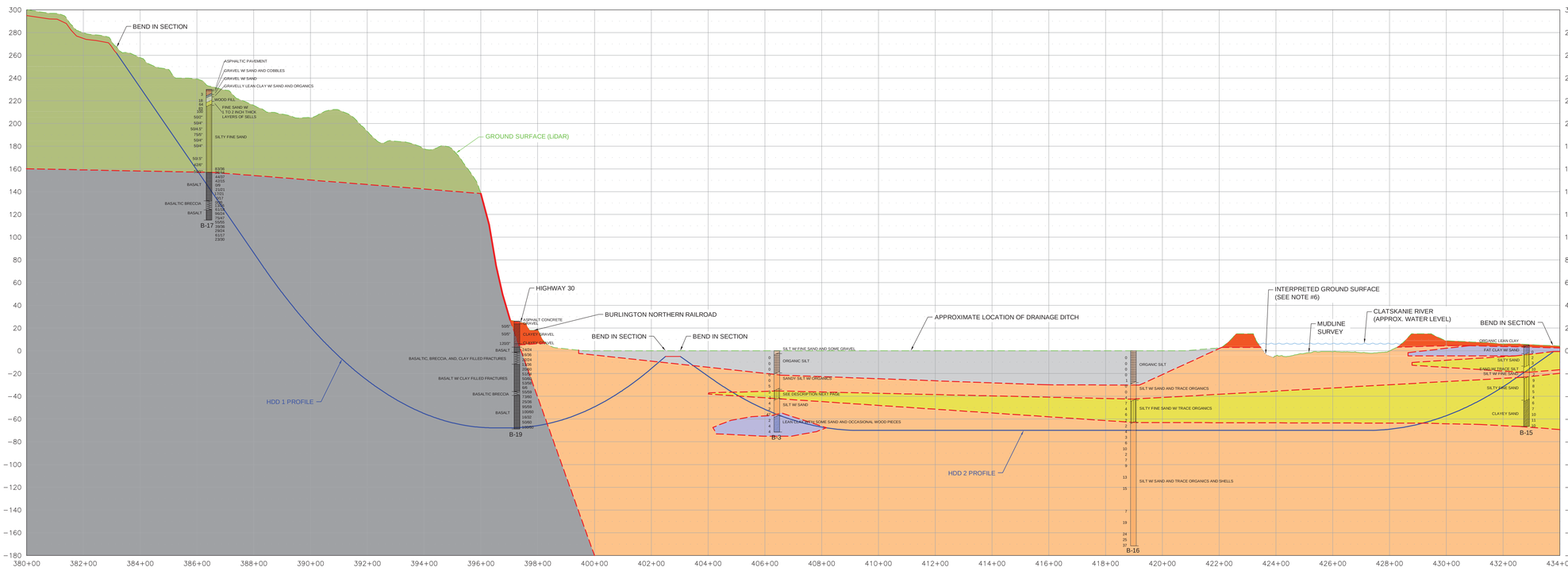
BCH BTL

DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

200' 0 200'
SCALE IN FEET

A



PROFILE

200' 0 200'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

Notes:
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Projection: NAD83 Oregon State Plane, North Zone, International Foot.

GEOLOGIC MATERIALS LEGEND:

Tertiary Rocks
- Tpbcc - Weathered Conyers Creek Member of Pittsburg Bluff Formation
- Tgrv - Basalt of Grays River Volcanic Group

Qal - Quaternary Alluvium
- Organic Silt
- Silty Sand, Clayey Sand and Sand With Silt
- Lean and Fat Clay
- Silt, Sandy Silt and Elastic Silt

Miscellaneous Materials
- Fill

LEGEND:
- HDD INSTALLATION ALIGNMENT AND PROFILE (SUBSURFACE)
- OPEN TRENCH INSTALLATION ALIGNMENT AND PROFILE
- MAJOR CONTOUR - 50' INTERVAL
- MINOR CONTOUR - 10' INTERVAL
- OBSERVED GEOLOGIC CONTACT
- INTERPRETED GEOLOGIC CONTACT

BORING LEGEND:
- SPT (N)
- TYPE OF SOIL
- TYPE OF ROCK
- RQD/REC (INCHES)
- Boring Location

GEOLOGIC CROSS SECTION STA. 380+00 TO 434+00

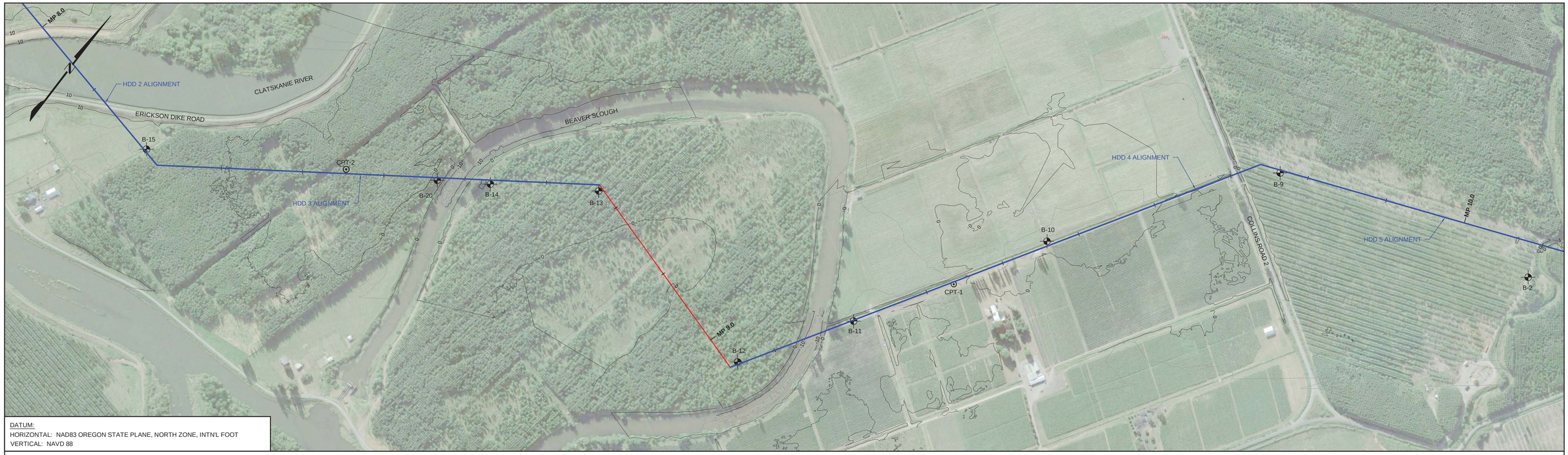
NW NATURAL - NORTH MIST PROJECT
COLUMBIA COUNTY, OREGON

GEOENGINEERS

FIGURE H-34

ISSUED DATE: SEPTEMBER 15, 2015

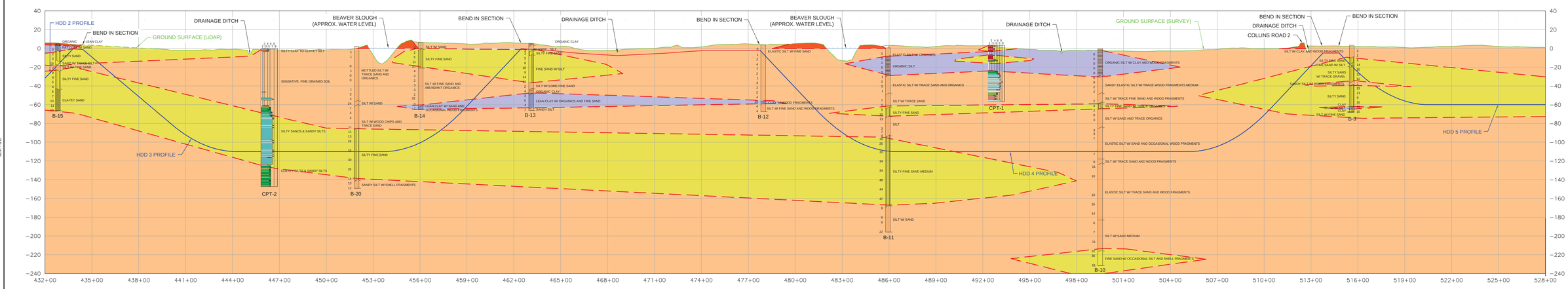
P:\0\0201413\700\Northmist Study\SHEET 2.DWG\TAB SHEET 2 modified on Sep 16, 2015- 9:41am
BGR - BTL



DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

300' 0 300'
SCALE IN FEET



PROFILE

300' 0 300'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

Notes:
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Projection: NAD83 Oregon State Plane, North Zone, International Foot.

GEOLOGIC MATERIALS LEGEND:

Tertiary Rocks
- Tpbcc - Weathered Conyers Creek Member of Pittsburg Bluff Formation
- Tgrv - Basalt of Grays River Volcanic Group

Qal - Quaternary Alluvium
- Organic Silt
- Silty Sand, Clayey Sand and Sand With Silt
- Lean and Fat Clay
- Silt, Sandy Silt and Elastic Silt

Miscellaneous Materials
- Fill

CPT LEGEND:

SENSITIVE FINE GRAINED	SILTY SAND TO SANDY SILT
ORGANIC MATERIAL	SAND TO SILTY SAND
CLAY	SAND
SILTY CLAY TO CLAY	GRAVELLY SAND TO SAND
CLAYEY SILT TO SILTY CLAY	VERY STIFF FINE GRAINED (*)
SANDY SILT TO CLAYEY SILT	SAND TO CLAYEY SAND (*)

LEGEND:
- HDD INSTALLATION ALIGNMENT AND PROFILE (SUBSURFACE)
- OPEN TRENCH INSTALLATION ALIGNMENT AND PROFILE
- MAJOR CONTOUR - 50' INTERVAL
- MINOR CONTOUR - 10' INTERVAL
- OBSERVED GEOLOGIC CONTACT
- INTERPRETED GEOLOGIC CONTACT

BORING LEGEND:
- TYPE OF SOIL — SPT (N)
- TYPE OF ROCK — RQD/REC (INCHES)
- Boring Location
- CPT Location

GEOLOGIC CROSS SECTION STA. 432+00 TO 528+00

NW NATURAL - NORTH MIST PROJECT
COLUMBIA COUNTY, OREGON

GEOENGINEERS

FIGURE H-35

ISSUED DATE: SEPTEMBER 15, 2015

BCR - BTL

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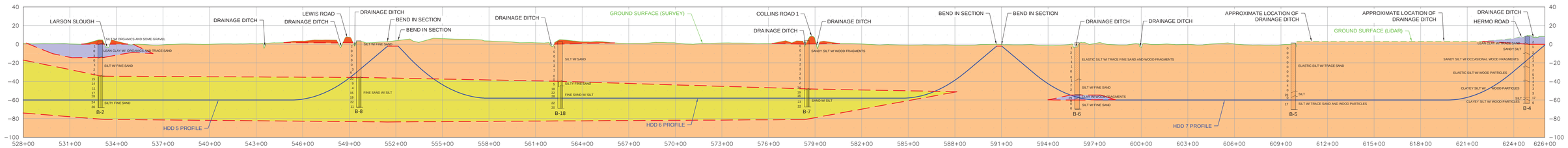
DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

300' 0 300'
SCALE IN FEET



PROFILE

300' 0 300'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

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Projection: NAD83 Oregon State Plane, North Zone, International Foot.

GEOLOGIC MATERIALS LEGEND:

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- Lean and Fat Clay
- Silt, Sandy Silt and Elastic Silt

Miscellaneous Materials
- Fill

LEGEND:
- HDD INSTALLATION ALIGNMENT AND PROFILE (SUBSURFACE)
- OPEN TRENCH INSTALLATION ALIGNMENT AND PROFILE
- MAJOR CONTOUR - 50' INTERVAL
- MINOR CONTOUR - 10' INTERVAL
- OBSERVED GEOLOGIC CONTACT
- INTERPRETED GEOLOGIC CONTACT

BORING LEGEND:
- TYPE OF SOIL
- SPT (N)
- Boring Location

GEOLOGIC CROSS SECTION
STA. 28+00 TO 2 +00

NW NATURAL - NORTH MIST PROJECT
COLUMBIA COUNTY, OREGON

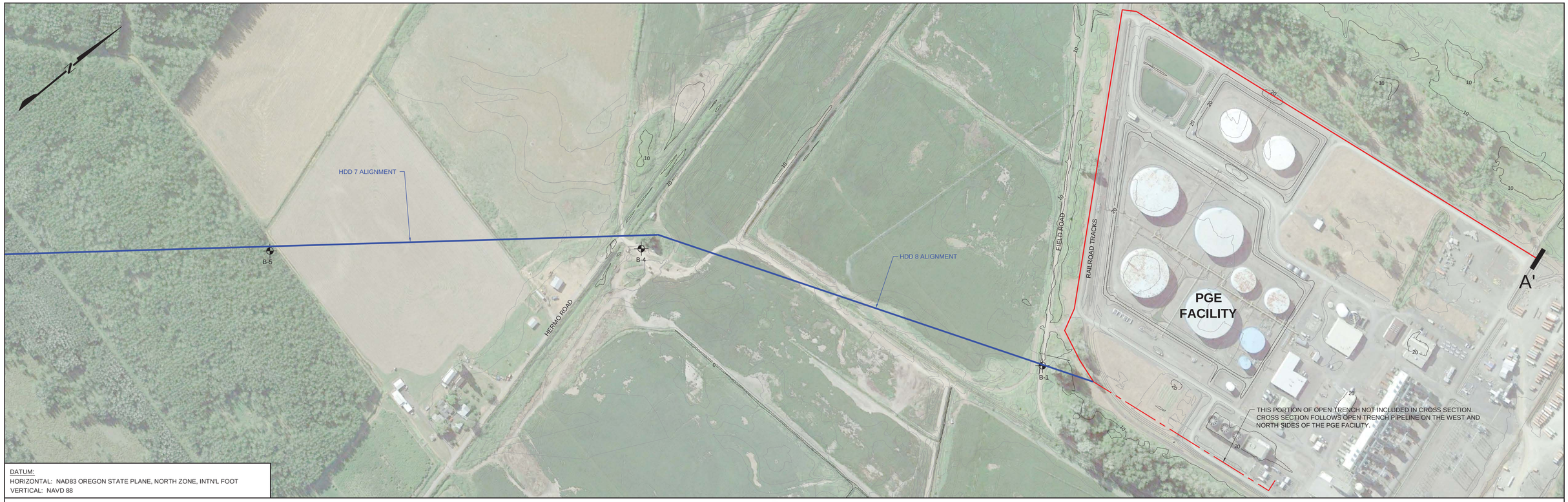
GEOENGINEERS

FIGURE H-36

ISSUED DATE: SEPTEMBER 15, 2015

BOR - BTL

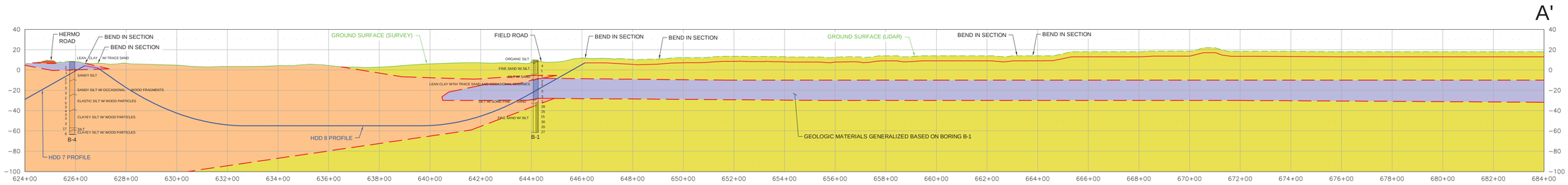
P:\0802421\Data\Maps\Map\Study\SHEET 1 (OVER)\FIG-SHEET 1 (OVER).mxd Modified on Sep 16, 2015 - 8:48am



DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

200' 0 200'
SCALE IN FEET



PROFILE

200' 0 200'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

Notes:
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Miscellaneous Materials
- Fill

LEGEND:
- HDD INSTALLATION ALIGNMENT AND PROFILE (SUBSURFACE)
- OPEN TRENCH INSTALLATION ALIGNMENT AND PROFILE
- MAJOR CONTOUR - 50' INTERVAL
- MINOR CONTOUR - 10' INTERVAL
- OBSERVED GEOLOGIC CONTACT
- INTERPRETED GEOLOGIC CONTACT

BORING LEGEND:
- TYPE OF SOIL
- SPT (N)
- Boring Location

GEOLOGIC CROSS SECTION STA. 624+00 TO 684+00

NW NATURAL - NORTH MIST PROJECT
COLUMBIA COUNTY, OREGON

GEOENGINEERS

FIGURE H-37

ISSUED DATE: SEPTEMBER 15, 2015

BCR BTL

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APPENDICES

GeoEngineers

APPENDIX H-A
Evidence of Consultation

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Brian C. Ranney

From: Brian C. Ranney
Sent: Wednesday, January 28, 2015 4:25 PM
To: Brian C. Ranney
Subject: Bill Burns Exhibit H evidence of Consultation Requirement.

Brian C. Ranney, RG, CEG
Senior Engineering Geologist | GeoEngineers, Inc.
Telephone: 503.603.6675
Fax: 503.620.5940
Mobile: 503.730.7728
Email: branney@geoengineers.com

15055 SW Sequoia Pkwy. Ste. 140
Portland, OR 97224
www.geoengineers.com

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From: Bill Burns [mailto:Bill.Burns@dogami.state.or.us]
Sent: Wednesday, January 28, 2015 4:06 PM
To: Brian C. Ranney
Cc: KILSDONK Duane
Subject: RE: Exhibit H evidence of Consultation Requirement.

Thanks Brian.
Bill

From: Brian C. Ranney [mailto:branney@geoengineers.com]
Sent: Friday, January 23, 2015 4:35 PM
To: Bill Burns
Cc: Brian C. Ranney
Subject: RE: Exhibit H evidence of Consultation Requirement.

Bill,

Thank you for taking the time to consult with me regarding NW Natural's proposed North Mist Expansion Project this afternoon (January 23, 2015). I appreciate your input into the geologic hazard evidence of consultation process. As we discussed in the phone call, I think we are in agreement on GeoEngineers' general process for the way in which we have

evaluated geologic hazards on the project thus far, including our LiDAR and site specific observation based landslide evaluation, our site specific seismic hazard evaluation and discussion of geotechnical work that has been completed on the project thus far. In addition, we will have recommendations for future geotechnical work, if required, to further evaluate geologic hazards for the project.

This email is intended to provide evidence of consultation with DOGAMI, so we can fulfill the evidence of consultation requirement for the Exhibit H report to be submitted as part of the site certificate application. If you wouldn't mind, please respond to this email so I can have specific evidence of consultation with DOGAMI.

If you have questions, or anything else to add to our discussion today, please do not hesitate to contact me.

Best Regards,

Brian C. Ranney, RG, CEG
Senior Engineering Geologist | GeoEngineers, Inc.
Telephone: 503.603.6675
Fax: 503.620.5940
Mobile: 503.730.7728
Email: branney@geoengineers.com

15055 SW Sequoia Pkwy. Ste. 140
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From: Yumei Wang [mailto:Yumei.Wang@dogami.state.or.us]
Sent: Thursday, January 15, 2015 12:11 PM
To: Brian C. Ranney; yumei.wang@state.or.us; Bill Burns
Subject: RE: Exhibit H evidence of Consultation Requirement.

Hi Brian,

My apologies for the delay. Please contact Bill Burns. 971-673-1538 and cc'd on here.

Yumei

From: Brian C. Ranney [mailto:branney@geoengineers.com]
Sent: Wednesday, January 14, 2015 8:23 AM
To: yumei.wang@state.or.us
Cc: Brian C. Ranney
Subject: [BULK] FW: Exhibit H evidence of Consultation Requirement.

Good morning Yumei,

I was just checking in to see if you were able to figure out who I should be in touch with to discuss evidence of consultation for an Exhibit H report for the proposed project noted in my previous email below.

Please provide an update when have a moment.

Thank you,

Brian

Brian C. Ranney, RG, CEG
Senior Engineering Geologist | GeoEngineers, Inc.
Telephone: 503.603.6675
Fax: 503.620.5940
Mobile: 503.730.7728
Email: branney@geoengineers.com

15055 SW Sequoia Pkwy. Ste. 140
Portland, OR 97224
www.geoengineers.com

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From: Brian C. Ranney
Sent: Monday, January 05, 2015 10:16 AM
To: yumei.wang@state.or.us
Cc: Brian C. Ranney
Subject: Exhibit H evidence of Consultation Requirement.

Good morning Yumei,

Thank you for taking the time to speak with me this morning regarding evidence of consultation as required by the Oregon Administrative Rules for preparation of Exhibit H of the EFSC submittal. As I indicated on the phone call, I am working on a preliminary compressor station siting and pipeline alignment for NW Natural. The compressor station is located in the Mist gas field area. The preliminary pipeline alignment begins at the proposed compressor station, generally trends north to north to northeast, crossing Highway 30 a couple of miles west of Clatskanie, and ends at an existing PGE facility on the south bank of the Columbia River in Port Westward.

GeoEngineers is completing the Exhibit H report for the project, and we intend to submit a draft to NW Natural this Wednesday. We have completed preliminary geotechnical work for the proposed compressor station, and also have completed subsurface investigations and draft horizontal directional drill (HDD) designs for several HDDs that are being considered along the pipeline alignment. We have also completed a site specific seismic hazard study for the project, LiDAR review/interpretation for landslides, and some site reconnaissance along the pipeline alignment.

I am reaching out to you so I can fulfill the requirement to provide evidence of consultation with DOGAMI in my Exhibit H report. if you could put me in touch with the correct person to talk with regarding the evidence of consultation, I would be very grateful.

Thank you,

Brian C. Ranney, RG, CEG
Senior Engineering Geologist | GeoEngineers, Inc.
Telephone: 503.603.6675
Fax: 503.620.5940
Mobile: 503.730.7728
Email: branney@geoengineers.com

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APPENDIX H-B
Recorded Earthquakes

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APPENDIX H-B
RECORDED EARTHQUAKES

TABLE H-B.1. RECORDED EARTHQUAKES WITHIN 50 MILES OF THE SITE

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1841	12	2	45.63	-122.67	41	--	V
1869	6	27	46.20	-123.60	17	--	--
1877	10	12	45.43	-122.80	48	--	III
1877	11	30	45.43	-122.80	48	--	III
1879	0	0	45.43	-122.80	48	--	IV
1882	5	1	45.43	-122.78	48	--	III
1883	9	29	45.50	-122.70	46	--	IV
1884	1	4	45.43	-122.78	48	--	IV
1885	10	10	45.43	-122.78	48	--	III
1892	2	4	45.43	-122.80	48	--	VI
1892	3	0	46.00	-122.80	22	--	--
1895	2	25	46.50	-122.40	43	--	V
1897	12	6	45.53	-123.10	36	--	V
1897	12	7	45.53	-123.17	35	--	III
1898	2	22	45.43	-122.80	48	--	IV
1898	2	22	45.43	-122.80	48	--	III
1900	9	28	45.90	-122.80	25	--	--
1904	6	16	45.43	-122.78	48	--	IV
1907	5	27	45.43	-122.77	48	--	III
1909	12	31	45.45	-122.80	47	--	IV
1910	2	8	45.50	-122.70	46	--	--
1910	2	15	45.45	-122.78	47	--	IV
1914	3	22	45.45	-122.78	47	--	IV
1914	9	5	45.45	-122.78	47	--	III
1915	5	19	45.45	-122.77	47	--	V
1915	11	18	45.87	-122.67	32	--	V
1918	2	13	45.45	-122.77	47	--	III
1920	11	9	45.48	-122.80	45	--	III
1921	3	4	45.48	-122.80	45	--	III
1921	9	22	45.48	-122.78	45	--	IV
1922	3	27	45.48	-122.78	45	--	IV
1922	5	15	45.48	-122.77	46	--	IV

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1924	9	19	45.73	-122.55	41	--	IV
1927	3	28	46.30	-124.07	40	--	IV
1930	6	17	46.70	-122.50	48	--	--
1932	1	14	45.48	-122.77	46	--	IV
1933	11	23	45.48	-122.77	46	--	III
1938	7	23	46.17	-123.83	27	--	IV
1939	4	13	45.50	-122.80	44	--	III
1939	11	15	45.50	-122.80	44	--	III
1939	11	29	46.30	-122.70	24	--	--
1941	2	16	45.50	-122.77	44	--	III
1941	7	26	45.40	-122.92	47	--	IV
1941	10	31	45.53	-122.62	47	--	IV
1941	12	29	45.50	-122.77	44	--	VI
1942	11	1	45.60	-122.70	41	--	V
1948	2	13	46.63	-123.07	32	--	IV
1948	3	1	45.67	-123.17	26	--	IV
1948	8	7	46.67	-122.97	35	--	III
1949	4	20	46.30	-122.70	24	--	III
1951	3	25	45.50	-122.70	46	--	II
1953	4	10	46.30	-123.50	18	--	IV
1953	12	15	45.50	-122.77	44	5	VI
1954	4	23	45.50	-122.70	46	--	IV
1954	11	11	46.68	-123.73	44	--	III
1956	12	15	46.15	-122.90	13	--	IV
1957	11	1	46.40	-122.30	45	--	--
1957	11	17	45.80	-124.20	47	--	--
1957	11	29	45.52	-122.78	43	--	III
1958	3	13	45.50	-122.70	46	--	II
1959	8	4	45.52	-122.78	43	--	III
1960	1	7	46.70	-122.70	43	--	V
1960	3	5	45.62	-122.67	41	3.5	IV
1961	1	2	46.20	-122.70	23	--	--
1961	1	4	45.80	-122.90	25	--	IV
1961	2	5	46.10	-122.30	42	--	--
1961	2	10	46.10	-122.30	42	--	--
1961	2	21	46.10	-122.30	42	--	--

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1961	5	26	46.00	-122.30	44	--	IV
1961	6	2	46.00	-122.30	44	--	III
1961	7	28	46.10	-122.30	42	--	IV
1961	10	7	45.70	-122.40	48	--	--
1961	11	7	45.50	-122.67	47	--	V
1961	11	7	45.70	-122.40	48	5	VI
1961	12	15	45.75	-122.87	28	--	III
1961	12	16	45.60	-122.60	45	--	--
1962	8	11	46.00	-123.50	10	--	VI
1962	9	12	46.10	-122.30	42	--	III
1962	11	3	46.00	-122.30	44	--	IV
1962	11	5	45.55	-122.60	47	5	VII
1962	11	6	45.60	-122.70	41	--	VI
1962	11	6	45.80	-122.50	41	--	VI
1962	11	6	45.80	-122.50	41	--	--
1962	11	6	45.81	-122.46	42	--	--
1962	11	6	45.60	-122.70	41	--	--
1962	11	6	45.60	-122.70	41	--	--
1962	11	6	45.90	-122.70	29	--	--
1962	11	9	46.10	-122.30	42	--	IV
1962	11	9	46.10	-122.30	42	--	--
1963	3	2	45.50	-122.60	49	--	IV
1963	9	5	46.10	-122.30	42	--	--
1963	10	22	46.10	-122.30	42	--	--
1963	12	27	45.70	-123.40	24	4.5	VI
1964	1	26	46.10	-122.40	37	--	V
1964	3	20	46.10	-122.30	42	--	II
1964	6	1	45.60	-123.00	33	--	--
1964	10	1	45.70	-122.80	33	5.3	V
1964	10	12	45.70	-122.80	33	4.3	--
1968	1	27	45.60	-122.60	45	3.7	IV
1968	5	13	45.60	-122.60	45	3.8	IV
1968	11	30	46.50	-122.40	43	--	V
1969	3	5	45.63	-122.82	36	3.5	III
1970	6	25	45.50	-122.75	45	3.6	IV
1971	12	29	46.44	-122.31	45	--	--

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1972	4	19	46.40	-122.28	46	--	--
1972	10	7	46.38	-122.42	39	--	--
1972	10	13	46.42	-122.39	41	--	--
1972	10	13	46.41	-122.40	40	--	--
1972	10	28	45.75	-122.73	33	--	--
1972	11	4	46.44	-122.32	45	--	--
1972	11	17	45.87	-122.63	33	3.1	--
1972	12	9	46.01	-122.72	24	--	--
1972	12	17	46.05	-122.94	14	--	--
1972	12	23	46.32	-124.07	41	--	--
1972	12	25	46.08	-122.75	21	--	--
1972	12	26	46.07	-122.75	22	--	--
1973	1	19	45.80	-122.81	28	--	--
1973	1	24	46.28	-122.46	35	--	--
1973	2	27	46.28	-122.43	36	--	--
1973	3	15	46.26	-122.26	44	--	--
1973	4	6	46.20	-122.55	30	--	--
1973	5	21	46.16	-122.71	22	--	--
1973	6	19	46.19	-123.12	3	--	--
1973	6	25	46.13	-122.53	31	--	--
1973	8	11	46.30	-122.49	34	--	--
1973	8	25	46.47	-122.26	48	--	--
1973	8	29	46.44	-123.45	22	--	--
1973	8	31	46.24	-122.36	39	--	--
1973	9	11	46.46	-122.43	41	--	--
1973	9	14	46.46	-122.43	41	--	--
1974	3	18	46.35	-122.51	34	--	--
1974	7	2	46.37	-123.40	17	--	--
1974	7	29	45.90	-122.60	33	3	--
1974	8	5	46.01	-122.56	32	--	--
1974	9	23	46.01	-122.59	30	--	--
1974	10	7	46.41	-122.27	46	--	--
1974	10	16	46.40	-122.30	45	--	--
1974	10	16	46.34	-122.29	44	--	--
1974	10	22	46.06	-122.53	32	--	--
1974	10	29	45.99	-123.11	9	--	--

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1974	11	7	46.41	-122.40	40	--	--
1974	11	15	46.48	-123.41	24	--	--
1974	12	5	46.49	-123.26	22	--	--
1974	12	5	46.27	-122.40	38	--	--
1974	12	10	45.67	-122.85	33	--	--
1975	4	9	46.42	-123.26	17	--	--
1975	6	25	46.00	-122.47	36	--	--
1975	7	8	46.48	-123.32	22	--	--
1975	9	1	46.12	-122.46	34	--	--
1975	9	17	46.35	-122.27	45	--	--
1975	9	17	46.33	-122.25	46	--	--
1975	10	8	46.35	-122.27	45	--	--
1975	10	10	46.21	-122.25	44	--	--
1975	10	13	46.50	-123.25	23	--	--
1975	11	21	46.28	-123.24	8	--	--
1975	11	21	46.29	-123.23	8	--	--
1975	11	21	46.28	-123.24	8	--	--
1975	12	6	46.36	-122.55	32	--	--
1975	12	6	46.37	-122.54	33	--	--
1975	12	6	46.36	-122.55	32	--	--
1976	1	9	46.41	-122.49	37	--	--
1976	2	14	46.45	-122.36	43	--	--
1976	2	19	46.47	-122.39	43	--	--
1976	2	20	46.43	-122.38	42	--	--
1976	5	8	46.33	-122.31	43	--	--
1976	7	25	45.80	-122.50	41	--	--
1976	7	28	46.24	-122.39	38	--	--
1976	8	18	46.35	-122.27	45	--	--
1976	8	19	46.34	-122.38	40	--	--
1976	9	2	45.81	-122.52	40	--	--
1976	9	9	46.18	-122.50	32	--	--
1976	9	30	46.32	-122.26	45	--	--
1976	10	27	46.45	-123.09	19	--	--
1976	12	2	46.11	-122.47	34	--	--
1977	1	12	46.48	-122.27	48	--	--
1977	2	11	46.10	-122.73	22	--	--

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1977	2	11	46.07	-122.72	23	--	--
1977	3	25	46.49	-122.58	36	--	--
1977	5	30	46.50	-122.31	47	--	--
1977	6	7	46.47	-122.32	46	--	--
1977	6	27	46.24	-122.88	15	--	--
1977	7	14	46.39	-122.48	36	--	--
1977	7	23	46.30	-123.28	10	3.6	--
1977	7	25	46.39	-123.05	16	--	--
1977	8	29	46.44	-123.10	19	--	--
1977	10	7	45.95	-122.25	47	4.1	--
1977	11	20	46.49	-122.40	43	--	--
1978	1	4	45.81	-122.57	38	--	--
1978	1	24	46.16	-122.47	34	--	--
1978	3	3	46.19	-122.50	32	--	--
1978	3	3	46.04	-122.67	26	--	--
1978	4	9	46.46	-122.52	37	--	--
1978	6	29	46.10	-122.92	13	3.8	--
1978	6	30	46.35	-123.20	12	3.6	--
1978	7	28	46.35	-123.45	18	--	--
1979	2	16	46.44	-122.45	39	--	--
1979	3	11	46.44	-122.40	41	3.9	--
1979	3	12	46.46	-122.42	41	--	--
1979	3	20	46.44	-122.41	41	--	--
1979	3	20	46.50	-123.18	22	--	--
1979	3	25	46.41	-122.36	42	--	--
1979	5	17	46.19	-122.81	17	--	--
1979	5	26	46.28	-122.35	40	--	--
1979	7	7	46.46	-122.32	45	--	--
1979	7	8	46.48	-122.31	46	--	--
1979	7	9	46.47	-122.35	44	--	--
1979	7	9	46.47	-122.30	46	--	--
1979	7	9	46.48	-122.28	48	--	--
1979	7	16	45.70	-122.81	32	--	--
1979	7	17	46.07	-122.99	11	--	--
1979	7	31	46.21	-122.77	20	--	--
1979	8	3	46.46	-122.33	45	--	--

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1979	8	9	46.40	-123.28	16	--	--
1979	8	19	46.44	-122.43	40	--	--
1979	9	9	46.49	-122.31	47	--	--
1979	10	17	46.44	-122.40	41	--	--
1979	12	21	45.96	-122.72	26	--	--
1979	12	25	46.34	-122.29	44	--	--
1979	12	25	46.36	-122.35	41	--	--
1980	1	11	45.80	-122.67	34	--	--
1980	1	27	46.29	-122.50	33	--	--
1980	2	13	46.01	-122.75	23	--	--
1980	3	5	46.27	-122.60	28	--	--
1980	3	6	46.21	-122.70	23	--	--
1980	3	21	46.02	-122.55	32	--	--
1980	3	24	46.30	-122.39	39	--	--
1980	3	25	46.58	-123.00	29	3.5	--
1980	3	25	46.60	-123.07	30	3.8	--
1980	3	25	46.60	-123.03	30	3.3	--
1980	3	26	46.58	-123.02	29	3.7	--
1980	3	26	46.60	-123.10	29	3.3	--
1980	3	26	46.60	-123.07	30	3.3	--
1980	3	26	46.60	-123.03	30	3	--
1980	3	26	46.60	-123.03	30	3.3	--
1980	3	26	46.60	-123.00	30	3.5	--
1980	3	26	46.22	-122.30	42	3.8	--
1980	3	26	46.20	-122.25	44	4.5	--
1980	3	27	46.08	-122.43	36	4	--
1980	3	28	46.27	-122.26	44	--	--
1980	4	3	46.37	-122.67	28	--	--
1980	4	5	46.19	-122.68	24	--	--
1980	4	5	46.37	-122.26	46	--	--
1980	4	7	46.13	-122.47	34	--	--
1980	4	7	46.24	-122.35	40	--	--
1980	4	7	46.27	-122.29	43	--	--
1980	4	8	46.20	-123.30	6	--	--
1980	4	8	46.37	-122.29	44	--	--
1980	4	8	46.31	-122.51	33	--	--

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1980	4	8	46.21	-122.90	13	--	--
1980	4	8	46.27	-122.92	14	--	--
1980	4	9	46.29	-122.66	26	--	--
1980	4	9	46.48	-122.32	46	--	--
1980	4	9	45.84	-122.82	26	--	--
1980	4	11	45.92	-122.83	23	--	--
1980	4	11	46.32	-122.26	45	--	--
1980	4	11	46.43	-122.86	23	--	--
1980	4	12	46.27	-122.96	12	--	--
1980	4	12	46.28	-122.26	44	--	--
1980	4	13	46.27	-122.39	38	--	--
1980	4	13	46.27	-122.58	29	--	--
1980	4	13	46.38	-122.60	31	--	--
1980	4	13	46.22	-122.84	16	--	--
1980	4	13	46.21	-122.83	17	--	--
1980	4	13	46.40	-122.32	44	--	--
1980	4	13	46.35	-122.49	35	--	--
1980	4	13	46.30	-122.25	45	--	--
1980	4	14	46.31	-122.28	44	--	--
1980	4	14	46.44	-122.25	48	--	--
1980	4	15	46.36	-122.38	40	--	--
1980	4	15	46.32	-122.34	41	--	--
1980	4	15	46.47	-122.26	48	--	--
1980	4	15	46.31	-122.34	41	--	--
1980	4	16	45.79	-122.89	25	--	--
1980	4	17	46.23	-122.75	21	--	--
1980	4	17	46.22	-122.33	41	--	--
1980	4	19	46.27	-122.41	37	--	--
1980	4	19	46.39	-122.26	46	--	--
1980	4	19	46.18	-123.64	18	--	--
1980	4	19	46.29	-122.40	38	--	--
1980	4	20	46.24	-122.41	37	--	--
1980	4	20	46.44	-122.34	44	--	--
1980	4	20	46.29	-122.42	37	--	--
1980	4	20	46.41	-123.94	39	--	--
1980	4	20	46.24	-122.75	21	--	--

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1980	4	20	46.41	-122.29	45	--	--
1980	4	20	46.28	-122.43	36	--	--
1980	4	20	46.31	-122.91	16	--	--
1980	4	21	46.35	-122.33	42	--	--
1980	4	21	46.14	-122.42	36	--	--
1980	4	21	46.20	-122.42	36	--	--
1980	4	23	46.34	-122.30	43	--	--
1980	4	23	46.25	-122.27	44	--	--
1980	4	24	46.24	-122.55	30	--	--
1980	4	24	45.99	-122.40	39	--	--
1980	4	24	46.26	-122.37	39	--	--
1980	4	24	46.35	-122.39	39	--	--
1980	4	25	46.41	-122.40	40	--	--
1980	4	26	46.44	-122.40	41	--	--
1980	4	27	46.04	-122.50	34	--	--
1980	4	27	46.33	-122.52	33	--	--
1980	4	28	46.10	-122.54	31	--	--
1980	4	29	46.23	-122.26	44	--	--
1980	4	29	46.33	-122.31	43	--	--
1980	4	29	46.41	-122.49	37	--	--
1980	5	1	46.17	-122.92	12	--	--
1980	5	2	46.14	-122.34	40	--	--
1980	5	2	46.24	-122.49	33	--	--
1980	5	5	46.02	-122.35	41	--	--
1980	5	6	46.24	-122.34	40	--	--
1980	5	7	46.20	-122.48	33	--	--
1980	5	8	46.32	-122.39	39	--	--
1980	5	8	46.38	-122.26	46	--	--
1980	5	8	45.92	-122.57	34	--	--
1980	5	10	45.99	-122.47	36	--	--
1980	5	11	46.08	-123.03	9	--	--
1980	5	12	46.25	-122.30	42	4.4	--
1980	5	13	46.24	-122.43	36	--	--
1980	5	15	46.33	-122.85	19	--	--
1980	5	15	46.40	-122.55	34	--	--
1980	5	16	46.24	-122.35	40	--	--

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1980	5	16	46.27	-122.56	30	--	--
1980	5	17	46.49	-122.32	46	--	--
1980	5	17	46.42	-122.31	45	--	--
1980	5	18	46.28	-122.35	40	--	--
1980	5	18	46.08	-122.66	25	--	--
1980	5	18	46.15	-122.75	20	--	--
1981	2	14	46.35	-122.25	46	--	--
1981	2	14	46.39	-122.34	43	--	--
1981	2	14	46.36	-122.25	46	--	--
1981	2	14	46.35	-122.25	46	--	--
1981	5	1	46.37	-122.25	46	2.9	IV
1981	5	13	46.37	-122.25	46	4.1	VI
1981	5	27	46.37	-122.26	46	2.7	--
1981	7	11	46.37	-122.25	46	--	--
1981	8	23	46.36	-122.25	46	--	--
1981	9	6	46.67	-123.88	48	3.1	IV
1981	11	8	45.60	-122.49	49	--	--
1982	3	1	46.35	-122.25	46	4.1	V
1982	11	21	45.90	-122.89	21	2.5	--
1983	3	13	46.24	-122.63	26	--	--
1983	3	15	46.51	-122.74	31	--	--
1983	5	11	45.65	-122.83	34	2.6	--
1983	12	29	46.27	-122.63	27	--	--
1984	6	4	46.21	-123.01	8	3.7	--
1984	7	16	46.43	-122.27	47	--	--
1984	8	5	46.45	-122.26	48	--	--
1984	12	11	45.47	-122.83	45	--	--
1985	6	7	45.68	-122.78	34	--	--
1986	3	11	45.94	-122.42	40	3.1	--
1987	9	11	46.35	-122.25	46	2.8	--
1987	10	2	45.63	-122.65	41	3	--
1989	8	1	45.61	-122.46	49	3.7	--
1990	4	6	45.47	-123.55	41	3.2	--
1990	5	18	46.44	-122.34	44	2.9	--
1990	6	18	45.99	-123.59	15	3	--
1990	9	29	46.16	-122.86	15	2.9	--

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
1990	9	29	46.16	-122.86	15	2.6	--
1991	3	5	45.79	-122.68	34	3.1	--
1991	7	22	45.64	-122.87	34	3.5	--
1991	7	22	45.64	-122.87	34	2.2	--
1991	7	27	45.63	-122.86	35	2.8	--
1991	10	18	45.63	-122.90	33	3.1	--
1991	10	18	45.63	-122.86	35	2.8	--
1991	10	21	45.63	-122.89	34	3	--
1991	11	9	46.74	-122.79	43	2.6	--
1991	11	10	46.74	-122.78	43	2.7	--
1991	12	30	46.74	-122.79	43	2.9	--
1992	3	15	46.22	-123.25	5	3	--
1993	1	10	46.47	-122.28	47	2	--
1995	2	13	45.56	-122.88	38	2.2	--
1995	4	2	45.92	-122.98	17	2.6	--
1995	6	13	45.92	-122.98	17	3	IV
1997	4	16	46.43	-122.33	44	2.6	--
1997	8	29	46.64	-122.43	48	2.2	--
1997	9	6	46.11	-122.48	34	2.5	--
1998	3	10	46.50	-122.40	43	2.8	--
1999	7	16	45.65	-122.77	36	3.1	--
1999	7	16	45.65	-122.77	36	2.3	--
1999	7	16	45.65	-122.77	36	2.3	--
1999	7	16	45.65	-122.77	36	3.2	--
1999	10	19	45.49	-123.11	38	2.8	--
2002	7	31	46.10	-123.43	7	2.8	--
2003	4	24	45.64	-122.75	37	3.9	--
2003	3	31	45.63	-122.76	38	2.7	--
2003	4	24	45.64	-122.75	37	3.9	III
2003	7	25	45.64	-122.74	38	3	III
2003	7	26	45.64	-122.74	38	2.8	--
2004	2	26	45.65	-122.75	37	3	III
2004	8	17	45.47	-122.85	44	2.6	--
2004	9	28	46.75	-122.78	44	2.6	--
2004	10	2	46.28	-122.62	28	2.6	--
2005	6	25	45.52	-122.64	47	2.7	III

Year	Month	Day	Latitude	Longitude	Distance	Magnitude	Epicentral MMI
2006	1	29	45.52	-122.63	47	2.8	III
2006	8	3	45.81	-122.61	36	3.8	IV
2006	8	9	45.80	-122.60	37	2.3	II
2006	11	6	45.52	-122.65	47	2.6	III
2006	12	21	46.50	-122.30	47	2.8	--
2007	3	1	45.65	-122.76	37	2.2	--
2007	5	11	46.21	-122.28	43	3	--
2007	7	3	46.31	-123.23	10	2.6	--
2008	3	20	46.53	-122.61	36	2.5	--
2008	4	26	46.06	-122.62	28	2.6	--
2008	6	4	45.64	-122.72	38	2.5	II
2008	9	9	46.33	-122.39	39	2.5	--
2008	9	9	46.33	-122.39	39	2.9	--
2008	11	19	45.91	-122.47	38	2.4	--
2009	3	20	46.33	-122.30	43	3.1	--
2009	5	10	45.51	-122.63	48	2	--
2009	5	11	45.51	-122.65	47	1.9	II
2009	7	8	45.52	-122.63	47	2.5	II
2009	9	5	45.51	-122.64	48	2.5	--

TABLE H-B-2. RECORDED EARTHQUAKES WITHIN 50 MILES WITH MODIFIED MERCALLI INTENSITY OF IV OR GREATER (USGS, 2009)

Year	Month	Day	Latitude	Longitude	Distance (miles)	Magnitude	Epicentral MMI
1895	2	25	46.50	-122.40	43	--	V
1960	1	7	46.70	-122.70	43	--	VI
1961	2	2	46.70	-122.80	40	--	V
1961	11	6	45.70	-122.70	36	5	VI
1968	11	30	46.50	-122.40	43	4.3	V
1980	4	1	46.22	-122.18	48	5	--
1980	4	3	46.22	-122.22	46	5	--
1980	4	25	46.25	-122.17	48	5	--
1980	5	8	46.22	-122.17	48	5	--
1980	5	18	46.20	-122.18	48	5.3	--
1981	2	13	46.35	-122.24	46	5.5	VI
1981	5	13	46.36	-122.25	46	4.5	--
1982	3	1	46.35	-122.25	46	4.4	--

TABLE H-B-3. RECORDED EARTHQUAKES WITHIN 50 MILES WITH REPORTED MAGNITUDE GREATER THAN 3.0 (USGS, 2015)

Year	Month	Day	Latitude	Longitude	Distance (miles)	Depth (km)	Magnitude
1974	7	29	45.900	-122.600	33.4	0	3.0
1979	3	11	46.464	-122.399	42.1	9	3.8
1980	5	12	46.251	-122.309	41.8	10	4.4
1980	5	24	46.333	-122.197	48.0	8	3.8
1980	5	28	46.338	-122.211	47.5	7	3.8
1980	5	28	46.338	-122.200	48.0	8	3.6
1981	2	14	46.351	-122.238	46.4	7	5.1
1981	2	14	46.354	-122.231	46.8	17	3.0
1981	2	14	46.354	-122.249	46.0	12	4.6
1981	2	14	46.344	-122.234	46.5	7	3.6
1981	5	13	46.366	-122.252	46.1	11	4.1
1981	9	6	46.665	-123.875	47.4	35	3.1
1982	3	1	46.350	-122.250	45.9	12	4.1
1984	6	4	46.210	-123.000	8.7	51	3.5
1986	3	11	45.940	-122.416	39.8	15	3.1

Year	Month	Day	Latitude	Longitude	Distance (miles)	Depth (km)	Magnitude
1987	10	2	45.628	-122.655	41.3	5	3.0
1989	8	1	45.609	-122.457	49.5	14	3.9
1990	4	6	45.467	-123.549	41.1	44	3.2
1990	4	13	46.785	-122.838	45.0	7	3.3
1990	6	18	45.987	-123.587	14.6	21	3.0
1991	3	5	45.786	-122.679	33.8	20	3.1
1991	7	22	45.638	-122.869	33.8	20	3.5
1991	10	18	45.633	-122.896	33.4	20	3.1
1991	10	21	45.631	-122.887	33.7	20	3.0
1992	3	15	46.217	-123.245	4.3	28	3.1
1995	6	13	45.918	-122.980	16.7	25	3.0
1999	7	16	45.648	-122.773	36.3	19	3.2
2003	4	24	45.638	-122.748	37.6	18	3.9
2003	7	25	45.640	-122.736	37.9	17	3.0
2004	2	26	45.646	-122.753	37.0	19	3.0
2006	8	3	45.809	-122.610	36.0	12	3.8
2009	3	20	46.329	-122.304	43.0	15	3.1
2010	11	16	46.561	-122.435	44.2	15	4.1
2012	1	25	46.342	-122.239	46.2	9	3.4
2012	3	18	46.764	-123.457	42.8	42	3.3
2012	6	5	45.681	-122.945	29.3	9	3.0
2012	11	19	45.649	-122.764	36.5	19	3.2
2013	1	31	45.919	-122.409	40.7	8	3.7
2013	8	3	46.327	-122.391	38.9	15	3.1
2013	8	24	46.323	-122.390	38.9	15	3.4
2013	8	24	46.324	-122.379	39.4	14	3.1
2013	8	23	46.313	-122.370	39.7	14	3.7
2014	4	7	45.398	-122.904	47.6	20	3.3
2014	9	16	46.330	-122.377	39.6	15	3.0
2015	6	25	45.489	-123.441	38.3	52	3.2
2015	9	3	46.356	-122.263	45.4	12	3.1

APPENDIX H-C
Preliminary Compressor Station Geotechnical Report

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Preliminary Geotechnical Evaluation

North Mist Pipeline Compressor Station
Columbia County, Oregon

for
NW Natural

September 18, 2015

GeoEngineers
Earth Science + Technology

Preliminary Geotechnical Evaluation

North Mist Pipeline Compressor Station
Columbia County, Oregon

for
NW Natural

September 18, 2015

GeoEngineers

1200 NW Naito Parkway, Suite 180
Portland, Oregon 97209
503.624.9274

Revised Preliminary Geotechnical Evaluation
North Mist Pipeline Compressor Station

Columbia County, Oregon

File No. 6024-157-03

September 18, 2015

Prepared for:

NW Natural
220 NW 2nd Avenue, Suite 300
Portland, Oregon 97209

Attention: Andrew Bauer

Prepared by:

GeoEngineers, Inc.
1200 NW Naito Parkway, Suite 180
Portland, Oregon 97209
503.624.9274

CERTIFIED OREGON BRIAN C. RANNEY No. E1917 ENGINEERING GEOLOGIST

EXP 11/30/2015

Brian Ranney

Brian C. Ranney, RG, CEG
Senior Engineering Geologist

REGISTERED PROFESSIONAL ENGINEER 65497PE OREGON JULY 09, 2001 TREVOR NATHAN HOYLES

Trevor Hoyles

Trevor N. Hoyles, PE
Principal

IDB:BCR:TNH:cje

EXP: 6/30/17

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GEOENGINEERS

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1.0 INTRODUCTION AND PROJECT UNDERSTANDING

This revised report summarizes GeoEngineers' geotechnical engineering evaluation for the proposed North Mist Pipeline Compressor Station to be located in Columbia County, Oregon. The location of the site is shown with respect to the surrounding area in the Vicinity Map, Figure 1. This report was revised to include our interpretation of landslide deposits at the subject site that were made subsequent to the original version of this report (dated June 30, 2014).

NW Natural proposes to construct a compressor station within a 7-acre site that generally occupies a gently sloping ridge top. The facility layout has not been designed so the extent of site grading and the specific location of proposed structures are not known at this time. The compressor station development will include filter separators, generators, launcher/receivers, water/waste oil tanks (40 barrels each), two compressor/cooler units and a small control station. The Site Plan, Figure 2, shows the preliminary site layout and equipment locations. However, we understand that the layout is subject to change.

We have assumed that canopy structures and the control station will be small and column loads will be lightly loaded on the order of 10 kips or less. We anticipate that wall loads will be less than 4 kips per linear foot (klf). We understand that the two compressors will be the heaviest equipment, weighing approximately 250 kips each.

The new compressor station is being planned as part of the North Mist Storage Project. Geologic hazards at the North Mist Pipeline Compressor site will be summarized in Exhibit H of the Energy Facility Siting Council (EFSC) site certificate amendment submittal for the proposed North Mist Storage Project.

2.0 PURPOSE AND SCOPE OF SERVICES

The purpose of our services was to explore subsurface soil and groundwater conditions at the site in order to provide geotechnical recommendations for the proposed compressor station. Our specific scope of services included the following:

1. Exploring subsurface conditions by drilling three borings to depths of 41.5 feet each and one boring to a depth of 37 feet where practical refusal was encountered on bedrock.
    a. Completing in-situ sampling using standard penetration testing (SPT) and/or Dames and Moore sampling. Obtaining samples at 5-foot intervals;
    b. Classifying the materials encountered in the borings in general accordance with ASTM International (ASTM) Standard Practices Test Method D 2488;
    c. Maintaining a log of each boring; and
    d. Observing groundwater conditions encountered in the borings.
2. Performing laboratory tests on select samples to determine index, or strength properties as necessary. Testing included the following:
    a. Eleven moisture contents and density determinations in accordance with ASTM Test Method D 2937 for site soil characterization and interpretation, and to evaluate the fill suitability of the native soils;

b. Four Atterberg limits tests in general accordance with ASTM D 4318; and

c. Four sieve analyses in general accordance with ASTM D 422.

3. Evaluating the collected data to determine the site's suitability for the proposed construction, including foundation support requirements and site stability.

4. Providing this report summarizing our findings and providing recommendations for additional site data collection and engineering analysis.

3.0 SITE CONDITIONS

3.1. Regional Geology

The proposed facility is located within mountainous terrain of the Oregon Coast Range. In Oregon, the Coast Range is a belt of moderately high mountains, extending along a north-south axis between the Columbia River and the Klamath Mountains. The core of this anticlinal structural chain is underlain by early Tertiary pillow basalts, lavas, and basalt breccias that were erupted underwater as oceanic islands. The flanks of the coast range are composed of marine sedimentary rocks that accumulated around the underwater oceanic islands. The volcanic and sedimentary rocks were later accreted onto the western edge of the North American continent by the subduction of the Juan de Fuca tectonic plate (Orr and Orr, 2000).

3.2. Site Geology and Soils

The Oregon Department of Geology and Mineral Industries (DOGAMI) geologic compilation mapping (DOGAMI, 2009) shows the site underlain by Quaternary aged landslide debris which is described as mixed grain sediments derived from landslide deposition.

Smythe (1986) identifies two soil types across the compressor station area: the Vernonia silt loam, and the Mayger silt loam. Both are deep soils formed from weathering of fine-grained marine sedimentary rocks. The Mayger silt loam is generally greater than 5 feet thick, while the Vernonia silt loam ranges from 3.5 to 5 feet thick over sedimentary bedrock.

3.3. Seismic Setting

The Oregon Coast Range is located within a relatively seismically quiet area of northwest Oregon. The main tectonic feature of northwest Oregon is the active subduction zone related to the Juan De Fuca Plate subducting beneath the North American plate (Geomatrix, 1995). There are two principal seismic sources that could affect ground motion hazards at the site: Cascadia subduction zone sources, and crustal sources occurring within the North American Plate; however, the most significant hazard at the site would be related to subduction sources.

Earthquakes in this region are derived from subduction zone sources, which can be further subdivided into the Juan de Fuca-North American plate interface (inter-slab) earthquakes and earthquakes occurring within the subducting Juan de Fuca Plate (intra-slab earthquakes). Based on a two percent in 50 years return period, the United States Geological Survey (USGS) predicts a maximum earthquake magnitude of 9.0 and a peak ground acceleration of 0.497g, at a source distance of 31 miles (Subduction Zone Source), (ASCE 7-10).

3.4. Surface Conditions

We performed a surface reconnaissance of the site on May 15, 2014. Our reconnaissance consisted of identifying potential boring locations, and observing general topographic and vegetative conditions. The site is located on a broad gently rolling terrace with elevations range from approximately 1,285 feet above mean sea level (MSL) in the southwest corner of the site to an approximately 1,320 feet above MSL on the eastern border of the site.

Except for the 40 foot wide road that was excavated prior to subsurface exploration, the site is currently undeveloped and consists of rolling topography that is occupied by a dense stand of mature Douglas Fir trees.

3.5. Subsurface Conditions

We explored subsurface conditions on May 29 and May 30, 2014 by advancing a total of four borings, three borings within the outside perimeter of the site and one boring in the middle section. The borings were advanced to depths of up to 40 feet below the ground surface (bgs). A representative from GeoEngineers observed the borings on a full-time basis, visually classified and collected the soil samples, and logged other pertinent drilling information. Soil samples were obtained from the borings at 5-foot-depth intervals using mud-rotary drilling techniques, and SPT samplers. A description of the field exploration is presented in Appendix A.

The borings encountered a wide range of materials at the foundation elevations from medium stiff silt and clay to loose sand. The material encountered in our borings was consistent with the geologic mapping by DOGAMI. The borings encountered between 12 and 34 feet of material that we interpret to be landslide deposits of variable materials ranging from gravel to elastic silt.

The following Table 1 summarizes the materials encountered in each boring.

TABLE 1. SUMMARY OF BORINGS

Boring ID	Depth (feet)	Conditions Encountered
ACSB-1	40.5	Approximately 2.5 feet of silt overlying medium dense gravel that extended to approximately 12.5 feet. Below 12.5 feet, the boring encountered approximately 20 feet of dense to very dense silty sand with gravel overlying very dense gravel that extended to the termination depth of 40.5 feet. Groundwater was not observed during drilling.
ACSB-2	41.5	Approximately 7 feet of medium stiff elastic silt overlying loose silty sand to a depth of 35 feet where the sands becomes medium dense to a depth of 41.5 feet, the maximum depth explored. Groundwater was not observed during drilling.
ACSB-3	40	Approximately 3 feet of sandy silt with gravel overlying loose to very dense clayey gravel to approximately 12 feet. Below 12 feet, the boring encountered medium dense to very dense sand with variation of gravel content that extended to the termination depth of 40 feet. Groundwater was not observed during drilling.
ACSB-4	37.5	Approximately 18 feet of medium stiff elastic silt overlying loose to medium dense sand to approximately 27.5 feet. Below 27.5 feet, the boring encountered very dense gravel that extended to the termination depth of 37.5 feet where practical refusal was encountered. Groundwater was not observed during drilling.

3.6. Groundwater Conditions

We did not observe static groundwater within the borings at the time of our explorations. However, it is important to note that we did not allow groundwater levels to equalize prior to backfilling the borings. During the explorations, we did not observe excessively wet soil samples that would help identify the groundwater table in the area. We anticipate that groundwater levels will fluctuate with precipitation, site utilization, and other factors.

4.0 CONCLUSIONS

Based on the subsurface conditions encountered by our borings, slope morphology observed in LiDAR hillshade models of the area and geologic mapping, it is our opinion that the landslide debris encountered at the site was deposited by a rapidly moving landslide (i.e. debris slide or mudflow) rather than a slow moving deep-seated landslide. Specifically, it is our interpretation that subsurface materials underlying the site consist of landslide debris deposited on intact, stable weathered bedrock. Moreover, we do not interpret there to be a slide plain underlying the site.

The subsurface conditions across the site are extremely variable, ranging from medium stiff elastic silt and clay, to loose sand and gravel to dense gravel. The medium stiff elastic silt and clay and the loose sand and gravel are moderately compressible. Foundations established within the moderately compressible soils will need to be mitigated to reduce settlement magnitudes to acceptable levels. Mitigation to control settlement typically includes the following or a combination of the following methods: establishing foundations on gravel pads up to several feet thick, ground improvement such as rammed aggregate piers (GeoPiers), and deep foundations such as augercast piling.

In order to evaluate the potential settlement that the planned compressor and other equipment will be subject to, it will be important to know the specific location of such equipment. We understand that the current layout shown in the Site Plan, Figure 2, is preliminary and subject to change. We recommend that GeoEngineers be given an opportunity to work with the design team during final design and layout selection and produce geotechnical recommendations for earthwork and foundation support once those plans are finalized. We recommend that an additional boring be completed for the compressors once that location is known. Based on our current explorations, it will be preferable to locate the compressors where granular soils were encountered rather than the elastic silt and clay.

5.0 LIMITATIONS

We have prepared this geotechnical engineering report for use by the NW Natural in accordance with our Master Services Agreement dated April 9, 2002 and our proposal dated January 17, 2014. Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

Please refer to Appendix B titled “Report Limitations and Guidelines for Use” for additional information pertaining to use of this report.

6.0 REFERENCES

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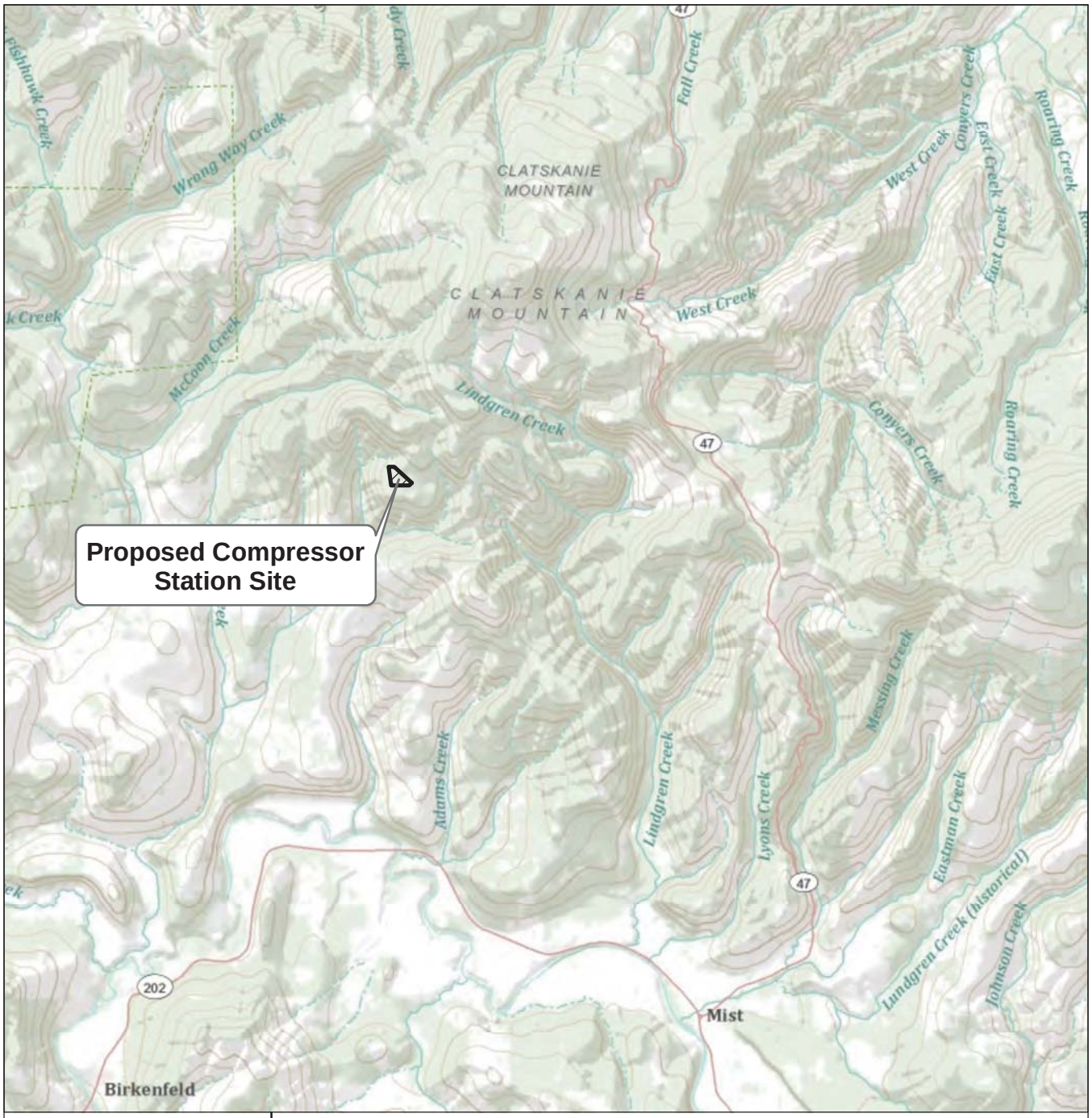
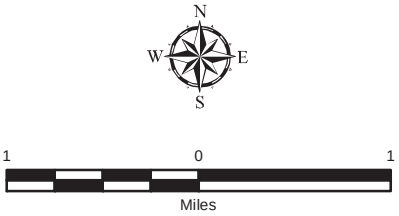
U.S. Geological Survey, Interactive Deaggregations, Earthquake Hazards Program. Last modified on 2008. http://geohazards.usgs.gov/deaggint/2008/, 2012.





Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
Data Sources: ESRI Data & Maps, Street Maps 2008.
Base map from ESRI Data Online.
Projection: NAD 1983, UTM Zone 10 North.

Vicinity Map

North Mist Pipeline Compressor Station
Columbia County, Oregon

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Figure 1

Map Revised: 24 June 2014 ccabrera

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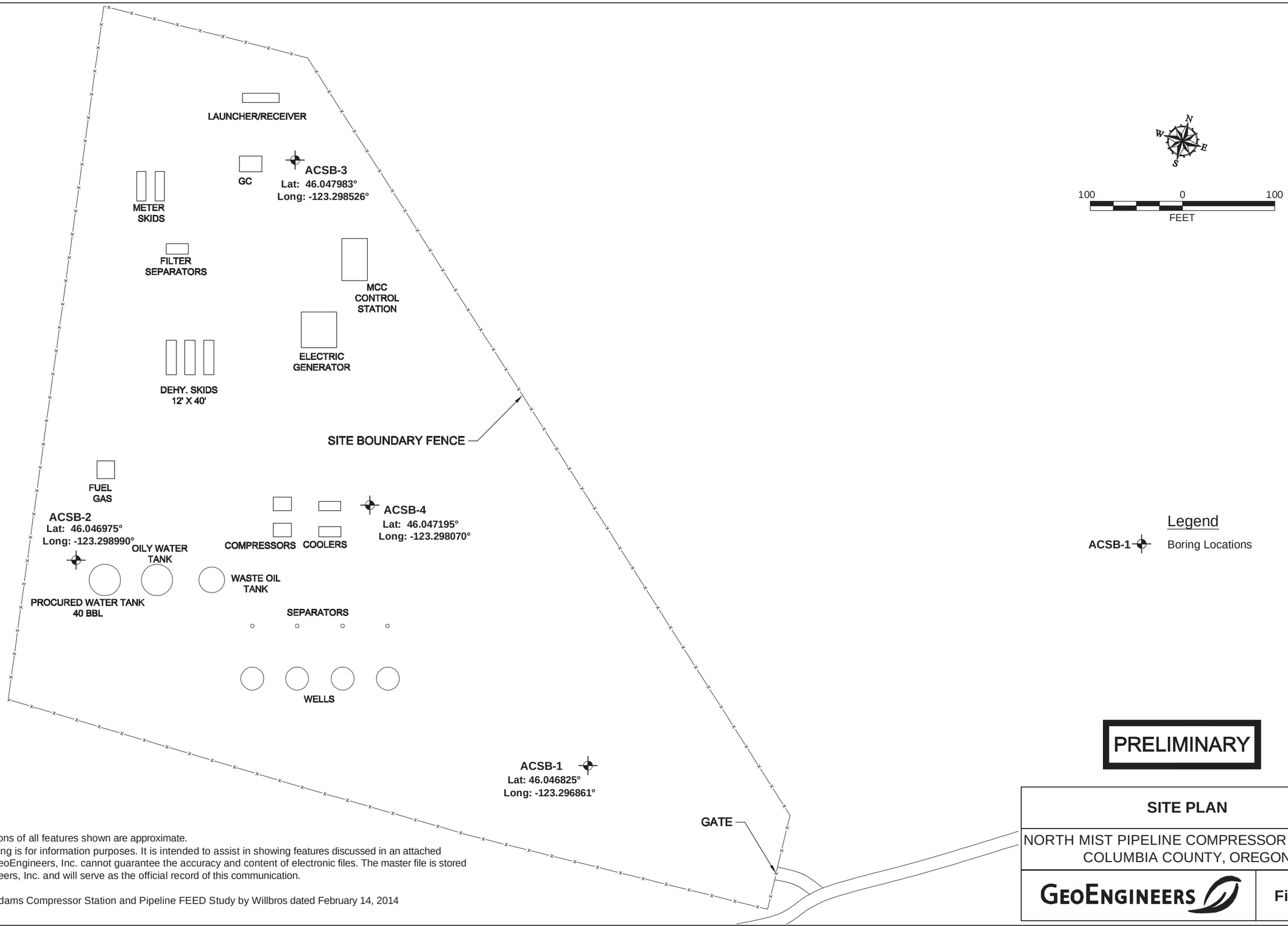

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Reference: Adams Compressor Station and Pipeline FEED Study by Willbros dated February 14, 2014

SITE PLAN

NORTH MIST PIPELINE COMPRESSOR STATION
COLUMBIA COUNTY, OREGON

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Figure 2

TNH : IDB

P:\6\602415703\Compressor Station\CAD\602415703 - Fig 2 Site Plan.dwg\TAB:FIG 2 modified on Jun 27, 2014 - 4:53pm

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APPENDICES

GeoEngineers

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APPENDIX A
Field Explorations and Laboratory Testing

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APPENDIX A
FIELD EXPLORATIONS AND LABORATORY TESTING

Field Explorations

We explored subsurface conditions on May 29 and May 30, 2014 by advancing a total of four borings, three borings within the outside perimeter of the site and one boring in the middle section, using mud-rotary drilling techniques. Subsurface Technologies of North Plains, Oregon drilled the borings to depths of 40 feet bgs. A representative from our office observed field activities, classified the materials encountered, obtained representative samples, observed groundwater conditions where possible and prepared a log of each exploration. The borings were backfilled with cement grout at the conclusion of each exploration.

Soils encountered in the borings were classified in the field by a GeoEngineers representative in general accordance with ASTM Standard Practice D 2488, the Standard Practice for the Classification of Soils (Visual-Manual Procedure) which is described in Figure A-1. The boring logs are presented in Figures A-2 through A-5. Soil classifications and sampling intervals are shown in the boring logs. Inclined lines at the material contacts shown on the log indicate uncertainty as to the exact contact elevation, rather than the inclination of the contact itself.

SPTs were performed during drilling in general accordance with ASTM Test Method D 1586. The sampler was driven with a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler 1 foot, or as otherwise indicated, into the soils is shown adjacent to the sample symbols on the boring log. Disturbed samples were obtained from the split barrel for subsequent classification and index testing.

The relative density of the SPT samples recovered at each interval was evaluated based on correlations with lab and field observations in general accordance with the values outlined in Table A-1 below.

TABLE A-1. CORRELATION BETWEEN BLOW COUNTS AND RELATIVE DENSITY *

Cohesive Soils (Clay/Silt)						
Parameter	Very Soft	Soft	Medium Stiff	Stiff	Very Stiff	Hard
Blows, N	< 2	2 – 4	4 - 8	8 – 16	16 - 32	>32
**Cohesionless Soils (Gravel/Sand/Silty Sand) ** **						
Parameter	Very Loose	Loose	Medium Dense	Dense	Very Dense	
Blows, N	0 – 4	4 – 10	10 – 30	30 - 50	> 50	

* After Terzaghi, K and Peck, R.B., "Soil Mechanics in Engineering Practice," John Wiley & Sons, Inc., 1962.

** Classification applies to soils containing additional constituents; that is, organic clay, silty or clayey sand, etc.

Laboratory Testing

General

Soil samples obtained from the explorations were transported to our laboratory in Portland, Oregon to confirm or modify field classifications, as well as to evaluate engineering properties of the samples. Representative samples were selected for laboratory testing consisting of moisture content determinations, dry unit weight, sieve analyses, unconfined compression tests and Atterberg limits tests. The laboratory testing procedures are discussed in more detail below.

Moisture Content Testing

Eleven moisture content tests were completed in general accordance with ASTM D 2216 for representative samples obtained from the explorations. The results of these tests are presented on the exploration logs in Figures A-2 and A-5 at the depths at which the samples were obtained.

Atterberg Limits Testing

Four Atterberg limits tests were performed on soil samples collected from our borings. The tests were used to classify the soil as well as to evaluate index properties and residual strength characteristics. The liquid limit and the plastic limit were estimated through a procedure performed in general accordance with ASTM D-4318 and are presented in Figure A-6.

Sieve Analysis

Four sieve analyses were performed on soil samples in general accordance with ASTM D 422. The results of the sieve analyses were plotted and classified in general accordance with the Unified Soil Classification System (USCS) and are presented in Figure A-7. The percentage passing the U.S. No. 200 sieve is shown on the boring logs.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	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
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		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
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
		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% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, 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 SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Material Description Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Sampler Symbol Descriptions

2.4-inch I.D. split barrel

Standard Penetration Test (SPT)

Shelby tube

Piston

Direct-Push

Bulk or grab

Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

Laboratory / Field Tests

%F	Percent fines
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PP	Pocket penetrometer
PPM	Parts per million
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

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FIGURE A-1

Drilled	Start 5/30/2014	End 5/30/2014	Total Depth (ft)	40.42	Logged By	IDB	Driller	Subsurface Technologies	Drilling Method	Mud Rotary
					Checked By	BCR				

Surface Elevation (ft) Vertical Datum	Undetermined	Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude Longitude	46.04682 -123.29606	System Datum	Geographic WGS84	Groundwater Date Measured	Depth to Water (ft) / Elevation (ft): Not encountered

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample: Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
	0						ML	Brown silt with sand			Topsoil was removed prior to drilling
							GM	Brown silty gravel with sand (medium dense, moist) (inferred landslide debris)			
	5	12	13	1 SA					46		SA; %F = 17, %Gravel = 54
	10	12	38	2							
							SM	Brown/gray silty sand with gravel (dense, moist) (decomposed bedrock)			
	15	14	50	3 SA					41		SA; %F = 32, %Gravel = 25
	20	14	71	4				Becomes very dense			Intermittent rig chatter from 20 to 25 feet
	25	12	19	5				Becomes medium dense			
	30	12	37	6							
							GP-GM	Gray-brown gravel with silt and sand and trace clay (very dense, moist) (decomposed bedrock)			
	35	5	50/5"	7							
	40	5	50/5"	8							

Note: See Figure A-1 for explanation of symbols

Log of Boring ACSB-1

GEOENGINEERS

Project: North Mist Pipeline Compressor Station
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-2
Sheet 1 of 1

Portland: Date:9/18/15 Path:C:\USERS\KJANC\DESKTOP\6024157 03.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Drilled	Start 5/29/2014	End 5/29/2014	Total Depth (ft)	41.5	Logged By	IDB	Checked By	BCR	Driller	Subsurface Technologies	Drilling Method	Mud Rotary
Surface Elevation (ft) Vertical Datum	Undetermined				Hammer Data	Auto 140 (lbs) / 30 (in) Drop			Drilling Equipment	Deidrich D-50 Turbo Track Rig		
Latitude Longitude	46.04697 -123.29879				System Datum	Geographic WGS84			Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)	
Notes:									Not encountered			

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
	0						MH	Brown sandy silt with trace gravel (medium stiff, moist) (inferred landslide debris)			Topsoil was removed prior to drilling
	5	18	7	1 AL				Decreased sand content below 5 feet	45		AL; PI = 24
							SM	Brown silty fine sand (loose, moist) (inferred landslide debris)			
	10	18	9	2 AL, %F					52		AL; PI = 3 %F = 31
	15	18	13	3				Becomes medium dense			
	20	18	5	4 %F				Becomes loose	59		%F = 23
	25	18	4	5				Becomes light brown			
	30	18	8	6							
							SC	Brown clayey sand (medium dense, moist) (decomposed bedrock)			
	35	18	16	7							
	40	16	18	8							

Note: See Figure A-1 for explanation of symbols

Log of Boring ACSB-2

GEOENGINEERS

Project: North Mist Pipeline Compressor Station
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-3
Sheet 1 of 1

Portland: Date:9/18/15 Path:C:\USERS\KJANC\DESKTOP\6024157 03.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Drilled	Start 5/29/2014	End 5/29/2014	Total Depth (ft)	40.1	Logged By	IDB	Driller	Subsurface Technologies	Drilling Method	Mud Rotary
					Checked By	BCR				

Surface Elevation (ft) Vertical Datum	Undetermined	Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude Longitude	46.04798 -123.29853	System Datum	Geographic WGS84	Groundwater Date Measured	Depth to Water (ft) / Elevation (ft): Not encountered

Notes:

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
	0								ML	Brown sandy silt with gravel			
									GC	Brown clayey gravel with sand (loose, moist) (inferred landslide debris)			
	5		10	7		1 SA					47		SA; %F = 29, %Gravel = 36
									GP-GC	Brown sandy gravel with clay (very dense, moist to wet) (inferred landslide debris)			Rig chatter from 8 to 12 feet
	10		10	50/6"		2 MC					26		Losing mud from 10 to 15 feet
									SM	Brown silty fine sand (medium dense, moist) (inferred landslide debris)			
	15		18	14		3 %F					62		%F = 31
									SP	Brown fine sand with trace clay, oxidation staining on bottom 6 inches (dense, moist) (decomposed bedrock)			
	20		17	56		4							
	25		4	50/4"		5				Becomes very dense with clay and some fine gravel			Drilling slowed Very hard drilling
									SC	Brown clayey fine to medium sand with trace gravel (very dense, moist) (decomposed bedrock)			
	30		9	50/3"		6							
	35		5	50/5"		7				With increased gravel content below 35 feet			
	40		1	50/1"		8							

Note: See Figure A-1 for explanation of symbols

Log of Boring ACSB-3

GEOENGINEERS

Project: North Mist Pipeline Compressor Station
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-4
Sheet 1 of 1

Portland: Date:9/18/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Drilled	Start 5/30/2014	End 5/30/2014	Total Depth (ft) 37.5	Logged By IDB / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) Vertical Datum	Undetermined		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude Longitude	46.04719 -123.29807		System Datum	Geographic WGS84	Groundwater Date Measured / Depth to Water (ft) / Elevation (ft)	Not encountered
Notes:						

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
	0								MH	Brown elastic silt with trace coarse sand (medium stiff, moist) (inferred landslide debris)			
	5		14	6		1 AL					40		AL; PI = 23
	10		16	4		2				Becomes sandy			
	15		14	5		3 AL, %F					49		AL; PI = 18 %F = 51
									SC	Brown clayey sand with gravel (medium dense, moist) (inferred landslide debris)			
	20		12	13		4 SA					48		SA; %F = 26, %Gravel = 33
	25		12	8		5				Becomes loose			
									GP-GC	Brown sandy gravel with clay (decomposed bedrock)			
	30		12	63		6							Decomposed basalt Rig chatter at 31 feet
	35		10	67		7							Very hard drilling
			0.3	50/1.5"		8							
										Refusal at 37.5 feet			

Note: See Figure A-1 for explanation of symbols

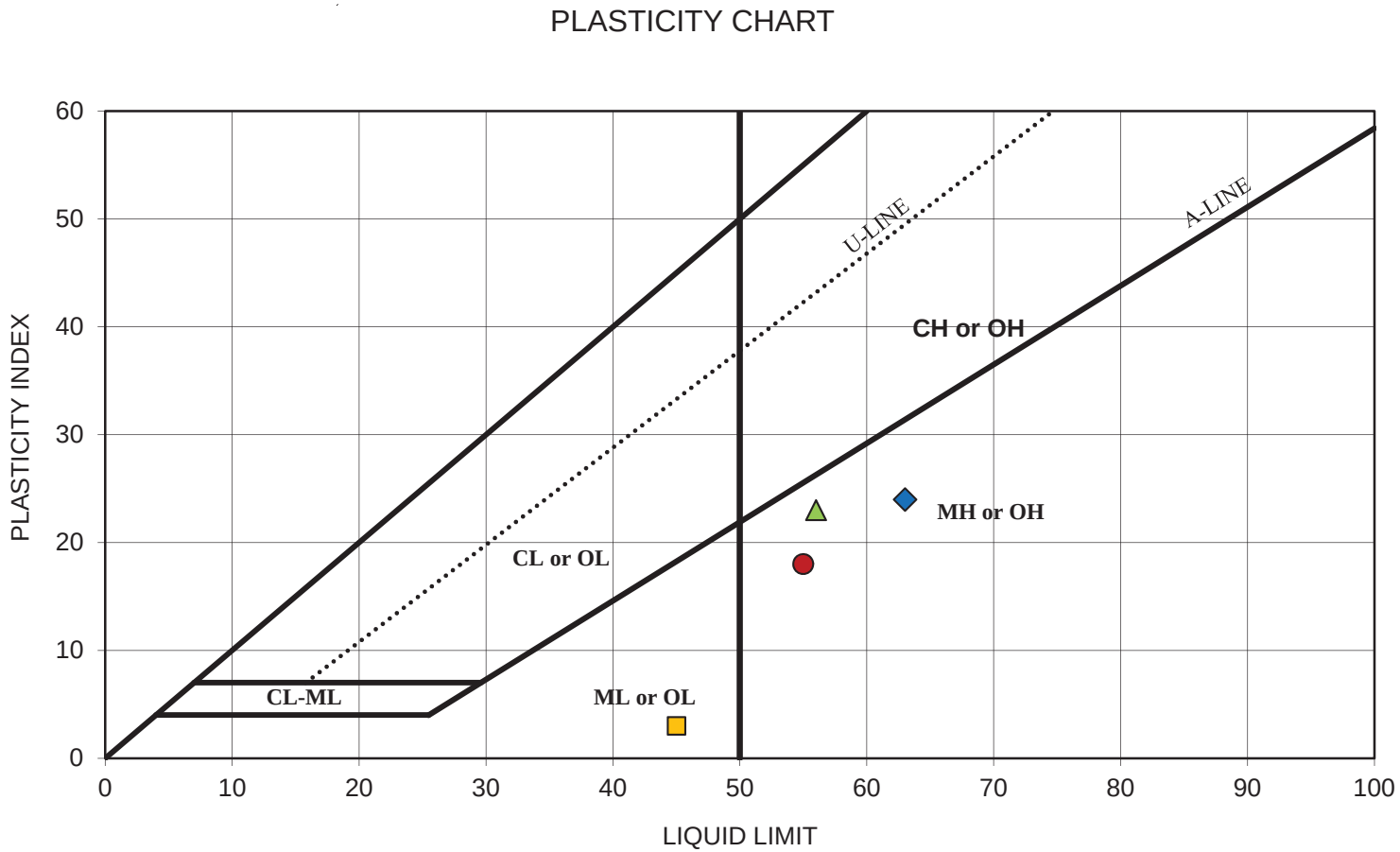
Log of Boring ACSB-4

GEOENGINEERS

Project: North Mist Pipeline Compressor Station
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-5
Sheet 1 of 1

Portland: Date:9/18/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD



Symbol	Sample ID	Sample Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	USCS	Soil Description
◆	ACSB-2 S-1	5	45	63	24	MH	Elastic silt with trace sand
■	ACSB-2 S-2	10	52	45	3	*SM	Silty fine sand
▲	ACSB-4 S-1	5	40	56	23	MH	Elastic silt with trace coarse sand
●	ACSB-4 S-3	15	49	55	18	*MH	Sandy elastic silt

*classification in conjunction with percent fines testing

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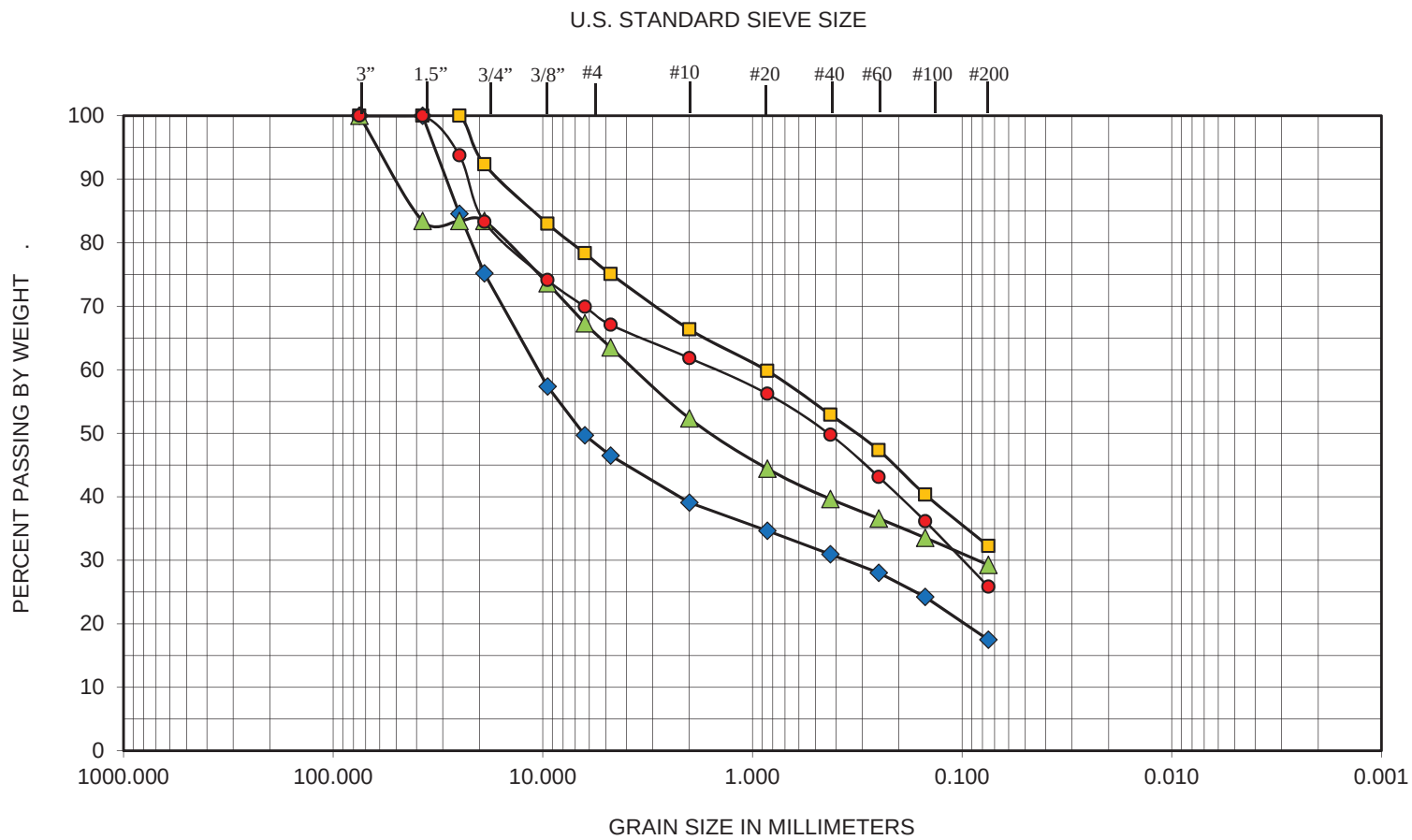
Atterberg Limits Test Results

North Mist Pipeline Compressor Station
Columbia County, Oregon

GeoEngineers

Figure A-6



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Sample ID	Sample Depth (feet)	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%)	USCS	Soil Description
◆	ACSB-1 S-1	5	46	54	29	17	GM	Silty gravel with sand
■	ACSB-1 S-3	15	41	25	43	32	SM	Silty sand with gravel
▲	ACSB-3 S-1	5	47	36	34	29	GC	Clayey gravel with sand
●	ACSB-4 S-4	20	48	33	41	26	SC	Clayey sand with gravel

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Sieve Analysis Results

North Mist Pipeline Compressor Station
Columbia County, Oregon

GeoEngineers

Figure A-7

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APPENDIX B
Report Limitations and Guidelines for Use

APPENDIX B
REPORT LIMITATIONS AND GUIDELINES FOR USE

This appendix provides information to help you manage your risks with respect to the use of this report.

Geotechnical and Environmental Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for the exclusive use of NW Natural and their authorized agents. This report is not intended for use by others, and the information contained herein is not applicable to other sites.

GeoEngineers structures our services to meet the specific needs of our clients. For example, a geotechnical or geologic study conducted for a civil engineer or architect may not fulfill the needs of a construction contractor or even another civil engineer or architect that are involved in the same project. Similarly, an environmental assessment study conducted for a property owner may not fulfill the needs of a prospective purchaser of the same property. Because each study is unique, each report is unique, prepared solely for the specific client and project site. Our report is prepared for the exclusive use of our Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. This report should not be applied for any purpose or project except the one originally contemplated.

A Geotechnical Engineering or Environmental Report Is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the proposed expansion of the proposed North Mist Pipeline Compressor Station to be located in Columbia County, Oregon. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, do not rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If important changes are made after the date of this report, GeoEngineers should be given the opportunity to review our interpretations and recommendations and provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by manmade events such as construction on or adjacent to the site, by new releases of hazardous substances, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. Always contact GeoEngineers before applying a report to determine if it remains applicable.

Most Geotechnical and Environmental Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations and laboratory test results from widely spaced sampling locations at the site. Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied our professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

Do not over-rely on the preliminary construction recommendations included in this report. These recommendations are not final, because they were developed principally from GeoEngineers' professional judgment and opinion. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for this report's recommendations if we do not perform construction observation.

Sufficient monitoring and consultation by GeoEngineers should be provided during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not construction activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. You could lower that risk by having GeoEngineers confer with appropriate members of the design team after submitting the report. Also retain GeoEngineers to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering or geologic report. Reduce that risk by having GeoEngineers participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical

engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognize that separating logs from the report can elevate risk.

Give Contractors a Complete Report and Guidance

Some owners and design professionals believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering or geologic report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might an owner be in a position to give contractors the best information available, while requiring them to at least share the financial responsibilities stemming from unanticipated conditions. Further, a contingency for unanticipated conditions should be included in your project budget and schedule.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and to adjacent properties.

Read These Provisions Closely

Some clients, design professionals and contractors may not recognize that the geoscience practices (geotechnical engineering or geology) are far less exact than other engineering and natural science disciplines. This lack of understanding can create unrealistic expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory "limitations" provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you are unclear how these "Report Limitations and Guidelines for Use" apply to your project or site.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings, or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants and no conclusions or inferences should be drawn regarding Biological Pollutants, as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria, and viruses, and/or any of their byproducts.

If Client desires these specialized services, they should be obtained from a consultant who offers services in this specialized field.

Have we delivered World Class Client Service?

Please let us know by visiting **www.geoengineers.com/feedback**.

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APPENDIX H-D
Final HDD Design Report

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Geotechnical Engineering and HDD Design

North Mist Pipeline
Columbia County, Oregon

for
NW Natural

September 18, 2015

GeoEngineers
Earth Science + Technology

Geotechnical Engineering and HDD Design

North Mist Pipeline
Columbia County, Oregon

for
NW Natural

September 18, 2015

GeoEngineers

1200 NW Naito Parkway, Suite 180
Portland, Oregon 97209
503.624.9274

Geotechnical Engineering and HDD Design

North Mist Pipeline
Columbia County, Oregon

File No. 6024-157-03

September 18, 2015

Prepared for:

NW Natural
220 NW 2nd Avenue, Suite 300
Portland, Oregon 97209

Attention: Andrew Bauer, RG

Prepared by:

GeoEngineers, Inc.
1200 NW Naito Parkway, Suite 180
Portland, Oregon 97209
503.624.9274

CERTIFIED OREGON BRIAN C. RANNEY No. E1917 ENGINEERING GEOLOGIST

11/30/2015

Brian C. Ranney, RG, CEG
Senior Engineering Geologist

REGISTERED PROFESSIONAL ENGINEER 65497PE OREGON JULY 09, 2004 TREVOR NATHAN HOYLES

Trevor N. Hoyles, PE
Principal

BCR:TNH:cje

EXP: 9/18/15

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EXECUTIVE SUMMARY

This report provides GeoEngineers, Inc.'s (GeoEngineers') geotechnical engineering and horizontal directional drilling (HDD) design recommendations for the proposed HDD installations along the North Mist Pipeline alignment in Columbia County, Oregon. The project consists of installing approximately 12 miles of new 24-inch-diameter pipeline, of which approximately 4.5 miles will be installed by means of eight HDD installations (HDD-1 through HDD-8). The proposed HDD installations cross Highway 30, a railroad, several local roadways, the Clatskanie River, Beaver Slough, Larson Slough and several drainage ditches.

The subsurface conditions along the proposed HDD alignments were evaluated by drilling 20 borings to depths of up to 230 feet below the existing ground surface (bgs), and conducting two Cone Penetrometer Tests (CPTs) to depth of up to 147 feet bgs. With the exception of HDD-1, the subsurface conditions encountered in the borings consisted of alluvial deposits, generally including interbedded very soft to medium stiff silt, very soft to medium stiff elastic silt, very soft to very stiff clay and very loose to dense sand with varying amounts of silt. Borings completed along/near the HDD-1 alignment encountered very soft to soft silt and clay and very loose to loose sand alluvium northeast of Highway 30, and medium dense to very dense sand overlying basalt bedrock southwest of Highway 30. The boring logs are included in Appendix A. The subsurface conditions present a variety of significant construction considerations relating to hole stability, steering, and cuttings removal. For some of the HDD installations, we have recommended the use of large diameter casing to mitigate some of the challenging conditions as described in this report.

Hydraulic fracture and drilling fluid surface release computations indicate that portions of the HDD installations have a high risk of hydraulic fracture and drilling fluid surface release, including some portions with safety factors of less than 1. However, where the proposed pipeline passes beneath potential U.S. Army Corps of Engineers (USACE) regulated levees (Clatskanie River, Beaver Slough), and other significant waterways (Larson Slough) the factors of safety are estimated to be greater than 2, provided the recommendations provided in this report are followed prior to and during construction.

Construction means and methods ultimately control the risk of hydraulic fracture and drilling fluid surface releases. If the HDD contractor operates with insufficient drilling fluid flow rates, inadequate drilling fluid properties or excessive rates of penetration, the annulus may become blocked through an accumulation of drill cuttings falling out of suspension and the risk of hydraulic fracture and drilling fluid surface release will be increased. If the hole becomes blocked and drilling fluid returns are lost, the hydraulic fracture and drilling fluid surface release analyses are no longer valid.

Based on the results of our site visits, subsurface exploration program, geotechnical engineering evaluations, HDD design, and HDD constructability review, it is our opinion the HDD method of installation along the proposed HDD segments is technically feasible. However, this opinion is based upon the HDD contractor adhering to the requirements contained herein and implementing plans and procedures that are in accordance with project design.

This Executive Summary should be used only in the context of the full report for which it is intended.

1.0 INTRODUCTION AND PROJECT DESCRIPTION

1.1 General

This report provides geotechnical engineering recommendations and HDD design, for eight proposed 24-inch-diameter HDD installations as part of the North Mist Expansion Project in Columbia County Oregon. The HDD installations will cross several features, including Highway 30, a railroad, several local roadways, the Clatskanie River, Beaver Slough, Larson Slough and several drainage ditches. The proposed HDD alignments are shown in the Vicinity Map, Figure 1.

1.2 Project Description and Basis of Design

The North Mist Expansion Project includes construction of approximately 12.4 miles of 24-inch-diameter natural gas pipeline, and construction of a compressor station. The pipeline begins in the mountains near Mist, Oregon, traverses across mountainous terrain to the Columbia River Valley, where it crosses the flat valley floor to an existing Portland General Electric (PGE) power generation facility adjacent to the Columbia River in Port Westward, Oregon. The segment of the pipeline within the Columbia River Valley will be installed using HDD methods, while the uplands segment will be installed using conventional open cut methods. The Clatskanie River and both sloughs are bounded by levees that are in the process of USACE certification.

The following table summarizes each of the eight HDD installations, along with the features crossed by each HDD installation.

TABLE 1. HDD CROSSINGS

HDD Number	HDD Design Length (feet)	Features Crossed
HDD-1	1,957	Highway 30, Railroad Tracks
HDD-2	3,130	Clatskanie River, Levees
HDD-3	2,875	Beaver Slough, Levees, Drainage Ditch, Poplar Tree Farms
HDD-4	3,685	Beaver Slough, Levees, Poplar Tree Farm, Blueberry Fields, Collins Road 2
HDD-5	3,750	Larson Slough, Levees, Lewis Road, Drainage Ditches, Poplar Tree Farms
HDD-6	3,900	Collins Road 1, Poplar Tree Farms
HDD-7	3,570	Hermo Road, Poplar Tree Farms, Blueberry Fields
HDD-8	1,985	Organic Mint Farm

Our HDD designs provided in Appendices C through J have been completed in general accordance with the latest versions of the U.S. Department of Transportation (DOT) regulations at 49 CFR 192, American Society of Mechanical Engineers (ASME) B31.8 and generally accepted practices within the natural gas industry. The HDD design engineering was completed based on the parameters presented below in Table 2.

TABLE 2. BASIS OF DESIGN FOR THE 24-INCH-DIAMETER NORTH MIST PIPELINE HDD INSTALLATIONS

Product Pipe Data	Design Parameter
Product Pipe Specifications	24" O.D. x 0.500 inches w.t.[1] API-5L X-52 steel pipe
Maximum Allowable Operating Pressure	809 psig[2]
Maximum Operating Temperature	55 degrees F
Assumed Tie-In Temperature	55 degrees F

Notes:

[1] w.t. – wall thickness

[2] psig – pounds per square inch gauge

2.0 PURPOSE AND SCOPE OF SERVICES

The purpose of our services was to explore subsurface conditions at the planned HDD locations in order to complete the HDD design and reporting for the eight proposed HDD installations. Our specific scope of services included:

1. Preparing preliminary HDD alignment and profile drawings for each proposed HDD to assist in developing the subsurface exploration program.
2. Completing a site reconnaissance to observe surface conditions, evaluate access to potential boring locations and locate borings.
3. Exploring subsurface conditions along the proposed HDD alignments by means of 20 borings that were drilled using mud rotary or rock coring techniques, as appropriate. The borings were drilled to depths ranging between 70 and 230 feet bgs. While observing the borings we:
    a. Obtained soil samples at representative intervals from the borings during standard penetration testing (SPT samples);
    b. Obtained continuous rock core within bedrock, where applicable;
    c. Classified the materials encountered in the borings in general accordance with ASTM International (ASTM) Standard Practices D 2488 (soil), and the Oregon Department of Transportation (ODOT) rock classification system (rock); and
    d. Maintained a detailed log of each boring.
4. Exploring subsurface conditions in two locations by conducting cone penetrometer testing (CPT) to depths of 60 and 147 feet bgs.
5. Performing index tests necessary to characterize subsurface conditions for use in crossing design. Testing included:
    a. Twenty Atterberg limits determinations in general accordance with ASTM D 4318;
    b. Thirty-nine percent fines determinations in general accordance with ASTM D 1140;
    c. Forty-nine moisture content determinations in general accordance with ASTM D 2216; and
    d. One Triaxial test in general accordance with ASTM D 4767m.

6. Performing hydraulic fracture analyses for each proposed HDD to aid in selecting the HDD profile depth and to characterize the risk of hydraulic fracture and the risk of releasing drilling fluid to the ground surface.
7. Completing eight HDD designs in accordance with applicable pipeline design codes, including:
    a. Alignment and profile of the HDD;
    b. Minimum pipeline installation radius;
    c. Installation stresses during HDD pullback; and
    d. Operating stresses on the pipe.
8. Preparing eight design drawings in AutoCAD format (24-inch x 36-inch). The drawings include the following:
    a. Required temporary workspace;
    b. Locations of the borings with respect to the HDD alignment and profile;
    c. Topography obtained from publically available DEM data; and
    d. Tax lot boundaries obtained from Columbia County.
9. Providing a draft HDD design report to the project team. Our draft report included the following:
    a. A summary of our site reconnaissance, including a surface description along the proposed alignments;
    b. A summary of our field explorations, subsurface materials and laboratory testing;
    c. A summary of our HDD engineering analyses, including drilling fluid losses, and hydraulic fracture analyses and drilling fluid surface release evaluations;
    d. Proposed entry, exit and pipe stringing workspace size and location;
    e. Minimum allowable pipe bending radius;
    f. Installation loads and operating stresses;
    g. Site access, water sources and noise mitigation;
    h. HDD conclusions and considerations, including workspace layout, risk of hydraulic fracture, drilling fluid surface release, hole instability, cuttings removal; and
    i. Geotechnical engineering considerations for temporary roads and workspaces, temporary excavations, construction dewatering and erosion control.
10. Providing this final report incorporating review comments provided by the project team, and site-specific bathymetric and topographic survey completed after issuance of the draft report.

3.0 SITE CONDITIONS

3.1 Geological Conditions

The proposed North Mist Pipeline starts approximately 6 miles southwest of Clatskanie Oregon in the mountainous terrain near Mist, Oregon, and extends northeastward approximately 7.5 miles where it enters

the Columbia River valley and continues approximately 4.5 miles northeastward to Port Westward, Oregon. The proposed HDD alignments are mostly situated within the Columbia River Valley floor, north of Highway 30.

3.1.1 Regional Geologic Setting

The proposed HDD alignments are located on the northern border of the Oregon Coast Range Physiographic Province. The Oregon Coast Range Province consists of a long, narrow belt of moderately high mountains and coastal headlands extending along a north-south axis from Washington State and the Columbia River in the north to the Middle Fork of the Coquille River to the south. The Coast Range is a structural mountain chain composed predominantly of pillow basalt, basalt breccia, and marine sediments that have been accreted onto the western edge of the North American continent by the subduction of the Juan de Fuca tectonic plate. The rugged mountains of the Coast Range comprise a drainage divide that has been incised by steep-sided valleys. West-flowing rivers drain into the Pacific Ocean, north-flowing streams empty into the Columbia River, and east-flowing streams form tributaries to the Willamette River.

3.1.2 Surficial Geology and Geomorphology

The proposed HDD installations begin in the foothills of the Oregon Coast Range south of Highway 30, and cross the broad Columbia River valley. The southwestern most HDD (HDD-1) extends beyond the valley floor into the bedrock hillslope, after crossing Highway 30. Rocks in the mountainous terrain southwest of Highway 30 include Tertiary -aged Columbia River Basalts and Grays River Volcanics that are generally underlain and interfingered with middle Oligocene to Miocene-aged marine sediments mostly consisting of sandstone, siltstone, and mudstone. Sediments in the alluvial plain northwest of Highway 30 include quaternary aged alluvium deposited by the Columbia River.

Published geologic mapping (DOGAMI, 2009) shows the proposed HDD installations underlain by two geologic units: Quaternary alluvium and Grays River Volcanics. The mapping shows the southern two-thirds of HDD-1, south of Highway 30, is underlain by basalt belonging to the Tillamook Group of the Grays River Volcanics. The Grays River Volcanics in the project area are described as blocky to columnar jointed dark gray to black basalt. The geologic map shows the northeastern portion of HDD-1, and HDD-2 through HDD-8, underlain by Quaternary-aged alluvium, which is described as silt, sand and gravel.

3.2 Surface Conditions

3.2.1 General

We performed a surface reconnaissance of each site in May of 2013, and also during our subsurface explorations conducted between March 2014 and March 2015. Our reconnaissance consisted of identifying potential HDD entry and exit workspaces, pipe stringing and fabrication areas, and observing general topographic and vegetative conditions at each HDD site.

3.2.2 Surface Description

As previously stated, surface conditions along the proposed HDD alignments generally consists of flat ground in an alluvial valley, with the exception of HDD-1, which extends into a bedrock hillslope. The elevation difference between the northeast and southwest ends of HDD-1 is approximately 260 feet. Much of this elevation difference is made up of an approximately 120-foot-high, nearly vertical cliff located on the southwest side of Highway 30. Surface features within the valley northeast of Highway 30 (along the

northeastern portion of HDD-1, and HDD-2 through HDD-8) includes the Clatskanie River, two sloughs and several drainage ditches, as shown in Figure 1. Vegetation within the valley includes a conifer forest, grass fields, poplar tree farms, blueberry farms and a mint farm that are crossed by several paved and gravel roadways. Surface conditions at HDD-1 through HDD-8 are described in the attached Appendices C through J, respectively.

3.3 Subsurface Conditions

3.3.1 General

Subsurface conditions were explored along the proposed HDD alignments by drilling 20 borings (B-1 through B-20) between May 2013 and March 2015. The borings were advanced to depths ranging from 70 to 230 feet bgs. A representative from GeoEngineers observed the borings on a full-time basis, visually classified and collected soil samples, and logged other pertinent drilling information. Details of the exploration program and the boring logs are presented in Appendix A. Our laboratory-testing program is presented in Appendix B.

3.3.2 Subsurface Description

Subsurface materials encountered in the borings completed along the proposed HDD-1 alignment generally consisted of medium dense to very dense sand overlying basalt bedrock in the southwestern third of the alignment, and interbedded very soft to medium stiff silt, very soft organic silt, very soft to soft clay, and loose sand in the northeastern portion of the alignment. Subsurface conditions encountered along the proposed HDD-2 through HDD-8 alignments generally consisted of interbedded very soft to medium stiff silt, very soft to medium stiff elastic silt, very soft to very stiff clay, and loose to medium dense sand. Subsurface conditions encountered along each HDD alignment are described in more detail in Appendices C through J, and on the boring logs included in Appendix A.

3.4 Groundwater Conditions

Groundwater conditions along the proposed HDD alignments were evaluated by researching well logs obtained from the Oregon Water Resources Department (OWRD, 2014). The static groundwater levels were not measured in the borings because of the presence of drilling fluid in the borings. In general, groundwater in the mountainous portion of HDD-1 is expected to be located several hundred feet below the ground surface. Although perched groundwater may be located within fractures in the basalt bedrock as it moves from the surface to the static groundwater table, which is expected to be between elevations of about 5 feet above mean sea level (MSL) and zero feet MSL. Depth to static groundwater within the valley in which HDD-2 through HDD-8 are located is expected to range between about 2 and 10 feet bgs, depending on site elevations (also corresponding to elevations ranging between about zero and 5 feet MSL).

We anticipate that groundwater levels will fluctuate depending on precipitation, site utilization or other factors. In addition, flooding could occur within the valley in which HDD-2 through HDD-8 are located during heavy or prolonged precipitation. Major waterways within or adjacent to the valley (the Clatskanie River, the Columbia River, Beaver Slough, Larson Slough) are bounded by dikes that reduce flooding of the valley floor by these waterways.

4.0 HDD DESIGN AND ENGINEERING ANALYSES

4.1 HDD Design

4.1.1 General

The HDD designs presented in Appendices C through J are generally based on the pipeline alignment and entry and exit points provided by NW Natural. The paragraphs below provide general conditions that influenced our HDD designs.

4.1.2 HDD-1

GeoEngineers' proposed HDD-1 design is presented in Appendix C of this report. The following conditions influenced the design geometry:

1. The bottom tangent was chosen to provide the maximum depth of cover given the currently known extent of subsurface conditions.
2. The entry angle, entry curve radius and exit curve radius were chosen to provide the maximum depth of cover beneath Highway 30 and the adjacent railroad tracks, while still allowing for a level bottom tangent section to the HDD profile.
3. The exit angle was chosen to exit within the sloping surface of Palm Hill Road, while maintaining the shortest HDD that is practical for this site.

4.1.3 HDD-2 through HDD-8

GeoEngineers' proposed HDD-2 through HDD-8 designs are presented in Appendix D through J of this report. The designs were based on the entry and exit points, and workspaces provided by NW Natural. The bottom tangent depth was chosen to provide the maximum depth of cover while still allowing for a -10 foot vertical construction tolerance within the extent of the known subsurface conditions. A typical angle of 10 degrees was selected for the entry angles. The design radii of the vertical curves were chosen to provide a margin between the design radii and the minimum allowable radius recommended based on the product pipe specifications and the anticipated operating conditions. A larger than typical radius was selected to reduce the potential steering difficulties that may be encountered in the very soft to soft/loose soil conditions encountered in many of the borings completed along the HDD alignments.

4.2 Hydraulic Fracture and Drilling Fluid Surface Release Evaluation

GeoEngineers completed hydraulic fracture and drilling fluid surface release analyses of each of the proposed eight HDD profiles. Our evaluation and results for each HDD are summarized in Appendices C through J. The following provides a general discussion of hydraulic fracture and drilling fluid surface release occurrence and evaluation methods.

4.2.1 Discussion of Hydraulic Fracture and Drilling Fluid Surface Release

4.2.1.1 General

During HDD installation, drilling fluid is transported under pressure through the drill pipe string to the cutting tool. For HDD installations like the North Mist Pipeline HDDs, pump pressures of several hundred pounds per square inch (psi) and pump rates of 150 to 400 gallons per minute (gpm) are typical. The drilling fluid typically has a specific gravity ranging from 1.1 to 1.2 (approximately 69 to 75 pounds per cubic foot).

The total drilling fluid pressure at the cutting tool is a function of pumping pressures, the elevation difference between the drill rig and the cutting tool, and friction losses. Soil and rock formations along the drill path experience maximum drilling fluid pressures in the immediate proximity of the drill bit or reaming tools. The energy (pressure) of the drilling fluid is steadily diminished along its path from the drill rig to the cutting tool and back to the rig through the annulus of the hole. Thus, the pumping pressure required to circulate the drilling fluid increases as the drill bit advances farther from the drill rig. Typically, the annular drilling fluid pressure at the cutting tool can range from 15 to 25 percent of the pump pressure.

4.2.1.2 Drilling Fluid Loss

Drilling fluid circulation may be reduced or lost during HDD operations by drilling fluid loss to the surrounding soil or by the accumulation of cuttings downhole that create a blockage, which may result in hydraulic fracture. These two processes are discussed below:

1. Formational fluid loss occurs when drilling fluid flows into surrounding permeable soil units either within the pore spaces of the soil or along preexisting fractures or voids in the formation.
2. Hydraulic fracturing and subsequent loss of drilling fluid can occur where the combined resisting force of the available overburden pressure and the shear strength of the overburden soil is less than the hydrostatic drilling fluid pressure and the pressures applied to the surrounding soil from the drilling fluid at the cutting tool.

Formational drilling fluid losses typically occur when the drilling fluid flows through the pore spaces in the soil through which the HDD profile passes. Thus, a formation with a higher porosity can potentially absorb a larger volume of drilling fluid than a formation with a lower porosity. Silty sands, silts and clays typically have a low susceptibility to formational drilling fluid losses. Coarse sand and gravel units with low percentages of silt and clay have a moderate to high susceptibility for drilling fluid loss. Proper management of the drilling fluid properties can reduce the volume of formational drilling fluid loss.

4.1.1.3 Hydraulic Fracture

Hydraulic fracture is a term typically used to describe the condition in which the downhole drilling fluid pressure exceeds the overburden pressure and shear strength of the soil surrounding a drill path. Soils that are most vulnerable to hydraulic fracture include relatively weak cohesive soils or loose granular soils with low shear strength. Medium dense to very dense sands and very stiff to hard silts and clays have a low to moderate hydraulic fracture potential. HDD installations with greater depth or drill paths in formations with higher shear strength may reduce the potential for hydraulic fracturing.

Photograph 1 - Example of Drilling Fluid Surface Release

4.2.1.4 Drilling Fluid Surface Release

Drilling fluid surface releases, commonly referred to as Frac-Outs, occur when drilling fluid emerges at the ground surface or in any other undesired location such as wetlands, utility trenches, basements, roads, railroads, and water bodies (Photograph 1). In practice, drilling fluid surface releases typically occur in proximity to the entry and exit points where annular pressures are high and soil cover is thin. Drilling fluid surface releases can also occur at locations along a drill path where there are low shear strength soils,

where soil cover is relatively thin or along preexisting fractures or voids. Other locations where drilling fluid surface releases can occur are along preferential pathways such as exploratory boring locations, within utility trenches, or along the edges of existing subsurface structures such as piles or utility poles.

The HDD contractor's construction procedures constitute another important factor influencing when and where drilling fluid loss occurs. If the contractor operates with insufficient drilling fluid flow rates, inadequate drilling fluid properties or excessive rates of penetration, the annulus may become blocked through an accumulation of drill cuttings falling out of suspension. This can occur within formations that typically have a low potential for hydraulic fracture. If the accumulation of cuttings creates a blockage downhole, the annulus may become over-pressurized, leading to hydraulic fracturing and potentially drilling fluid surface releases. Our analysis does not account for this over-pressurized condition.

4.2.1.5 Hydraulic Fracture Calculations

The procedures used to evaluate the potential for drilling fluid loss through hydraulic fracturing are based primarily on research completed by Delft Geotechnics, as discussed in Appendix B of the USACE Report CPAR-GL-98 (Staheli, et al., 1998) The methodologies used to estimate the hydraulic fracture potential outlined in the research are based on cavity expansion theory. The cavity expansion model is used to estimate the maximum effective pressure in the drill hole before plastic deformation of the drill hole occurs.

In order to evaluate the hydraulic fracture and drilling fluid surface release potential for an HDD installation, assumptions must be made when selecting the input parameters. The assumptions used in the model include the extent and uniformity of soil layers, hydrostatic groundwater pressures, drilling fluid properties, penetration rates and drilling fluid flow rates. The soil strength properties are estimated based on interpretations of the boring logs and laboratory test results. The drilling fluid properties, penetration rates and pump rates are estimated based on generally accepted, best management practices (BMPs) of the HDD industry. Consequently, the results of the evaluation are only estimates of the potential for hydraulic fracture and drilling fluid surface releases. The model input parameters we selected for the hydraulic fracture and drilling fluid surface release analyses for each HDD are presented in Appendices C through J.

The drilling fluid properties are dependent on the field conditions and the construction practices of the HDD contractor and drilling fluid engineer. Changes in these properties can significantly affect the potential for hydraulic fracture and drilling fluid surface releases.

Based on the soil properties, rheological parameters and anticipated tool dimensions, the model considers the total and effective overburden stresses, shear strengths of the soil, and the estimated drilling fluid pressures along the drill path. A comparison is then made of the estimated drilling fluid pressures immediately behind the drill bit and the ability of the soil to resist plastic deformation. The evaluation considers only the hydraulic fracture potential during pilot hole operations assuming the drilling fluid returns are continuously maintained to the entry point.

The factor of safety against hydraulic fracturing of the soil surrounding the drill bit is defined as the ratio of the formation limit pressure to the estimated annular drilling fluid pressure. The factor of safety against drilling fluid surface releases is defined as the maximum factor of safety against hydraulic fracture calculated for all of the soil units above specified points along the drill path.

In some cases, the evaluation may indicate a high potential for, or a low factor of safety against, hydraulic fracture in the soils surrounding the drill bit; however, a higher-strength layer may be present above the

weaker layer that may reduce the migration of drilling fluid toward the ground surface, thus providing a higher factor of safety against drilling fluid surface releases.

Table 3 below shows the relative risk associated with the estimated factors of safety against hydraulic fracture and drilling fluid surface releases.

TABLE 3. RELATIVE HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE RISK

Factor of Safety	Relative Risk
Less than 1	Very High
Between 1 and 1.5	High
Between 1.5 and 2	Moderate
Greater than 2	Low

4.3 Installation Stresses

The analyses of installation loads and stresses are based on the product pipe being installed along the designed path using the BMPs of the HDD industry. The addition of water into the product pipe is the standard method that contractors typically use to control buoyancy of the product pipe during the installation procedure. The proposed 24-inch-diameter steel product pipe should be buoyant in the anticipated drilling fluid weights. As such, the HDD contractor may utilize buoyancy control by adding water in the product pipe to reduce positive buoyancy during pullback operations. Depending on the weight of the drilling fluid in the hole during pullback operations, the calculated pullback forces may be reduced by utilizing buoyancy control. We recommend the HDD contractor evaluate the need for buoyancy control based on the weight of the drilling fluid returns during the swab pass. Our analyses include a range of cases with differing levels of buoyancy control.

The five cases analyzed are as follows:

1. The annulus contains 9.5 pounds per gallon (lb/gal) drilling fluid and the product pipe is empty.
2. The annulus contains 9.5 lb/gal drilling fluid and the product pipe is full of water.
3. The annulus contains 12 lb/gal drilling fluid and the product pipe is empty.
4. The annulus contains 12 lb/gal drilling fluid and the product pipe is full of water.
5. The annulus contains 10.5 lb/gal drilling fluid and the product pipe is filled such that neutral buoyancy is achieved.

The analyses are based upon the methods developed by the Pipeline Research Committee International (PRCI) of the American Gas Association (PR-227-9424, 1995). The only deviation from this guide in calculating the installation stresses is a more conservative allowable tensile stress (F_t).

The equation recommended in the PRCI Design Guide is shown in **Equation 1** below:

$$F_t = 0.9 * \text{SMYS (Specified Minimum Yield Strength)}$$

The allowable tensile stress used for our analyses is derived from Sections 2.4.1, 3.1.2 and 3.2 of the American Petroleum Institute (API) Recommended Practice 2A – WSD (WSD Recommended Practice 2A-WSD, 1993).

Section 3.2 of the API Recommended Practice defines the allowable tensile stress of cylindrical members as shown in **Equation 2** below:

$$F_t = 0.6 * SMYS$$

Sections 2.4.1 and 3.1.2 of the API Recommended Practice permit the allowable tensile stress, defined in Equation 2, to be increased by one-third, yielding a design factor of 0.8, which is more conservative than 0.9 as listed in the PRCI Design Guide.

The equation used in our analyses is shown in **Equation 3** below:

$$F_t = 0.8 * SMYS$$

The installation loads and stresses we calculated for each of the eight proposed HDD profiles are provided in Appendices C through J.

4.4 Operating Stresses

The analysis of operating stresses takes into consideration the stresses imposed on the product pipe during operation to verify that acceptable limits are not exceeded. The operating stresses on a pipeline installed by directional drilling include hoop stress from the maximum allowable operating pressure (MAOP), hoop stress from external pressure applied by the groundwater acting on the outside of the product pipe, elastic bending as the product pipe conforms to the shape of the drilled hole, and thermal expansion and contraction stresses resulting from the difference between the constructed temperature and the operating temperature. For our analysis, both the installation and operating temperatures were assumed to be 55 degrees Fahrenheit. We can further evaluate different installation and operating temperatures, if requested. The operating stresses we calculated for each of the eight HDD crossings are provided in Appendices C through J of this report.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This section summarizes our conclusions and recommendations for the HDD installations associated with the North Mist Expansion Project. Refer to Appendices C through J for conclusions and recommendations specific to each of the eight HDD installations.

5.1 HDD Design and Construction Considerations

5.1.1 General

Based on the information available, the results of the exploration and laboratory-testing program, and our engineering analyses, it is our opinion that the proposed HDD installations are technically feasible. However, this opinion is based upon the HDD contractor adhering to the recommendations contained herein and implementing plans and procedures that are in accordance with generally accepted HDD construction practices.

The contractor's means and methods during construction are critical to the successful completion of the HDDs. Specifically, during pilot hole jetting/drilling, only small deviations from the design for horizontal and vertical curvature should be allowed so that pull load forces similar to those estimated by the calculations can be maintained. The HDD contractor's ability to maintain drilling fluid returns and proper drilling fluid properties with appropriate penetration and drilling fluid flow rates will also be important factors to consider during drilling, because hole conditions and downhole annular drilling fluid pressures will be directly affected by these operations.

We recommend contacting GeoEngineers immediately if subsurface conditions are claimed to be different than presented in this report. Because the subsurface conditions can vary between explorations, we recommend that GeoEngineers personnel be on site to document the drilling process in real time to mitigate risks and increase the potential for a successful installation of these HDDs. We recommend retaining a qualified drilling fluid technician to evaluate the drilling fluid properties on a continuous basis during the entire drilling and installation process. Close coordination between the contractor and the drilling fluid technician is vital to maintaining proper drilling fluid properties, penetration rates and drilling fluid flow rates required for our calculations to remain valid. If proper construction techniques as described herein are used in conjunction with the presence of a GeoEngineers representative and a drilling fluid technician, we anticipate the likelihood to be high for successfully completing the proposed HDD installation.

General conclusions and construction considerations for the proposed HDD installations are discussed below. Additional site-specific final design and construction considerations for each HDD, where applicable, are discussed in Appendices C through J of this report.

5.1.2 USACE Permit Requirements

Because HDD installations 2, 3, 4 and 5 will cross beneath levees under pending jurisdiction of the USACE, special construction requirements will likely be enforced on this project. Based on our experience with similar projects, the special construction requirements may include, but are not limited to, the following items:

1. The drilling fluid properties must be tested once every hour by a third party "Mud Engineer." The required tests include, at a minimum, drilling fluid weight, pH, Marsh Funnel viscosity, sand content, plastic viscosity, yield point and water loss.
2. The safety factor against hydraulic fracture under the levees should be greater than 2.0. However, under certain circumstances safety factors of greater than 1.5 have been accepted.
3. As soon as practical after the product pipe is pulled into the reamed hole, the annulus between the reamed hole and the installed product pipe must be grouted with a cement-bentonite grout at both ends of the drill profile. The required depth of grouting is determined by a total stress analysis that results in a factor of safety of 1.2. We have not conducted this analysis in conjunction with this HDD design report. The contractor is responsible for submitting a plan for installing the grout.
4. A third-party geotechnical engineer is required to be on site during all HDD operations. The third-party engineer and all USACE staff shall be permitted full-time access to the drill cab, all drilling operations and data.
5. The USACE and the local levee district must be notified at least 3 working days prior to the start of construction.

6. Pilot hole and reaming operations within the pressure monitoring zone (PMZ), which is typically defined as a zone extending along a 1H:1V (horizontal to vertical) line projected outward from the bottom of the levee toe and to a point 300 feet away from of either levee toe, must be completed during daylight hours to facilitate inspection by USACE personnel. Work within the PMZ will begin during daylight hours and will run continuously until exiting the PMZ. If this requires working after dark, work may continue with continuous observation by the third party geotechnical engineer and the USACE representative. However, the contractor should make every effort to cross through the PMZ early enough in the day to cross entirely during daylight hours.
7. The USACE typically limits the allowable annular drilling fluid pressure when jetting or reaming the hole within the PMZ. Annular drilling fluid pressures above the allowable limit specified by the USACE are not permitted and the project will be stopped until a revised drill plan to prevent such occurrence is approved by the USACE
8. The contractor must use a secondary survey system capable of monitoring and recording annular drilling fluid pressures when jetting or reaming the hole through the PMZ. The annular pressure sensor is required to be within 5 feet of the drill bit or reaming tool.
9. At least 48 hours prior to the start of HDD operations, the USACE inspector, HDD contractor, third-party "Mud Engineer" and third-party geotechnical engineer must meet to review the following
    a. HDD contractors drilling plan;
    b. HDD contractors post-installation grouting plan of the product pipe annulus;
    c. Third-party "Mud Engineer" drilling fluid plan, including brand and type of bentonite, polymers, and additives planned to be used to maintain appropriate drilling fluid properties;
    d. HDD contractors levee repair/replacement plan in the event that drilling fluid surface releases occur within the levee foundation;
    e. HDD contractors hole abandonment and evacuation plan; and
    f. HDD contractor's contingency and mitigation plan in the event that drilling fluid surface releases occur.
10. Changes to the drilling plan that will affect the potential for hydraulic fracture and/or drilling fluid surface releases must be submitted to the USACE for approval prior to implementation, along with an updated hydraulic fracture and drilling fluid surface release analysis utilizing the changed parameters.
11. Any ground fractures created within the USACE PMZ will require the installation of a grout curtain from the ground surface to the drill profile and any ground fractures created within the levee cross section will also require the removal and reconstruction of the levee profile.
12. The USACE requires full-depth grouting of all seepage pathways created by drilling fluid surface releases along the entire HDD alignment. As a result, the HDD contractor should install casing on both the entry and exit sides to prevent drilling fluid surface releases. The diameter of the casing, should be sufficiently large so that the pilot bit and hole-opening tools can be retracted into the casing as needed to flush any cuttings from the casing. The outside diameter of the casing will likely range from 36 to 42 inches. To facilitate HDD operations, a smaller diameter casing (approximately 14-inch diameter) will likely have to be centralized within the larger casing.

13. The USACE requires the drilling fluid annular solids during all reaming operations to be maintained below 20 percent.
14. The USACE requires that the penetration rate during HDD operations be maintained such that the annular solids are less than 20 percent. An annular solids table should be prepared prior to HDD operations to establish the appropriate penetration rates.

During the bidding process, the prospective HDD contractors should be made aware of the permit stipulations so that they can prepare a submittal that accounts for the additional permit requirements. GeoEngineers can assist in answering questions regarding the permitting process and requirements.

5.1.3 Pilot Hole Survey and Specifications

A secondary survey system (TruTracker, ParaTrack or equivalent) will be required through the pilot hole process. We recommend that the survey coils for the secondary survey system be placed at least as wide as the survey probe is deep. As a result, the HDD will require the survey coils to increase in size from approximately 20 feet wide near the entry and exit locations to a minimum of 240 feet wide along HDD-1 and up to about 120 feet wide along HDD-2 through HDD-8. The placement of the coils is limited to areas where ground surface conditions, permit requirements and agreements with landowners allow. Accurate secondary survey measurements may not be obtained if the coil corners are not properly surveyed. We recommend that the contractor review the project plans and workspace limitations to determine the most appropriate configuration for the secondary survey system.

The design drawings in Appendices C through J include the necessary geometric information required to complete the pilot hole and should be provided to the selected HDD contractor along with this report. For pilot hole operations, we recommend that the HDD contractor complete the pilot hole as closely as possible to the designed HDD profile while still maintaining three-joint horizontal and vertical radii equal to or greater than 1,900 feet for HDD-1 and 2,400 feet for HDD-2 through HDD-8. We recommend a horizontal tolerance of 5 feet left and 5 feet right of the designed alignment and a vertical tolerance of 2 feet above and 10 feet below the designed profile. We also recommend that, upon completion of the pilot hole, GeoEngineers have the opportunity to review the pilot hole survey data prior to the start of hole opening operations. The contractor should be responsible for producing and submitting an as-built drawing of the pilot hole survey data within two weeks of the completion of the pilot hole. This as-built drawing should be reviewed by GeoEngineers prior to storing the data in the project file for future reference as to the location of the installed pipeline.

Additional specifications for construction of the HDDs are presented in NW Natural's specification packet, which is included in Appendix K.

5.1.4 Hydraulic Fracture and Drilling Fluid Surface Release

The following table summarizes the risk of drilling fluid surface release at each HDD installation based on our analyses as discussed in Appendices C through J. Refer to the hydraulic fracture and drilling fluid surface release sections of Appendix C through J for more details specific to each HDD.

TABLE 4. RELATIVE RISK OF DRILLING FLUID SURFACE RELEASE

HDD Number	Expected Subsurface Conditions	Relative Risk of [1, 2] Drilling Fluid Surface Release	Risk Factors/Notes
HDD-1	Sand Overlying Basalt/Interbedded Silt, Organic Silt, Sand and Clay	Low	Higher risk within 100 feet of entry point due to relatively little soil cover.
HDD-2	Interbedded Silt, Organic Silt, Sand and Clay	Low to high	If drilled from west to east, there is a moderate to high risk of drilling fluid surface releases to the Clatskanie River and adjacent levees. The risk can be reduced to low by utilizing the pilot hole intersect method of construction.
HDD-3	Interbedded Silt, Sand and Clay	Low	Sand layers on east side of Beaver Slough will likely restrict upward movement of drilling fluid.
HDD-4	Interbedded Silt, Sand and Clay	Low to moderate	When drilled south to north, risk is low in northern half of HDD (including Beaver Slough) and moderate in southern half of HDD. Recommend drilling from south to north.
HDD-5	Silt and Clay Overlying Sand	Low to Moderate	Generally low risk, but moderate risk to Lewis Road. Silt soils will increase the risk of drilling fluid surface release near the entry and exit points.
HDD-6	Silt and Clay Overlying Sand	Low	Silt soils increase the risk of drilling fluid surface release near the entry and exit points.
HDD-7	Silt and Clay	Low to Very High	Low to moderate risk within about 750 feet of the entry point, very high for remainder of crossing. Very soft to soft silt and clay soils with no overlying sand layers to restrict upward movement of drilling fluid.
HDD-8	Silt in Southwestern half of the HDD Profile, Interbedded Silt, Sand and Clay in Northeastern half of the HDD Profile	Low to High	Generally low to moderate in southwest half of crossing; high in northeastern half of crossing as the pilot hole progresses through clay soils and nears the exit point.

Notes:

[1] See attached appendices for additional construction considerations and recommendations.

[2] Risk does not include within 100 feet of the entry and exit point where we typically consider the risk to be high because of reduced soil cover and/or increased annular drilling fluid pressure.

Although not necessarily shown in the analysis, based on our experience, the risk of drilling fluid surface releases during construction is elevated within approximately 100 feet of the entry and exit points of all HDD installations regardless of subsurface conditions. Near the entry point, the risk is elevated because of the relatively thin soil cover within approximately 100 feet of the entry point. Near the exit point, the risk is elevated because of the relatively thin soil cover, and then exacerbated because of the relatively high pump pressures required to maintain drilling fluid returns to the entry side of the HDD.

Construction means and methods will greatly affect the risk of hydraulic fracture and drilling fluid surface releases. If the HDD contractor operates with insufficient drilling fluid flow rates, inadequate drilling fluid properties or excessive rates of penetration, the annulus may become blocked through an accumulation of

drill cuttings falling out of suspension and the risk of hydraulic fracture and drilling fluid surface releases will be increased. If the hole becomes blocked and drilling fluid returns are lost, the hydraulic fracture and drilling fluid surface release evaluation is no longer valid. The HDD contractor should maintain drilling fluid returns at all times during each stage of the HDD process.

It is our opinion that minor formational drilling fluid loss should be expected within the subsurface conditions encountered along the crossing. We anticipate that the formational drilling fluid loss within the sandy soils throughout the designed HDD profile should be relatively small when compared to the total volume of drilling fluid required for the project, as long as the HDD contractor maintains proper drilling fluid properties and drilling fluid returns at all times during each stage of the HDD process. The HDD contractor should also maintain annular solids content below 30 percent (and preferably below 20 percent) during pilot hole and reaming operations to help reduce the risk of the annulus becoming blocked from an accumulation of drill cuttings falling out of suspension from the drilling fluid.

We recommend that the contractor establish a contingency and mitigation plan in the event that drilling fluid surface releases occur; these plans should be reviewed and approved by the project team prior to the start of construction.

5.1.5 Drill Hole Stability

In general, the subsurface conditions encountered in the borings consisted of alternating layers of very soft to medium stiff silt and elastic silt, very soft to very stiff clay, and loose to medium dense sand. In general, we expect that there is a relatively low risk of drill hole instability along HDD-2 through HDD-8. Proper management of drilling fluid properties throughout the HDD installation process should help maintain the stability of the drilled hole.

We encountered caving of our vertical exploratory boring B-17, which was completed along the southwestern portion of HDD-1. In addition, because of the elevation difference between the northeast and southwest sides of the HDD, the southwestern approximately 810 feet of HDD-1 will be a “dry hole” section of the HDD profile. “Dry hole” refers to a portion of the HDD profile that will not be continuously filled with drilling fluid during construction. The lack of drilling fluid in the dry hole section can present challenges during HDD operations, most significantly hole collapse within the sand and fill soils observed within the upper 73 feet of the soil profile in boring B-17. Collapse of the bore hole could result in sink hole formation that may adversely affect the ground surface along the dry hole section of the alignment. For these reasons, we recommend that the contractor install large diameter casing within the exit tangent of the HDD profile that extends to the contact of the sand and underlying basalt. We estimate that approximately 300 feet of casing will need to be installed to reach the basalt bedrock. The casing could be installed over the drill pipe after the pilot hole is completed through the upper 73 feet of sand and fill. The casing should remain in place through reaming, swabbing and pullback operations. Additional discussion of hole collapse and recommended mitigation for HDD-1 is included in the “Construction Considerations” section of Appendix C.

The HDD contractor should use BMPs to reduce the potential for hydraulic fracture and drilling fluid surface releases. This includes, but is not limited to, maintaining drilling fluid circulation during all phases of HDD operations to prevent the annular drilling fluid pressures from exceeding the maximum allowable pressure. However, the HDD contractor should be careful to not over-mine the hole in the sand units to reduce the potential for hole collapse.

5.1.6 Cuttings Removal and Annular Solids

The HDD contractor should use care in removing cuttings from the drilled holes, especially when attempting to remove fat clay, elastic silt and gravel sized particles. We expect that elastic silt and clay may be encountered in each of the HDD installations. We also expect that gravel sized particles may be produced from cuttings of the basalt bedrock along the profile of HDD-1.

Based on our experience, cuttings removal in fat clays and elastic silts is typically more challenging than in other non-cohesive soils. In some cases, relatively dry fat clays or elastic silts may swell and block the drill hole. Alternatively, the clay cuttings may "ball up" forming large diameter particles that fall out of suspension and are more difficult to remove than smaller clay particles that remain in suspension. Therefore, the potential for the hole to become plugged with cuttings is elevated along each of the proposed HDD crossings where the drill path is within highly plastic fat clay or elastic silt. In the event that the hole becomes plugged, and drilling fluid circulation ceases, downhole annular pressures can increase dramatically. This temporary spike in downhole annular pressure can dramatically increase the risk of hydraulic fracture and inadvertent returns of drilling fluid.

Based on our experience, cuttings removal of gravel-sized particles can be challenging. Often drilling fluid does not have enough carrying capacity to remove the coarse gravel sized particles from the drilled/reamed hole and the gravel-sized particles fall out of suspension. When this occurs, the gravel can accumulate within the lowest section of a drilled or reamed hole, and may not be able to be effectively removed from the hole using conventional reaming and swabbing tools. If relatively high pull and rotary torque forces are observed in the lowest section of the HDD-1 profile while conducting reaming passes or swab passes prior to pull back, they may indicate an accumulation of cuttings in this area. If this is the case during construction, the contractor should consider over-sized reaming passes or sending a "junk basket" downhole to remove cuttings from the lowest section of the HDD profile and facilitate successful installation of the product pipe. Additional discussion on cuttings removal along the HDD-1 profile is provided in Appendix C.

If cuttings are not effectively removed from the hole during HDD operations, pullback forces could be excessively high during pullback of the 24-inch-diameter product pipe, the product pipe could become lodged in the hole, or the product pipe could become damaged. The failure to effectively remove cuttings from the hole could potentially result in failure of the HDD installation. Therefore, we recommend that the drilling contractor maintain drilling fluid returns at all times, and use appropriate means and methods (appropriate penetration rates, drilling fluid management, mechanical methods) to adequately remove the cuttings from the hole during the HDD process.

In order to reduce the potential for down hole blockage during HDD operations, the annular solids in the drilling fluid should be maintained within acceptable limits, which is typically less than about 20 to 30 percent.

5.1.7 Minimum Allowable Product Pipe Bending Radius

Based on the design geometries presented in the HDD design drawings in Appendices C through J, and proposed product pipe specifications, the minimum allowable three-joint horizontal and vertical radii over any consecutive three-joint section should not be less than 1,900 feet along the HDD-1 profile and not less than 2,400 feet along the HDD-2 through HDD-8 profiles. We recommend that the three-joint radius be calculated for each three-joint section jetted during pilot hole operations. The design radii of the entry and

exit vertical curves for HDD-1 is 2,400 feet. The design radii of the entry and exit vertical curves for HDD-2 through HDD-8 are 3,000 feet.

5.1.8 Installation Load Considerations

We analyzed the anticipated pull loads based upon different drilling fluid weights in the hole. We also evaluated the anticipated pull loads with and without the use of buoyancy control. We recommend that the contractor utilize a drill rig that provides a factor of safety between the drill rig capacity and the anticipated pull loads. In addition, the contractor should install a deadman anchor of sufficient capacity to withstand the anticipated pull loads; these aspects are generally left to the contractor's discretion as approved by the owner. The anticipated installation loads for various drilling fluid weights for each of the proposed HDD installations are provided in the attached Appendices C through J. The installation loads can be reduced by utilizing buoyancy control during pullback operations, as shown by the calculations provided in Appendices C through J.

The HDD contractor may utilize a relatively large drill rig to complete the HDD installations. As a result, the drill rig may have a pullback capacity capable of causing damage to the product pipe during installation. Additional discussion of the estimated installations loads and safe pull loads is provided in Appendices C through J.

5.1.9 Site Access

With the exception of the exit workspace and pipe stringing workspace for HDD-1, the entry, exit and pipe stringing and fabrication workspaces are located within a relatively flat alluvial plain that is currently in use as agricultural land. We expect that the surface soils will be relatively soft and may not support construction equipment. Therefore, construction of temporary access roads may be required prior to mobilization of equipment to the workspaces. Depending upon conditions at the time of construction, load-dispersing materials such as timber mats will likely be required to maintain stabilization of the ground surface for equipment accessing the workspaces, as discussed in the "Geotechnical Engineering Considerations" section of this report (Section 5.2).

5.1.10 Workspace Considerations

With the exception of the southwest side (exit side) workspace for HDD-1, The HDD workspaces are located within a relatively flat alluvial plain that is currently in use as agricultural land. We expect that the surface soils will be relatively soft and may not support construction equipment. We expect that the surface soils will be relatively soft and may not support construction equipment. Therefore, stabilization of the ground surface within the entry, exit and pipe stringing and fabrication workspaces may be required to support the relatively heavily loaded construction equipment. Geotechnical engineering recommendations for stabilizing the ground surface within workspaces is presented in Section 5.2.1 of this report.

5.1.11 Water Sources

A reliable source of water for drilling operations is required during the HDD installation process. In addition, water is also required for the hydrostatic testing of the product pipe. Unless permits can be obtained to use water from the Clatskanie River, Columbia River or one of the sloughs near the proposed pipeline alignment, the water for drilling operations will likely have to be obtained from a local source and transported to the site.

5.1.12 Noise Mitigation Techniques

The proposed temporary entry and exit workspace for the HDDs are generally located far enough away from residential development such that we do not anticipate that noise mitigation will be required. However, if noise mitigation is required or requested, diesel power units associated with heavy equipment may be outfitted with noise-reducing mufflers. In addition, the noise can be muffled by placing baffles around the equipment to further reduce noise emissions. The actual placement of the noise reduction measures should be implemented by the selected HDD contractor as required by permit or construction documents.

5.2 Geotechnical Engineering Considerations

5.2.1 Temporary Site Access and Workspace Areas

If landowner agreements and/or permit requirements require ground disturbance to be mitigated, or the site soils cannot support construction equipment, we recommend the construction of temporary construction entrances, access roads and work pad areas (as appropriate). These improvements should consist of board or timber mats or a minimum 12-inch-thick layer of 4-inch quarry spalls. If soft or wet near-surface soils are encountered, several layers of mats may be necessary to provide adequate support for the heavy equipment entering the site. Also, a layer of woven geotextile fabric (TC Mirafi 600X or equivalent) or biaxial geogrid (Tensar BX 1200 or equivalent) may be placed below the mats to provide separation between the timber mats or gravel and/or provide additional subgrade support.

Temporary entrances and access roads should be constructed with culverts and other improvements necessary to allow surface water runoff to drain without ponding or changing off-site drainage patterns.

Temporary work pad areas for staging drilling equipment, pipeline materials and excavation equipment will be necessary at the entry and exit sides. The size and location of workspace areas to accommodate the HDD and pipeline tie-in activities depend on the available space and right-of-way (ROW) constraints. Temporary entry, exit and product pipe stringing workspaces for the project are shown in the Site Plan and Profile drawings and HDD Design Drawings presented in Appendices C through J.

All temporary site improvements should be removed upon completion of the product pipe installation, and the areas should be restored in accordance with the project site restoration plan.

5.2.2 HDD Installation

During HDD operations, a drilling fluid containment pit will be required at both the drill entry and exit workspaces. Depending on the practices of the HDD contractor, drilling fluid containment pit excavations are typically constructed adjacent to the centerline near the entry and exit point locations and are approximately 20 feet long by 10 feet wide by 6 feet deep.

With the exception of the southwest side (exit side) of HDD-1, based on the explorations completed at the sites, soils within the planned excavation depths are anticipated to consist of very soft silt or clay soils. On the southwest side of HDD-1, near surface soils are expected to consist of gravel, clay and wood fill. Conventional equipment, such as backhoes or excavators, should be suitable for excavation of these soils.

5.2.3 Temporary Excavations

Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the contractor. All temporary cuts in excess of 4 feet in height should be shored or sloped in accordance

with Occupational Safety and Health Administration (OSHA) regulation 1926 Subpart P, Appendix B – Sloping and Benching. For planning purposes, soils encountered within the exploratory borings in the vicinity of the excavation areas should be classified as Type C Soil. Temporary excavations in Type C soil should be inclined no steeper than 1.5H:1V. These allowable cut slope inclinations are applicable to excavations above the groundwater table only. Steeper temporary slope inclinations may be allowed if soil conditions are determined to be suitable by the field geotechnical engineer. For open cuts, we recommend that:

- No traffic, construction equipment, stockpiles or supplies should be allowed within a distance of at least 5 feet from the top of the cut.
- Construction activities should be scheduled to reduce the length of time the cuts are left open.
- Erosion control measures should be implemented as appropriate to limit runoff from the site.
- Surface water should be diverted away from the excavations.

5.2.4 Construction Dewatering

Depending on the time of year construction is completed, or precipitation conditions at the time of construction, groundwater may be encountered within 2 feet of the surface of HDD-2 through HDD-8, and the northeastern side (entry side) of HDD-1. As a result, dewatering of the shallow excavations may be required. Ultimately, the contractor should have the responsibility of determining whether dewatering measures are needed at the time of work. If dewatering measures are required and sandy soils are encountered, the contractor may need to use a series of well points or pumped wells. Because of the shallow nature of entry and exit pits, we do not anticipate that dewatering would result in significant groundwater drawdown that would affect groundwater wells in the area.

The contractor should be prepared to handle the effluent that will be generated during dewatering operations. The effluent may need to be treated in a settlement tank, sediment trap or basin in order to meet discharge permit requirements for sediment content. Additionally, filter bags or filter socks might be necessary at the end of the outfall pipe or hose to reduce sediment discharge.

Although our observations within boring B-17 and the basalt cliff adjacent to Highway 30 did not indicate significant groundwater flowing through fractures of the basalt located south of Highway 30 along HDD-1, there is a risk that perched groundwater could be encountered within the fractures of the basalt. Perched groundwater encountered within fractures of the basalt could release large volumes of water that would flow out of the drilled/reamed hole at the entry point. The contractor should develop a contingency plan to handle large, continuous volumes of water that could be generated by drilling through fractures in the basalt.

5.2.5 Erosion Control

To reduce the potential for migration of sediment off site and into adjacent wetlands or receiving waters during HDD operations, we recommend that the project specific Erosion and Sediment Control Plan (ESCP), state and local regulations be followed during and after construction operations. Proper BMPs should be implemented in accordance with a design that meets state and local regulations to reduce the risk of construction-related impacts to wetlands, wetland buffers, sensitive resource sites and other areas adjacent to the work areas.

Potential sources or causes of erosion and sedimentation depend upon construction methods, slope length and gradient, amount of soil exposed and/or disturbed, soil type, construction sequencing and weather. We recommend that the following erosion control measures be included in construction planning:

- Scheduling excavation and construction to reduce soil exposure;
- Retaining existing vegetation whenever feasible;
- Directing runoff away from denuded areas;
- Preparing drainage ways and outlets to handle concentrated or increased runoff;
- Using sediment traps, stilling basins or filter socks to collect, detain and settle sediment from surface water runoff or water pumped from the entry and exit pit excavations;
- Confining sediment to the project site by using silt fences and straw bales;
- Temporarily covering soil stockpiles during construction when necessary;
- Conducting routine inspections of the construction site to verify the effectiveness of the measures and to determine the need for maintenance or additional measures;
- Collecting, containing and disposing of drilling spoils at a predetermined approved site; and
- Revegetating or mulching all disturbed surfaces to provide erosion protection after construction is complete.

Construction procedures should be designed to reduce the opportunity for erosion to occur. Clearing, excavation and grading should be limited to those areas necessary for construction of temporary improvements. The construction limits should be clearly marked in the field, and equipment should not be allowed outside the work area. Prompt grading, mulching and revegetation should help to limit erosion.

Silt fences should be constructed around the perimeter of the work areas to reduce the possibility for transport of sediment off site. Straw bales should also be incorporated as necessary to augment the silt fences.

Stockpiles of excavated materials or erodible raw material such as soil, sand, backfill and drill spoil materials should be covered during wet weather, and small diversion berms should be used to prevent stormwater runoff from entering or eroding stockpiles. Excavated soil should be reused as much as possible. Any excess material transported off site for disposal should be handled in accordance with applicable regulations at authorized disposal facilities.

Until permanent erosion protection is established and stabilized, periodic monitoring should be performed to evaluate the effectiveness of post-construction erosion control measures and to repair and/or modify them as appropriate. Areas of observed significant erosion should be repaired using an appropriate combination of the methods discussed above.

6.0 LIMITATIONS

We have prepared this report for use by NW Natural. The report is not intended for use by others, and the information contained herein is not applicable to other sites. The data and report should be provided to

prospective contractors, but our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions. The conclusions and recommendations in this report should be applied in their entirety.

Variations in subsurface conditions are possible between the explorations. Subsurface conditions may also vary with time. A contingency for unanticipated conditions should be included in the project budget and schedule for such an occurrence. We recommend that sufficient monitoring, testing and consultation be provided by GeoEngineers during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork and pipeline installation activities comply with contract plans and specifications.

The scope of our services does not include services related to construction safety precautions. Our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures, except as specifically described in our report for consideration in developing a drill plan.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No warranty or other conditions, express or implied, should be understood.

Please refer to Appendix L, titled “Report Limitations and Guidelines for Use,” for additional information pertaining to use of this report.

7.0 REFERENCES

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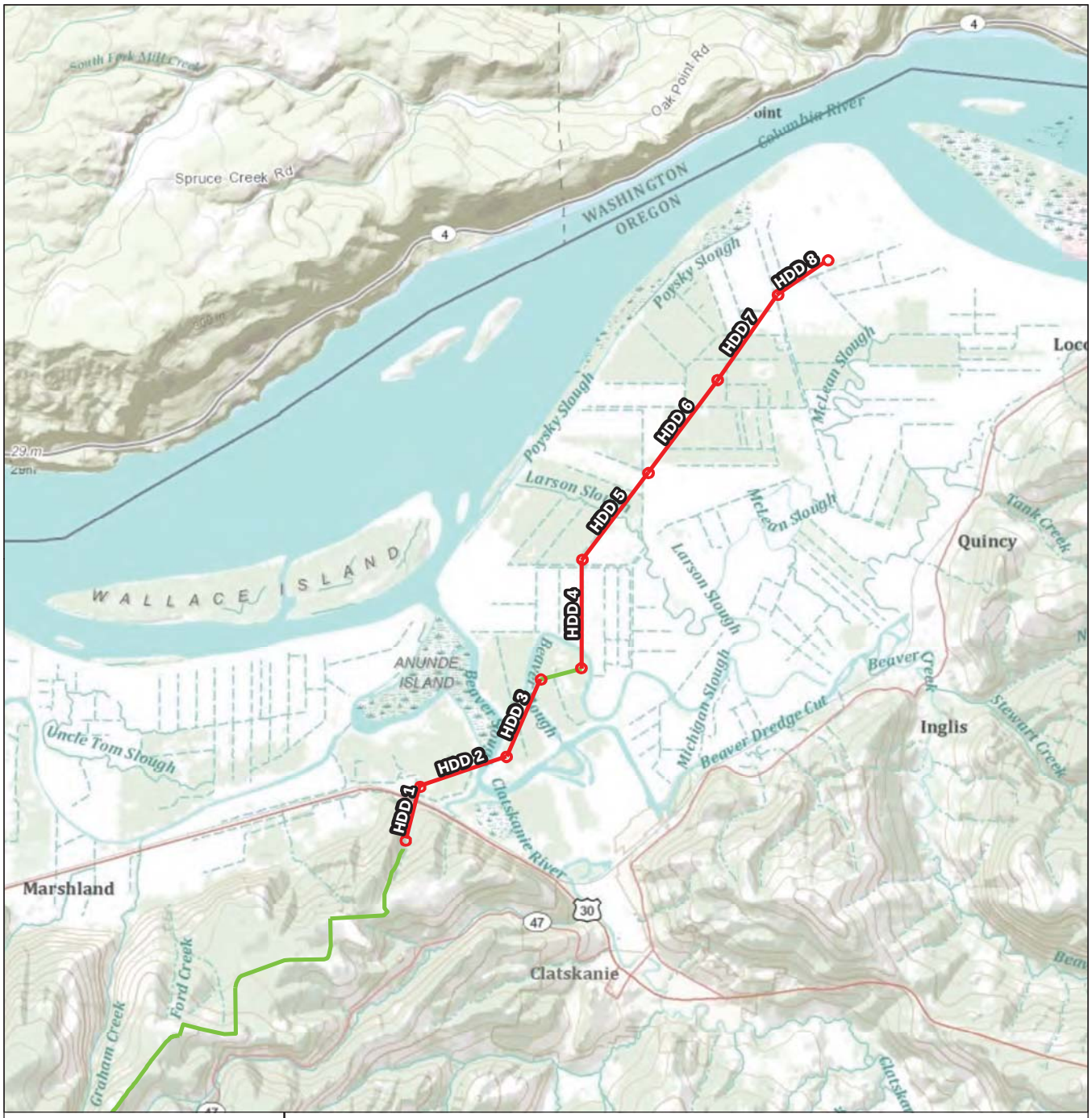


Legend

Proposed HDD

Open Trench

N
W E
S

1 0 1
Miles

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
Data Sources: ESRI Data & Maps, Street Maps 2008.
Base map from ESRI Data Online.
Projection: NAD 1983, UTM Zone 10 North.

Vicinity Map

North Mist Pipeline
Columbia County, Oregon

GEOENGINEERS

Figure 1

Office: PORT Path: P:\6\6024157\GIS\MXD\602415703_VicinityMap_NMP.mxd Map Revised: 30 June 2014 ccabrera

APPENDICES

GeoEngineers

APPENDIX A
Field Explorations

APPENDIX A
FIELD EXPLORATIONS

We explored subsurface conditions at each site on various dates between May 2013 and March 2015 by advancing a total of 20 borings along the proposed HDD alignments using mud rotary and rock coring drilling techniques. We also advanced two CPTs. Subsurface Technologies of North Plains, Oregon drilled/advanced the borings and CPTs to depths ranging from 70 to 230 feet bgs. A representative from our office observed field activities, classified the materials encountered, obtained representative samples, observed groundwater conditions where possible and prepared a log of each exploration. The borings were backfilled with cement grout at the conclusion of each exploration.

Soil samples were obtained from the borings at 5-foot-depth intervals using split spoon and Dames & Moore (2.4-inch I.D. split barrel sampler) samplers. Rock samples were obtained using continuous rock coring techniques. Soils encountered in the borings were classified in the field by a GeoEngineers representative in general accordance with ASTM Standard Practice D 2488, the Standard Practice for the Classification of Soils (Visual-Manual Procedure) which is described in Figure A-1. Rock encountered in our borings was classified in general accordance with the ODOT Soil and Rock Classification Manual (ODOT, 1987), which is described in Figure A-2. The boring logs are presented in Figures A-3 through A-22. Soil classifications and sampling intervals are shown in the boring logs. Inclined lines at the material contacts shown on the log indicate uncertainty as to the exact contact elevation, rather than the inclination of the contact itself. Logs of the CPTs are presented in Figures A-23 and A-24.

SPTs were performed during soil drilling in general accordance with ASTM Test Method D 1586. The sampler was driven with a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler 1 foot, or as otherwise indicated, into the soils is shown adjacent to the sample symbols on the boring log. Disturbed samples were obtained from the split barrel for subsequent classification and index testing. Note that without use of a conversion calculation for blow counts where a Dames & Moore sampler was used, "N" values utilized for geotechnical engineering calculations are only applicable to the SPT tests where the split spoon samplers were used. The relative density of the SPT samples recovered at each interval was evaluated based on correlations with lab and field observations in general accordance with the values outlined in Table A-1 below.

TABLE A-1. CORRELATION BETWEEN BLOW COUNTS AND RELATIVE DENSITY *

Cohesive Soils (Clay/Silt)						
Parameter	Very Soft	Soft	Medium Stiff	Stiff	Very Stiff	Hard
Blows, N	< 2	2 – 4	4 - 8	8 – 16	16 - 32	>32
**Cohesionless Soils (Gravel/Sand/Silty Sand) ** **						
Parameter	Very Loose	Loose	Medium Dense	Dense	Very Dense	
Blows, N	0 – 4	4 – 10	10 – 30	30 - 50	> 50	

* After Terzaghi, K and Peck, R.B., "Soil Mechanics in Engineering Practice," John Wiley & Sons, Inc., 1962.

** Classification applies to soils containing additional constituents; that is, organic clay, silty or clayey sand, etc.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	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
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		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
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
		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% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, 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 SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Material Description Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Sampler Symbol Descriptions

2.4-inch I.D. split barrel

Standard Penetration Test (SPT)

Shelby tube

Piston

Direct-Push

Bulk or grab

Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

Laboratory / Field Tests

%F	Percent fines
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PP	Pocket penetrometer
PPM	Parts per million
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

GEOENGINEERS

FIGURE A-1

Scale of Relative Rock Weathering (ODOT, 1987)

Designation	Field Identification
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric. Decomposition extends up to 1 inch into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Predominantly Decomposed	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

Scale of Relative Rock Hardness (ODOT, 1987)

Term	Hardness Designation	Field Identification	Approximate Unconfined Compressive Strength
Extremely Soft	R0	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
Very Soft	R1	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife. Scratched with fingernail.	100-1000 psi
Soft	R2	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.	1000-4000 psi
Medium Hard	R3	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4000-8000 psi
Hard	R4	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.	8000-16000 psi
Very Hard	R5	Cannot be scratched by knife or sharp pick. Specimen requires many blows of hammer to fracture or chip. Hammer rebounds after impact.	> 16000 psi

Rock Quality Designation (RQD)

RQD (Percent)	Description of Rock Quality
0 to 25	Very Poor
25 to 50	Poor
50 to 75	Fair
75 to 90	Good
90 to 100	Excellent

RQD is a modified core recovery measurement which expresses the number of hard and sound rock pieces of 4" or more in size as a percentage of the total length of core run.

Discontinuity Spacing (ODOT, 1987)

Description for Bedding, Foliation, or Flow Banding	Spacing	Description of Joints, Faults, or Other Fractures
Very Thickly	>10 feet	Very Widely
Thickly	3-10 feet	Widely
Medium	1-3 feet	Moderately Close
Thinly	2-12 inches	Closely
Very Thinly	< 2 inches	Very Closely

EXPLANATION OF BEDROCK TERMS

GEOENGINEERS

FIGURE A-2

Drilled	Start 5/20/2013	End 5/20/2013	Total Depth (ft) 71.5	Logged By AJF	Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) Vertical Datum	8		Hammer Data	Auto 140 (lbs) / 30 (in) Drop		Drilling Equipment	D-50 Turbo Track Rig
Latitude Longitude	46.17051 -123.17865		System Datum	Geographic WGS84		Groundwater Date Measured	Depth to Water (ft) / Elevation (ft): See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								OL	Brown organic silt (soft, moist)			
5									SM	Gray fine sand with silt (loose, moist)			
	5		18	1	4								
0										Grades to brown			
	10		18	2	1					Becomes silty, very loose and wet			
-5									ML	Dark brown silt with sand (soft, wet)			
	15		18	3	2								
-10									CL	Dark brown lean clay with trace sand and occasional organics (soft, wet)			
	20		18	4	2								
-15													
	25		18	5	3								
-20													
	30		18	6	3					With increased woody pieces and other organic material			
-25													
	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-1

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-3
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate:LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	7	3				CL	Dark brown lean clay wtih trace sand, organics and wood pieces (soft, wet)			
-30									ML	Dark gray silt with some fine sand (soft, moist)			
	40		18	8	3						53	91	
-35									SM	Gray silty fine sand (medium dense, moist)			
	45		18	9	28								
-40													
	50		14	10	25						24	20	
-45													
	55		15	11	15								
-50													
	60		14	12	30								
-55													
	65		14	13	20					With decreasing silt content below 65 feet			
-60													
	70		16	14	27								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-1 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-3
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157 03_HDD REPORT_09-14-15.GPJ DBTemplate:LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 5/22/2013	End 5/22/2013	Total Depth (ft) 71.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum	4		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	D-50 Turbo Track Rig
Latitude / Longitude	46.14666 / -123.20542		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								ML	Dark brown silt with organics and some gravel (moist) (fill)			
0									CL	Gray lean clay with organics and trace sand (very soft, moist)			
	5		18	1	1								
-5													
	10		18	2	0					Becomes wet with increased sand content and decreased organic content			
-10													
	15		18	3	3					Increasing silt with trace fine sand below 15 feet			
									ML	Gray silt with fine sand (very soft, moist)			
-15													
	20		18	4	0								
-20													
	25		18	5	1						58	80	
-25													
	30		18	6	2					Becomes sandy			
-30													
	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-2

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-4
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	7	2				ML	Gray sandy silt (very soft, moist)			
35									SM	Gray silty fine sand (medium dense, moist)			
	40		16	8	15								
40													
	45		15	9	14					With decreasing silt content			
45													
	50		14	10	11								
50													
	55		18	11	17						31	13	
55													
	60		14	12	28								
60													
	65		16	13	16								
65													
	70		14	14	14								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-2 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-4
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 5/23/2013	End 5/23/2013	Total Depth (ft) 71.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum	0		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	D-50 Turbo Track Rig
Latitude / Longitude	46.12044 / -123.23010		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								ML	Brown silt with fine sand and some gravel (moist)			
									OL	Gray/light brown organic silt (very soft, wet)			
5	5		18	1	0								Wood pieces in sample; small rootlets
10	10		18	2	0								
15	15		18	3	0								
20	20		18	4	0				ML	Gray-brown sandy silt with organics (very soft, wet)			Wood pieces in sample
25	25		18	5	0								
30	30		5	6	5					Becomes medium stiff	70	57	
35	35								SM	See description next page			

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-3

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-5
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		3	7	3				SM	Gray silty sand with occasional organics (very loose, wet)			
40	40		1	8	1								
									ML	Gray silt with sand (soft, moist)			
45	45		4	9	4						63	79	
50	50		2	10	2								
55	55		47 9	11 11a	47					Becomes light gray and very stiff			
									CL	Brown lean clay wtih sand and occasional wood pieces (very soft to soft, moist)			
60	60		2	12	2								
65	65		4	13	4								
70	70		4	14	4								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-3 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-5
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled Start 5/27/2014	End 5/27/2014	Total Depth (ft) 71.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) Vertical Datum 9		Hammer Data Auto 140 (lbs) / 30 (in) Drop		Drilling Equipment Deidrich D-50 Turbo Track Rig	
Latitude 46.16747 Longitude -123.18450		System Datum Geographic WGS84		Groundwater Date Measured / Depth to Water (ft) / Elevation (ft): See Notes	

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	FIELD DATA: Interval / Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							CL	Brown lean clay with trace sand (soft, moist)			
5	5	14	1	2								
								ML	Gray silt with sand (very soft, moist)			
0	10	18	2	1						49	74	
-5	15	18	3	2					Becomes sandy and wet	54	60	
								ML	Gray sandy silt with occasional wood fragments (soft, moist)			
-10	20	18	4	2								
-15	25	18	5	3					Decreasing sand content with abundant organics below 25 feet			
-20	30	0	6	3								
								MH	Gray-brown elastic silt with wood particles (soft, moist)			
-25	35											

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-4

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-6
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	7	2				MH	Gray-brown elastic silt with wood particles (soft, moist)	60		AL; PI = 45
30													
	40		0		5								
			18	8	3								
35													
	45		18	9	4					Becomes medium stiff			
									ML	Gray clayey silt with wood particles (soft, moist)			
40													
	50		18	10	3								
45													
	55		18	11	3								
50													
	60		18	12	3						58		AL; PI = 12
55													Rig chatter from 64 to 64.5 feet
	65		4	13	17				ML	Light gray silt with wood particles (very stiff, moist)			
60													
	70			14	6					Becomes gray and medium stiff			

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-4 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-6
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled Start 5/28/2014	End 5/28/2014	Total Depth (ft) 71.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum 2		Hammer Data Auto 140 (lbs) / 30 (in) Drop		Drilling Equipment Deidrich D-50 Turbo Track Rig	
Latitude 46.16379 / Longitude -123.18833		System Datum Geographic WGS84		Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft) See Notes	

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								MH	Gray-brown elastic silt with trace sand (very soft, moist)			
0													
	5		3	1	0								
-5													
	10		18	2	0					With increased organics (wood fragments) below 10 feet	95		AL; PI = 34
-10													
	15		18	3	0								
-15													
	20		18	4	0								
-20													
	25		18	5	0								
-25													
	30		18	6	0						87		AL; PI = 51
-30													
	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-5

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-7
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
-35	35	18	7	0				MH	Gray-brown elastic silt with organics (wood fragments) and trace sand (very soft, moist)			
-40	40	18	8	0								
-45	45	18	9	4								
-50	50	18	10	0					Increasing sand content	108	83	
								ML	Light gray silt (very stiff, moist)			
-55	55	10	11	23						62		AL; non-plastic
								ML	Gray silt with trace sand and wood particles (very soft, moist)			
-60	60	18	12	0								
-65	65	4	13	17					Becomes very stiff			
	70	18	14									

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-5 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-7
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/18/2014	End 3/18/2014	Total Depth (ft) 71.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum	1		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude / Longitude	46.16084 / -123.19126		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								MH	Gray elastic silt with trace fine sand and wood fragments (very soft, moist)			
0													
-5	5		18	1	1								
-10	10		14	2	2						68	95	
-15	15		16	3	1					Decreasing sand content	65	97	AL; PI = 17
-20	20		18	4	1								
-25	25		18	5	1								
-30	30		18	6	0								
	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-6

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-8
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
-35	35		18	7 7	0				MH	Gray elastic silt with trace fine sand and wood fragments (very soft, moist)	73	96	
-40	40		18	8	1				ML	Gray silt with fine sand (very soft, moist)			
-45	45		18	9	2								
-50	50		8	10	2								
-55	55		18	11	29					Becomes very stiff with wood fragments from 55 to 56 feet			
									ML	Light gray silt with wood fragments (very stiff, moist)			
-60	60		3	12	0				ML	Gray silt with fine sand (very soft, moist)			
-65	65		18	13	0								
-70	70		8	14	0								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-6 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-8
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/11/2014	End 3/12/2014	Total Depth (ft)	71.5	Logged By / Checked By	AJF / BCR	Driller	Subsurface Technologies	Drilling Method	Mud Rotary
Surface Elevation (ft) Vertical Datum	3		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig				
Latitude Longitude	46.15703 -123.19515		System Datum	Geographic WGS84	Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)			
Notes: Groundwater not observed due to presence of drilling fluid in boring					See Notes					

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							ML	Brown and orange mottled sandy silt with wood fragments (very soft, moist)			
0												
	5	18	1	0								
-5									Becomes gray and lacks wood fragments			
	10	16	2	0						46	52	
-10												
	15	16	3	2								
-15												
	20	18	4	3					Decreasing sand content			
-20									Becomes soft with some fine sand and wood fragments			
	25	18	5	2						74	93	
-25												
	30	18	6	2					Increasing sand content			
-30									Becomes gray and with fine sand			
	35											

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-7

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-9
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		16	7	3				ML	Gray silt with fine sand and wood fragments (soft, moist)			
-35													
	40		18	8	5					Become medium stiff			
-40													
	45		18	9	2					Becomes soft	43	76	
-45													
	50		12	10	14					Becomes stiff			
-50									SP-SM	Gray fine to medium sand with silt (medium dense, moist)			
	55		14	11	19						32	8	
-55													
	60		14	12	16								
-60													
	65		14	13	23								
-65													
	70		16	14	22								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-7 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-9
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157 03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/12/2014	End 3/12/2014	Total Depth (ft) 71.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum	3		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude / Longitude	46.15066 / -123.20215		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								ML	Brown silt with fine sand (very soft, moist)			
0													
	5		18	1	2					Becomes gray and orange mottled with trace sand			
-5													
	10		18	2	0					With wood fragments below 10 feet			
-10													
	15		18	3	0								
-15													
	20		18	4	0								
-20													
	25		18	5	0								
-25													
	30		18	6	3					Becomes soft with increased fine sand content			
-30													
	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-8

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-10
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		12	7	6				ML	Gray and orange mottled silt with fine sand and wood fragments (medium stiff, moist)	44	77	
-35													
	40		14	8	20				SP-SM	Gray fine sand with silt (medium dense, moist)			
-40													
	45		10	9	9					Becomes loose			
-45													
	50		14	10	4								
-50													
	55		12	11	15					Becomes medium dense	33	11	
-55													
	60		14	12	19								
-60													
	65		14	13	22								
-65													
	70		12	14	11								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-8 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-10
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157 03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/11/2014	End 3/11/2014	Total Depth (ft) 71.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) Vertical Datum	3		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude / Longitude	46.14320 / -123.21018		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								ML	Brown silt with clay and wood fragments (very soft, moist)			
0													
	5		18	1	2								
-5													
	10		18	2	1					Increasing sand content			
-10									SM	Gray silty fine sand (loose, wet)			
	15		12	3	6						38	35	
-15									SP-SM	Gray fine sand with silt (medium dense, wet)			
	20		14	4	14								
-20									SM	Gray silty fine sand with trace gravel (medium dense, wet)			
	25		16	5	10						36	21	
-25													
	30		15	6	12					Lacks gravel below 30 feet			
-30													
	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-9

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-11
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		12	7	11				SM	Gray silty fine sand (medium dense, wet)			
-35													
	40		18	8	2				ML	Gray fine sandy silt with wood fragments (soft, moist)	47	52	
-40									SM	Gray silty fine sand (medium dense, moist)			
	45		18	9	13								
-45													
	50		14	10	21								
-50													Lost circulation at 53 feet
	55		14	11	9					Becomes loose	41	23	Circulation regained at 55 feet
-55													
	60		16	12	10					Becomes medium dense			
-60													
	65		18	13a 13b	52				CL	Light gray clay (very stiff, moist)			
-65									SP-SM	Gray fine to coarse sand with silt (medium dense, moist)			
	70		18	14a 14b 14c	10				CL	Light gray clay (stiff, moist)			
									ML	Gray silt with fine sand (stiff, moist)			

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-9 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-11
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled Start 3/2/2015	End 3/4/2015	Total Depth (ft) 231.5	Logged By IDB / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum	0	Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude / Longitude	46.13888 / -122.21050	System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								OL	Gray organic silt with clay and wood fragments (very soft, moist)			
-5	5		18	1	0								
-10	10		18	2	0								
-15	15		18	3	0								
-20	20		18	4	0								
-25	25		18	5	0								
-30	30		14	6	6				MH	Gray sandy elastic silt with trace wood fragments (medium stiff, moist)	46	67	
-35	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-10

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-12
Sheet 1 of 6

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	7	9				MH	Gray elastic silt with sand and trace wood fragments (soft, moist)	70	72	
40	40		18	8	2						91		AL; PI = 36
45	45		18	9	2								
									ML	Gray silt with trace fine sand and wood fragments (stiff, moist)			
50	50		18	10	24						60	97	AL; non-plastic
55	55		18	11	2					Becomes soft	53	90	
									SM	Gray silty fine sand with trace organics (loose, moist)			
60	60		18	12	4						46	13	
									ML	Gray silt with sand and trace organics (very soft to soft, moist)			
65	65		18	13	2						46	85	
70	70		18	14	0					Decreased sand content			
75	75		9	15	3					With trace shell fragments	91	55	

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-10 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-12
Sheet 2 of 6

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
								ML	Gray sandy silt with trace organics (soft, moist)			
80	80							SM	Gray silty sand with trace organics (very loose, moist)			
		18	16	10						59	38	
85	85	18	17	3						71	46	
								MH	Gray elastic silt with sand and occasional wood fragments (soft, moist)			
90	90	18	18	3						57		AL; PI = 16
95	95	18	19	7					Becomes medium stiff			
100	100	18	20	9					Increased sand content			
105	105											
110	110	18	21	7					Decreased sand content			
115	115											

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-10 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-12
Sheet 3 of 6

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
								ML	Gray sandy silt (stiff, moist)			
120	120	18	22	9						44	70	
								MH	Gray elastic silt with trace sand and wood fragments (stiff, moist)			
125	125	18	23	11						57		AL; PI = 26
130	130											
135	135	18	24	10					Lacks wood fragments			
140	140											
145	145	18	25	13					With trace wood fragments and gravel			
150	150											
155	155	18	26	10					Lacks gravel			
160	160											

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-10 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-12
Sheet 4 of 6

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
								MH	Gray elastic silt with trace sand and trace wood fragments (stiff, moist)			
165	165	18	27	15								
170	170											
175	175	18	28	14								
180	180											
								ML	Gray silt with sand (medium stiff, moist)			
185	185	18	29	6						43		AL; PI = 3
190	190											
195	195	18	30	7								
200	200											

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-10 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-12
Sheet 5 of 6

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157 03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
								ML	Gray silt with sand (stiff, moist)			
205	205	18	31	11						42		AL; PI = 9
210	210											
215	215	18	32	32					Becomes very stiff			
								SP	Gray fine sand with occasional silt and shell fragments (dense, moist)			
220	220	8	33	36					With trace organics, decreased silt and shell content			
225	225											
230	230	16	34	61					Becomes very dense			

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-10 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-12
Sheet 6 of 6

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/4/2015	End 3/6/2015	Total Depth (ft) 196.5	Logged By IDB / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum	2		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude / Longitude	46.13512 / -123.21054		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								MH	Brown elastic silt with organics (very soft, moist)			
0													
	5		16	1	0					With trace wood fragments			
5													
									OL	Dark brown organic silt (very soft, moist)			
	10		8	2	0								
10													
	15		18	3	2					Becomes gray			
15													
	20		18	4	0					Becomes brown			
20													
	25		18	5	0								
25													
	30		18	6	1				MH	Gray elastic silt with trace sand and organics (very soft, moist)	76		AL; PI = 16
30													
	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-11

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-13
Sheet 1 of 5

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	7	0				MH	Gray elastic silt with trace sand and organics (very soft, moist)			
-35													
	40		18	8	3					Becomes soft with trace organics			
-40													
	45		18	9	1					Becomes very soft with trace wood fragments	57		AL; PI = 10
-45													
									ML	Gray silt with trace sand (soft, moist)			
	50		18	10	3						64	94	AL; PI = 8 Triaxial shear test at 50 feet
-50													
	55		18	11	7					Becomes medium stiff and wet	58	95	
-55													
										Becomes very soft			
	60		18	12	0								
-60													
									SP-SM	Gray fine sand with silt (loose, wet)			
	65		14	13	5						59	13	
-65													
	70		13	14	10					Becomes loose to medium dense			
-70													
									ML	Light gray silt with trace sand (very stiff, wet)			
	75		11	15	21						59	97	AL; non-plastic

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-11 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-13
Sheet 2 of 5

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
-75								ML	Light gray silt (very stiff, wet)			
-80	80	18	16	42								
-85	85	0	17	3					Becomes soft			
		0	18	7					Becomes medium stiff			
-90	90	14	19	4					Becomes sandy and soft	43	51	
								SM	Gray silty fine sand (medium dense, moist)			
-95	95	15	20	19						40	39	
-100	100	13	21	25					With decreased fines content	32	23	
-105	105											
-110	110	14	22	30						34	26	
-115	115											

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-11 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-13
Sheet 3 of 5

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
								SM	Gray silty fine sand (medium dense, moist)			
120	120	14	23	34					Becomes dense	32	27	
125	125											
130	130	12	24	34					With trace shell fragments	32	32	
135	135											
140	140	16	25	48					Lacks shell fragments	26	30	
145	145											
150	150	14	26	44								
155	155											
160	160											

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-11 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-13
Sheet 4 of 5

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
			16	27	47				SM	Gray silty fine sand (dense, moist)			
160													
	165												
165													
									ML	Gray silt with sand (stiff, moist)			
	170		18	28	9						37	73	
170													
	175												
175													
	180		18	29	6					Becomes medium stiff			
180													
	185		18	30	6								
185													
	190												
190													
	195		18	31	22					Becomes very stiff			

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-11 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-13
Sheet 5 of 5

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/10/2014	End 3/10/2014	Total Depth (ft) 71.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum	4		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude / Longitude	46.13300 / -123.21072		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
0								MH	Gray elastic silt with fine sand (very soft, moist)			
5		18	1	0								
10		18	2	1								
15		18	3	2					Becomes soft with increasing sand content			
20		18	4	4					Becomes sandy, medium stiff and wet	55	62	
25		18	5	7					Becomes stiff			
30		18	6	2					Becomes soft and moist with wood fragments			
35												

Elevation (feet): 0, -5, -10, -15, -20, -25, -30

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-12

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-14
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	7	1				MH	Gray fine sandy elastic silt with wood fragments (very soft, moist)	60		AL; PI = 19
35													
	40		18	8	3					Becomes soft with trace sand	100	95	
40													
	45		18	9	2								
45													
	50		18	10	2								
50													
	55		18	11	4								
55													
	60		18	12a 12b	28				CL	Light gray clay with wood fragments (very stiff, moist)			
									ML	Gray silt with fine sand and wood fragments (soft, moist)			
60													
	65		18	13	4								
65													
	70		18	14	4								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-12 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-14
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/7/2014	End 3/7/2014	Total Depth (ft) 71.5	Logged By IDB / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum	7		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude / Longitude	46.131.75 / -123.21596		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								OH	Brown organic clay (dense, moist) (topsoil)			
5									MH	Light brown and yellow-orange mottled elastic silt with trace fine sand and trace organics (very soft, moist)			
	5		18	1	2						59		AL; PI = 28
0									SM	Brown and gray silty fine to medium sand (very loose, moist)			
	10		18	2	3					Becomes gray	47	40	
5									SP-SM	Brown and gray fine sand with silt (loose, moist)			
	15		18	3	5						38	6	
10													
	20		15	4	8								
15													
	25		12	5	10					Becomes medium dense			
20													
	30		14	6	9					Becomes loose			
25													
	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-13

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-15
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		15	7	14				SP-SM	Brown and gray fine sand with silt (medium dense, moist)			
-30													
	40		13	8	11								
-35									ML	Light gray and gray mottled silt with fine sand (very soft, moist)			
	45		18	9	2						51	94	AL = nonplastic
-40													
									OL	Gray organic clay (soft, moist)			
	50		18	10	4						85		
-45													
									CL	Gray lean clay with organics and fine sand (soft, moist)			
	55		18	11	3						60		
-50													
	60		18	12	0					Becomes very soft with decreased organic content			
-55													
	65		18	13	4					Becomes soft			
-60													
									ML	Gray sandy silt with trace organics (medium stiff, moist)			
	70		16	14	7						42	68	AL; PI = 4

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-13 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-15
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled Start 3/21/2014	End 3/21/2014	Total Depth (ft) 71.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum	8	Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude / Longitude	46.13001 / -123.21717	System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Depth (feet)	Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
0							ML	Brown silt with sand (soft, moist)			
5	18	1	2					Becomes brown-gray and orange mottled and sandy			
							SM	Gray silty fine sand (very loose, wet)			
10	16	2	2								
15	12	3	5					Becomes loose	39	18	
20	12	4	11					Becomes medium dense			
25	12	5	10								
							ML	Gray-brown silt with fine sand and abundant organics (soft, moist)			
30	18	6	4						130		
35											

Elevation (feet): 5, 0, -5, -10, -15, -20, -25

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-14

GeoEngineers

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-16
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	7	3				ML	Gray-brown sandy silt with abundant organics (soft, moist)			
-30													
	40		18	8	2					Becomes gray with wood fragments and occasional fine sand	83	91	
-35													
	45		18	9	3								
-40													
	50		18	10	3					Decreased sand content	72	95	
-45													
	55		18	11	2								
-50													
	60		10	12	22					Becomes very stiff			
-55													
	65		18	13	0					Becomes very soft			
-60													
									CL	Gray lean clay with sand and occasional wood fragments (medium stiff, moist)			
	70		18	14	7								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-14 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-16
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/6/2014	End 3/6/2014	Total Depth (ft) 71.5	Logged By IDB / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) Vertical Datum	5		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude / Longitude	46.12481 / -123.22125		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								OH	Light brown organic lean clay (dense, moist) (topsoil)			
									CH	Gray fat clay with sand and occasional organics (very soft, wet)			
0	5		18	1	0								
									SM	Gray silty sand with trace organics (very loose, moist)			
-5	10		18	2	2								
-10	15		15	3	3								
									SP	Gray fine to medium sand with trace silt (loose to medium dense, moist)			
-15	20		15	4	10						28	3	
									ML	Gray silt with fine sand (very soft to soft, moist)			
-20	25		18	5	2						52	78	
									SM	Gray silty fine sand (loose, moist)			
-25	30		15	6	9								
-30	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-15

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-17
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate:LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		15	7	8				SM	Gray silty fine sand (loose, wet)			
-35	40		18	8	5								
-40	45		18	9	4								
									SC	Gray clayey sand (loose, wet)			
-45	50		18	10	6								
-50	55		18	11	7								
										Becomes medium dense, olive green and moist with increasing clay content			
-55	60		16	12	10								
-60	65		18	13	11					Becomes yellow mottled with trace organics			
-65	70		14	14	10								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-15 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-17
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157 03_HDD REPORT_09-14-15.GPJ DBTemplate:LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/9/2015	End 3/10/2015	Total Depth (ft) 171.5	Logged By IDB / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) Vertical Datum	0		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude Longitude	46.12330 -123.22627		System Datum	Geographic WGS84	Groundwater Date Measured	Depth to Water (ft) / Elevation (ft): See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								OL	Brown organic silt (very soft, moist)			
-5	5		18	1	0								
-10	10		18	2	0								
-15	15		18	3	0								
-20	20		18	4	0					Becomes gray			
-25	25		18	5	1								
									ML	Gray silt with sand and trace organics (very soft, moist)			
-30	30		18	6	0								
-35	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-16

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-18
Sheet 1 of 5

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	7	0				ML	Gray silt with sand and trace organics (very soft, moist)			
-40	40		18	8	4					Becomes soft			
									SM	Gray silty fine sand with trace organics (loose, wet)			
-45	45		18	9	7						47	17	
-50	50		6	10	4								
-55	55		18	11	6					Decreased sand content	62	32	
-60	60		18	12	2					Becomes very loose			
									ML	Gray silt with sand and trace organics and shells (soft, wet)			
-65	65		18	13	2						63	74	
-70	70		18	14	4						59	81	
-75	75		18	15	3								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-16 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-18
Sheet 2 of 5

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
								ML	Gray silt with sand and trace organics and shells (soft, wet)			
80	80	18	16	6					Becomes medium stiff			
85	85	18	17	10					Becomes stiff			
90	90	18	18	2					Becomes soft			
95	95	18	19	7					Becomes medium stiff			
100	100	18	20	9					Becomes sandy and stiff	38	66	
105	105											
110	110	18	21	13						38	63	
115	115											

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-16 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-18
Sheet 3 of 5

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157 03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
120	120	18	22	15				ML	Gray silt with sand and trace wood fragments (stiff, moist)			
125	125											
130	130	18	23	19						48	75	
135	135											
140	140	18	24	7					Becomes medium stiff			
145	145											
150	150	18	25	19					Becomes very stiff	43	82	
155	155								Becomes sandy			
160	160											

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-16 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-18
Sheet 4 of 5

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate:LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
			18	26	24				ML	Gray sandy silt with trace wood fragments (very stiff, moist)	40	70	
165	165		16	27	25								
170	170		18	28	37					Becomes hard with trace wood fragments			

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-16 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-18
Sheet 5 of 5

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 6/16/2014	End 6/18/2014	Total Depth (ft) 115	Logged By IDB / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) Vertical Datum	230		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	
Latitude / Longitude	46.11782 / -123.23356		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								AC	Asphaltic pavement			
									GP	Brown gravel with sand (medium dense, moist) (base rock)			
									GP	Brown gravel with sand and cobbles (loose to medium dense, moist) (fill)			
225	5		7	1	3				CL	Brown gravelly lean clay with sand and organics (soft, moist) (fill)			
									Fill	Wood fill			
220	10		0	2	18				SP	Gray fine sand with 1 to 2 inch thick layers of sells (very dense, moist)			
			18	3	64					1-inch thick brown clay layer at 11.4 feet			
215	15		18	4	83				SM	Gray silty fine sand (very dense, moist)			
210	20		50/5.5"	5							30	38	
			8	6	100					Occasional 1 to 4 inch thick layers of shells below 20 feet			
205	25		14.5	7	50/2"								
200	30		10	8	50/4"						34	19	
195	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-17

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-19
Sheet 1 of 3

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate:LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		10.5	9	50/4.5"				SM	Gray silty fine sand with abundant shell fragments (very dense, moist)			
190	40		2	10	75/5"								
185	45		10	11	50/4"					Abundant shell fragments in lower 6 inches of sampler			
180	50		10	12	50/4"								
175	55		3.5	13	75/3.5"								
170	60		0	14	50/.5"								
165	65		6	15	42/6"					Abundant shell fragments	26	17	
160	70		7	16	50/1"								
			36	R1		83			BSLT	Gray basalt; fresh, medium hard, closely fractured			
155	75		36	R2		44				Becomes hard			

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-17 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-19
Sheet 2 of 3

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
									BSLT	Gray basalt; fresh, hard, closely fractured			
			15	R3		42							
150	80									Red baked contact from 80 to 81 feet Becomes moderately decomposed, medium hard, very closely fractured			
			9	R4		0							
			21	R5		21				Becomes bluish green, decomposed, extremely soft, closely fractured			
			21	R6		17				Becomes fresh and medium hard Becomes very closely fractured between 84.5 and 85 feet			
145	85												
			17	R7		0				Very closely fractured			
			36	R8		0				Closely fractured			
140	90									Very closely fractured Moderately weathered between 90.5 and 91 feet			
			26	R9		13				Becomes fresh, medium hard, closely fractured			
			18	R10		61							
135	95		24	R11		96							
			47	R12		75							
									BREC	Gray basaltic breccia; fresh, medium hard, closely fractured			
130	100												
			55	R13		55				Closely fractured			
125	105									Rubble zone from 101 to 101.5 feet			
			36	R14		39			BSLT	Gray basalt; fresh, medium hard, very closely fractured			
										Becomes moderately fractured Becomes very closely fractured Brecciated zone from 109 to 109.6 feet			
			24	R15		29							
120	110									Becomes closely fractured			
			17	R16		61				Brecciated zone from 111 to 111.5 feet			
			30	17		23							
115	115									Becomes closely fractured			

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-17 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-19
Sheet 3 of 3

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/13/2014	End 3/13/2014	Total Depth (ft) 71.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) Vertical Datum	Undetermined		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude / Longitude	46.15361 / -123.19928		System Datum	Geographic WGS84	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								ML	Brown silt with sand (very soft, moist)			
	5		18	1	1					Becomes gray and orange mottled with trace sand			
	10		18	2	0					With occasional wood fragments below 10 feet			
	15		18	3	0					Decreasing fine sand	63	93	
	20		18	4	0					Becomes gray			
	25		18	5	2					Becomes soft			
	30		18	6	2								
	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-18

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-20
Sheet 1 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	7	0				ML	Gray silt with fine sand and occasional wood fragments (very soft, moist)	47	79	
	40		18	8	0					With wood fragments			
									SM	Gray silty fine sand (loose, wet)			
	45		14	9	5								
									SP-SM	Gray fine sand with silt (medium dense, moist)			
	50		12	10	18						27	5	
	55		12	11	22								
	60		14	12	28								
	65		16	13	22								
	70		14	14	20								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-18 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-20
Sheet 2 of 2

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled Start 11/24/2014	End 12/1/2014	Total Depth (ft) 95	Logged By MK / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) / Vertical Datum 25		Hammer Data Auto 140 (lbs) / 30 (in) Drop		Drilling Equipment Deidrich D-50 Turbo Track Rig	
Latitude 46.12044 / Longitude -123.2334		System Datum Geographic WGS84		Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft) See Notes	

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								AC	Asphalt concrete			
									GW	Gravel (road subgrade)			
									GC	Brown clayey gravel (very dense, moist) (fill)			
20	5		10	1	50/5"								Drill bouncing
													Rough drilling
15	10		5	2	50/5"					Becomes gray			
10	15		3	3									Slow/rough drilling
5	20		2	4	120/3"				GC	Gray clayey gravel (very dense, wet) (fill)			No recovery, sample washed out
			40	1									
									BSLT	Basalt; gray, fresh, closely fractured, hard			
0	25		24	2		24							Smooth drilling
			36	3		16							
									BREC	Basaltic Breccia; red and gray, clay filled fractures, slightly weathered, closely fractured, soft Becomes greenish gray			
-5	30		24	4		22							
			36	5		11				Becomes reddish brown and moderately weathered			
-10	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-19

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-21
Sheet 1 of 3

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		60	6		20				Becomes bluish gray and predominantly decomposed			
									BSLT	Basalt; gray, clay filled fractures, moderately weathered, closely fractured, soft			
-15	40		54	7		51				With some cemented joints, fresh, hard			
-20	45		60	8		50							
										Basalt; gray and brown, clay filled fractures, slightly weathered, very closely fractured, medium hard			
-25	50		58	9		53				Becomes gray and closely fractured			
										Becomes gray and reddish brown			
										Basalt; gray, vesicular, fresh, clsoely fractured, hard			Faster drilling
-30	55		6	10		6							
										Lacks vesicles			
-35	60		59	11		55				Basalt; gray, fresh, closely fractured, hard			
									BREC	Basaltic Breccia; gray and red, slightly weathered, closely fractured, medium hard			Slow drilling
-40	65		60	12		73							
									BSLT	Basalt; greenish gray, slightly weathered, closely fractured, soft			Fast drilling
										Becomes gray, fresh, closely fractured, hard			
										Becomes slightly weathered and medium hard			
-45	70		36	13		25				Becomes hard			
										Becomes green and brown, very closely fractured and very soft			
			59	14		95				Becomes gray, fresh, moderately close fractured and hard			
-50	75												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-19 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-21
Sheet 2 of 3

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
			60	15		100							
-55	80												
			32	16		16				Becomes green and gray, with small vesicles, slightly weathered, closely fractured, medium hard Lacks vesicles			
-60	85		60	17		50				Becomes gray and very closely fractured Becomes closely fractured, fresh, and hard			
-65	90		60	18		100							
-70	95												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-19 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-21
Sheet 3 of 3

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Drilled	Start 3/23/2015	End 3/24/2015	Total Depth (ft) 151.5	Logged By AJF / Checked By BCR	Driller Subsurface Technologies	Drilling Method Mud Rotary
Surface Elevation (ft) Vertical Datum	Undetermined		Hammer Data	Auto 140 (lbs) / 30 (in) Drop	Drilling Equipment	Deidrich D-50 Turbo Track Rig
Latitude Longitude			System Datum	Geographic	Groundwater Date Measured / Depth to Water (ft) / Elevation (ft)	See Notes

Notes: Groundwater not observed due to presence of drilling fluid in boring

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								ML	Light brown-orange mottled silt with trace sand and organics (very soft, moist)			
	5		18	1	1								
	10		18	2	1					With occasional wood chips			
	15		18	3	2						69		DD = 58 pcf Losing circulation
	20		18	4	0					Becomes gray			
	25		18	5	1								
	30		18	6	0								Still losing circulation
	35												

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-20

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-22
Sheet 1 of 4

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157-03_HDD REPORT_09-14-15.GPJ DBTemplate:LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	7	0				ML	Gray silt with trace sand and occasional wood chips (very soft, moist)			
	40		18	8	5					Becomes soft			
	45		18	9	1					Becomes very soft			
	50		18	10	3					Becomes soft			
	55		18	11	3								
									ML	Light gray silt with sand (very stiff, moist)			
	60		8	12	24								
									ML	Gray silt with wood chips and trace sand (medium stiff, moist)			Lost circulation
	65		18	13	7								
	70		18	14	4					Decreasing wood chips	64	96	
	75		18	15	4								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-20 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-22
Sheet 2 of 4

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157 03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
								ML	Gray silt with occasional wood chips and trace sand (medium stiff, moist)			
	80	18	16	14					Becomes sandy and stiff with wood chips			
	85	12	17	11					Becomes wet	46	66	
								SM	Gray silty fine sand (medium dense, wet)			
	90	10	18	11						36	18	
	95	10	19	13					With trace organics	37	19	
	100	12	20	18					Becomes moist to wet			
	105											
	110	12	21	18						31	12	
	115											

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-20 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

Figure A-22
Sheet 3 of 4

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157 03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Sample/Run	Blows/foot	RQD %	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
								SM	Gray silty fine sand (dense, moist to wet)			
	120	12	22	30								
	125											
	130	10	23	28					Becomes medium dense	29	18	
	135											
	140	0		14								
								ML	Gray sandy silt with shell fragments (stiff, moist)			
	145	18	24	13								
	150	18	25	12								

Note: See Figure A-1 for explanation of symbols and Figure A-2 for rock classification.

Log of Boring B-20 (continued)

GEOENGINEERS

Project: North Mist Expansion Project
Project Location: Columbia County, Oregon
Project Number: 6024-157-03

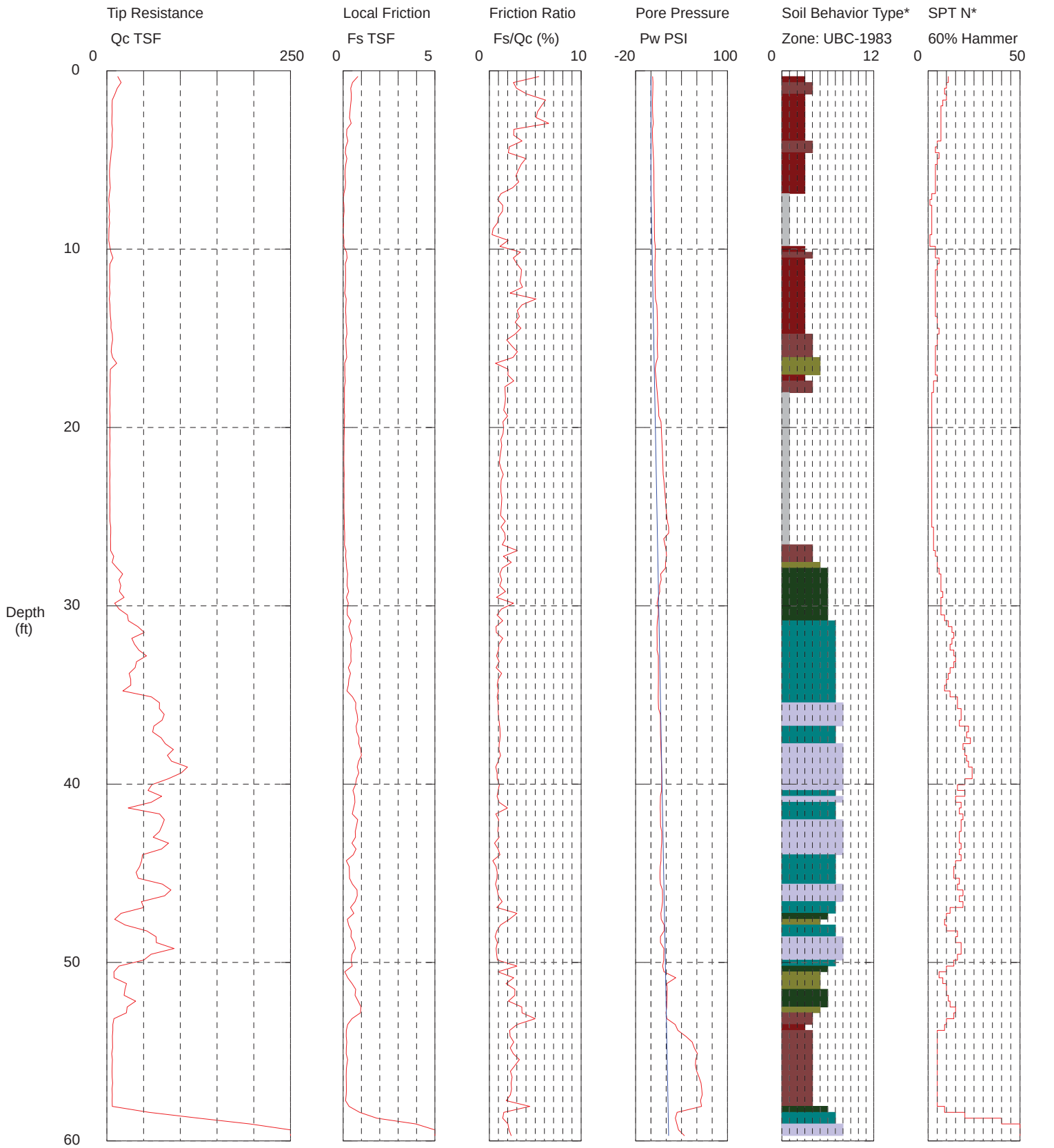
Figure A-22
Sheet 4 of 4

Portland: Date:9/14/15 Path:C:\USERS\KJANC\DESKTOP\6024157\03_HDD REPORT_09-14-15.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_SOIL_ROCK

Subsurface Technologies

Operator: SAM
Sounding: CPT-1
Cone Used: DDG1170

CPT Date/Time: 3/11/2015 10:19:47 AM
Location: NORTH MIST PIPELINE
Job Number: 6024-57-03



Maximum Depth = 59.71 feet

Depth Increment = 0.328 feet

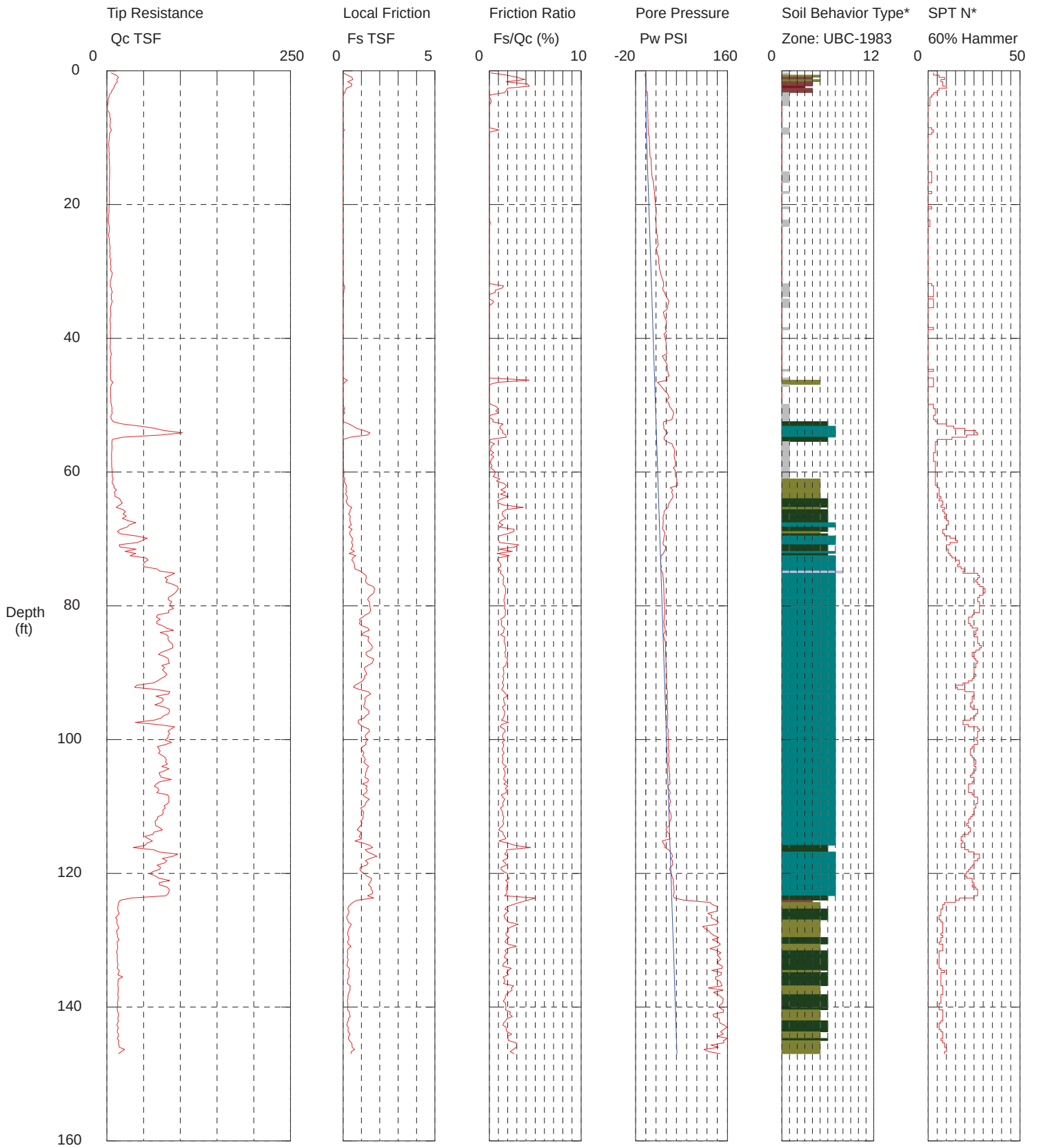
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

Subsurface Technologies

Operator: SAM
Sounding: CPT-2
Cone Used: DDG1170

CPT Date/Time: 3/11/2015 2:21:11 PM
Location: NORTH MIST PIPELINE
Job Number: 6024-57-03



Maximum Depth = 146.98 feet

Depth Increment = 0.328 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

APPENDIX B
Laboratory Testing

APPENDIX B
LABORATORY TESTING

General

With the exception of Triaxial testing, samples obtained from the explorations were transported to our Portland, Oregon laboratory and tested to confirm or modify field classifications, as well as to evaluate engineering properties of the samples. Representative soil and samples were selected for laboratory testing consisting of percent fines, moisture content determinations and Atterberg limits determinations. Triaxial tests were conducted by Cooper Testing Laboratory in Palo Alto, California. The laboratory testing procedures are discussed in more detail below.

Atterberg Limits Testing

Atterberg limits were performed on selected soil samples. The tests were used to classify and evaluate index properties of the soil. The liquid limit and the plastic limit were estimated through a procedure performed in general accordance with ASTM D 4318. The results of the Atterberg limits testing are shown in Figures B-1 through B-5.

Percent Fines Determinations

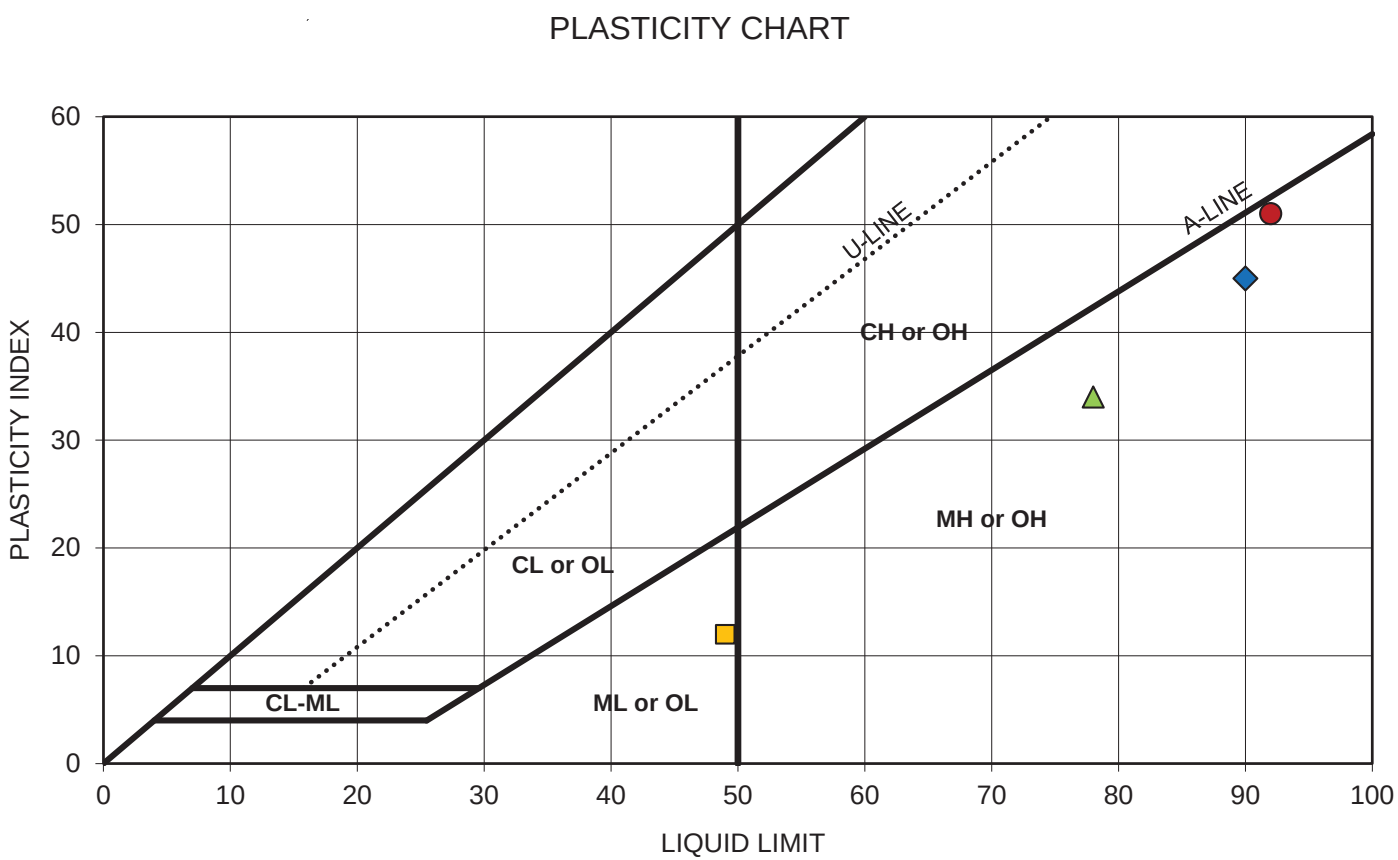
Percent fines determinations were performed on soil samples obtained from the borings. The tests were used to evaluate the relative amounts of coarse and fine grained particles present in the samples and were completed in general accordance with ASTM D 1140. The results of the testing are presented on the boring logs at their respective sample depths.

Moisture Content Determinations

Moisture content determinations were performed on select soil samples in general accordance with ASTM D 2216. The results of the moisture content determinations are shown on the attached boring logs.

Triaxial Testing

One consolidated, undrained triaxial test with pore pressure dissipation was conducted on a soil sample in general accordance with ASTM D 4767m. The results of the triaxial test are shown in Figure B-6.



Symbol	Sample ID	Sample Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	USCS	Soil Description
◆	B-4 S-7	35	60	90	45	MH	Elastic silt with wood particles
■	B-4 S-12	60	58	49	12	ML	Silt with wood particles
▲	B-5 S-2	10	95	78	34	MH	Elastic silt with trace sand
●	B-5 S-6	30	87	92	51	MH	Elastic silt with trace sand and wood fragments

Atterberg Limits Test Results

North Mist Expansion
Columbia County, Oregon

GeoEngineers

Figure B-1

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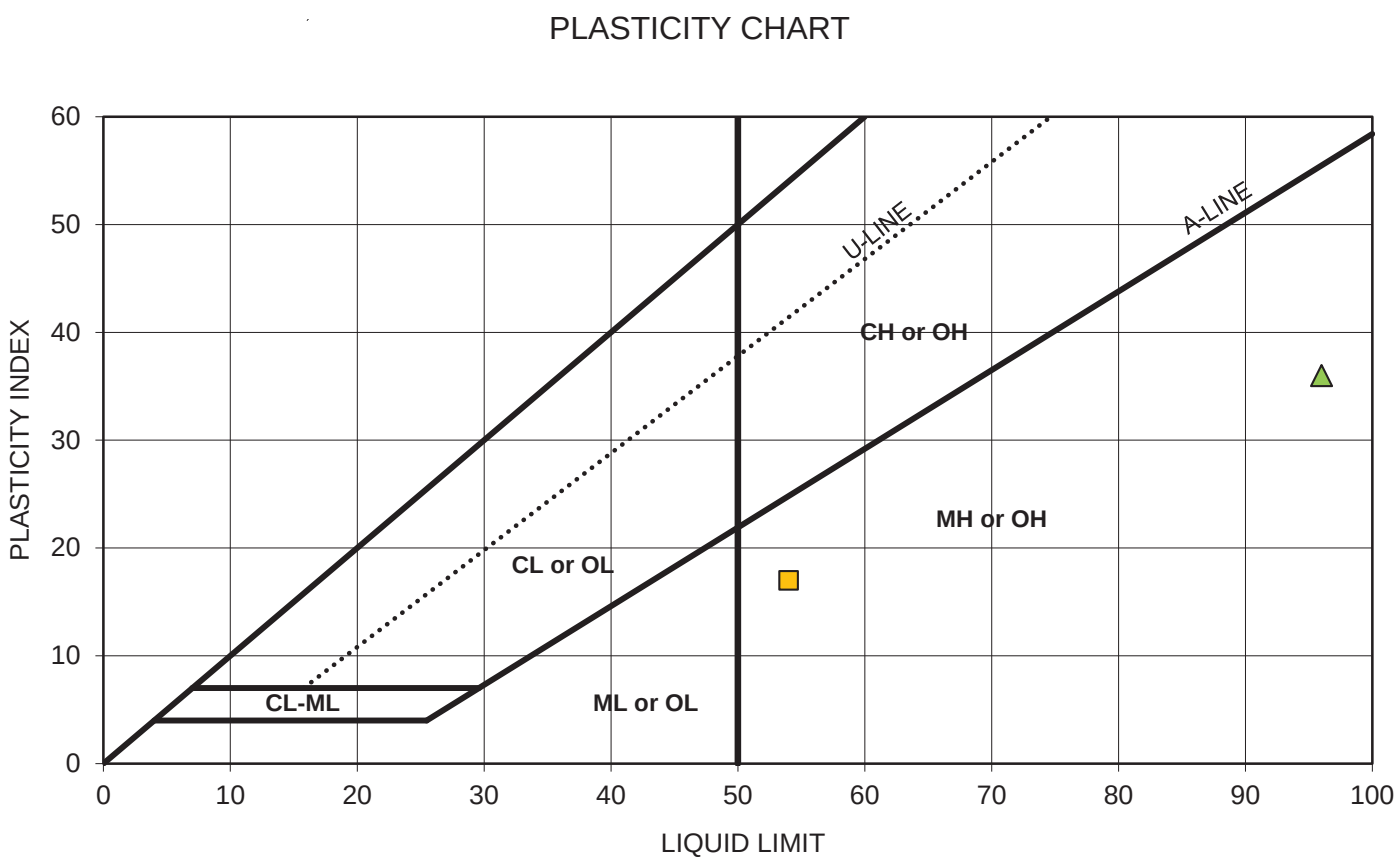

Symbol	Sample ID	Sample Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	USCS	Soil Description
	B-5 S-11	55	62	NA	NA	ML	Silt (non-plastic)
■	B-6 S-3	15	65	54	17	MH	Elastic silt with trace fine sand
▲	B-10 S-8	40	91	96	36	MH	Elastic silt with wood particles
	B-10 S-10	50	60	NA	NA	ML	Silt (non-plastic)

Atterberg Limits Test Results

North Mist Expansion
Columbia County, Oregon

GeoEngineers

Figure B-2

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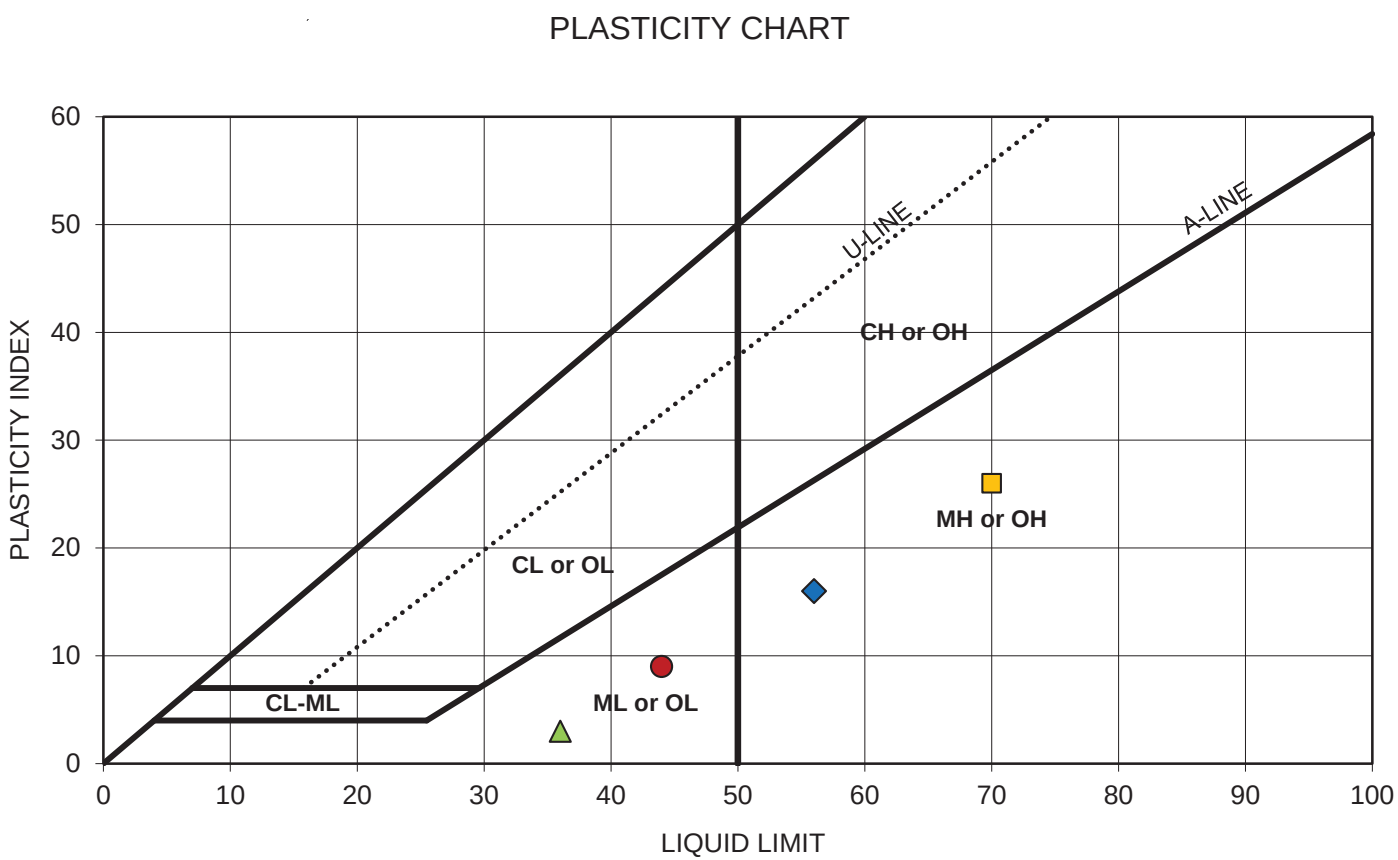

Symbol	Sample ID	Sample Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	USCS	Soil Description
◆	B-10 S-18	90	57	56	16	MH	Elastic silt with trace sand
■	B-10 S-23	125	57	70	26	MH	Elastic silt with trace sand and wood fragments
▲	B-10 S-29	185	43	36	3	ML	Silt
●	B-10 S-31	205	42	44	9	ML	Silt

Atterberg Limits Test Results

North Mist Expansion
Columbia County, Oregon

GeoEngineers

Figure B-3

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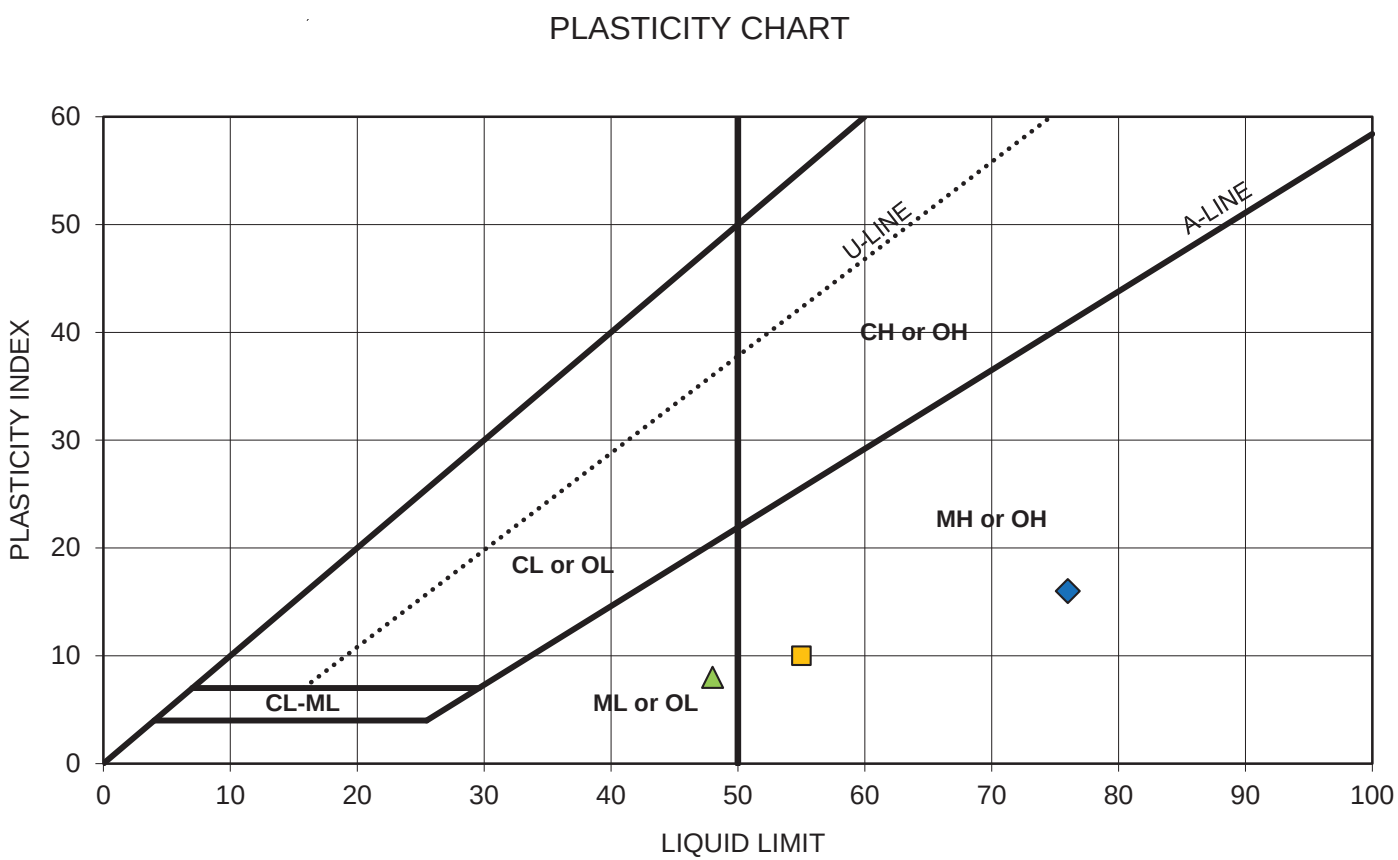


Symbol	Sample ID	Sample Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	USCS	Soil Description
◆	B-11 S-6	30	76	76	16	MH	Elastic Silt with trace sand and organics
■	B-11 S-9	45	57	55	10	MH	Elastic Silt with trace wood fragments
▲	B-11 S-10	50	64	48	8	ML	Silt with trace sand
	B-11 S-15	75	59	NA	NA	ML	Silt (non-plastic)

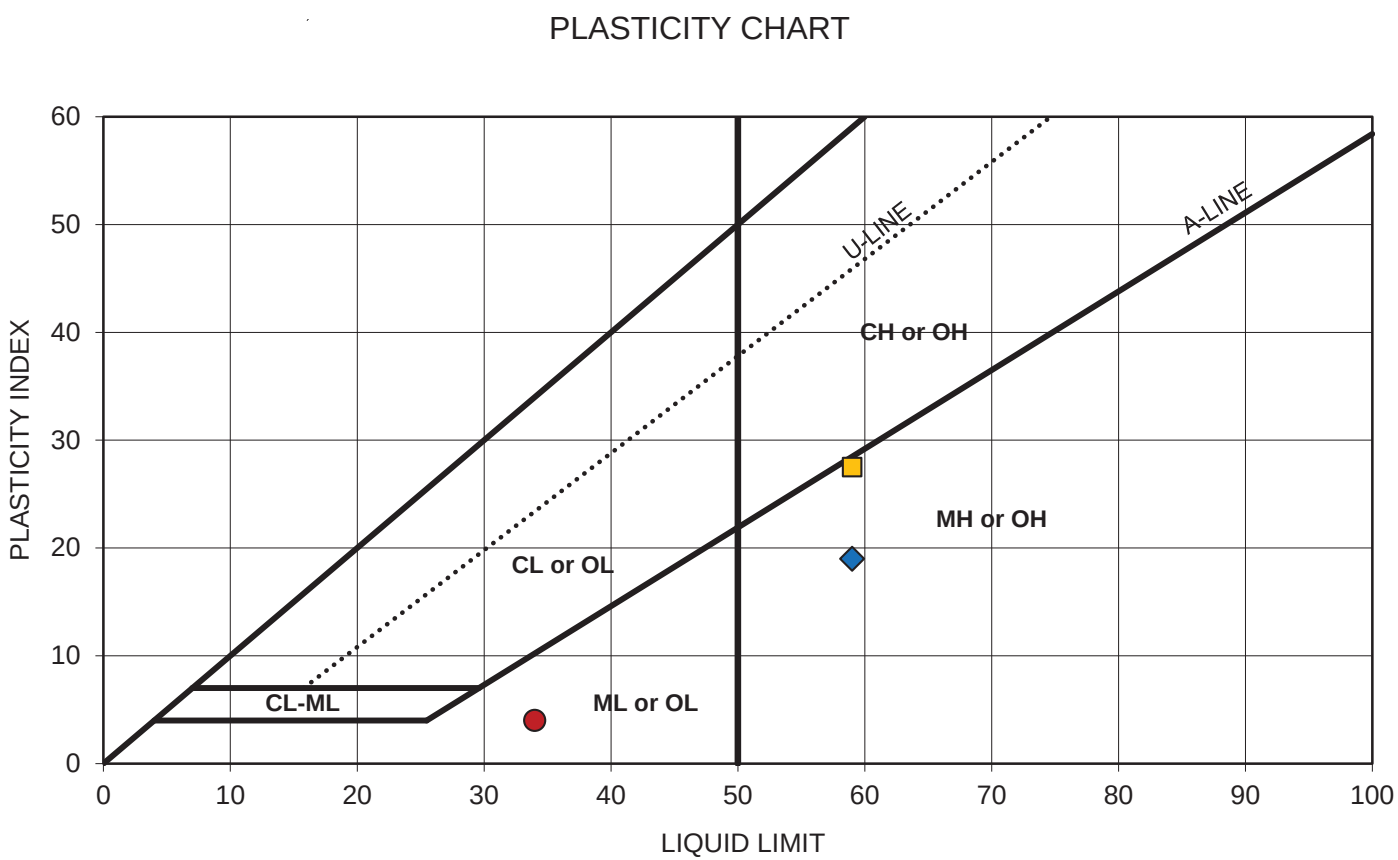
Atterberg Limits Test Results

North Mist Expansion
Columbia County, Oregon

GeoEngineers

Figure B-4

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed, and should not be interpreted as representative of any other samples obtained at other times, depths or locations, or generated by separate operations or processes.



Symbol	Sample ID	Sample Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	USCS	Soil Description
◆	B-12 S-7	35	60	59	19	MH	Elastic silt with fine sand
■	B-13 S-1	5	59	59	28	MH	Elastic silt with trace fine sand and trace organics
▲	B-13 S-9	45	51	NA	NA	ML	Silt (non-plastic) with some fine sand
●	B-13 S-14	70	42	34	4	ML	Fine sandy silt

Atterberg Limits Test Results

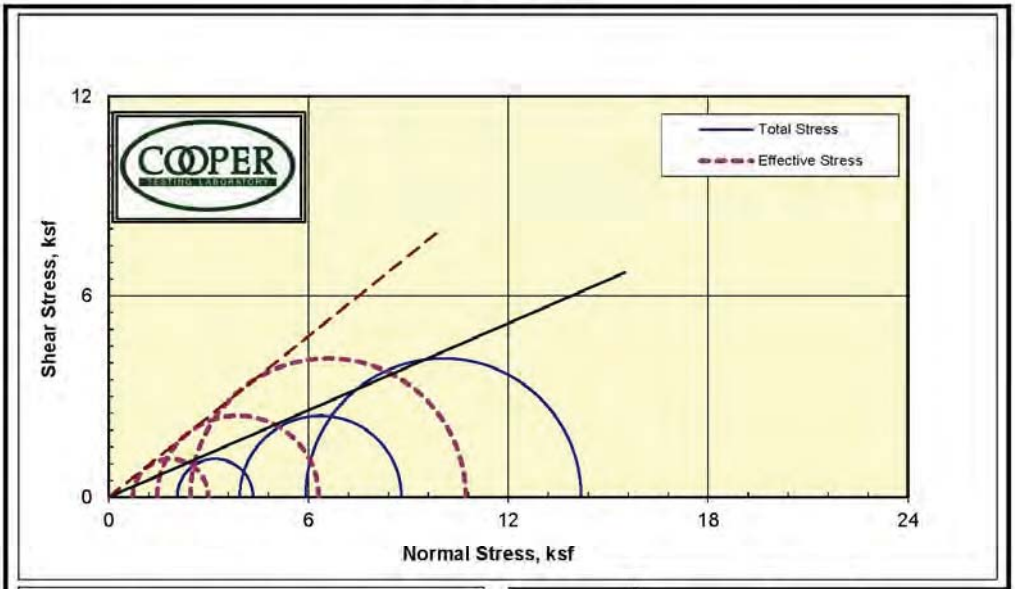
North Mist Expansion
Columbia County, Oregon

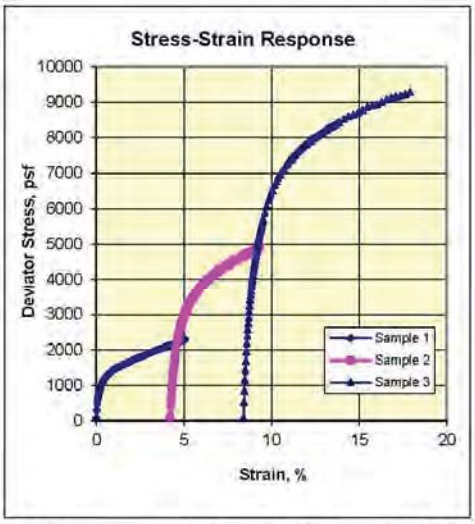
GeoEngineers

Figure B-5

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed, and should not be interpreted as representative of any other samples obtained at other times, depths or locations, or generated by separate operations or processes.

Triaxial Consolidated Undrained with Pore Pressure
(ASTM D4767m)





Stage	1	2	3
MC, %	51.9		
Dry Dens., pcf.	68.9		
Sat. %	96.9		
Void Ratio	1.447		
Diameter in	2.40		
Height, in	4.85		
	Final		
MC, %	42.6	40.6	39.2
Dry Dens., pcf.	69.3	70.8	72.0
Sat. %	100.0	100.0	100.0
Void Ratio	1.150	1.096	1.059
Diameter, in	2.40	2.42	2.44
Height, in	4.80	4.65	4.47
Cell, psi	73.3	87.2	100.9
BP, psi	59.0	59.9	59.8
	Effective Stresses At:		
Strain, %	5.0	5.0	5.0
Deviator ksf	2.274	4.856	8.278
Excess PP	1.342	2.481	3.463
Sigma 1	2.990	6.308	10.725
Sigma 3	0.716	1.451	2.447
P, ksf	1.853	3.879	6.586
Q, ksf	1.137	2.428	4.139
Stress Ratio	4.174	4.346	4.383
Rate in/min	0.0005	0.0005	0.0005

Total C	0	Effective C	0.0
Total Phi	23.4	Effective Phi	38.7

©

Job No.: 880-003 **Date:** 4/10/2015
Client: GeoEngineers BY:DC
Project: 6024-157-03
Sample: B-11;S10 @ 50' Dark Grayish Brown SILT (slightly plastic)
Remarks: ** Staged Test ** Strengths at 5% strain

Triaxial Test Result

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure B-6

APPENDIX C
HDD-1

APPENDIX C
HDD-1

General

This appendix provides the HDD design recommendations for proposed HDD-1 along the North Mist Pipeline alignment located in Columbia County, Oregon. The HDD site plan and profile is provided in Figure C-1 and C-2, respectively, of this appendix. A full size construction drawing showing the design profile is provided in the attached Drawing No. HDD-1. The design drawing includes the necessary geometric information required to complete the pilot hole.

Project Description and Basis of Design

The proposed HDD installation will be a 24-inch-diameter steel pipeline crossing Highway 30 and an adjacent railroad track. The proposed pipeline alignment is oriented northeast-southwest (entry to exit), as shown in Figure C-1. The HDD design was completed based on the parameters presented below in Table C-1.

TABLE C-1. BASIS OF DESIGN FOR THE 24-INCH-DIAMETER HDD-1

Carrier Pipe Data	Design Parameter
Carrier Pipe Specifications	24 inches x 0.500 inches w.t.[1] API-5L X-52 steel pipe
Horizontal Crossing Length	1,957 feet
Maximum Allowable Operating Pressure	809 psig[2]
Maximum Operating Temperature	55 degrees F
Assumed Tie-In Temperature	55 degrees F

Notes:
[1] w.t. – wall thickness
[2] psig – pounds per square inch gauge

SITE DESCRIPTION

Surface Conditions

The HDD alignment starts within the Columbia River Valley and extends southwest up the very steep western valley wall, and terminating within the hillslopes to the west. Highway 30 and the adjacent railroad tracks are situated at the base of the valley wall at the western edge of the valley floor.

Specifically, the HDD starts on the southwest end of the proposed HDD alignment within a relatively flat agricultural field that is situated at approximate elevation zero feet above MSL. Approximately 450 feet southwest of the proposed entry point, the ground surface along the proposed alignment slopes upward at approximately 50 percent to an existing railroad track that is situated on a relatively flat fill bench at approximate elevation 20 feet MSL. On the southwest side of the railroad track, the ground surface slopes upward again at approximately 30 percent to meet the paved surface of Highway 30, which is located at an elevation of approximately 25 feet MSL. Southwest of Highway 30, the ground surface slopes very steeply upward to an elevation of approximately 180 feet MSL, and then slopes upward at approximately seven to eight percent across gently rolling terrain to the proposed exit point, which is located within Palm Hill Road at an elevation of approximately 262 feet MSL. Palm Hill Road is a double lane paved roadway.

Near the proposed exit point, the ground surface on the west side of Palm Hill Road slopes very steeply upward. The ground surface on the east side of Palm Hill Road slopes gently downward to a small creek. Hence, without significant grading, a workspace situated in this area would have to be completely within Palm Hill Road.

During our reconnaissance, we observed basalt in an outcrop on the southwest side of Highway 30 near the alignment. The basalt was very fine grained, medium hard to hard and appeared to be closely to moderately closely fractured.

Subsurface Conditions

We completed three borings (B-3, B-17 and B-19) along the proposed HDD alignment at the locations shown in Figure C-1. Subsurface conditions encountered in each boring are described in more detail below.

Boring B-3 was completed about 200 feet north of Highway 30, and about 650 feet east of the proposed alignment. This boring was completed during a previous phase of the project when the proposed alignment was located east of the currently proposed alignment. Boring B-3 encountered approximately 3 feet of silt overlying very soft organic silt that extended to approximately 19 feet bgs. Below 19 feet bgs, the boring encountered approximately 15 feet of very soft to medium stiff sandy silt with organics overlying loose sand to roughly 44 feet bgs. Soft to medium stiff silt was encountered between about 44 feet bgs and 58 feet bgs. Below 58 feet bgs, the boring encountered very soft to soft lean clay with occasional wood pieces to 71.5 feet bgs, the maximum depth explored.

Boring B-17 was completed on Palm Hill Road, approximately 300 feet northeast of the proposed exit point. Beneath the asphaltic pavement and associated base rock, boring B-17 encountered approximately 8 feet of fill consisting of larger diameter quarry run aggregate (estimated to be 4-inch-diameter angular aggregate) and wood overlying medium dense to very dense sand with occasional layers of shell fragments that extended to 73 feet bgs. Below 73 feet bgs the boring encountered fresh, medium hard, closely fractured basalt that extended to 115 feet bgs, the maximum depth explored. There was a basaltic breccia interbedded with the basalt between 98 and 106 feet bgs. Rock Quality Designation (RQD) values of the basalt were highly variable, ranging between zero and 96 percent. However, the RQD values averaged about 40 percent. While drilling B-17 through the sand within the upper portion of the soil profile, the boring caved on two occasions, which required re-drilling and installation of casing to stabilize the bore hole. It is not clear if the fill materials or the underlying sand caved in while drilling the boring.

Boring B-19 was completed in the southern most travel lane of Highway 30 (eastbound traffic), approximately 140 feet west of the proposed alignment. Beneath the asphaltic pavement and associated base rock, boring B-17 encountered approximately 21 feet of very dense gravel fill overlying generally slightly weathered to fresh, closely fractured and hard basalt with a couple slightly weathered, closely fractured and medium hard breccia layers. RQD values of the basalt were variable, generally ranging between about 50 and 100 percent. RQD values of the breccia ranged between 11 and 73 percent.

Subsurface conditions encountered in our borings are shown graphically in Figure C-1, and are described in detail in the boring logs in Appendix A.

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE EVALUATION

Model Input Parameters

The HDD geometry used for our analyses of HDD-1 is shown in Figures C-1 and C-2, and in the HDD Design Drawing HDD-1 in this appendix. Based on the results of the exploration program and subsequent laboratory-testing program, the soil properties used in the evaluation are presented in Table C-2 below.

TABLE C-2. ESTIMATED SOIL PROPERTIES

Soil Description	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Very Soft Organic Silt	90	0	50
Very Soft Silt	100	0	100
Loose Silty Sand	110	26	0
Medium Stiff Silt with Sand	105	10	350
Medium Stiff Lean Clay	100	0	500
Loose Gravel Fill	110	26	0
Dense to Very Dense Sand	125	34	0
Medium Hard Basalt/Breccia	144	36	4,000

Based on available information and common HDD construction procedures, the tool dimensions and rheological properties used in the evaluation are summarized in Table C-3. Because these parameters are dependent upon the HDD contractor's means and methods, the hydraulic fracture and drilling fluid surface release evaluation should be refined during construction of the HDD installations.

TABLE C-3. ESTIMATED TOOL DIMENSIONS AND RHEOLOGICAL PROPERTIES

Parameter	Value
Pilot Hole Bit Diameter	12.25 inches
Drill Pipe Diameter	6.625 inches
Drilling Fluid Weight	9.5 ppg
Plastic Viscosity	18 CP
Yield Point	35 lb/100 sf

Notes:
ppg = pounds per gallon; CP = centipoise; lb/100 sf = pounds per 100 square feet

Results of Hydraulic Fracture and Drilling Fluid Surface Release Evaluation

The results of the hydraulic fracture evaluation are presented in Figures C-3 and C-4. Figure C-3 shows the calculated formation limit pressure (green line) and the estimated drilling fluid pressure shown as the red line, which represents the drilling fluid pressure along the HDD profile based on the anticipated drilling fluid properties shown in Table C-3.

When evaluating the risk of hydraulic fracture and drilling fluid surface releases, the analysis computes two types of factors of safety. These are:

- Factor of Safety against localized hydraulic fracture; and
- Factor of Safety against drilling fluid surface release.

Local Hydraulic Fracture: The factor of safety against hydraulic fracture is the ratio of the formation limit pressure to the estimated drilling fluid pressure along the profile, shown as the green line in Figure C-4. This represents the factor of safety against hydraulic fracture of the soil immediately surrounding the HDD profile and is a localized condition.

Drilling Fluid Surface Release: The factors of safety against drilling fluid surface release considers the strength of the soil column above the HDD profile that resists drilling fluid migrating to the ground surface. It is computed by comparing the formation limit pressure of the soil units above a specific location along the planned HDD alignment to the anticipated drilling fluid pressure at the same location. The factors of safety against drilling fluid surface releases are shown in Figure C-4 at selected points shown as red triangles.

The model indicates that the risk of localized hydraulic fracture is generally low except within about 100 feet of the entry point, adjacent to, and north of the railroad tracks where the risk of localized hydraulic fracture is high to very high.

As shown by the red triangles in Figure C-4, the factors of safety against drilling fluid surface releases are generally greater than 2.0 (low risk), but drop to about 1.0 within 100 feet of the entry point where the risk is very high, as is expected during a typical HDD installation. The factors of safety were not calculated beyond about pipeline station 398+00 because at this point and to the southwest, the HDD profile mostly passes through basalt bedrock, where the formation limit pressures are extremely high, and the corresponding factors of safety would also be extremely high. In addition, once the HDD profile passes beyond the drilling fluid equilibrium point at approximate station 390+80, without a blockage in the hole there is theoretically zero drilling fluid pressure in the hole and calculation of a factor of safety against drilling fluid release is not applicable.

INSTALLATION LOADS AND OPERATING STRESSES

Installation Loads

The analyses of installation loads and operational stresses are based on the carrier pipe being installed along the designed drill path using the BMPs of the HDD industry. The addition of water into the carrier pipe is the standard method that contractors typically use to control buoyancy of the carrier pipe during the installation procedure. The proposed 24-inch-diameter carrier pipe will be positively buoyant in the anticipated drilling fluid weights. The HDD Contractor may choose to add water to the carrier pipe to try to achieve neutral buoyancy during pullback and reduce the required pull force during installation of the carrier pipe. Thus, our analyses include a range of cases with differing levels of buoyancy control. The following table presents a summary of the calculated installation loads for the HDD.

TABLE C-4. INSTALLATION LOADS FOR THE 24-INCH-DIAMETER HDD-1[1]

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Effective Pipe Weight[2] (lb/ft)	Pullback Force[3] (lb)
9.5	Empty	-97	207,000
9.5	Full	83	110,000
12	Empty	-156	267,000
12	Full	24	93,000
10.5	Neutral	0	105,000

Notes:
[1] See the HDD Design Summary and Calculations summaries provided in this appendix for detailed calculations.
[2] Negative values indicate upward force (positive buoyancy).
[3] Assumes a fully open drilled hole.
[4] Assumes a minimum pipeline radius of 1,900 feet.

Because the HDD contractor might utilize a relatively large HDD drill rig to complete the installation, the drill rig may have a pullback capacity capable of causing damage to the carrier pipe during installation. While the estimated installation forces provided in Table C-4 suggest that the pullback forces should be less than 267,000 pounds, improper preparation of the hole prior to pullback operations, or delays during pullback operations may cause pullback forces to exceed those estimated in the calculations.

Operating Stresses

For our operating stresses analysis, the installation and operating temperatures were assumed to be 55 degrees Fahrenheit. We can further evaluate different installation and operating temperatures, if requested. The following table presents a summary of the operating stresses for the carrier pipe specifications proposed for the HDD.

TABLE C-5. SUMMARY OF OPERATING STRESSES FOR THE 24-INCH-DIAMETER HDD-1

Stress Component	Stress (psi)	Percent SMYS[1] (%)	Maximum Allowable Percent SMYS (%)
Longitudinal Bending Stress	15,567	30	-
Hoop Stress	18,711	36	50[2]
Longitudinal Tensile Stress from Hoop Stress	5,613	11	-
Longitudinal Stress from Thermal Expansion	0	0	90[3]
Maximum Net Longitudinal Stress	21,181	41	90[4]
Maximum Shear Stress	14,333	28	45[5]
Maximum Combined Effective Stress	28,665	55	90[6]

Notes:
[1] Specified Minimum Yield Stress.
[2] Limited by design factor from DOT regulations, Title 49 CFR Part 192.111 for gas.
[3] Limited by Section 402.3.2 of ASME B31.4.
[4] Limited by Section 833.3 of ASME B31.8 for gas.
[5] Limited by Section 402.3.1 of ASME B31.4.
[6] Limited by Section 833.4 of ASME B31.8 for gas.

CONCLUSIONS AND RECOMMENDATIONS

Elevation Difference and Dry Hole Section of the HDD Profile

Because of the elevation difference between the northeast and southwest ends of the HDD, we recommend conducting HDD operations from the lower elevation, northeastern side of the HDD to facilitate drilling fluid returns and cuttings removal, and to prevent build-up of drilling fluid pressure from elevation head, which can increase the potential for drilling fluid surface releases and also cause a flush of drilling fluid upon exit of the pilot hole at the low end of the HDD.

The difference in elevation between the entry (low side) and exit point (high side) of approximately 260 vertical feet, which will cause the drilling fluid within the hole to drain to the point of equilibrium equal to the elevation of the entry point. Any section of the hole above the point of equilibrium is commonly referred to as "dry hole," and will not have the benefit of being filled with or supported by drilling fluid. This dry hole condition can increase the risk of hole collapse, groundwater intrusion and poor cuttings removal from the annulus which, in turn may lead to additional risks (ground settlement, loss of drilling fluid returns, hole flushing), and ultimately can prevent the successful installation of the carrier pipe. The dry hole section of HDD-1 extends from approximate station 390+80 to the exit point (approximately 810 feet along the HDD profile). Of that, approximately 300 feet is within the sand and fill overburden soils observed within the upper 73 feet of the soil profile in boring B-17, and the remainder is expected to be within basalt bedrock. There is a low risk of hole collapse within the portion of the dry hole segment located within basalt bedrock (approximate station 386+00 to 390+80). We expect there is a high risk of hole collapse along the dry hole segment within the overburden soils from approximate station 386+00 to the exit point. The potential is further elevated based on our observations of hole caving while drilling through the overburden soils in boring B-17.

In order to mitigate the potential for hole collapse, we recommend that the contractor install large diameter casing from the exit point to the contact with the underlying basalt bedrock. Based on boring B-17, we estimate that approximately 300 feet of casing will need to be installed to reach the basalt bedrock. The casing could be installed over the drill pipe after the pilot hole is completed through the upper fill and sand soils. The casing should remain in place through reaming, swabbing and pullback operations. Although the use of casing is critical to mitigate the potential for hole collapse, its use also introduces a number of challenges to the project including:

- The carrier pipe FBE and ARO coating could be damaged by the leading edge of the casing as the carrier pipe is pulled into it. However, in our experience, it is uncommon for damage to extend into the steel of the carrier pipe. The risk of potential damage can be reduced by placing a high-density polyethylene (HDPE) sleeve over the carrier pipe for pullback operations. Placing a HDPE sleeve over the carrier pipe would also mitigate potential cathodic protection issues between the carrier pipe and the casing if the casing could not be removed after construction. However, it is the contractor's responsibility to choose the appropriate means and methods to preserve the integrity of the carrier pipe and carrier pipe coating during pullback operations.
- The casing may be difficult to be removed after construction. In our experience, rotating the casing on a daily basis can help reduce the force required for extraction.

Because of the length of casing and potential difficulties removing the casing after construction, the welds between each joint of steel casing should be conducted by a certified welder familiar with welding and fabricating carrier pipe strings.

Cuttings Removal

Drilling in the basalt bedrock may create gravel-sized cuttings that can be difficult to remove from the lowest section of the reamed hole during construction. Inadequate removal of cuttings could result in failure of the HDD. If relatively high pull and rotary torque forces are observed in the lowest section of the HDD profile while conducting swab passes prior to pull back, they may indicate an accumulation of cuttings in this area. If this is the case during construction, the contractor should consider over-sized reaming passes or sending a "junk basket" downhole to removing cuttings from the lowest section of the HDD profile and facilitate successful installation of the carrier pipe.

Drilling Fluid Surface Release

Based on our analyses, there is a low risk of drilling fluid surface releases along the majority of HDD-1. Although, there is a relatively high potential for drilling fluid surface release within approximately 100 feet of the entry point where the HDD is passing through very soft organic silt and silt within the upper 35 feet.

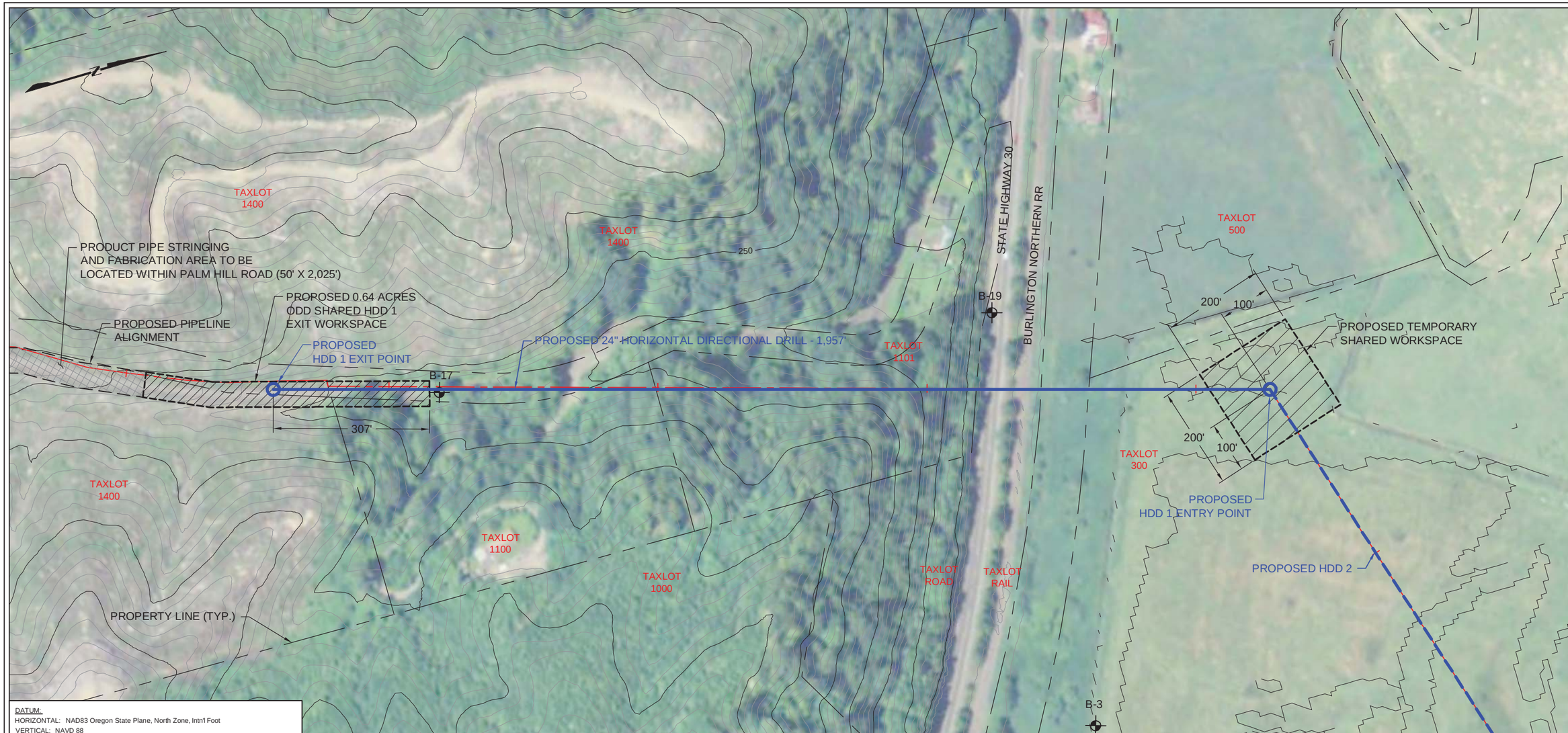
We recommend that the contractor establish a contingency and mitigation plan in the event that drilling fluid surface releases occur; these plans should be reviewed and approved by the project team prior to the start of construction.

It will be extremely important for the contractor to maintain drilling fluid returns at all times, and monitor the highway and railroad tracks for drilling fluid surface returns and settlement during construction. The contractor should stage an employee near the railroad tracks and Highway 30 to visually observe the surface for indications of drilling fluid releases at all times during construction.

Workspace Considerations

The proposed exit workspace and pipe stringing fabrication area are located within Palm Hill Road. Near the proposed exit point, there is a very steep cut slope on the west side of Palm Hill Road, and a ravine that confines a small stream on the east side of the road. These topographic features limit the available workspace to within Palm Hill Road, an area that is less than typically desired. Therefore, arrangements will have to be made to close Palm Hill Road during construction to allow for staging of exit side equipment. Residential traffic in the area could be routed to Highway 30 or Highway 47 southwest of the exit workspace during construction.

The pipe stringing and fabrication workspace is also situated within Palm Hill Road. The carrier pipe could be fabricated within one lane of Palm Hill Road, but partial two-lane closures will be required to situate pipe handling and welding equipment adjacent to the carrier pipe during construction.



NOT FOR CONSTRUCTION:
THE HDD DESIGN DRAWING IS INCLUDED AS HDD 1 IN APPENDIX C.

PLAN
200' 0 200'
SCALE IN FEET

Major Contour Interval = 50'
Minor Contour Interval = 10'

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Refer to the borings logs in the accompanying report for more detailed soil descriptions.
4. GeoEngineers, Inc. has not verified the field location of the existing utilities.

Reference: Ground surface DEM (1/9 arc second) and aerial photos downloaded from http://nationalmap.gov.
Base file provided by NorthWest Natural.

LEGEND:

Boring Location

SITE PLAN
HDD 1

NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

GEOENGINEERS

FIGURE C-1

BCR : BTL

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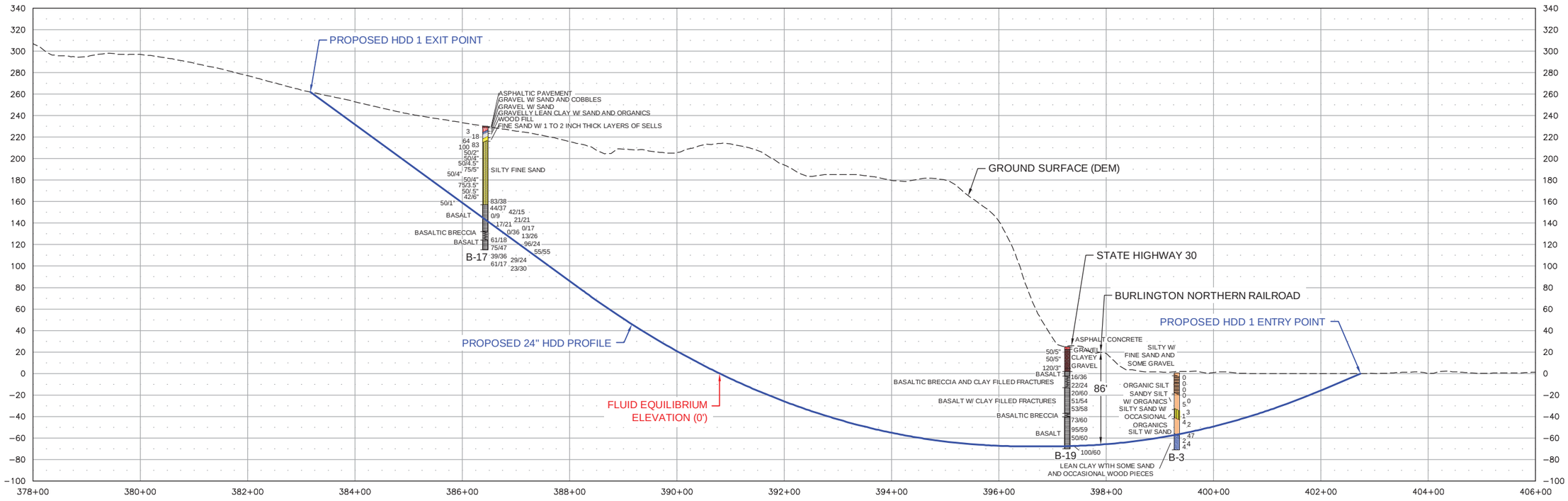

NOT FOR CONSTRUCTION:
THE HDD DESIGN DRAWING IS INCLUDED AS HDD 1 IN APPENDIX C.

PROFILE

200' 0 200'
HORIZONTAL SCALE IN FEET

100' 0 100'
VERTICAL SCALE IN FEET

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Refer to the borings logs in the accompanying report for more detailed soil descriptions.
4. GeoEngineers, Inc. has not verified the field location of the existing utilities.

Reference: Ground surface DEM (1/9 arc second) and aerial photos downloaded from http://nationalmap.gov.
Base file provided by NorthWest Natural.

LEGEND:

TYPE OF SOIL — SPT (N)

TYPE OF ROCK — RQD/%REC

PROFILE
HDD 1

NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

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FIGURE C-2

BCR : BTL

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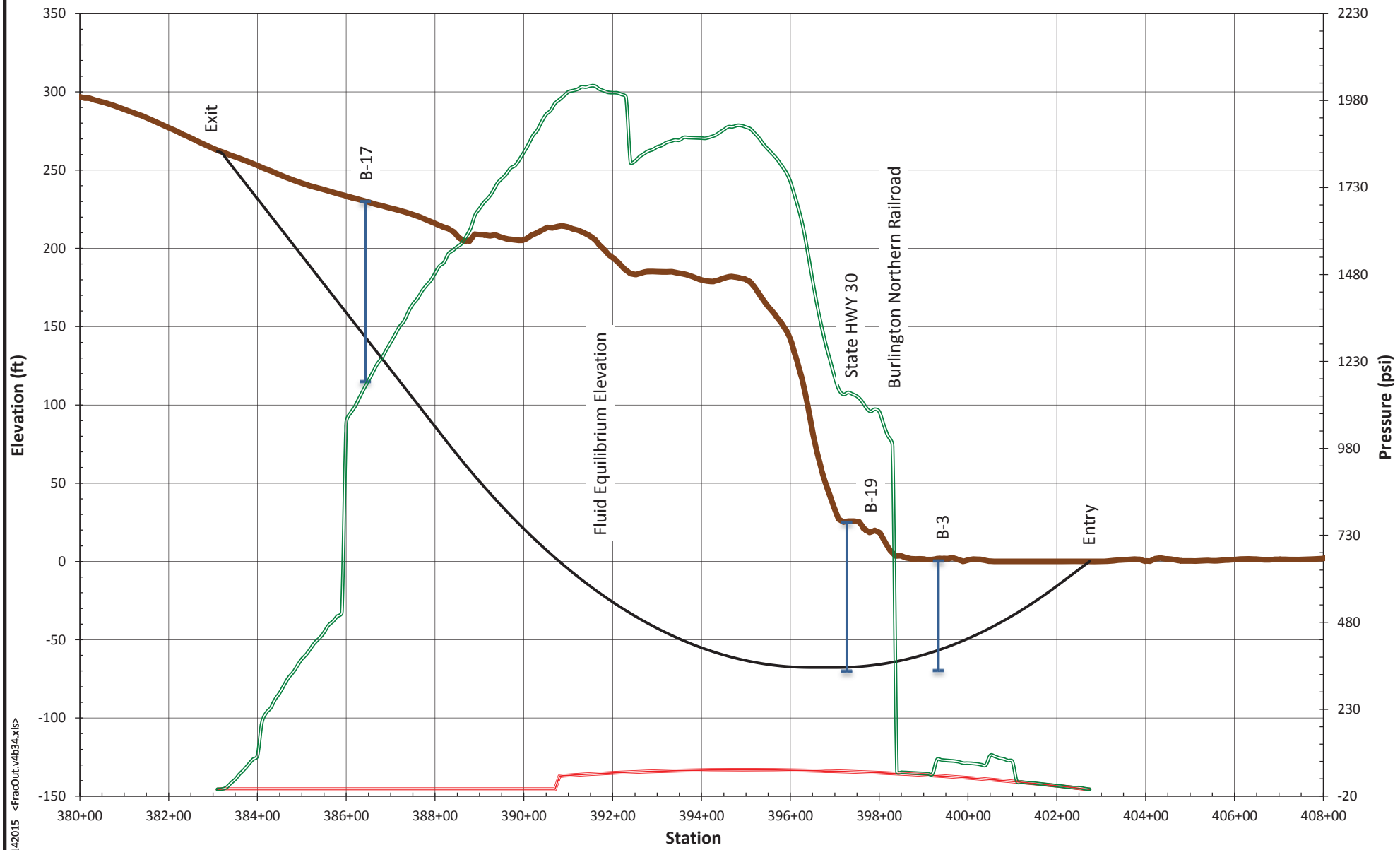
NW NATURAL - NORTH MIST PIPELINE HDD 1



Crossing Length (ft)	1957
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	18
Yield Point (lb/100 ft)	35

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Estimated Annular Drilliing Fluid Pressure (psi) for Pilot Hole
- Formation Limit Pressure (psi)

ESTIMATED ANNULAR DRILLING FLUID AND FORMATION LIMIT PRESSURES

NW NATURAL - NORTH MIST PIPELINE HDD 1

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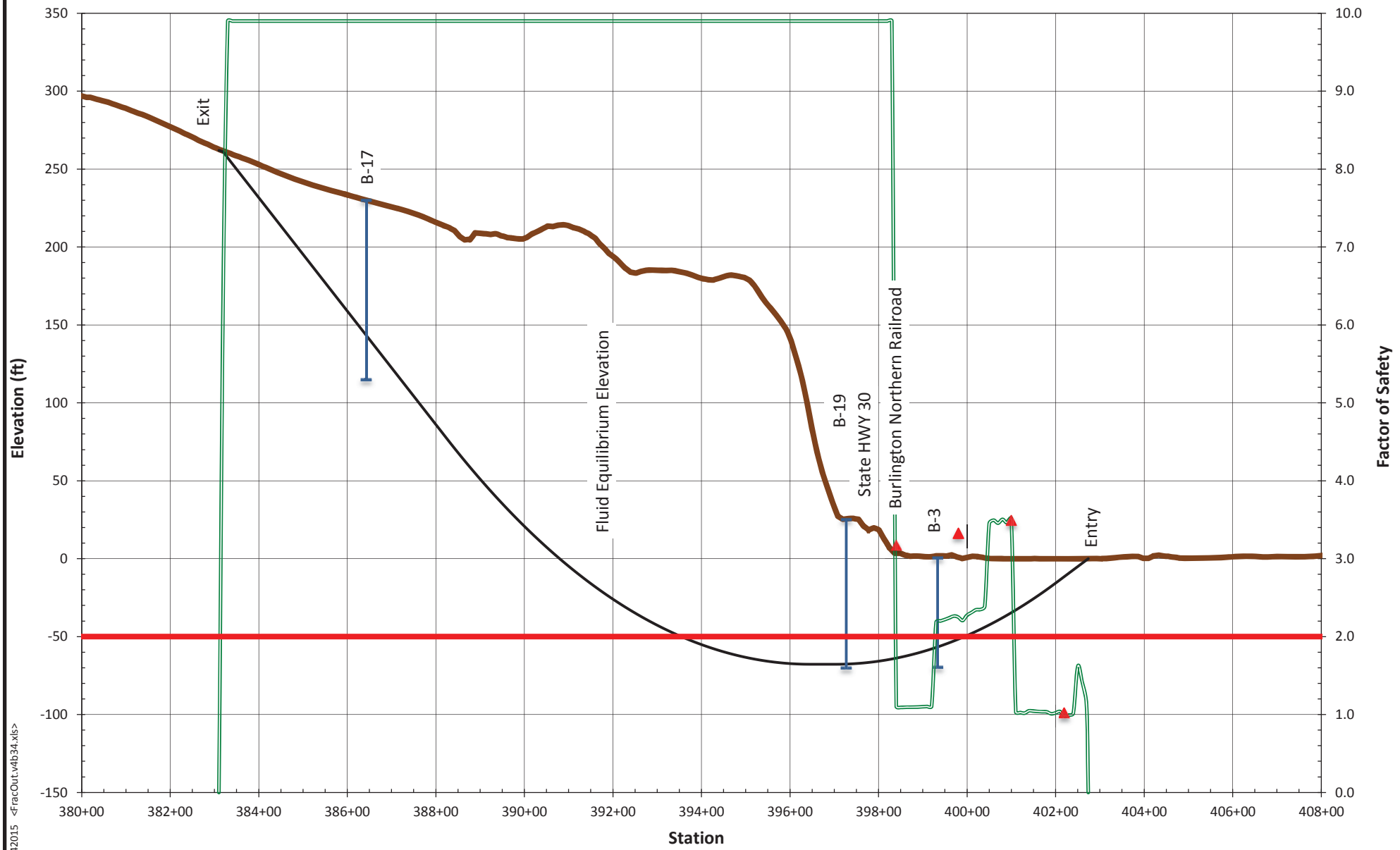
FIGURE C-3

06024-157-03 JAH/AES 09142015 <FracOut.v4b34.xls>

NW NATURAL - NORTH MIST PIPELINE HDD 1



Crossing Length (ft)	1957
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	18
Yield Point (lb/100 ft)	35

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Drilling Fluid Surface Release Factor of Safety for Pilot Hole
- Hydraulic Fracture Factor of Safety for Pilot Hole
- Factor of Safety = 2

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE FACTORS OF SAFETY

NW NATURAL - NORTH MIST PIPELINE HDD 1

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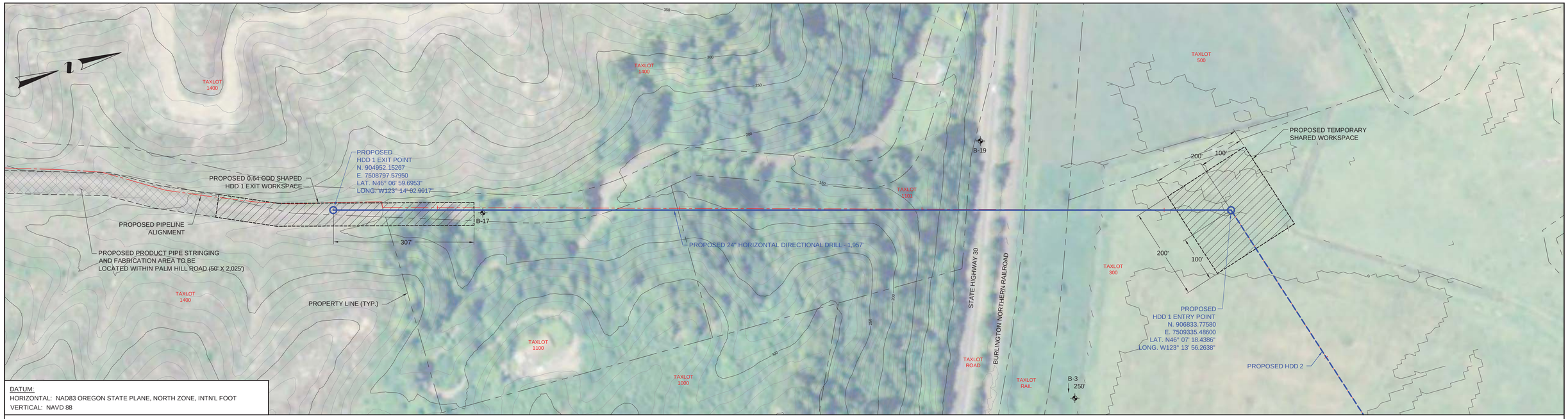
FIGURE C-4

06024-157-03 JAH/AES 09142015 <FracOut.v4b34.xls>

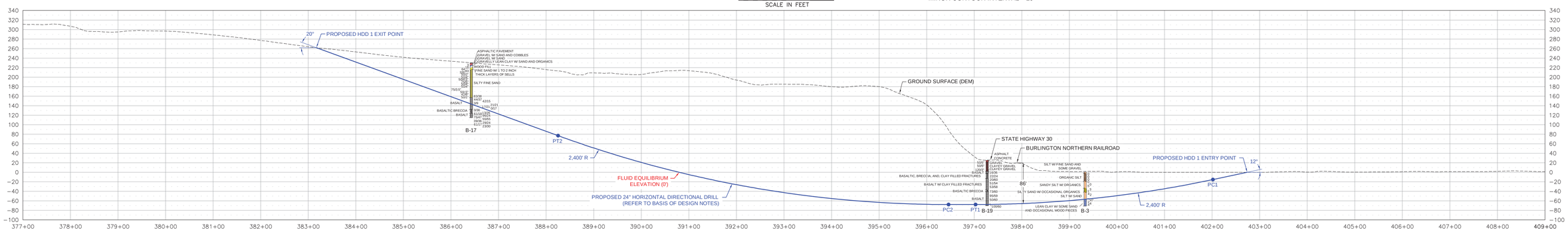


DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

100' 0 100'
SCALE IN FEET

MAJOR CONTOUR INTERVAL = 50'
MINOR CONTOUR INTERVAL = 10'

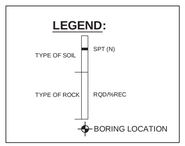


DIRECTIONAL DRILL DATA HDD 1		
DESCRIPTION	STATION * (FT)	ELEVATION (FT)
ENTRY @ 12°	402+73.80	0.02
P C 1 (12.00° @ 2,400 FT R.)	402+01.77	-15.30
P T 1	397+02.78	-67.74
P C 2 (20.00° @ 2,400 FT R.)	396+45.94	-67.74
P T 2	388+25.09	77.00
* EXIT @ 20°	383+16.80	262.00
HORIZONTAL DISTANCE = 1,957.00 FT		
DIRECTIONAL DRILL PIPE LENGTH = 2,011.81 FT		

* THE STATIONING IS BASED ON AN ARBITRARY REFERENCE POINT

RECOMMENDED TOLERANCES	
ITEM	TOLERANCE
PILOT HOLE ENTRY ANGLE	INCREASE ANGLE UP TO 1° (STEEPER), BUT NO DECREASE IN ANGLE ALLOWED.
PILOT HOLE ENTRY LOCATION	AS PER COORDINATES PROVIDED BY COMPANY WITH NO CHANGES WITHOUT COMPANY APPROVAL.
PILOT HOLE EXIT ANGLE	INCREASE ANGLE UP TO 1° (STEEPER) OR DECREASE UP TO 2° (FLATTER).
PILOT HOLE EXIT LOCATION	UP TO 20 FEET BEYOND OR 10 FEET SHORT OF THE EXIT STAKE. BETWEEN 5 FEET LEFT AND 5 FEET RIGHT OF CENTERLINE.
PILOT HOLE DEPTH	UP TO 2 FEET ABOVE THE DESIGN DRILL PROFILE ALLOWED. UP TO 10 FEET BELOW THE DESIGN DRILL PROFILE ALLOWED.
PILOT HOLE ALIGNMENT	SHALL REMAIN WITHIN 5 FEET LEFT OR RIGHT OF THE HDD ALIGNMENT.

LEGEND:



PROFILE

100' 0 100'
HORIZONTAL SCALE IN FEET
100' 0 100'
VERTICAL SCALE IN FEET

NOTES

1. ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT-OF-WAY OR FROM APPROVED ACCESS ROADS.
2. WORK SPACE: MAXIMUM WORK SPACE LIMITS ARE DEPICTED. RESTRICT CLEARING TO THE WORK SPACE INDICATED AT THE ENTRY AND EXIT POINTS AND PRODUCT PIPE STRINGING AND FABRICATION AREA ALONG THE CONSTRUCTION RIGHT-OF-WAY. CLEARING BETWEEN THE ENTRY AND EXIT POINTS REQUIRES PRIOR APPROVAL FROM THE ENVIRONMENTAL INSPECTOR AND IS LIMITED TO THE AMOUNT NECESSARY TO STRING SURVEY WIRES AND INSTALL PUMPS AND PIPING TO OBTAIN WATER (WHERE APPROVED).
3. WATER SOURCE: DRILL WATER AND HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE.
4. HYDROSTATIC TEST: PRE-INSTALLATION AND POST-INSTALLATION HYDROSTATIC TESTS SHALL BE CONDUCTED IN ACCORDANCE WITH THE HYDROSTATIC TEST PLAN. TEST WATER SHALL BE SAMPLED AND TESTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE TEST WATER SHALL BE DISCHARGED IN AN UPLAND AREA INTO AN EROSION CONTROL STRUCTURE OF STRAW BALES AND/OR SILT FENCES, GEOTEXTILE FILTER BAG, OR COLLECTED IN A TRUCK AND HAULED TO AN APPROVED DISPOSAL SITE. UPON COMPLETION OF DEWATERING AND DRYING, A CALIPER PIG SURVEY SHALL BE COMPLETED IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
5. SPILL-PREVENTION: REFUELING OF ALL EQUIPMENT SHALL BE COMPLETED IN ACCORDANCE WITH THE SPCC PLAN.
6. EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE APPROVED CONSTRUCTION RIGHT-OF-WAY AT THE DRILL EXIT POINT AS SHOWN. AFTER THE PILOT HOLE IS COMPLETE, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO NORTHWEST NATURAL FOR APPROVAL. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULL BACK.
8. DRILLING FLUID DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING FLUID AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING FLUID WHICH INADVERTENTLY SURFACES AT POINTS OTHER THAN THE ENTRY OR EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.
9. CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN THE CLEAN-UP AND RESTORATION REQUIREMENTS.
10. GEOTECHNICAL DATA: BORE HOLES ARE OFFSET FROM THE PIPELINE CENTERLINE AS SHOWN ON THE PLAN VIEW. THE GEOTECHNICAL INFORMATION PROVIDED ON THIS DRAWING IS A GENERAL SUMMARY. REFER TO THE APPLICABLE GEOTECHNICAL REPORT IN THE CONTRACT DOCUMENTS FOR MORE DETAILED INFORMATION.
11. IF THE TERRAIN ALLOWS AND ACCESS IS PERMITTED, CONTRACTOR SHALL UTILIZE LOW GROUND PRESSURE EQUIPMENT OR OTHER EQUIPMENT APPROVED BY OWNER, TO FACILITATE CONTAINMENT AND CLEAN-UP OF ANY INADVERTENT RETURNS THAT OCCUR DURING THE HDD INSTALLATION PROCESS.
12. THE MINIMUM ALLOWABLE THREE JOINT RADIUS SHALL NOT BE LESS THAN 1,900 FEET.
13. AERIAL PHOTOS AND GROUND SURFACE DEM (1/9 ARC SECOND) DOWNLOADED FROM HTTP://VIEWER.NATIONALMAP.GOV/VIEWER/. BASE FILES PROVIDED BY NORTHWEST NATURAL.
14. CONTRACTOR IS RESPONSIBLE FOR CALLING OREGON ONE-CALL AND PHYSICALLY LOCATING ALL UNDERGROUND UTILITIES PRIOR TO BEGINNING CONSTRUCTION. IF ANY UTILITY IS LOCATED WITHIN 15 FEET OF THE DESIGNED HDD PROFILE AND ALIGNMENT, CONTRACTOR SHALL OBTAIN APPROVAL FROM NORTHWEST NATURAL PRIOR TO INITIATING HDD OPERATIONS.
15. A SITE SPECIFIC SURVEY DOCUMENTING EXISTING UTILITIES HAS NOT BEEN CONDUCTED ALONG THE PROPOSED PIPELINE ALIGNMENT. A SITE SPECIFIC TOPOGRAPHIC AND UTILITY SURVEY SHOULD BE COMPLETED PRIOR TO FINAL ISSUANCE OF THESE PLANS. DURING CONSTRUCTION, IT IS THE CONTRACTORS RESPONSIBILITY TO IDENTIFY AND PROTECT ANY UTILITY THAT MAY BE AFFECTED BY THE HDD OPERATIONS.
16. CONTRACTOR SHALL ADHERE TO THE SPECIFICATIONS AND REQUIREMENTS PER NORTHWEST NATURAL SPECIFICATIONS, CONTRACT DOCUMENTS, AND SPECIAL PERMIT CONDITIONS, EXCEPT AS NOTED ON THIS DRAWING.

FINAL

BASIS OF DESIGN:

1. PRODUCT PIPE WILL CONSIST OF 24" O.D. X 0.500" W.T., API-5L X-52 PIPE WITH 14-16 MILS OF FUSION BONDED EPOXY (FBE) AND A MINIMUM OF 40 MILS OF ABRASION RESISTANT OVERLAY (ARO).
2. MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) = 809 psi

NOTE: THIS IS A FULL SIZE DRAWING THAT IS INTENDED TO BE PRINTED ON A 24" X 36" SHEET OF PAPER.

REFERENCE DRAWINGS	
DRAWING NO.	TITLE

REVISIONS						
NO.	DATE	BY	DESCRIPTION	W.O.NO.	CHK.	APP.
A	07/02/14	MWC	ISSUED AS DRAFT		BCR	TNH
B	04/20/15	BTL	ISSUED AS DRAFT (24-INCH REDESIGN)		BCR	TNH
C	09/15/15	BTL	ISSUED FOR FINAL		BCR	TNH

GEOENGINEERS
1200 NW NAITO PARKWAY, SUITE 180
PORTLAND, OREGON 97209
TELEPHONE: (503) 624-9274
FAX: (503) 620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
STATION 377+00 TO 409+00
HDD 1
COLUMBIA COUNTY, OREGON

NW Natural

DRAWN BY: MWC	DATE: 06/02/14	ISSUED FOR BID:	SCALE: AS NOTED
CHECKED BY: BCR	DATE: 06/02/14	ISSUED FOR CONSTRUCTION:	
APPROVED BY:	DATE:	DRAWING NUMBER: HDD 1	SHEET 1
WO:		TIME: 01:02 PM DATE: 09/09/15 PATH: P:\B0024157\04\CAD\HDD 1_FINAL Rev C.dwg	OF 1

HDD Design Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 1 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe Diameter = 24.000 in

Pipe Material = Steel

Yield Stress = 52,000 psi

Wall Thickness = 0.5 in

Assumed Installation Temp = 55 °F

Assumed Operating Temp= 55 °F

Design Factor = 0.5

MAOP = 809 psi

Drill Data Box

Point	Station (ft)	Elevation (ft)
ENTRY @ 12°	40,273.80	0.02
P C 1 (12.00° @ 2,400 ft R.)	40,201.77	-15.30
P T 1	39,702.78	-67.74
P C 2 (20.00° @ 2,400 ft R.)	39,645.94	-67.74
P T 2	38,825.09	77.00
EXIT @ 20°	38,316.80	262.00

Horizontal Alignment Length = 1,957.00 ft

Profile Segment Information

Segment Name	Segment Type	Segment Length (ft)
ENTRY TANGENT	Straight	73.64
ENTRY CURVE	Vertical Curve	502.65
BOTTOM TANGENT	Straight	56.85
EXIT CURVE	Vertical Curve	837.76
EXIT TANGENT	Straight	540.91

Pipe Length = 2,011.81 ft

Installation Load Summary

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Buoyancy Control (lb/ft)	Effective Pipe Weight (lb/ft)	Total Installation Force (lb)
9.50	Empty	0.00	-97.46	207,000
9.50	Full	180.04	82.58	110,000
12.00	Empty	0.00	-156.21	267,000
12.00	Full	180.04	23.83	93,000
10.50	Neutral	120.96	0.00	105,000

GeoEngineers

Minimum Radius Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 1 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters:

Pipe Diameter = 24.000 in **MAOP =** 809 psi **Factor of Safety =** 2.00

Wall Thickness = 0.500 in **SMYS =** 52,000 psi

D/t Ratio = 48.00 **Modulus of Elasticity (E) =** 2.96E+007 psi

Hoop Stress:

Calculated Hoop Stress = (MAOP * Pipe Diameter) / (2 * Wall Thickness) = 19,416 psi

Longitudinal Stress:

Calculated Longitudinal Stress = Hoop Stress / 2 = 9,708 psi

Allowable Stress:

Calculated Allowable Stress = SMYS / Factor of Safety = 26,000 psi

Bending Stress:

Calculated Bending Stress = Allowable Stress - Longitudinal Stress = 16,292 psi

Minimum Radius:

Calculated Minimum Radius = (E * Pipe Diameter) / (2 * Bending Stress) = 1,817 ft

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 1 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe diameter =	24.000 in	**Minimum Radius of Curvature =**	1,900 ft
Wall Thickness =	0.500 in	**Coefficient of Thermal Expansion =**	6.5E-06 in/in/°F
SMYS =	52,000 psi	**Assumed Installation Temperature =**	55 °F
MAOP =	809 psi	**Assumed Operating Temperature =**	55 °F
Poissons's Ratio =	0.30	**Temperature Derating Factor =**	1.00
Young's Modulus (E) =	2.96E+007 psi	**Groundwater Table Head =**	67.74 ft
Design Factor =	0.5		

Stress Analyses

Longitudinal Stress from Bending =	15,567 psi	
Percent SMYS =	29.94 %	
Hoop Stress =	18,711 psi	
Percent SMYS =	35.98 %	Limited by Design Factor (0.5) according to 49 CFR 192.111
Longitudinal Tensile Stress from Hoop Stress =	5,613 psi	
Percent SMYS =	10.80 %	
Longitudinal Stress from Thermal Expansion =	0 psi	
Percent SMYS =	0.00 %	Limited to 90% SMYS by ASME/ANSI B31.4 section 402.3.2
Net Longitudinal Stress (Comp. side of Curve) =	-9,954 psi	
Percent SMYS =	19.14 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Net Longitudinal Stress (Tension side of Curve) =	21,181 psi	
Percent SMYS =	40.73 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Maximum Shear Stress =	14,333 psi	
Percent SMYS =	27.56 %	Limited to 45% SMYS by ASME/ANSI B31.4 section 402.3.1
Combined BiaxialSress Check =	28,665 psi	
Percent SMYS =	55.13 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.4

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 1 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 1 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	2,012 ft
Moment of Inertia =	2,549 in^4
Pipe Face Area =	36.91 in^2
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft^3
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft^3
Pipe Exterior Volume =	3.14 ft^3/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft^3/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft^3
Effective Weight of Pipe =	-97.46 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	540.91 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	24,470 lb
Friction Force =	14,861 lb
Segment Weight =	18,029 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	57,360 lb
Cumulative Force =	**57,360 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,554 psi	
Cumulative Axial Stress =	1,554 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	2,191 psi	7,537 psi
Combined Stress =	0.0374	< 1.0
Total Stress =	0.0866	< 1.0

GeoEngineers

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	2,400 ft
Segment Type =	Vertical Curve	**Angle Turned =**	20.00 deg
Segment Length =	837.76 ft	**Center Displacement =**	36.46 ft

Segment Force Components

Normal Force =	67,424 lb
Drag Force =	37,899 lb
Friction Force =	20,227 lb
Segment Weight =	14,177 lb
Tension =	149,891 lb
Average Tension =	103,626 lb
Segment Force =	92,531 lb
Cumulative Force =	**149,891 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	2,507 psi	
Cumulative Axial Stress =	4,061 psi	41,600 psi
Bending Stress =	15,579 psi	36,050 psi
Hoop Stress =	3,905 psi	7,537 psi
Combined Stress =	0.5298	< 1.0
Total Stress =	0.5815	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	56.85 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	2,572 lb
Friction Force =	1,662 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	4,234 lb
Cumulative Force =	**154,125 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	115 psi	
Cumulative Axial Stress =	4,175 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	3,905 psi	7,537 psi
Combined Stress =	0.1004	< 1.0
Total Stress =	0.2880	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	2,400 ft
Segment Type =	Vertical Curve	Angle Turned =	12.00 deg
Segment Length =	502.65 ft	Center Displacement =	13.15 ft

Segment Force Components	
Normal Force =	52,016 lb
Drag Force =	22,740 lb
Friction Force =	15,605 lb
Segment Weight =	-5,120 lb
Tension =	202,953 lb
Average Tension =	178,539 lb
Segment Force =	48,828 lb
Cumulative Force =	**202,953 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,323 psi	
Cumulative Axial Stress =	5,498 psi	41,600 psi
Bending Stress =	15,579 psi	36,050 psi
Hoop Stress =	3,905 psi	7,537 psi
Combined Stress =	0.5643	< 1.0
Total Stress =	0.6228	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	73.64 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	3,331 lb
Friction Force =	2,106 lb
Segment Weight =	-1,492 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	3,945 lb
Cumulative Force =	**206,898 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	107 psi	
Cumulative Axial Stress =	5,605 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	3,284 psi	7,537 psi
Combined Stress =	0.1347	< 1.0
Total Stress =	0.2239	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 1 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	2,012 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	82.58 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	540.91 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	24,470 lb
Friction Force =	12,593 lb
Segment Weight =	-15,278 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	21,785 lb
Cumulative Force =	**21,785 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	590 psi	
Cumulative Axial Stress =	590 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	267 psi	7,537 psi
Combined Stress =	0.0142	< 1.0
Total Stress =	0.0016	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	2,400 ft
Segment Type =	Vertical Curve	Angle Turned =	20.00 deg
Segment Length =	837.76 ft	Center Displacement =	36.46 ft

Segment Force Components	
Normal Force =	-29,856 lb
Drag Force =	37,899 lb
Friction Force =	8,957 lb
Segment Weight =	-12,014 lb
Tension =	65,584 lb
Average Tension =	43,684 lb
Segment Force =	43,799 lb
Cumulative Force =	**65,584 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,187 psi	
Cumulative Axial Stress =	1,777 psi	41,600 psi
Bending Stress =	15,579 psi	36,050 psi
Hoop Stress =	476 psi	7,537 psi
Combined Stress =	0.4749	< 1.0
Total Stress =	0.1889	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	56.85 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	2,572 lb
Friction Force =	1,408 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	3,980 lb
Cumulative Force =	**69,564 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	108 psi	
Cumulative Axial Stress =	1,884 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	476 psi	7,537 psi
Combined Stress =	0.0453	< 1.0
Total Stress =	0.0071	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	2,400 ft
Segment Type =	Vertical Curve	Angle Turned =	12.00 deg
Segment Length =	502.65 ft	Center Displacement =	13.15 ft

Segment Force Components	
Normal Force =	-11,498 lb
Drag Force =	22,740 lb
Friction Force =	3,449 lb
Segment Weight =	4,339 lb
Tension =	103,541 lb
Average Tension =	86,553 lb
Segment Force =	33,978 lb
Cumulative Force =	**103,541 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	920 psi	
Cumulative Axial Stress =	2,805 psi	41,600 psi
Bending Stress =	15,579 psi	36,050 psi
Hoop Stress =	476 psi	7,537 psi
Combined Stress =	0.4996	< 1.0
Total Stress =	0.2108	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	73.64 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	3,331 lb
Friction Force =	1,785 lb
Segment Weight =	1,264 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	6,380 lb
Cumulative Force =	**109,922 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	173 psi	
Cumulative Axial Stress =	2,978 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	400 psi	7,537 psi
Combined Stress =	0.0716	< 1.0
Total Stress =	0.0094	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 1 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	2,012 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	-156.21 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 1 of 5**

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	540.91 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	24,470 lb
Friction Force =	23,819 lb
Segment Weight =	28,899 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	77,188 lb
Cumulative Force =	**77,188 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	2,091 psi	
Cumulative Axial Stress =	2,091 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	2,768 psi	7,537 psi
Combined Stress =	0.0503	< 1.0
Total Stress =	0.1389	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	2,400 ft
Segment Type =	Vertical Curve	**Angle Turned =**	20.00 deg
Segment Length =	837.76 ft	**Center Displacement =**	36.46 ft

Segment Force Components

Normal Force =	100,427 lb
Drag Force =	37,899 lb
Friction Force =	30,128 lb
Segment Weight =	22,724 lb
Tension =	198,068 lb
Average Tension =	137,628 lb
Segment Force =	120,880 lb
Cumulative Force =	**198,068 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	3,275 psi	
Cumulative Axial Stress =	5,366 psi	41,600 psi
Bending Stress =	15,579 psi	36,050 psi
Hoop Stress =	4,933 psi	7,537 psi
Combined Stress =	0.5611	< 1.0
Total Stress =	0.8002	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	56.85 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	2,572 lb
Friction Force =	2,664 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	5,236 lb
Cumulative Force =	**203,304 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	142 psi	
Cumulative Axial Stress =	5,508 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	4,933 psi	7,537 psi
Combined Stress =	0.1324	< 1.0
Total Stress =	0.4625	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	2,400 ft
Segment Type =	Vertical Curve	Angle Turned =	12.00 deg
Segment Length =	502.65 ft	Center Displacement =	13.15 ft

Segment Force Components	
Normal Force =	74,757 lb
Drag Force =	22,740 lb
Friction Force =	22,427 lb
Segment Weight =	-8,207 lb
Tension =	262,690 lb
Average Tension =	232,997 lb
Segment Force =	59,386 lb
Cumulative Force =	**262,690 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,609 psi	
Cumulative Axial Stress =	7,116 psi	41,600 psi
Bending Stress =	15,579 psi	36,050 psi
Hoop Stress =	4,933 psi	7,537 psi
Combined Stress =	0.6032	< 1.0
Total Stress =	0.8558	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	73.64 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	3,331 lb
Friction Force =	3,375 lb
Segment Weight =	-2,392 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	4,315 lb
Cumulative Force =	**267,006 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	117 psi	
Cumulative Axial Stress =	7,233 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	4,149 psi	7,537 psi
Combined Stress =	0.1739	< 1.0
Total Stress =	0.3593	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 1 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	2,012 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	23.83 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 1 of 5**

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	540.91 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	24,470 lb
Friction Force =	3,634 lb
Segment Weight =	-4,409 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	23,695 lb
Cumulative Force =	**23,695 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	642 psi	
Cumulative Axial Stress =	642 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	844 psi	7,537 psi
Combined Stress =	0.0154	< 1.0
Total Stress =	0.0129	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	2,400 ft
Segment Type =	Vertical Curve	Angle Turned =	20.00 deg
Segment Length =	837.76 ft	Center Displacement =	36.46 ft

Segment Force Components	
Normal Force =	-1,740 lb
Drag Force =	37,899 lb
Friction Force =	522 lb
Segment Weight =	-3,467 lb
Tension =	59,171 lb
Average Tension =	41,433 lb
Segment Force =	35,476 lb
Cumulative Force =	**59,171 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	961 psi	
Cumulative Axial Stress =	1,603 psi	41,600 psi
Bending Stress =	15,579 psi	36,050 psi
Hoop Stress =	1,504 psi	7,537 psi
Combined Stress =	0.4707	< 1.0
Total Stress =	0.2431	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	56.85 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	2,572 lb
Friction Force =	406 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	2,978 lb
Cumulative Force =	**62,149 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	81 psi	
Cumulative Axial Stress =	1,684 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,504 psi	7,537 psi
Combined Stress =	0.0405	< 1.0
Total Stress =	0.0430	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	2,400 ft
Segment Type =	Vertical Curve	Angle Turned =	12.00 deg
Segment Length =	502.65 ft	Center Displacement =	13.15 ft

Segment Force Components	
Normal Force =	4,662 lb
Drag Force =	22,740 lb
Friction Force =	1,399 lb
Segment Weight =	1,252 lb
Tension =	88,939 lb
Average Tension =	75,544 lb
Segment Force =	26,789 lb
Cumulative Force =	**88,939 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	726 psi	
Cumulative Axial Stress =	2,409 psi	41,600 psi
Bending Stress =	15,579 psi	36,050 psi
Hoop Stress =	1,504 psi	7,537 psi
Combined Stress =	0.4901	< 1.0
Total Stress =	0.2611	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	73.64 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	3,331 lb
Friction Force =	515 lb
Segment Weight =	365 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	4,211 lb
Cumulative Force =	**93,150 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	114 psi	
Cumulative Axial Stress =	2,523 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,265 psi	7,537 psi
Combined Stress =	0.0607	< 1.0
Total Stress =	0.0348	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 1 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	2,012 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	246.76 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	0.00 lb/ft

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy — Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	540.91 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	24,470 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	24,470 lb
Cumulative Force =	**24,470 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	663 psi	
Cumulative Axial Stress =	663 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	2,422 psi	7,537 psi
Combined Stress =	0.0159	< 1.0
Total Stress =	0.1060	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	2,400 ft
Segment Type =	Vertical Curve	Angle Turned =	20.00 deg
Segment Length =	837.76 ft	Center Displacement =	36.46 ft

Segment Force Components	
Normal Force =	10,886 lb
Drag Force =	37,899 lb
Friction Force =	3,266 lb
Segment Weight =	0 lb
Tension =	68,901 lb
Average Tension =	46,686 lb
Segment Force =	44,431 lb
Cumulative Force =	**68,901 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,204 psi	
Cumulative Axial Stress =	1,867 psi	41,600 psi
Bending Stress =	15,579 psi	36,050 psi
Hoop Stress =	4,317 psi	7,537 psi
Combined Stress =	0.4770	< 1.0
Total Stress =	0.5893	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	56.85 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	2,572 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	2,572 lb
Cumulative Force =	**71,473 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	70 psi	
Cumulative Axial Stress =	1,936 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	4,317 psi	7,537 psi
Combined Stress =	0.0465	< 1.0
Total Stress =	0.3299	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	2,400 ft
Segment Type =	Vertical Curve	Angle Turned =	12.00 deg
Segment Length =	502.65 ft	Center Displacement =	13.15 ft

Segment Force Components	
Normal Force =	13,116 lb
Drag Force =	22,740 lb
Friction Force =	3,935 lb
Segment Weight =	0 lb
Tension =	102,082 lb
Average Tension =	86,777 lb
Segment Force =	30,609 lb
Cumulative Force =	**102,082 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	829 psi	
Cumulative Axial Stress =	2,765 psi	41,600 psi
Bending Stress =	15,579 psi	36,050 psi
Hoop Stress =	4,317 psi	7,537 psi
Combined Stress =	0.4986	< 1.0
Total Stress =	0.6131	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	73.64 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	3,331 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	3,331 lb
Cumulative Force =	**105,413 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	90 psi	
Cumulative Axial Stress =	2,856 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	3,630 psi	7,537 psi
Combined Stress =	0.0686	< 1.0
Total Stress =	0.2398	< 1.0

APPENDIX D
HDD-2

APPENDIX D
HDD-2

General

This appendix provides GeoEngineers' HDD design recommendations for the proposed HDD-2 along the proposed North Mist Pipeline alignment located in Columbia County, Oregon. The general site plan and profile is provided in Figure D-1 of this appendix. A full size construction drawing showing the design profile is provided in the attached Drawing No. HDD-2. The design drawing includes the necessary geometric information required to complete the pilot hole.

Project Description and Basis of Design

The proposed HDD installation will be a 24-inch-diameter steel pipeline crossing the Clatskanie River. The proposed pipeline alignment is oriented southwest-northeast (entry to exit), as shown in Figure D-1. The HDD design was completed based on the parameters presented below in Table D-1.

TABLE D-1. BASIS OF DESIGN FOR THE 24-INCH-DIAMETER HDD-2

Carrier Pipe Data	Design Parameter
Carrier Pipe Specifications	24 inches x 0.500 inches w.t.[1] API-5L X-52 steel pipe
Horizontal Crossing Length	3,130 feet
Maximum Allowable Operating Pressure	809 psig[2]
Maximum Operating Temperature	55 degrees F
Assumed Tie-In Temperature	55 degrees F

Notes:
[1] w.t. – wall thickness
[2] psig – pounds per square inch gauge

SITE DESCRIPTION

Surface Conditions

Topography along the proposed HDD alignment generally consists of a relatively flat alluvial valley that is cut by the Clatskanie River. The HDD starts within a relatively flat grass field roughly 1,900 feet southwest of the Clatskanie River. The proposed entry point and entry workspace are situated at an elevation of approximately zero feet MSL. Roughly 1,900 feet northeast of the entry point, the proposed alignment crosses the Clatskanie River, which is bounded to the northeast and southwest by approximately 15-foot-high levees. Bathymetric data obtained August 2015 by Westlake Consultants, Inc. indicates the mudline of the Clatskanie River is situated between approximately 0 to -5 feet MSL along the HDD alignment. After crossing the river, the proposed alignment traverses a very gently sloping grass field and exits within the proposed exit workspace, which is situated within a relatively flat Poplar tree farm at an elevation of approximately 2 feet MSL. The proposed pipe stringing and fabrication area is also situated within this tree farm. At the time of our site visit, this tree farm was occupied by approximately 30-foot-tall Poplar trees that are being cultivated in approximately 10-foot-wide rows.

Subsurface Conditions

We completed three borings (B-3, B-15 and B-16) along or near the proposed HDD alignment in the locations shown in Figure D-1. Descriptions of soils encountered in each boring completed along or near the alignment are provided below.

Boring B-3 was completed about 200 feet north of Highway 30, and about 650 feet east of the proposed alignment. This boring was completed during a previous phase of the project when the proposed alignment was located east of the currently proposed alignment. Boring B-3 encountered approximately 3 feet of silt overlying very soft organic silt that extended to approximately 19 feet bgs. Below 19 feet bgs, the boring encountered approximately 15 feet of very soft to medium stiff sandy silt with organics overlying loose sand to roughly 44 feet bgs. Soft to medium stiff silt was encountered between about 44 feet bgs and 58 feet bgs. Below 58 feet bgs, the boring encountered very soft to soft lean clay with occasional wood pieces that extended to 71.5 feet bgs, the maximum depth explored.

Boring B-15 was completed about 420 feet northeast of the Clatskanie River and 20 feet north of the proposed alignment. Boring B-15 generally encountered approximately 8 feet of very soft fat clay with sand overlying very loose sand to a depth of 18 feet, where generally loose to medium dense silty and clayey sand with an interbed of silt was encountered to a depth of 71.5 feet bgs, the maximum depth explored. An approximately 5-foot-thick layer of very soft to soft silt was encountered between about 23 and 28 feet bgs.

Boring B-16 was completed about 435 feet west of the Clatskanie River and about 30 feet north of the proposed alignment. Boring B-16 generally encountered approximately 28 feet of very soft organic silt overlying very soft silt to a depth of about 44 feet at which point loose sand with varying amounts of silt was encountered to approximately 63 feet bgs. Below 63 feet bgs, the boring encountered soft silt to about 80 feet bgs where the silt became medium stiff to stiff and extended to 171.5 feet, the maximum depth explored.

Subsurface conditions encountered in our borings are shown graphically in Figure D-1, and are described in detail in the boring logs in Appendix A.

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE EVALUATION

Model Input Parameters

The HDD geometry used for our analyses of HDD-2 is shown in Figure D-1, and in the HDD design drawing HDD-2 in this appendix. Based on the results of the exploration program and subsequent laboratory-testing program, the soil properties used in the evaluation are presented in Table D-2 below.

TABLE D-2. ESTIMATED SOIL PROPERTIES

Soil Description	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Very Soft to Soft Organic Silt/Silt with Organics	90-100	0	50-100
Very Soft to Soft Lean Clay with Occasional Organics	100	0	500
Stiff Silt with Sand	105	20	0
Loose to Medium Dense Silty/Clayey Sand or Sand with Clay/Silt	100-110	26-30	0
Very Soft Fat Clay with Sand	95	0	50

Based on available information and common HDD construction procedures, the tool dimensions and rheological properties used in the evaluation are summarized in Table D-3. Because these parameters are dependent upon the HDD contractor's means and methods, the hydraulic fracture and drilling fluid surface release evaluation should be refined during construction of the HDD installations.

TABLE D-3. ESTIMATED TOOL DIMENSIONS AND RHEOLOGICAL PROPERTIES

Parameter	Value
Pilot Hole Bit Diameter	12.25 inches
Drill Pipe Diameter	6.625 inches
Drilling Fluid Weight	9.5 ppg
Plastic Viscosity	12 CP
Yield Point	24 lb/100 sf

Notes:
ppg = pounds per gallon; CP = centipoise; lb/100 sf = pounds per 100 square feet

Results of Hydraulic Fracture and Drilling Fluid Surface Release Evaluation

The results of the hydraulic fracture evaluation are presented in Figures D-2 through D-5. We completed one analysis that assumes the HDD is drilled from west to east (Figures D-2 and D-3) and one assuming the HDD is drilled from east to west (Figures D-4 and D-5). Figures D-2 and D-4 show the calculated formation limit pressure (green line) and the estimated drilling fluid pressure shown as the red line, which represents the drilling fluid pressure along the HDD profile based on the anticipated drilling fluid properties shown in Table D-3.

When evaluating the risk of hydraulic fracture and drilling fluid surface releases, the analysis computes two types of factors of safety. These are:

- Factor of Safety against localized hydraulic fracture; and
- Factor of Safety against drilling fluid surface release.

Local Hydraulic Fracture: The factor of safety against hydraulic fracture is the ratio of the formation limit pressure to the estimated drilling fluid pressure along the profile, shown as the green line in Figures D-3

and D-5. This represents the factor of safety against hydraulic fracture of the soil immediately surrounding the HDD profile and is a localized condition.

Drilling Fluid Surface Release: The factors of safety against drilling fluid surface release considers the strength of the soil column above the HDD profile that resists drilling fluid migrating to the ground surface. It is computed by comparing the formation limit pressure of the soil units above a specific location along the planned HDD alignment to the anticipated drilling fluid pressure at the same location. The factors of safety against drilling fluid surface releases are shown in Figures D-3 and D-5 at selected points shown as red triangles.

If the HDD is drilled from west to east, the model indicates that the risk of localized hydraulic fracture (green line in Figure D-3) is generally low, except beneath the Clatskanie River and the levee to the west of the river, where the factors of safety are between about 1.5 and 2.0 indicating the risk is moderate. The corresponding factors of safety against drilling fluid surface release (red triangles in Figure D-3) also range between about 1.5 and 2.0 in this area of the Clatskanie River. Otherwise, the factors of safety against drilling fluid surface release are generally greater than 2.0, indicating a low risk of drilling fluid surface release.

If the crossing is drilled from east to west, the factors of safety against hydraulic fracture (green line in Figure D-5) and drilling fluid surface release (red triangles in Figure D-5) are increased to greater than 2.0 under the Clatskanie River and adjacent levees, but gradually decrease to less than 1.5 within the last approximately 500 feet of the profile, representing a high risk of drilling fluid surface release within that segment of the HDD profile.

INSTALLATION LOADS AND OPERATING STRESSES

Installation Loads

The analyses of installation loads and operational stresses are based on the product pipe being installed along the designed drill path using the BMPs of the HDD industry. The addition of water into the product pipe is the standard method that contractors typically use to control buoyancy of the product pipe during the installation procedure. The proposed 24-inch-diameter product pipe will be positively buoyant in the anticipated drilling fluid weights. The HDD Contractor may choose to add water to the product pipe to try and achieve neutral buoyancy during pullback and reduce the required pull force during installation of the product pipe. Thus, our analyses include a range of cases with differing levels of buoyancy control. The following table presents a summary of the calculated installation loads for the HDD.

TABLE D-4. INSTALLATION LOADS FOR THE 24-INCH-DIAMETER HDD-2[1]

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Effective Pipe Weight[2] (lb/ft)	Pullback Force[3] (lb)
9.5	Empty	-97	257,000
9.5	Full	83	209,000
12	Empty	-156	319,000
12	Full	24	164,000
10.5	Neutral	0	154,000

Notes:
[1] See the HDD Design Summary and Calculations summaries provided in this appendix for detailed calculations.
[2] Negative values indicate upward force (positive buoyancy).
[3] Assumes a fully open drilled hole.
[4] Assumes a minimum pipeline radius of 2,400 feet.

Operating Stresses

For our operating stresses analysis, the installation and operating temperatures were assumed to be 55 degrees Fahrenheit. We can further evaluate different installation and operating temperatures, if requested. The following table presents a summary of the operating stresses for the product pipe specifications proposed for the HDD.

TABLE D-5. SUMMARY OF OPERATING STRESSES FOR THE 24-INCH-DIAMETER HDD-2

Stress Component	Stress (psi)	Percent SMYS[1] (%)	Maximum Allowable Percent SMYS (%)
Longitudinal Bending Stress	12,324	24	-
Hoop Stress	18,688	36	50[2]
Longitudinal Tensile Stress from Hoop Stress	5,606	11	-
Longitudinal Stress from Thermal Expansion	0	0	90[3]
Maximum Net Longitudinal Stress	17,931	34	90[4]
Maximum Shear Stress	12,703	24	45[5]
Maximum Combined Effective Stress	25,406	49	90[6]

Notes:
[1] Specified Minimum Yield Stress.
[2] Limited by design factor from DOT regulations, Title 49 CFR Part 192.111 for gas.
[3] Limited by Section 402.3.2 of ASME B31.4.
[4] Limited by Section 833.3 of ASME B31.8 for gas.
[5] Limited by Section 402.3.1 of ASME B31.4.
[6] Limited by Section 833.4 of ASME B31.8 for gas.

CONCLUSIONS AND RECOMMENDATIONS

HDD-2 crosses beneath the Clatskanie River and its adjacent levees that are pending certification by the USACE. As such, HDD-2 will be subject to the requirements for HDD crossings under levees by the USACE. Among others, the USACE will require that the calculated factor of safety against hydraulic fracture under

the levees be at least 1.5 and possibly 2.0. Conclusions regarding hydraulic fracture and drilling fluid surface release are presented below.

Soft soils encountered in the borings may present steering difficulties during construction. The contractor should be prepared to encounter steering difficulties, particularly on the southwest side of the HDD profile where subsurface conditions are expected to consist of very soft silt and loose sand.

The soft soils observed in boring B-3 may not provide adequate drill pipe reaction mass to progress the pilot hole eastward along the relatively long HDD profile. Therefore, we recommend that the contractor install steel casing along the entry tangent of the HDD profile to provide a reaction mass for allowing a greater transfer of axial loads through the drill pipe string to the drill bit during pilot hole drilling. The casing maintains hole uniformity and prevents the drill pipe string from being pushed into the soil formation while advancing the drill bit. Upon completion of the pilot hole, or prior to reaming the cased section of the hole, the casing is typically removed.

Hydraulic Fracture and Drilling Fluid Surface Release

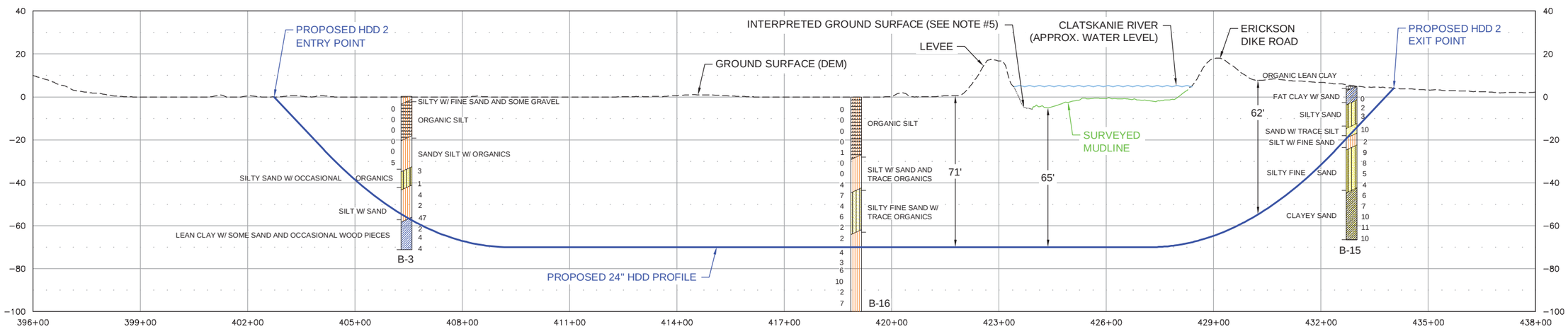
Our analysis shows that if the crossing is drilled from the west towards the east, the factors of safety against drilling fluid surface release under the Clatskanie River and the adjacent levees are between 1.5 and 2.0, but may be increased to greater than 2.0 if the crossing is drilled from east to west. However, the factors of safety against drilling fluid surface release drop to less than 1.5 within the last 500 feet of the profile if the crossing is drilled from east to west. Additionally, safety factors against hydraulic fracture drop to less than 1.0 over the last approximately 1,000 feet of the profile if the crossing is drilled from east to west. To reduce the overall risk of drilling fluid surface release, and particularly the risk to the Clatskanie River and adjacent levees, we recommend using the pilot hole intersect method of pilot hole construction. By using the pilot hole intersect method of construction, and choosing the intersect point with regard to the estimated risk of hydraulic fracture and drilling fluid surface release, the risk of hydraulic fracture and drilling fluid surface release is relatively low along most of the proposed HDD profile, with the exception of within 100 feet of entry and exit, where the risk is typically high due to the reduced soil cover.

We recommend that the contractor establish a contingency and mitigation plan in the event that drilling fluid surface releases occur; these plans should be reviewed and approved by the project team prior to the start of construction. It will be important for the contractor to maintain drilling fluid returns at all times, and monitor the first 100 feet of the HDD alignment for drilling fluid surface releases during construction.

NOT FOR CONSTRUCTION:
THE HDD DESIGN DRAWING IS INCLUDED AS HDD 2 IN APPENDIX D.

PLAN
300' 0 300'
SCALE IN FEET

Major Contour Interval = 25'
Minor Contour Interval = 5'



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Refer to the borings logs in the accompanying report for more detailed soil descriptions.
4. GeoEngineers, Inc. has not verified the field location of the existing utilities.
5. Ground surface not obtained during site survey. The ground surface was interpreted between DEM data and site-specific survey in order to perform hydraulic fracture and drilling fluid surface release analyses.

Reference: Ground surface DEM (1/9 arc second) and aerial photos downloaded from http://nationalmap.gov. Base files provided by NorthWest Natural. Bathymetric survey data provided by Westlake Consultants, Inc., obtained August 2015.

PROFILE
300' 0 300'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

LEGEND:

TYPE OF SOIL
SPT (N)
Boring Location

SITE PLAN AND PROFILE
HDD 2

NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

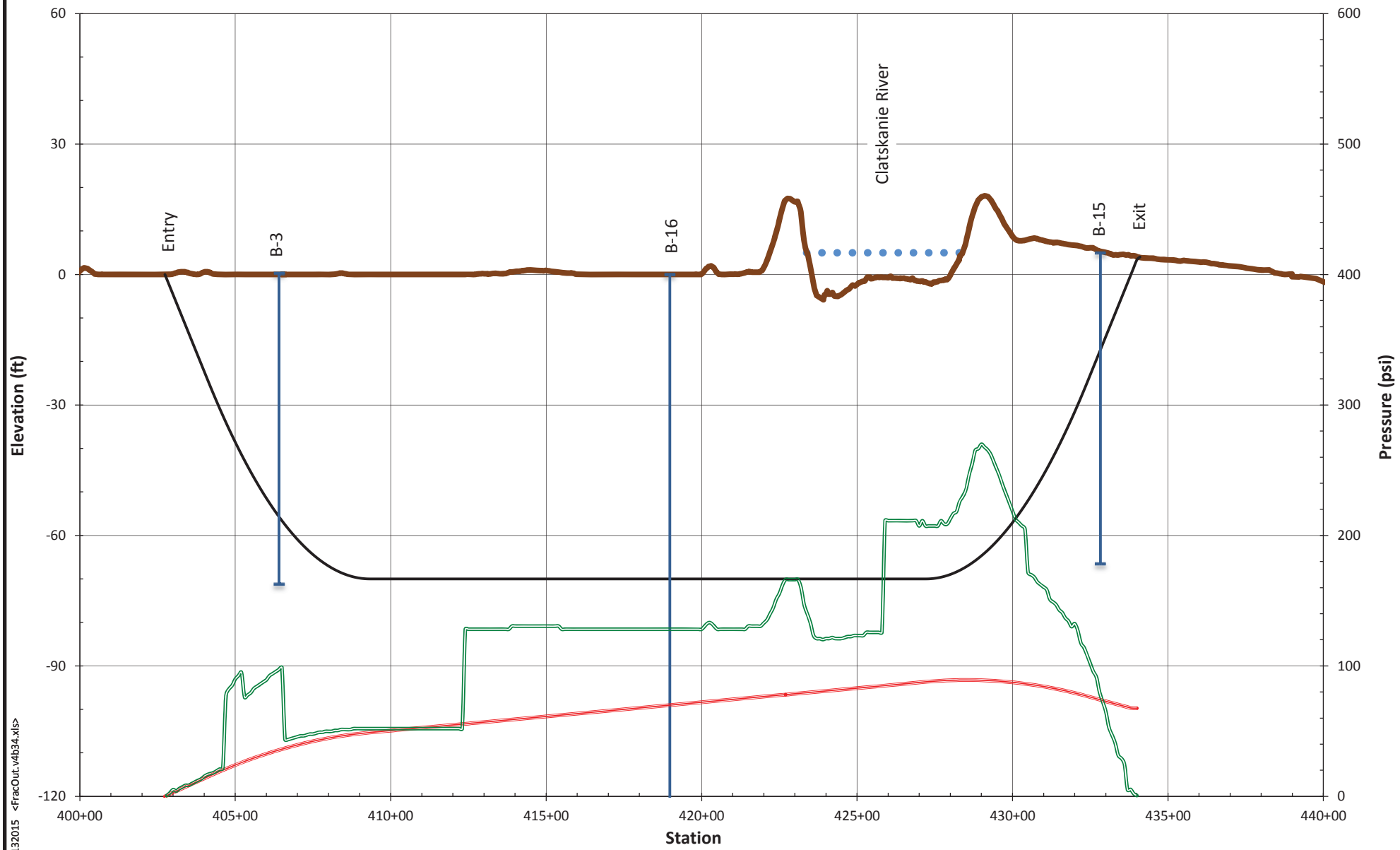
GEOENGINEERS

FIGURE D-1

BCR : TJB

P:\6\0242157\04\CAD\Figure D-1.dwg\TAB:Figure D-1 modified on Sep 14, 2015 - 12:31pm

NW NATURAL - NORTH MIST PIPELINE HDD 2



Crossing Length (ft)	3130
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	12
Yield Point (lb/100 ft)	24

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Estimated Annular Drilliing Fluid Pressure (psi) for Pilot Hole
- Formation Limit Pressure (psi)

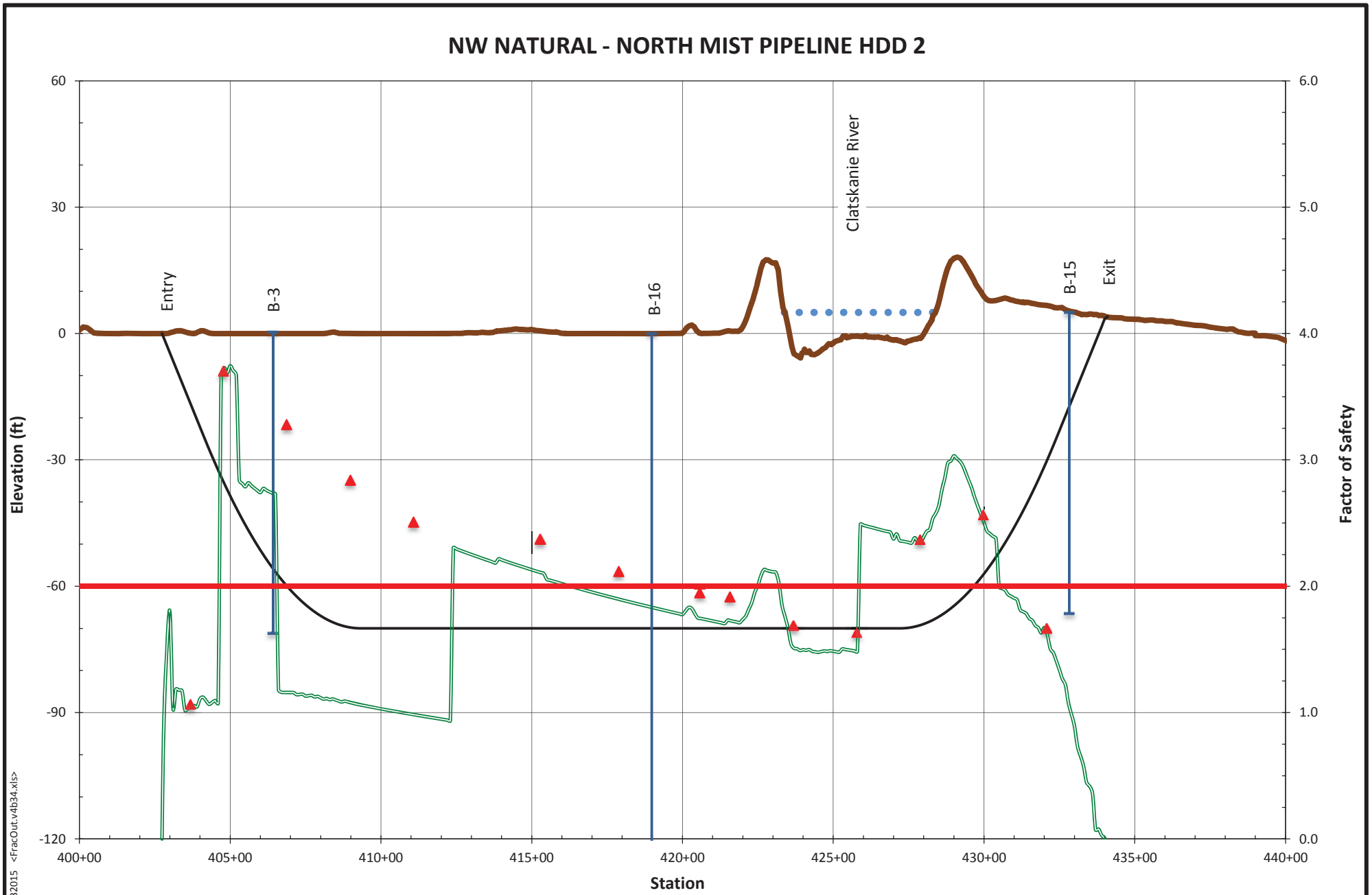
ESTIMATED ANNULAR DRILLING FLUID AND FORMATION LIMIT PRESSURES

NW NATURAL - NORTH MIST PIPELINE HDD 2

GEOENGINEERS

FIGURE D-2

06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>



Crossing Length (ft)	3130
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	12
Yield Point (lb/100 ft)	24

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Drilling Fluid Surface Release Factor of Safety for Pilot Hole
- Hydraulic Fracture Factor of Safety for Pilot Hole
- Factor of Safety = 2

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE FACTORS OF SAFETY

NW NATURAL - NORTH MIST PIPELINE HDD 2

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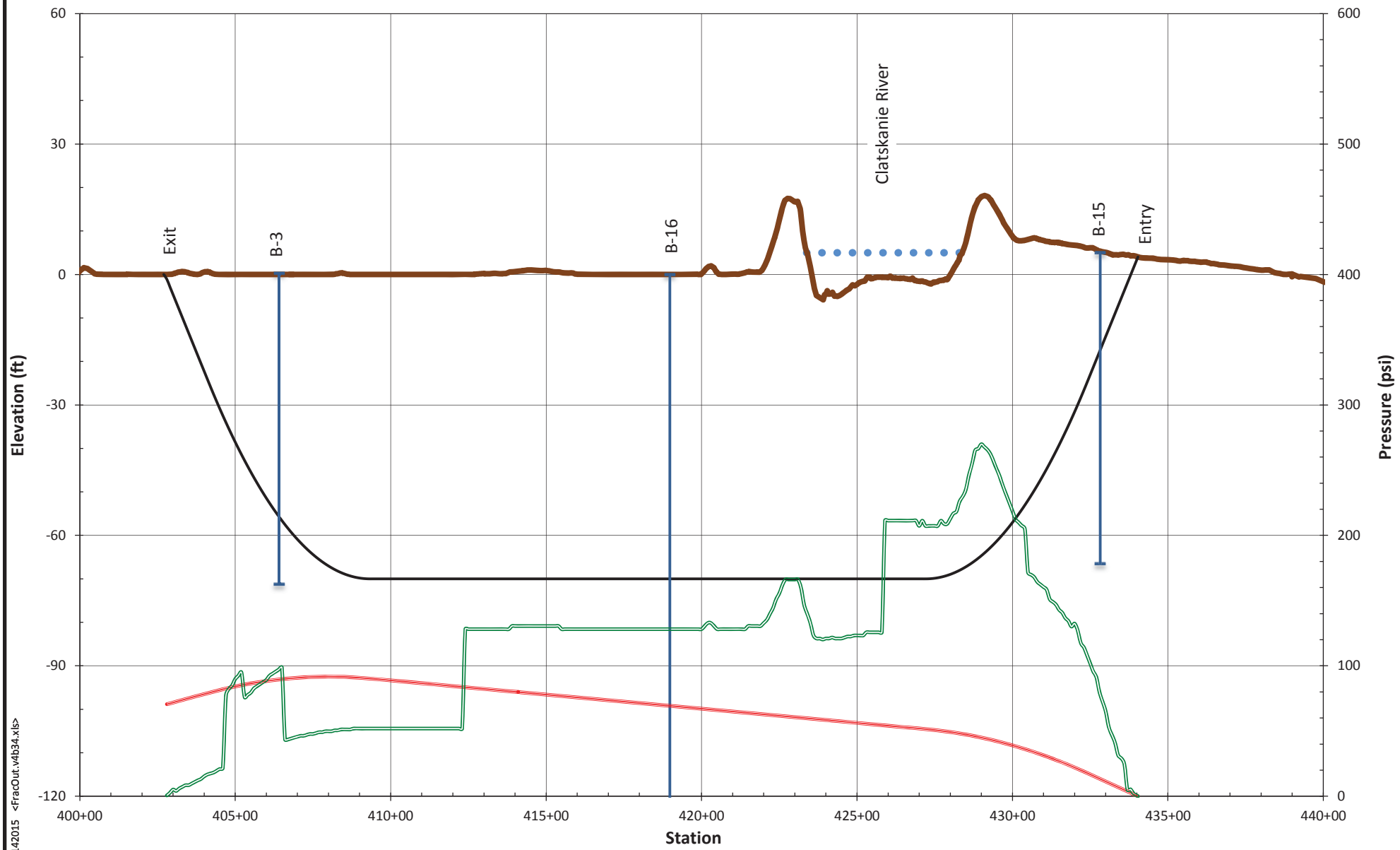
FIGURE D-3

06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>

NW NATURAL - NORTH MIST PIPELINE HDD 2



Crossing Length (ft)	3130
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	12
Yield Point (lb/100 ft)	24

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Estimated Annular Drilliing Fluid Pressure (psi) for Pilot Hole
- Formation Limit Pressure (psi)

ESTIMATED ANNULAR DRILLING FLUID AND FORMATION LIMIT PRESSURES

NW NATURAL - NORTH MIST PIPELINE HDD 2

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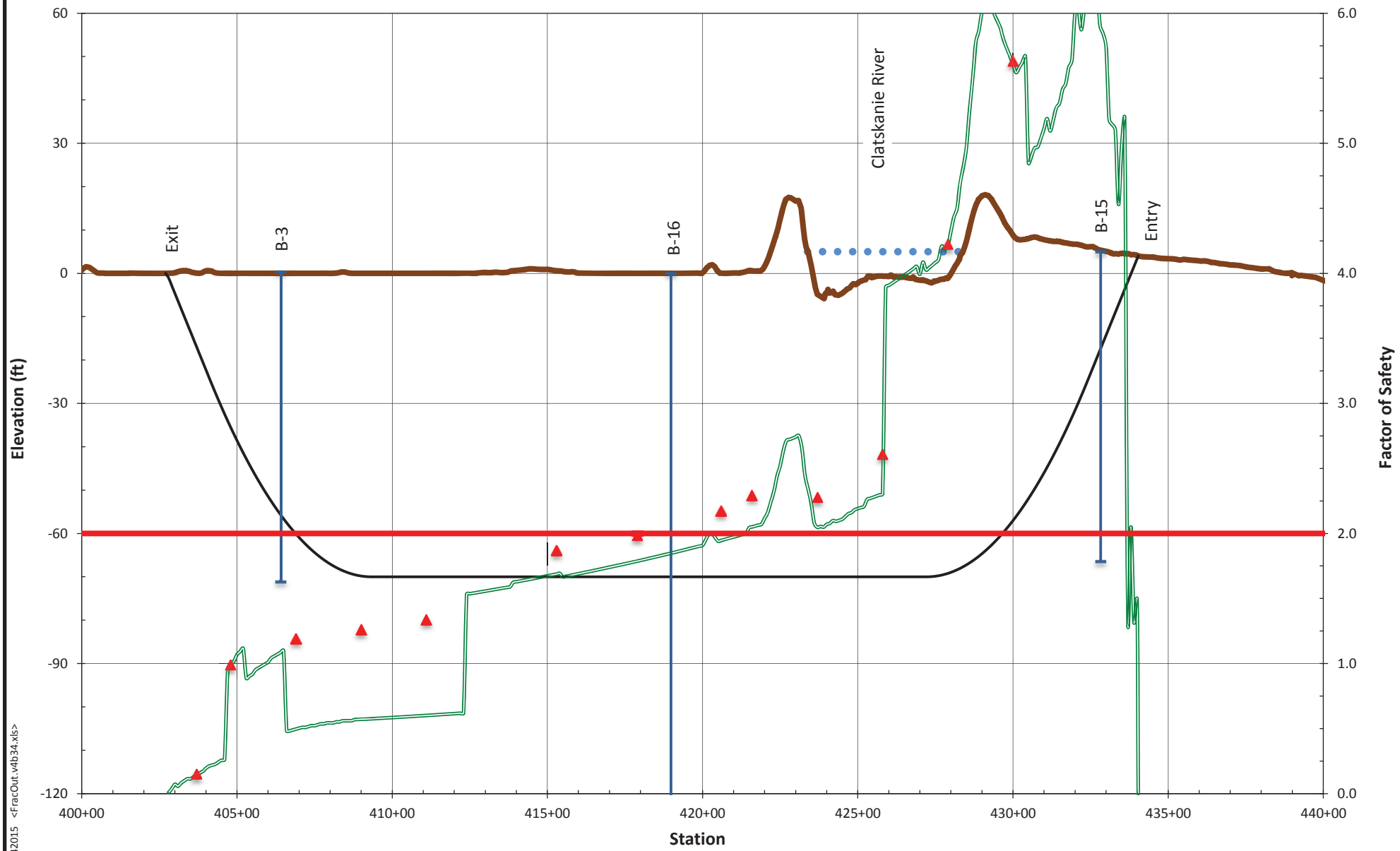
FIGURE D-4

06024-157-03 JAH/AES 09142015 <FracOut.v4b34.xls>

NW NATURAL - NORTH MIST PIPELINE HDD 2



Crossing Length (ft)	3130
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	12
Yield Point (lb/100 ft)	24

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Drilling Fluid Surface Release Factor of Safety for Pilot Hole
- Hydraulic Fracture Factor of Safety for Pilot Hole
- Factor of Safety = 2

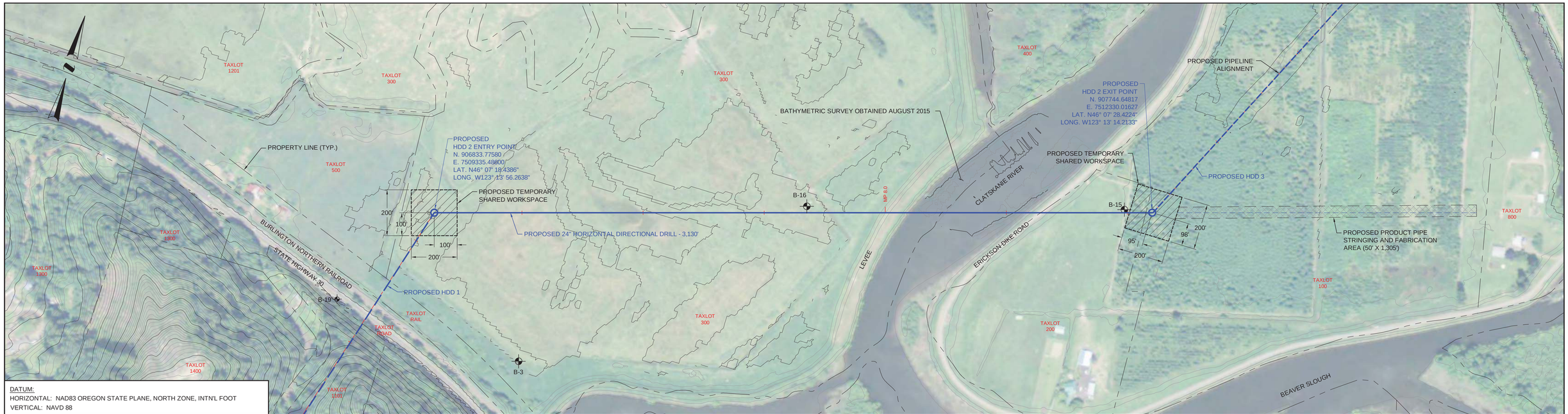
HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE FACTORS OF SAFETY

NW NATURAL - NORTH MIST PIPELINE HDD 2

GEOENGINEERS

FIGURE D-5

06024-157-03 JAH/AES 09142015 <FracOut.v4b34.xls>

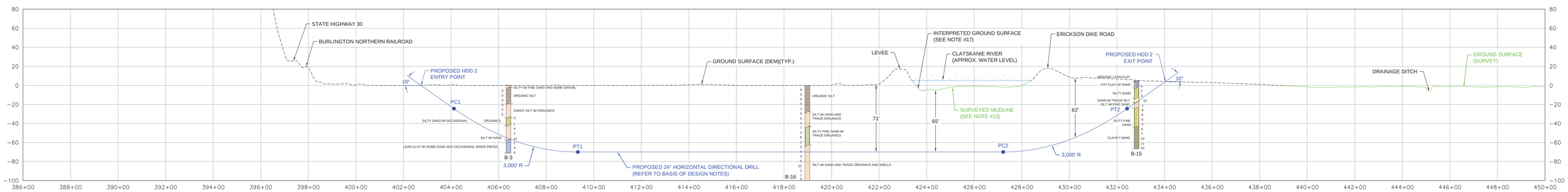


DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

200' 0 200'
SCALE IN FEET

MAJOR CONTOUR INTERVAL - 25'
MINOR CONTOUR INTERVAL = 5'



PROFILE

200' 0 200'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

DIRECTIONAL DRILL DATA HDD 2		
DESCRIPTION	STATION (FT)	ELEVATION (FT)
ENTRY @ 10°	402+73.75	0.01
P C 1 (10.00° @ 3,000 FT R.)	404+12.31	-24.42
P T 1	409+33.25	-70.00
P C 2 (10.00° @ 3,000 FT R.)	427+21.45	-70.00
P T 2	432+42.39	-24.42
EXIT @ 10°	434+03.75	4.03
HORIZONTAL DISTANCE = 3,130.00 FT		
DIRECTIONAL DRILL PIPE LENGTH = 3,139.94 FT		

RECOMMENDED TOLERANCES	
ITEM	TOLERANCE
PILOT HOLE ENTRY ANGLE	INCREASE ANGLE UP TO 1° (STEEPER), BUT NO DECREASE IN ANGLE ALLOWED.
PILOT HOLE ENTRY LOCATION	AS PER COORDINATES PROVIDED BY COMPANY WITH NO CHANGES WITHOUT COMPANY APPROVAL.
PILOT HOLE EXIT ANGLE	INCREASE ANGLE UP TO 1° (STEEPER) OR DECREASE UP TO 2° (FLATTER).
PILOT HOLE EXIT LOCATION	UP TO 20 FEET BEYOND OR 10 FEET SHORT OF THE EXIT STAKE. BETWEEN 5 FEET LEFT AND 5 FEET RIGHT OF CENTERLINE.
PILOT HOLE DEPTH	UP TO 2 FEET ABOVE THE DESIGN DRILL PROFILE ALLOWED. UP TO 10 FEET BELOW THE DESIGN DRILL PROFILE ALLOWED.
PILOT HOLE ALIGNMENT	SHALL REMAIN WITHIN 5 FEET LEFT OR RIGHT OF THE HDD ALIGNMENT.

LEGEND:

TYPE OF SOIL — SPT (N)

BORING LOCATION

NOTES

1. ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT-OF-WAY OR FROM APPROVED ACCESS ROADS.
2. WORK SPACE: MAXIMUM WORK SPACE LIMITS ARE DEPICTED. RESTRICT CLEARING TO THE WORK SPACE INDICATED AT THE ENTRY AND EXIT POINTS AND PRODUCT PIPE STRINGING AND FABRICATION AREA ALONG THE CONSTRUCTION RIGHT-OF-WAY. CLEARING BETWEEN THE ENTRY AND EXIT POINTS REQUIRES PRIOR APPROVAL FROM THE ENVIRONMENTAL INSPECTOR AND IS LIMITED TO THE AMOUNT NECESSARY TO STRING SURVEY WIRES AND INSTALL PUMPS AND PIPING TO OBTAIN WATER (WHERE APPROVED).
3. WATER SOURCE: DRILL WATER AND HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE.
4. HYDROSTATIC TEST: PRE-INSTALLATION AND POST-INSTALLATION HYDROSTATIC TESTS SHALL BE CONDUCTED IN ACCORDANCE WITH THE HYDROSTATIC TEST PLAN. TEST WATER SHALL BE SAMPLED AND TESTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE TEST WATER SHALL BE DISCHARGED IN AN UPLAND AREA INTO AN EROSION CONTROL STRUCTURE OF STRAW BALES AND/OR SILT FENCES, GEOTEXTILE FILTER BAG, OR COLLECTED IN A TRUCK AND HAULED TO AN APPROVED DISPOSAL SITE. UPON COMPLETION OF DEWATERING AND DRYING, A CALIPER PIG SURVEY SHALL BE COMPLETED IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
5. SPILL-PREVENTION: REFUELING OF ALL EQUIPMENT SHALL BE COMPLETED IN ACCORDANCE WITH THE SPCC PLAN.
6. EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE APPROVED CONSTRUCTION RIGHT-OF-WAY AT THE DRILL EXIT POINT AS SHOWN. AFTER THE PILOT HOLE IS COMPLETE, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO NORTHWEST NATURAL FOR APPROVAL. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULL BACK.
8. DRILLING FLUID DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING FLUID AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING FLUID WHICH INADVERTENTLY SURFACES AT POINTS OTHER THAN THE ENTRY OR EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.
9. CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN THE CLEAN-UP AND RESTORATION REQUIREMENTS.
10. GEOTECHNICAL DATA: BORE HOLES ARE OFFSET FROM THE PIPELINE CENTERLINE AS SHOWN ON THE PLAN VIEW. THE GEOTECHNICAL INFORMATION PROVIDED ON THIS DRAWING IS A GENERAL SUMMARY. REFER TO THE APPLICABLE GEOTECHNICAL REPORT IN THE CONTRACT DOCUMENTS FOR MORE DETAILED INFORMATION.
11. IF THE TERRAIN ALLOWS AND ACCESS IS PERMITTED, CONTRACTOR SHALL UTILIZE LOW GROUND PRESSURE EQUIPMENT OR OTHER EQUIPMENT APPROVED BY OWNER, TO FACILITATE CONTAINMENT AND CLEAN-UP OF ANY INADVERTENT RETURNS THAT OCCUR DURING THE HDD INSTALLATION PROCESS.
12. THE MINIMUM ALLOWABLE THREE JOINT RADIUS SHALL NOT BE LESS THAN 2,400 FEET.
13. AERIAL PHOTOS AND GROUND SURFACE DEM (1/9 ARC SECOND) DOWNLOADED FROM HTTP://VIEWER.NATIONALMAP.GOV/VIEWER/. BASE FILES PROVIDED BY NORTHWEST NATURAL. BATHYMETRIC SURVEY DATA PROVIDED BY WESTLAKE CONSULTANTS, INC., OBTAINED AUGUST 2015.
14. CONTRACTOR IS RESPONSIBLE FOR CALLING OREGON ONE-CALL AND PHYSICALLY LOCATING ALL UNDERGROUND UTILITIES PRIOR TO BEGINNING CONSTRUCTION. IF ANY UTILITY IS LOCATED WITHIN 15 FEET OF THE DESIGNED HDD PROFILE AND ALIGNMENT, CONTRACTOR SHALL OBTAIN APPROVAL FROM NORTHWEST NATURAL PRIOR TO INITIATING HDD OPERATIONS.
15. A SITE SPECIFIC SURVEY DOCUMENTING EXISTING UTILITIES HAS NOT BEEN CONDUCTED ALONG THE PROPOSED PIPELINE ALIGNMENT. A SITE SPECIFIC TOPOGRAPHIC AND UTILITY SURVEY SHOULD BE COMPLETED PRIOR TO FINAL ISSUANCE OF THESE PLANS. DURING CONSTRUCTION, IT IS THE CONTRACTORS RESPONSIBILITY TO IDENTIFY AND PROTECT ANY UTILITY THAT MAY BE AFFECTED BY THE HDD OPERATIONS.
16. CONTRACTOR SHALL ADHERE TO THE SPECIFICATIONS AND REQUIREMENTS PER NORTHWEST NATURAL SPECIFICATIONS, CONTRACT DOCUMENTS, AND SPECIAL PERMIT CONDITIONS, EXCEPT AS NOTED ON THIS DRAWING.
17. GROUND SURFACE NOT OBTAINED DURING SITE SURVEY. THE GROUND SURFACE WAS INTERPRETED BETWEEN DEM DATA AND SITE-SPECIFIC SURVEY IN ORDER TO PERFORM HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE ANALYSES.

FINAL

BASIS OF DESIGN:

1. PRODUCT PIPE WILL CONSIST OF 24" O.D. X 0.500" W.T., API-5L X-52 PIPE WITH 14-16 MILS OF FUSION BONDED EPOXY (FBE) AND A MINIMUM OF 40 MILS OF ABRASION RESISTANT OVERLAY (ARO).
2. MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) = 809 psi

NOTE: THIS IS A FULL SIZE DRAWING THAT IS INTENDED TO BE PRINTED ON A 24" X 36" SHEET OF PAPER.

REFERENCE DRAWINGS	
DRAWING NO.	TITLE

REVISIONS						
NO.	DATE	BY	DESCRIPTION	W.O.NO.	CHK.	APP.
A	07/02/14	MWC	ISSUED AS DRAFT		BCR	TNH
B	04/20/15	BTL	ISSUED AS DRAFT (24-INCH REDESIGN)		BCR	TNH
C	09/15/15	BTL	ISSUED FOR FINAL		BCR	TNH

GEOENGINEERS
1200 NW NAITO PARKWAY, SUITE 180
PORTLAND, OREGON 97209
TELEPHONE: (503) 624-9274
FAX: (503) 620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
STATION 386+00 TO 450+00
HDD 2
COLUMBIA COUNTY, OREGON

NW Natural

DRAWN BY: MWC	DATE: 06/02/14	ISSUED FOR BID:	SCALE: AS NOTED
CHECKED BY: BCR	DATE: 06/02/14	ISSUED FOR CONSTRUCTION:	
APPROVED BY:	DATE:	DRAWING NUMBER: HDD 2	SHEET 1
WO:		TIME: 05:59 PM DATE: 09/10/15 PATH: P:\0\60243157\04\CAD\HDD 2_FINAL Rev C.dwg	OF 1

HDD Design Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 2 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe Diameter = 24.000 in

Pipe Material = Steel

Yield Stress = 52,000 psi

Wall Thickness = 0.5 in

Assumed Installation Temp = 55 °F

Assumed Operating Temp= 55 °F

Design Factor = 0.5

MAOP = 809 psi

Drill Data Box

Point	Station (ft)	Elevation (ft)
ENTRY @ 10°	40,273.75	0.01
P C 1 (10.00° @ 3,000 ft R.)	40,412.31	-24.42
P T 1	40,933.25	-70.00
P C 2 (10.00° @ 3,000 ft R.)	42,721.45	-70.00
P T 2	43,242.39	-24.42
EXIT @ 10°	43,403.75	4.03

Horizontal Alignment Length = 3,130.00 ft

Profile Segment Information

Segment Name	Segment Type	Segment Length (ft)
ENTRY TANGENT	Straight	140.70
ENTRY CURVE	Vertical Curve	523.60
BOTTOM TANGENT	Straight	1,788.20
EXIT CURVE	Vertical Curve	523.60
EXIT TANGENT	Straight	163.84

Pipe Length = 3,139.94 ft

Installation Load Summary

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Buoyancy Control (lb/ft)	Effective Pipe Weight (lb/ft)	Total Installation Force (lb)
9.50	Empty	0.00	-97.46	257,000
9.50	Full	180.04	82.58	209,000
12.00	Empty	0.00	-156.21	319,000
12.00	Full	180.04	23.83	164,000
10.50	Neutral	120.96	0.00	154,000

GeoEngineers

Minimum Radius Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 2 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters:

Pipe Diameter = 24.000 in **MAOP =** 809 psi **Factor of Safety =** 2.00

Wall Thickness = 0.500 in **SMYS =** 52,000 psi

D/t Ratio = 48.00 **Modulus of Elasticity (E) =** 2.96E+007 psi

Hoop Stress:

Calculated Hoop Stress = (MAOP * Pipe Diameter) / (2 * Wall Thickness) = 19,416 psi

Longitudinal Stress:

Calculated Longitudinal Stress = Hoop Stress / 2 = 9,708 psi

Allowable Stress:

Calculated Allowable Stress = SMYS / Factor of Safety = 26,000 psi

Bending Stress:

Calculated Bending Stress = Allowable Stress - Longitudinal Stress = 16,292 psi

Minimum Radius:

Calculated Minimum Radius = (E * Pipe Diameter) / (2 * Bending Stress) = 1,817 ft

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 2 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe diameter =	24.000 in	**Minimum Radius of Curvature =**	2,400 ft
Wall Thickness =	0.500 in	**Coefficient of Thermal Expansion =**	6.5E-06 in/in/°F
SMYS =	52,000 psi	**Assumed Installation Temperature =**	55 °F
MAOP =	809 psi	**Assumed Operating Temperature =**	55 °F
Poissons's Ratio =	0.30	**Temperature Derating Factor =**	1.00
Young's Modulus (E) =	2.96E+007 psi	**Groundwater Table Head =**	70.00 ft
Design Factor =	0.5		

Stress Analyses

Longitudinal Stress from Bending =	12,324 psi	
Percent SMYS =	23.70 %	
Hoop Stress =	18,688 psi	
Percent SMYS =	35.94 %	Limited by Design Factor (0.5) according to 49 CFR 192.111
Longitudinal Tensile Stress from Hoop Stress =	5,606 psi	
Percent SMYS =	10.78 %	
Longitudinal Stress from Thermal Expansion =	0 psi	
Percent SMYS =	0.00 %	Limited to 90% SMYS by ASME/ANSI B31.4 section 402.3.2
Net Longitudinal Stress (Comp. side of Curve) =	-6,718 psi	
Percent SMYS =	12.92 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Net Longitudinal Stress (Tension side of Curve) =	17,931 psi	
Percent SMYS =	34.48 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Maximum Shear Stress =	12,703 psi	
Percent SMYS =	24.43 %	Limited to 45% SMYS by ASME/ANSI B31.4 section 402.3.1
Combined BiaxialSress Check =	25,406 psi	
Percent SMYS =	48.86 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.4

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 2 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 2 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,140 ft
Moment of Inertia =	2,549 in^4
Pipe Face Area =	36.91 in^2
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft^3
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft^3
Pipe Exterior Volume =	3.14 ft^3/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft^3/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft^3
Effective Weight of Pipe =	-97.46 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty — Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	163.84 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	7,412 lb
Friction Force =	4,718 lb
Segment Weight =	2,773 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	14,902 lb
Cumulative Force =	**14,902 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	404 psi	
Cumulative Axial Stress =	404 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	337 psi	7,537 psi
Combined Stress =	0.0097	< 1.0
Total Stress =	0.0022	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	10.00 deg
Segment Length =	523.60 ft	**Center Displacement =**	11.42 ft

Segment Force Components

Normal Force =	36,991 lb
Drag Force =	23,687 lb
Friction Force =	11,097 lb
Segment Weight =	4,447 lb
Tension =	65,231 lb
Average Tension =	40,067 lb
Segment Force =	50,329 lb
Cumulative Force =	**65,231 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,363 psi	
Cumulative Axial Stress =	1,767 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	877 psi	7,537 psi
Combined Stress =	0.3846	< 1.0
Total Stress =	0.1443	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	1,788.20 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	80,896 lb
Friction Force =	52,281 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	133,177 lb
Cumulative Force =	**198,408 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	3,608 psi	
Cumulative Axial Stress =	5,375 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	877 psi	7,537 psi
Combined Stress =	0.1292	< 1.0
Total Stress =	0.0359	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	52,853 lb
Drag Force =	23,687 lb
Friction Force =	15,856 lb
Segment Weight =	-4,447 lb
Tension =	249,360 lb
Average Tension =	223,884 lb
Segment Force =	50,952 lb
Cumulative Force =	**249,360 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,380 psi	
Cumulative Axial Stress =	6,755 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	877 psi	7,537 psi
Combined Stress =	0.5045	< 1.0
Total Stress =	0.2458	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	140.70 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	6,365 lb
Friction Force =	4,051 lb
Segment Weight =	-2,381 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	8,035 lb
Cumulative Force =	**257,395 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	218 psi	
Cumulative Axial Stress =	6,973 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	337 psi	7,537 psi
Combined Stress =	0.1676	< 1.0
Total Stress =	0.0331	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 2 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,140 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	82.58 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	163.84 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	7,412 lb
Friction Force =	3,998 lb
Segment Weight =	-2,350 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	9,060 lb
Cumulative Force =	**9,060 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	245 psi	
Cumulative Axial Stress =	245 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	41 psi	7,537 psi
Combined Stress =	0.0059	< 1.0
Total Stress =	0.0001	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	10.00 deg
Segment Length =	523.60 ft	**Center Displacement =**	11.42 ft

Segment Force Components

Normal Force =	-21,780 lb
Drag Force =	23,687 lb
Friction Force =	6,534 lb
Segment Weight =	-3,769 lb
Tension =	42,047 lb
Average Tension =	25,553 lb
Segment Force =	32,987 lb
Cumulative Force =	**42,047 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	894 psi	
Cumulative Axial Stress =	1,139 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	107 psi	7,537 psi
Combined Stress =	0.3695	< 1.0
Total Stress =	0.1070	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	1,788.20 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	80,896 lb
Friction Force =	44,303 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	125,199 lb
Cumulative Force =	**167,246 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	3,392 psi	
Cumulative Axial Stress =	4,531 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	107 psi	7,537 psi
Combined Stress =	0.1089	< 1.0
Total Stress =	0.0127	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	-4,749 lb
Drag Force =	23,687 lb
Friction Force =	1,425 lb
Segment Weight =	3,769 lb
Tension =	197,551 lb
Average Tension =	182,398 lb
Segment Force =	30,305 lb
Cumulative Force =	**197,551 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	821 psi	
Cumulative Axial Stress =	5,352 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	107 psi	7,537 psi
Combined Stress =	0.4708	< 1.0
Total Stress =	0.1834	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	140.70 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	6,365 lb
Friction Force =	3,433 lb
Segment Weight =	2,018 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	11,815 lb
Cumulative Force =	**209,366 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	320 psi	
Cumulative Axial Stress =	5,672 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	41 psi	7,537 psi
Combined Stress =	0.1363	< 1.0
Total Stress =	0.0189	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 2 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,140 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	-156.21 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	163.84 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	7,412 lb
Friction Force =	7,561 lb
Segment Weight =	4,444 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	19,418 lb
Cumulative Force =	**19,418 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	526 psi	
Cumulative Axial Stress =	526 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	426 psi	7,537 psi
Combined Stress =	0.0126	< 1.0
Total Stress =	0.0035	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	56,450 lb
Drag Force =	23,687 lb
Friction Force =	16,935 lb
Segment Weight =	7,128 lb
Tension =	84,103 lb
Average Tension =	51,761 lb
Segment Force =	64,685 lb
Cumulative Force =	**84,103 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,752 psi	
Cumulative Axial Stress =	2,278 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,108 psi	7,537 psi
Combined Stress =	0.3969	< 1.0
Total Stress =	0.1656	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	1,788.20 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	80,896 lb
Friction Force =	83,799 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	164,695 lb
Cumulative Force =	**248,798 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	4,462 psi	
Cumulative Axial Stress =	6,740 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,108 psi	7,537 psi
Combined Stress =	0.1620	< 1.0
Total Stress =	0.0568	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 4 of 5**

Segment Parameters

Segment Name =	ENTRY CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	10.00 deg
Segment Length =	523.60 ft	**Center Displacement =**	11.42 ft

Segment Force Components

Normal Force =	75,156 lb
Drag Force =	23,687 lb
Friction Force =	22,547 lb
Segment Weight =	-7,128 lb
Tension =	310,450 lb
Average Tension =	279,624 lb
Segment Force =	61,652 lb
Cumulative Force =	**310,450 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,670 psi	
Cumulative Axial Stress =	8,410 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,108 psi	7,537 psi
Combined Stress =	0.5443	< 1.0
Total Stress =	0.2999	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 5 of 5**

Segment Parameters

Segment Name =	ENTRY TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	140.70 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	6,365 lb
Friction Force =	6,493 lb
Segment Weight =	-3,816 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	9,042 lb
Cumulative Force =	**319,492 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	245 psi	
Cumulative Axial Stress =	8,655 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	426 psi	7,537 psi
Combined Stress =	0.2081	< 1.0
Total Stress =	0.0513	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 2 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,140 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	23.83 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 1 of 5**

Segment Parameters			
Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	163.84 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	7,412 lb
Friction Force =	1,154 lb
Segment Weight =	-678 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	7,888 lb
Cumulative Force =	**7,888 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	214 psi	
Cumulative Axial Stress =	214 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	130 psi	7,537 psi
Combined Stress =	0.0051	< 1.0
Total Stress =	0.0003	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	10.00 deg
Segment Length =	523.60 ft	**Center Displacement =**	11.42 ft

Segment Force Components

Normal Force =	-3,550 lb
Drag Force =	23,687 lb
Friction Force =	1,065 lb
Segment Weight =	-1,088 lb
Tension =	32,617 lb
Average Tension =	20,252 lb
Segment Force =	24,729 lb
Cumulative Force =	**32,617 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	670 psi	
Cumulative Axial Stress =	884 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	338 psi	7,537 psi
Combined Stress =	0.3634	< 1.0
Total Stress =	0.1088	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	1,788.20 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	80,896 lb
Friction Force =	12,785 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	93,681 lb
Cumulative Force =	**126,298 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	2,538 psi	
Cumulative Axial Stress =	3,421 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	338 psi	7,537 psi
Combined Stress =	0.0822	< 1.0
Total Stress =	0.0102	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	8,747 lb
Drag Force =	23,687 lb
Friction Force =	2,624 lb
Segment Weight =	1,088 lb
Tension =	156,321 lb
Average Tension =	141,309 lb
Segment Force =	30,023 lb
Cumulative Force =	**156,321 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	813 psi	
Cumulative Axial Stress =	4,235 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	338 psi	7,537 psi
Combined Stress =	0.4439	< 1.0
Total Stress =	0.1680	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	140.70 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	6,365 lb
Friction Force =	991 lb
Segment Weight =	582 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	7,938 lb
Cumulative Force =	**164,259 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	215 psi	
Cumulative Axial Stress =	4,450 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	130 psi	7,537 psi
Combined Stress =	0.1070	< 1.0
Total Stress =	0.0125	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 2 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,140 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	246.76 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	0.00 lb/ft

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 1 of 5**

Segment Parameters			
Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	163.84 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	7,412 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	7,412 lb
Cumulative Force =	**7,412 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	201 psi	
Cumulative Axial Stress =	201 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	372 psi	7,537 psi
Combined Stress =	0.0048	< 1.0
Total Stress =	0.0025	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	4,121 lb
Drag Force =	23,687 lb
Friction Force =	1,236 lb
Segment Weight =	0 lb
Tension =	33,572 lb
Average Tension =	20,492 lb
Segment Force =	26,160 lb
Cumulative Force =	**33,572 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	709 psi	
Cumulative Axial Stress =	909 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	969 psi	7,537 psi
Combined Stress =	0.3640	< 1.0
Total Stress =	0.1343	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	1,788.20 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	80,896 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	80,896 lb
Cumulative Force =	**114,468 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	2,191 psi	
Cumulative Axial Stress =	3,101 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	969 psi	7,537 psi
Combined Stress =	0.0745	< 1.0
Total Stress =	0.0253	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	14,971 lb
Drag Force =	23,687 lb
Friction Force =	4,491 lb
Segment Weight =	0 lb
Tension =	147,138 lb
Average Tension =	130,803 lb
Segment Force =	32,669 lb
Cumulative Force =	**147,138 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	885 psi	
Cumulative Axial Stress =	3,986 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	969 psi	7,537 psi
Combined Stress =	0.4379	< 1.0
Total Stress =	0.1908	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	140.70 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	6,365 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	6,365 lb
Cumulative Force =	**153,503 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	172 psi	
Cumulative Axial Stress =	4,158 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	372 psi	7,537 psi
Combined Stress =	0.1000	< 1.0
Total Stress =	0.0144	< 1.0

APPENDIX E
HDD-3

APPENDIX E
HDD-3

General

This appendix provides GeoEngineers HDD design recommendations for proposed HDD-3 along the North Mist Pipeline alignment located in Columbia County, Oregon. The general site plan and profile is provided in Figure E-1 of this appendix. A full size construction drawing showing the design profile is provided in the attached Drawing No. HDD-3. The design drawing includes the necessary geometric information required to complete the pilot hole.

Project Description and Basis of Design

The proposed HDD installation will be a 24-inch-diameter steel pipeline crossing a small drainage ditch and Beaver Slough. The proposed pipeline alignment is oriented northeast-southwest (entry to exit), as shown in Figure E-1. The HDD design was completed based on the parameters presented below in Table E-1.

TABLE E-1. BASIS OF DESIGN FOR THE 24-INCH-DIAMETER HDD-3

Carrier Pipe Data	Design Parameter
Carrier Pipe Specifications	24 inches x 0.500 inches w.t.[1] API-5L X-52 steel pipe
Horizontal Crossing Length	2,875 feet
Maximum Allowable Operating Pressure	809 psig[2]
Maximum Operating Temperature	55 degrees F
Assumed Tie-In Temperature	55 degrees F

Notes:
[1] w.t. – wall thickness
[2] psig – pounds per square inch gauge

SITE DESCRIPTION

Surface Conditions

Topography along the proposed HDD alignment generally consists of a relatively flat alluvial valley that is cut by a relatively small drainage ditch and Beaver Slough. The HDD begins within a Poplar tree farm property on the northeast side of the crossing. The proposed entry point and entry workspace are situated at an approximate elevation of 5.4 feet MSL. Vegetation within the proposed entry workspace currently consists of approximately 10-foot-high Poplar trees. The proposed HDD alignment crosses Beaver Slough and a small drainage ditch approximately 840 and 1,800 feet southwest of the proposed entry point, respectively. Beaver Slough is approximately 140 feet wide and 20 feet deep measured from the top of the southwest levee. Bathymetric data obtained by Westlake Consultants, Inc., in August 2015 places the mudline of Beaver slough at a minimum elevation of approximately -16 feet MSL along the HDD alignment. The drainage ditch is approximately 7 feet wide and 5 feet deep. The proposed exit workspace is situated within a Poplar tree farm at an elevation of approximately 4.0 feet MSL. Vegetation within the exit workspaces consists of approximately 30-foot-tall Poplar trees. The pipe stringing and fabrication workspace extends northeast of the proposed entry workspace across relatively flat ground that is vegetated with approximately 30-foot-high Poplar trees.

Subsurface Conditions

We completed five subsurface explorations (B-13, B-14, B-15, B-20 and CPT-2) along the proposed HDD alignment in the locations shown in Figure E-1. In general, subsurface conditions encountered in the borings consisted of interbedded sand, silt and clay. Subsurface conditions are described in more detail below.

Boring B-13 was completed near the proposed entry point. In general, subsurface conditions encountered in boring B-13 consisted of approximately 8 feet of very soft elastic silt overlying loose sand that extended to approximately 41.5 feet bgs. Below 41.5 feet bgs, the boring encountered very soft silt to approximately 48 feet bgs overlying soft organic clay that extended to approximately 54 feet bgs. Below 54 feet bgs, the boring encountered soft lean clay to about 69 feet bgs overlying medium stiff silt that extended to 71.5 feet bgs, the maximum depth explored.

Boring B-14 was completed approximately 150 feet northeast of Beaver Slough and about 25 feet southeast of the proposed alignment. Subsurface conditions encountered in boring B-14 generally consisted of approximately 8 feet of soft silt with sand overlying very loose to medium dense silty sand that extended to approximately 28 feet bgs. Below about 28 feet bgs, the boring encountered soft silt with abundant organics to approximately 68 feet bgs overlying medium stiff lean clay with occasional wood fragments that extended to 71.5 feet bgs, the maximum depth explored.

Boring B-15 was completed near the proposed exit point, approximately 280 feet south of the Clatskanie River. Boring B-15 generally encountered approximately 8 feet of soft fat clay with sand overlying very loose to loose to medium dense sand with varying amounts of silt that extended to 71.5 feet bgs, the maximum depth explored. An approximately 5-foot-thick layer of very soft to soft silt was encountered between about 23 and 28 feet bgs.

B-20 was completed approximately 50 feet west of Beaver Slough and about 30 feet south of the proposed HDD alignment. B-20 encountered approximately 58 feet of very soft to soft silt, overlying a 5-foot-thick layer of very stiff silt that was in-turn overlying medium stiff to stiff silt that extended to a depth of approximately 87 feet. Below about 87 feet, the boring encountered medium dense to dense silty sand that extended to about 143 feet bgs, and was overlying stiff silt that extended to 151.5 feet bgs, the maximum depth explored.

CPT-2 was completed approximately 645 feet west of Beaver Slough, and about 30 feet north of the HDD alignment. CPT-2 generally encountered similar materials as boring B-20. The CPT generally encountered about 60 feet of sensitive fine-grained soil (likely similar to the very soft silt seen in the upper profile of B-20) overlying silty sands and sandy silts that extended to about 120 feet bgs. Below about 120 feet bgs, the CPT encountered clayey silts and sandy silts that extended to 160 feet bgs, the maximum depth explored.

Subsurface conditions encountered in our borings are shown graphically in Figure E-1, and are described in detail in the boring and CPT logs in Appendix A.

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE EVALUATION

Model Input Parameters

The HDD geometry used for our analyses of HDD-3 is shown in Figure E-1, and in the HDD design Drawing No. HDD-3 in this appendix. Based on the results of the exploration program and subsequent laboratory-testing program, the soil properties used in the evaluation are presented in Table E-2 below.

TABLE E-2. ESTIMATED SOIL PROPERTIES

Soil Description	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Very Soft Elastic Silt	100	0	250
Loose to Medium Dense Sand with Silt	100-115	26-30	0
Soft Silt with Sand	110	0	350
Soft Lean Clay	110	0	500
Medium Stiff to Stiff Silt with Sand	110-115	23	0
Very Soft Fat Clay	95	0	50

Based on available information and common HDD construction procedures, the tool dimensions and rheological properties used in the evaluation are summarized in Table E-3. Because these parameters are dependent upon the HDD contractor's means and methods, the hydraulic fracture and drilling fluid surface release evaluation should be refined during construction of the HDD installations.

TABLE E-3. ESTIMATED TOOL DIMENSIONS AND RHEOLOGICAL PROPERTIES

Parameter	Value
Pilot Hole Bit Diameter	12.250 inches
Drill Pipe Diameter	6.625 inches
Drilling Fluid Weight	9.5 ppg
Plastic Viscosity	10 CP
Yield Point	20 lb/100 sf

Notes:
ppg = pounds per gallon; CP = centipoise; lb/100 sf = pounds per 100 square feet

Results of Hydraulic Fracture and Drilling Fluid Surface Release Evaluation

The results of the hydraulic fracture evaluation are presented in Figures E-2 and E-3. Figure E-2 shows the calculated formation limit pressure (green line) and the estimated drilling fluid pressure shown as the red line, which represents the drilling fluid pressure along the HDD profile based on the anticipated drilling fluid properties shown in Table E-3.

When evaluating the risk of hydraulic fracture and drilling fluid surface releases, the analysis computes two types of factors of safety. These are:

- Factor of Safety against localized hydraulic fracture; and
- Factor of Safety against drilling fluid surface release.

Local Hydraulic Fracture: The factor of safety against hydraulic fracture is the ratio of the formation limit pressure to the estimated drilling fluid pressure along the profile, shown as the green line in Figure E-3. This represents the factor of safety against hydraulic fracture of the soil immediately surrounding the HDD profile and is a localized condition.

Drilling Fluid Surface Release: The factors of safety against drilling fluid surface release considers the strength of the soil column above the HDD profile that resists drilling fluid migrating to the ground surface. It is computed by comparing the formation limit pressure of the soil units above a specific location along the planned HDD alignment to the anticipated drilling fluid pressure at the same location. The factors of safety against drilling fluid surface releases are shown in Figure E-3 at selected points shown as red triangles.

The model indicates that the risk of localized hydraulic fracture is generally low throughout the proposed HDD profile (including beneath Beaver Slough and the adjacent levees), except between about 200 to 400 feet west of the proposed entry point. In this area, the risk of hydraulic fracture is moderate to high, with factors of safety of about 1.5. This is shown by the green line in Figure E-3.

As shown by the red triangles in Figure E-3, the factors of safety against drilling fluid surface returns are generally greater than 2.0 indicating a low risk of drilling fluid surface release. However, the risk becomes moderate to very high within about 100 feet of the entry and exit points, as is typical with HDD installations.

INSTALLATION LOADS AND OPERATING STRESSES

Installation Loads

The analyses of installation loads and operational stresses are based on the product pipe being installed along the designed drill path using the BMPs of the HDD industry. The addition of water into the product pipe is the standard method that contractors typically use to control buoyancy of the product pipe during the installation procedure. The proposed 24-inch-diameter product pipe will be positively buoyant in the anticipated drilling fluid weights. The HDD Contractor may choose to add water to the product pipe to try and achieve neutral buoyancy during pullback and reduce the required pull force during installation of the product pipe. Thus, our analyses include a range of cases with differing levels of buoyancy control. The following table presents a summary of the calculated installation loads for the HDD.

TABLE E-4. INSTALLATION LOADS FOR THE 24-INCH-DIAMETER HDD-3[1]

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Effective Pipe Weight[2] (lb/ft)	Pullback Force[3] (lb)
9.5	Empty	-97	237,000
9.5	Full	83	194,000
12	Empty	-156	294,000
12	Full	24	148,000
10.5	Neutral	0	142,000

Notes:
[1] See the HDD Design Summary and Calculations summaries provided in this appendix for detailed calculations.
[2] Negative values indicate upward force (positive buoyancy).
[3] Assumes a fully open drilled hole.
[4] Assumes a minimum pipeline radius of 2,400 feet.

Because the HDD contractor might utilize a relatively large HDD drill rig to complete the installation, the drill rig may have a pullback capacity capable of causing damage to the product pipe during installation. While the estimated installation forces provided in Table E-4 suggest that the pullback forces should be less than 294,000 pounds, improper preparation of the hole prior to pullback operations or delays during pullback operations may cause pullback forces to exceed those estimated in the calculations.

Operating Stresses

For our operating stresses analysis, the installation and operating temperatures were assumed to be 55 degrees Fahrenheit. We can further evaluate different installation and operating temperatures, if requested. The following table presents a summary of the operating stresses for the product pipe specifications proposed for the HDD.

TABLE E-5. SUMMARY OF OPERATING STRESSES FOR THE 24-INCH-DIAMETER HDD 3

Stress Component	Stress (psi)	Percent SMYS[1] (%)	Maximum Allowable Percent SMYS (%)
Longitudinal Bending Stress	12,324	24	-
Hoop Stress	18,272	35	50[2]
Longitudinal Tensile Stress from Hoop Stress	5,482	11	-
Longitudinal Stress from Thermal Expansion	0	0	90[3]
Maximum Net Longitudinal Stress	17,806	34	90[4]
Maximum Shear Stress	12,557	24	45[5]
Maximum Combined Effective Stress	25,115	48	90[6]

Notes:
[1] Specified Minimum Yield Stress.
[2] Limited by design factor from DOT regulations, Title 49 CFR Part 192.111 for gas.
[3] Limited by Section 402.3.2 of ASME B31.4.
[4] Limited by Section 833.3 of ASME B31.8 for gas.
[5] Limited by Section 402.3.1 of ASME B31.4.
[6] Limited by Section 833.4 of ASME B31.8 for gas.

CONCLUSIONS AND RECOMMENDATIONS

HDD-3 crosses beneath Beaver Slough and its adjacent levees that are pending certification by the USACE. As such HDD-3 will be subject to the requirements for HDD crossings under levees by the USACE. Among others, the USACE will require that the calculated factor of safety against hydraulic fracture under the levees by at least 1.5 and possibly 2.0. The "Hydraulic Fracture and Drilling Fluid Surface Release" section in this appendix provides a discussion, conclusions and recommendations for construction pertaining to hydraulic fracture and drilling fluid surface release.

The current HDD design places the proposed entry point on the northeast side of the HDD and the exit point on the southwest side of the HDD, to reduce the risk of hydraulic fracture and drilling fluid surface releases to Beaver Slough and the adjacent levees. However, pipe stringing and fabrication workspace is limited on the southwest side of the HDD, and NW Natural prefers to place the pipe stringing and fabrication workspace on the northeast side of the HDD. Therefore, the drill rig will need to be moved to the southwest side of the HDD for pullback operations.

The available length of the proposed pipe stringing and fabrication workspace is limited by Beaver Slough on both the southwest and northeast sides of the crossing. As proposed by NW Natural, the pipe stringing and fabrication workspace on the northeast side of the HDD is approximately 1,275 feet long. Because of this space limitation, the product pipe will need to be fabricated in several sections that will be required to be welded together during pullback operations. We recommend starting pullback of the product pipe with the shortest assembled product pipe string.

Cuttings Removal

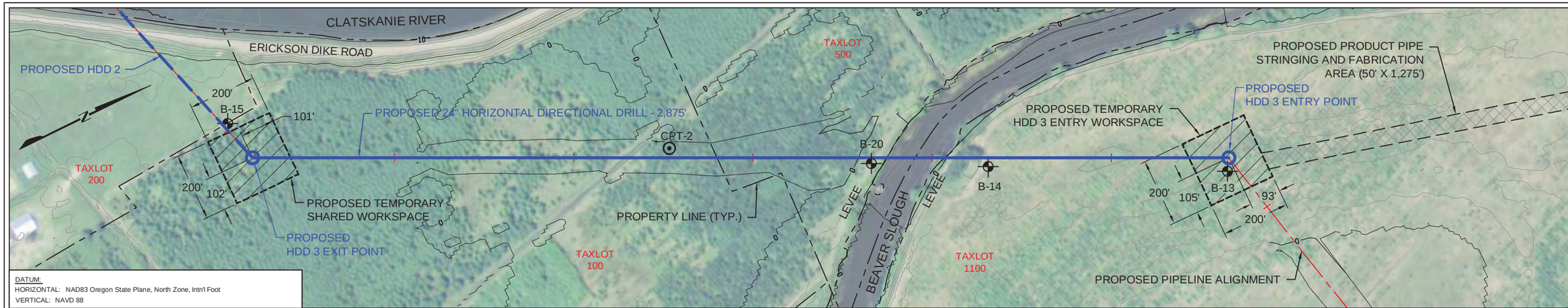
The proposed HDD profile will likely encounter elastic silt soils that may present difficulty with cuttings removal. The contractor should consider the soils observed in the borings completed along the alignment and utilize strategies to facilitate cuttings removal. Refer to Section 5.1.6 of this report for further discussion on cuttings removal within clay/elastic silt soils.

Hydraulic Fracture and Drilling Fluid Surface Releases

Based on our analysis, if the proposed HDD is drilled from the east towards the west, the factors of safety against hydraulic fracture and drilling fluid surface release below Beaver Slough and the adjacent levees is greater than 2.0. Therefore, we recommend that the contractor drill HDD-3 from the east towards the west.

The contractor will likely be required to complete the HDD in accordance with the requirements of the USACE, examples of which are include in the "Conclusions and Recommendations" section of the main body of this report. It will be extremely important for the contractor to maintain drilling fluid returns at all times, and monitor the alignment for drilling fluid surface releases during construction. The contractor should stage an employee near the slough to visually observe the surface for indications of drilling fluid releases at all times during construction.

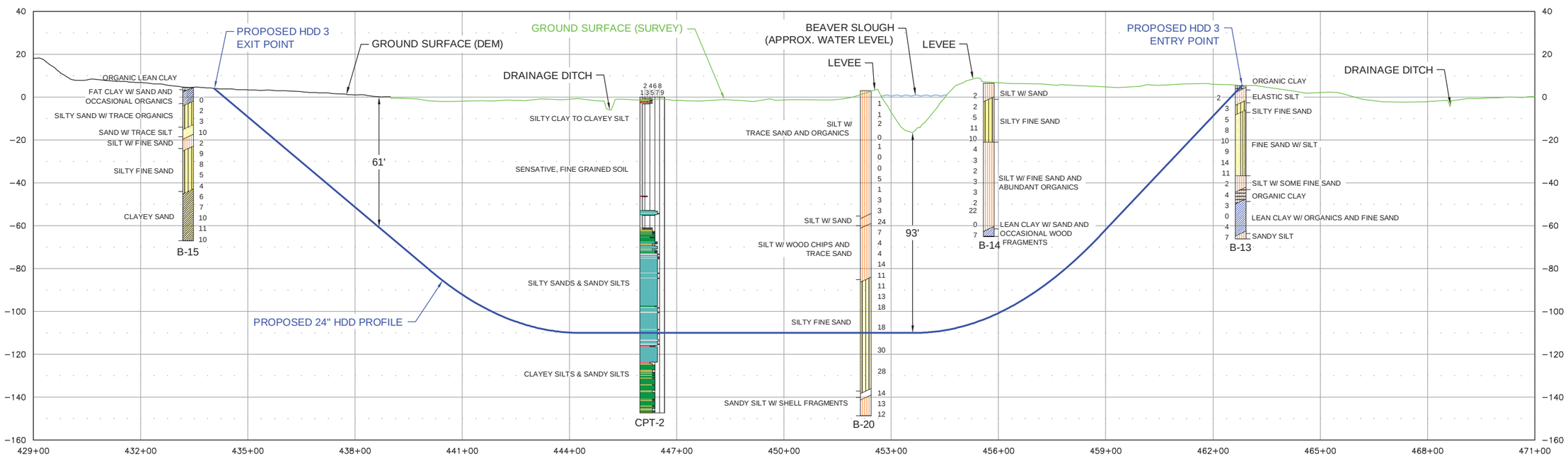
We recommend that the contractor establish a contingency and mitigation plan in the event that drilling fluid surface releases occur; these plans should be reviewed and approved by the project team prior to the start of construction.



NOT FOR CONSTRUCTION:
THE HDD DESIGN DRAWING IS INCLUDED AS HDD 3 IN APPENDIX E.

PLAN
300' 0 300'
SCALE IN FEET

Major Contour Interval = 10'
Minor Contour Interval = 2'



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Refer to the borings logs in the accompanying report for more detailed soil descriptions.
4. GeoEngineers, Inc. has not verified the field location of the existing utilities.

Reference: Ground surface DEM (1/9 arc second) and aerial photos downloaded from http://nationalmap.gov. Base files provided by NorthWest Natural. Ground surface and bathymetric survey data provided by Westlake Consultants, Inc., obtained August 2015.

PROFILE
300' 0 300'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

LEGEND:

TYPE OF SOIL
SPT (N)
Boring Location

SITE PLAN AND PROFILE
HDD 3

NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

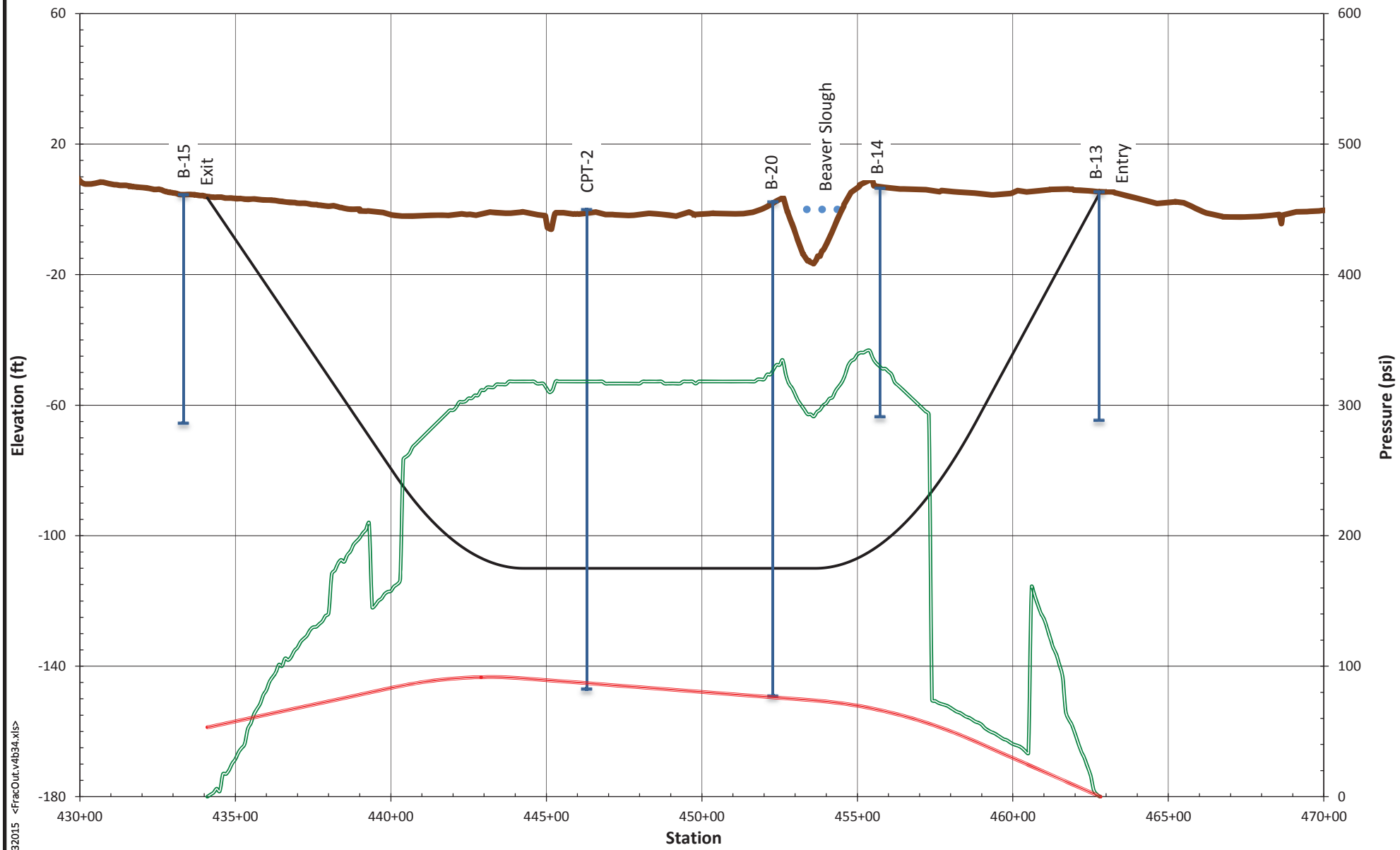
GEOENGINEERS

FIGURE E-1

BCR : TJB

P:\6\60241157\04\CAD\Figure E-1.dwg\TAB:Figure E-1 modified on Sep 14, 2015 - 12:55pm

NW NATURAL - NORTH MIST PIPELINE HDD 3



Crossing Length (ft)	2875
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	10
Yield Point (lb/100 ft)	20

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Formation Limit Pressure (psi)
- Estimated Annular Drilling Fluid Pressure (psi) for Pilot Hole

ESTIMATED ANNULAR DRILLING FLUID AND FORMATION LIMIT PRESSURES

NW NATURAL - NORTH MIST PIPELINE HDD 3

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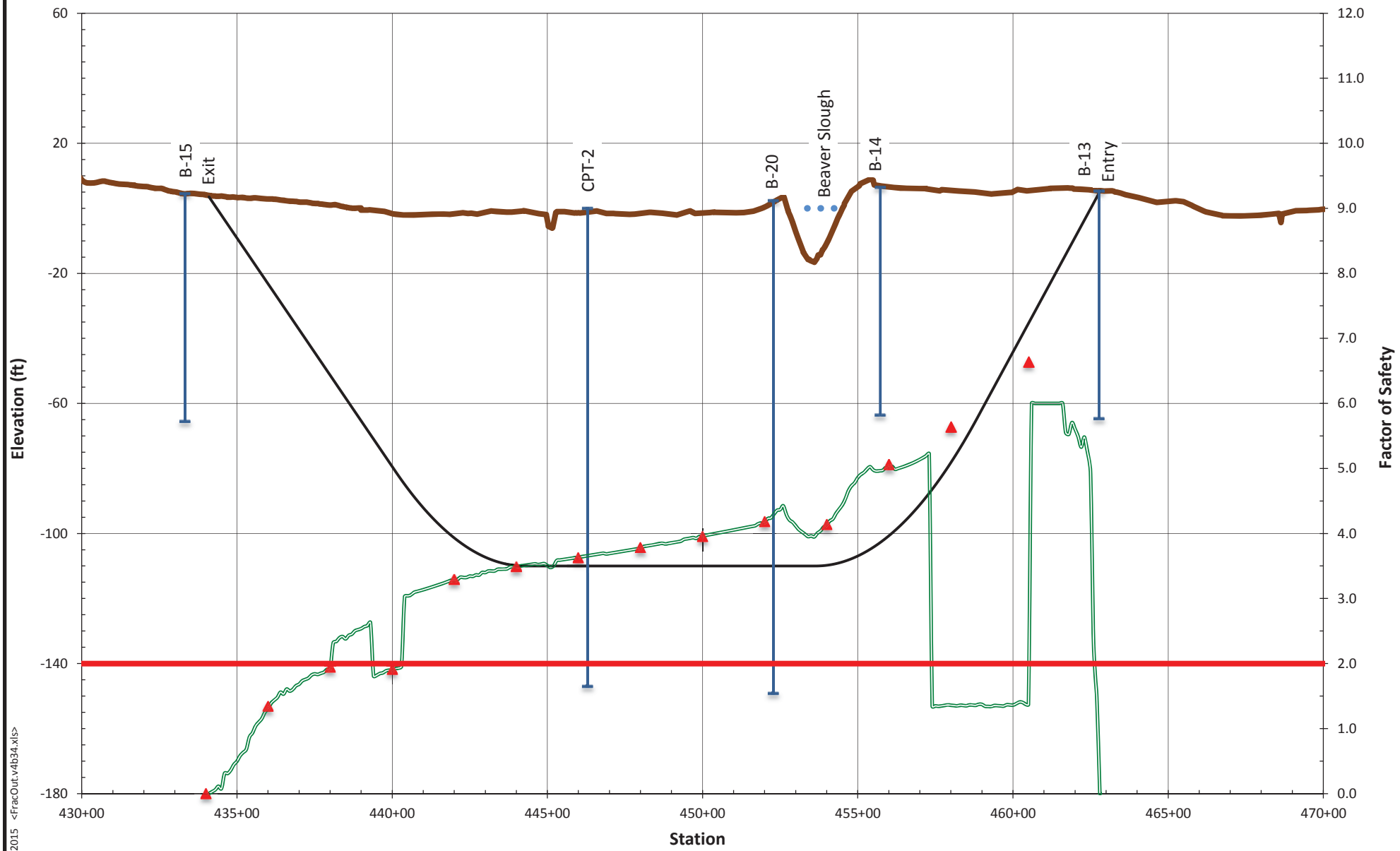
FIGURE E-2

06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>

NW NATURAL - NORTH MIST PIPELINE HDD 3



Crossing Length (ft)	2875
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	10
Yield Point (lb/100 ft)	20

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Hydraulic Fracture Factor of Safety for Pilot Hole
- Drilling Fluid Surface Release Factor of Safety for Pilot Hole
- Factor of Safety = 2

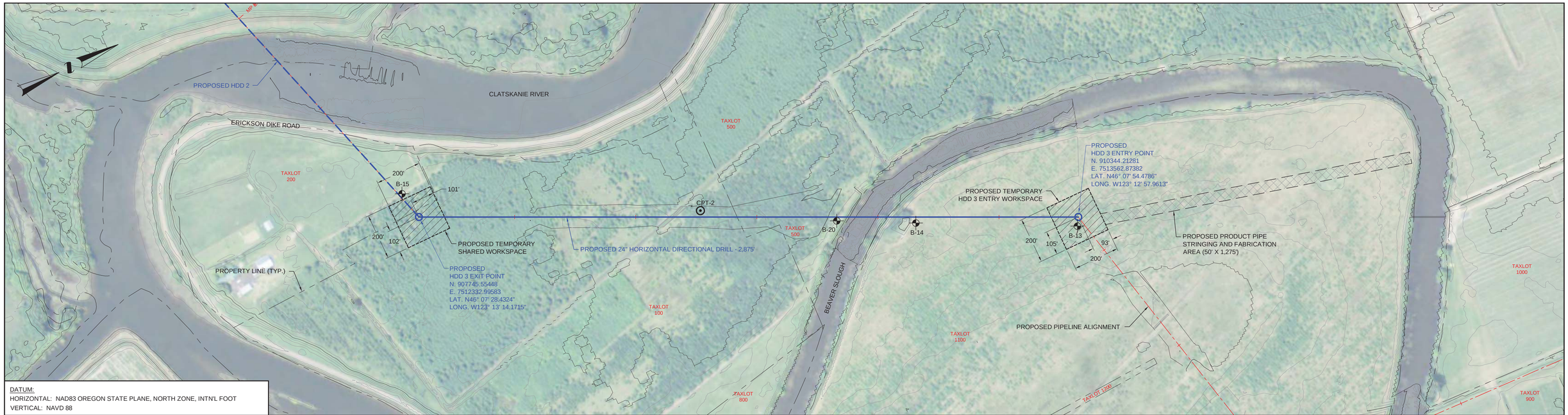
HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE FACTORS OF SAFETY

NW NATURAL - NORTH MIST PIPELINE HDD 3

GEOENGINEERS

FIGURE E-3

06024-157-03 JAH/AES 09132015 <FracOut.y4b34.xls>

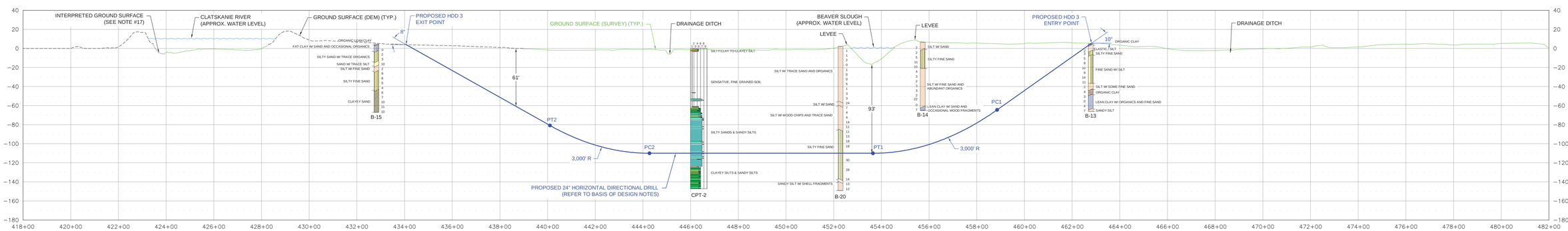


DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

200' 0 200'
SCALE IN FEET

MAJOR CONTOUR INTERVAL - 10'
MINOR CONTOUR INTERVAL = 2'



DIRECTIONAL DRILL DATA HDD 3		
DESCRIPTION	STATION (FT)	ELEVATION (FT)
ENTRY @ 10°	462+81.50	5.43
P C 1 (10.00° @ 3,000 FT R.)	458+85.33	-64.42
P T 1	453+64.39	-110.00
P C 2 (8.00° @ 3,000 FT R.)	444+27.40	-110.00
P T 2	440+09.88	-80.80
EXIT @ 8°	434+06.50	3.99
HORIZONTAL DISTANCE = 2,875.00 FT		
DIRECTIONAL DRILL PIPE LENGTH = 2,891.06 FT		

RECOMMENDED TOLERANCES	
ITEM	TOLERANCE
PILOT HOLE ENTRY ANGLE	INCREASE ANGLE UP TO 1° (STEEPER), BUT NO DECREASE IN ANGLE ALLOWED.
PILOT HOLE ENTRY LOCATION	AS PER COORDINATES PROVIDED BY COMPANY WITH NO CHANGES WITHOUT COMPANY APPROVAL.
PILOT HOLE EXIT ANGLE	INCREASE ANGLE UP TO 1° (STEEPER) OR DECREASE UP TO 2° (FLATTER).
PILOT HOLE EXIT LOCATION	UP TO 20 FEET BEYOND OR 10 FEET SHORT OF THE EXIT STAKE. BETWEEN 5 FEET LEFT AND 5 FEET RIGHT OF CENTERLINE.
PILOT HOLE DEPTH	UP TO 2 FEET ABOVE THE DESIGN DRILL PROFILE ALLOWED. UP TO 10 FEET BELOW THE DESIGN DRILL PROFILE ALLOWED.
PILOT HOLE ALIGNMENT	SHALL REMAIN WITHIN 5 FEET LEFT OR RIGHT OF THE HDD ALIGNMENT.

LEGEND:

TYPE OF SOIL — SPT (N)

BORING LOCATION

PROFILE

200' 0 200'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

NOTES

1. ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT-OF-WAY OR FROM APPROVED ACCESS ROADS.
2. WORK SPACE: MAXIMUM WORK SPACE LIMITS ARE DEPICTED. RESTRICT CLEARING TO THE WORK SPACE INDICATED AT THE ENTRY AND EXIT POINTS AND PRODUCT PIPE STRINGING AND FABRICATION AREA ALONG THE CONSTRUCTION RIGHT-OF-WAY. CLEARING BETWEEN THE ENTRY AND EXIT POINTS REQUIRES PRIOR APPROVAL FROM THE ENVIRONMENTAL INSPECTOR AND IS LIMITED TO THE AMOUNT NECESSARY TO STRING SURVEY WIRES AND INSTALL PUMPS AND PIPING TO OBTAIN WATER (WHERE APPROVED).
3. WATER SOURCE: DRILL WATER AND HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE.
4. HYDROSTATIC TEST: PRE-INSTALLATION AND POST-INSTALLATION HYDROSTATIC TESTS SHALL BE CONDUCTED IN ACCORDANCE WITH THE HYDROSTATIC TEST PLAN. TEST WATER SHALL BE SAMPLED AND TESTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE TEST WATER SHALL BE DISCHARGED IN AN UPLAND AREA INTO AN EROSION CONTROL STRUCTURE OF STRAW BALES AND/OR SILT FENCES, GEOTEXTILE FILTER BAG, OR COLLECTED IN A TRUCK AND HAULED TO AN APPROVED DISPOSAL SITE. UPON COMPLETION OF DEWATERING AND DRYING, A CALIPER PIG SURVEY SHALL BE COMPLETED IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
5. SPILL-PREVENTION: REFUELING OF ALL EQUIPMENT SHALL BE COMPLETED IN ACCORDANCE WITH THE SPCC PLAN.
6. EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE APPROVED CONSTRUCTION RIGHT-OF-WAY AT THE DRILL EXIT POINT AS SHOWN. AFTER THE PILOT HOLE IS COMPLETE, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO NORTHWEST NATURAL FOR APPROVAL. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULL BACK.
8. DRILLING FLUID DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING FLUID AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING FLUID WHICH INADVERTENTLY SURFACES AT POINTS OTHER THAN THE ENTRY OR EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.
9. CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN THE CLEAN-UP AND RESTORATION REQUIREMENTS.
10. GEOTECHNICAL DATA: BORE HOLES ARE OFFSET FROM THE PIPELINE CENTERLINE AS SHOWN ON THE PLAN VIEW. THE GEOTECHNICAL INFORMATION PROVIDED ON THIS DRAWING IS A GENERAL SUMMARY. REFER TO THE APPLICABLE GEOTECHNICAL REPORT IN THE CONTRACT DOCUMENTS FOR MORE DETAILED INFORMATION.
11. IF THE TERRAIN ALLOWS AND ACCESS IS PERMITTED, CONTRACTOR SHALL UTILIZE LOW GROUND PRESSURE EQUIPMENT OR OTHER EQUIPMENT APPROVED BY OWNER, TO FACILITATE CONTAINMENT AND CLEAN-UP OF ANY INADVERTENT RETURNS THAT OCCUR DURING THE HDD INSTALLATION PROCESS.
12. THE MINIMUM ALLOWABLE THREE JOINT RADIUS SHALL NOT BE LESS THAN 2,400 FEET.
13. AERIAL PHOTOS AND GROUND SURFACE DEM (1/9 ARC SECOND) DOWNLOADED FROM HTTP://VIEWER.NATIONALMAP.GOV/VIEWER/. BASE FILES PROVIDED BY NORTHWEST NATURAL. GROUND SURFACE AND BATHYMETRIC SURVEY DATA PROVIDED BY WESTLAKE CONSULTANTS, INC., OBTAINED AUGUST 2015.
14. CONTRACTOR IS RESPONSIBLE FOR CALLING OREGON ONE-CALL AND PHYSICALLY LOCATING ALL UNDERGROUND UTILITIES PRIOR TO BEGINNING CONSTRUCTION. IF ANY UTILITY IS LOCATED WITHIN 15 FEET OF THE DESIGNED HDD PROFILE AND ALIGNMENT, CONTRACTOR SHALL OBTAIN APPROVAL FROM NORTHWEST NATURAL PRIOR TO INITIATING HDD OPERATIONS.
15. A SITE SPECIFIC SURVEY DOCUMENTING EXISTING UTILITIES HAS NOT BEEN CONDUCTED ALONG THE PROPOSED PIPELINE ALIGNMENT. A SITE SPECIFIC TOPOGRAPHIC AND UTILITY SURVEY SHOULD BE COMPLETED PRIOR TO FINAL ISSUANCE OF THESE PLANS. DURING CONSTRUCTION, IT IS THE CONTRACTORS RESPONSIBILITY TO IDENTIFY AND PROTECT ANY UTILITY THAT MAY BE AFFECTED BY THE HDD OPERATIONS.
16. CONTRACTOR SHALL ADHERE TO THE SPECIFICATIONS AND REQUIREMENTS PER NORTHWEST NATURAL SPECIFICATIONS, CONTRACT DOCUMENTS, AND SPECIAL PERMIT CONDITIONS, EXCEPT AS NOTED ON THIS DRAWING.
17. GROUND SURFACE NOT OBTAINED DURING SITE SURVEY. THE GROUND SURFACE WAS INTERPRETED BETWEEN DEM DATA AND SITE-SPECIFIC SURVEY IN ORDER TO PERFORM HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE ANALYSIS.

FINAL

BASIS OF DESIGN:

1. PRODUCT PIPE WILL CONSIST OF 24" O.D. X 0.500" W.T., API-5L X-52 PIPE WITH 14-16 MILS OF FUSION BONDED EPOXY (FBE) AND A MINIMUM OF 40 MILS OF ABRASION RESISTANT OVERLAY (ARO).
2. MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) = 809 psi

NOTE: THIS IS A FULL SIZE DRAWING THAT IS INTENDED TO BE PRINTED ON A 24" X 36" SHEET OF PAPER.

REFERENCE DRAWINGS	
DRAWING NO.	TITLE

REVISIONS						
NO.	DATE	BY	DESCRIPTION	W.O.NO.	CHK.	APP.
A	07/02/14	MWC	ISSUED AS DRAFT		BCR	TNH
B	04/20/15	BTL	ISSUED AS DRAFT (24-INCH REDESIGN)		BCR	TNH
C	09/15/15	BTL	ISSUED FOR FINAL		BCR	TNH

GEOENGINEERS
1200 NW NAITO PARKWAY, SUITE 180
PORTLAND, OREGON 97209
TELEPHONE: (503) 624-9274
FAX: (503) 620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
STATION 418+00 TO 482+00
HDD 3
COLUMBIA COUNTY, OREGON

NW Natural

DRAWN BY: MWC	DATE: 06/03/14	ISSUED FOR BID:	SCALE: AS NOTED
CHECKED BY: BCR	DATE: 06/03/14	ISSUED FOR CONSTRUCTION:	
APPROVED BY:	DATE:	DRAWING NUMBER: HDD 3	SHEET 1
WO:		TIME: 09:09 PM DATE: 09/10/15 PATH: P:\850\24157\05\ICAD\HDD 3_FINAL Rev C.dwg	OF 1

HDD Design Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 3 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe Diameter = 24.000 in

Pipe Material = Steel

Yield Stress = 52,000 psi

Wall Thickness = 0.5 in

Assumed Installation Temp = 55 °F

Assumed Operating Temp= 55 °F

Design Factor = 0.5

MAOP = 809 psi

Drill Data Box

Point	Station (ft)	Elevation (ft)
ENTRY @ 10°	46,281.50	5.43
P C 1 (10.00° @ 3,000 ft R.)	45,885.33	-64.42
P T 1	45,364.39	-110.00
P C 2 (8.00° @ 3,000 ft R.)	44,427.40	-110.00
P T 2	44,009.88	-80.80
EXIT @ 8°	43,406.50	3.99

Horizontal Alignment Length = 2,875.00 ft

Profile Segment Information

Segment Name	Segment Type	Segment Length (ft)
ENTRY TANGENT	Straight	402.29
ENTRY CURVE	Vertical Curve	523.60
BOTTOM TANGENT	Straight	936.99
EXIT CURVE	Vertical Curve	418.88
EXIT TANGENT	Straight	609.31

Pipe Length = 2,891.06 ft

Installation Load Summary

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Buoyancy Control (lb/ft)	Effective Pipe Weight (lb/ft)	Total Installation Force (lb)
9.50	Empty	0.00	-97.46	237,000
9.50	Full	180.04	82.58	194,000
12.00	Empty	0.00	-156.21	294,000
12.00	Full	180.04	23.83	148,000
10.50	Neutral	120.96	0.00	142,000

GeoEngineers

Minimum Radius Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 3 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters:

Pipe Diameter = 24.000 in **MAOP =** 809 psi **Factor of Safety =** 2.00

Wall Thickness = 0.500 in **SMYS =** 52,000 psi

D/t Ratio = 48.00 **Modulus of Elasticity (E) =** 2.96E+007 psi

Hoop Stress:

Calculated Hoop Stress = (MAOP * Pipe Diameter) / (2 * Wall Thickness) = 19,416 psi

Longitudinal Stress:

Calculated Longitudinal Stress = Hoop Stress / 2 = 9,708 psi

Allowable Stress:

Calculated Allowable Stress = SMYS / Factor of Safety = 26,000 psi

Bending Stress:

Calculated Bending Stress = Allowable Stress - Longitudinal Stress = 16,292 psi

Minimum Radius:

Calculated Minimum Radius = (E * Pipe Diameter) / (2 * Bending Stress) = 1,817 ft

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 3 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe diameter =	24.000 in	**Minimum Radius of Curvature =**	2,400 ft
Wall Thickness =	0.500 in	**Coefficient of Thermal Expansion =**	6.5E-06 in/in/°F
SMYS =	52,000 psi	**Assumed Installation Temperature =**	55 °F
MAOP =	809 psi	**Assumed Operating Temperature =**	55 °F
Poissons's Ratio =	0.30	**Temperature Derating Factor =**	1.00
Young's Modulus (E) =	2.96E+007 psi	**Groundwater Table Head =**	110.00 ft
Design Factor =	0.5		

Stress Analyses

Longitudinal Stress from Bending =	12,324 psi	
Percent SMYS =	23.70 %	
Hoop Stress =	18,272 psi	
Percent SMYS =	35.14 %	Limited by Design Factor (0.5) according to 49 CFR 192.111
Longitudinal Tensile Stress from Hoop Stress =	5,482 psi	
Percent SMYS =	10.54 %	
Longitudinal Stress from Thermal Expansion =	0 psi	
Percent SMYS =	0.00 %	Limited to 90% SMYS by ASME/ANSI B31.4 section 402.3.2
Net Longitudinal Stress (Comp. side of Curve) =	-6,843 psi	
Percent SMYS =	13.16 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Net Longitudinal Stress (Tension side of Curve) =	17,806 psi	
Percent SMYS =	34.24 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Maximum Shear Stress =	12,557 psi	
Percent SMYS =	24.15 %	Limited to 45% SMYS by ASME/ANSI B31.4 section 402.3.1
Combined BiaxialSress Check =	25,115 psi	
Percent SMYS =	48.30 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.4

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 3 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 3 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	2,891 ft
Moment of Inertia =	2,549 in^4
Pipe Face Area =	36.91 in^2
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft^3
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft^3
Pipe Exterior Volume =	3.14 ft^3/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft^3/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft^3
Effective Weight of Pipe =	-97.46 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty — Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	609.31 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	27,564 lb
Friction Force =	17,641 lb
Segment Weight =	8,264 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	53,469 lb
Cumulative Force =	**53,469 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,448 psi	
Cumulative Axial Stress =	1,448 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,021 psi	7,537 psi
Combined Stress =	0.0348	< 1.0
Total Stress =	0.0207	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	33,212 lb
Drag Force =	18,950 lb
Friction Force =	9,964 lb
Segment Weight =	2,848 lb
Tension =	95,194 lb
Average Tension =	74,332 lb
Segment Force =	41,725 lb
Cumulative Force =	**95,194 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,130 psi	
Cumulative Axial Stress =	2,579 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,367 psi	7,537 psi
Combined Stress =	0.4041	< 1.0
Total Stress =	0.1871	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	936.99 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	42,388 lb
Friction Force =	27,394 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	69,783 lb
Cumulative Force =	**164,976 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,890 psi	
Cumulative Axial Stress =	4,469 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,367 psi	7,537 psi
Combined Stress =	0.1074	< 1.0
Total Stress =	0.0511	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	49,955 lb
Drag Force =	23,687 lb
Friction Force =	14,986 lb
Segment Weight =	-4,447 lb
Tension =	214,189 lb
Average Tension =	189,583 lb
Segment Force =	49,213 lb
Cumulative Force =	**214,189 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,333 psi	
Cumulative Axial Stress =	5,802 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,367 psi	7,537 psi
Combined Stress =	0.4816	< 1.0
Total Stress =	0.2546	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	402.29 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	18,199 lb
Friction Force =	11,583 lb
Segment Weight =	-6,808 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	22,974 lb
Cumulative Force =	**237,163 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	622 psi	
Cumulative Axial Stress =	6,425 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	827 psi	7,537 psi
Combined Stress =	0.1544	< 1.0
Total Stress =	0.0424	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 3 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	2,891 ft
Moment of Inertia =	2,549 in^4
Pipe Face Area =	36.91 in^2
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft^3
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft^3
Pipe Exterior Volume =	3.14 ft^3/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft^3/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft^3
Effective Weight of Pipe =	82.58 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 1 of 5**

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	609.31 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	27,564 lb
Friction Force =	14,949 lb
Segment Weight =	-7,003 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	35,510 lb
Cumulative Force =	**35,510 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	962 psi	
Cumulative Axial Stress =	962 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	139 psi	7,537 psi
Combined Stress =	0.0231	< 1.0
Total Stress =	0.0010	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	-14,620 lb
Drag Force =	18,950 lb
Friction Force =	4,386 lb
Segment Weight =	-2,413 lb
Tension =	60,819 lb
Average Tension =	48,164 lb
Segment Force =	25,308 lb
Cumulative Force =	**60,819 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	686 psi	
Cumulative Axial Stress =	1,648 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	182 psi	7,537 psi
Combined Stress =	0.3817	< 1.0
Total Stress =	0.1169	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	936.99 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	42,388 lb
Friction Force =	23,214 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	65,602 lb
Cumulative Force =	**126,421 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,777 psi	
Cumulative Axial Stress =	3,425 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	182 psi	7,537 psi
Combined Stress =	0.0823	< 1.0
Total Stress =	0.0082	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	-8,901 lb
Drag Force =	23,687 lb
Friction Force =	2,670 lb
Segment Weight =	3,769 lb
Tension =	159,217 lb
Average Tension =	142,819 lb
Segment Force =	32,796 lb
Cumulative Force =	**159,217 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	888 psi	
Cumulative Axial Stress =	4,313 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	182 psi	7,537 psi
Combined Stress =	0.4458	< 1.0
Total Stress =	0.1647	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	402.29 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	18,199 lb
Friction Force =	9,815 lb
Segment Weight =	5,769 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	33,783 lb
Cumulative Force =	**193,000 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	915 psi	
Cumulative Axial Stress =	5,228 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	116 psi	7,537 psi
Combined Stress =	0.1257	< 1.0
Total Stress =	0.0168	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 3 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	2,891 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	-156.21 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	609.31 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	27,564 lb
Friction Force =	28,276 lb
Segment Weight =	13,246 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	69,086 lb
Cumulative Force =	**69,086 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,872 psi	
Cumulative Axial Stress =	1,872 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,290 psi	7,537 psi
Combined Stress =	0.0450	< 1.0
Total Stress =	0.0332	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	49,484 lb
Drag Force =	18,950 lb
Friction Force =	14,845 lb
Segment Weight =	4,564 lb
Tension =	122,290 lb
Average Tension =	95,688 lb
Segment Force =	53,204 lb
Cumulative Force =	**122,290 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,441 psi	
Cumulative Axial Stress =	3,313 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,727 psi	7,537 psi
Combined Stress =	0.4218	< 1.0
Total Stress =	0.2276	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	936.99 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	42,388 lb
Friction Force =	43,909 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	86,297 lb
Cumulative Force =	**208,588 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	2,338 psi	
Cumulative Axial Stress =	5,651 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,727 psi	7,537 psi
Combined Stress =	0.1358	< 1.0
Total Stress =	0.0816	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 4 of 5**

Segment Parameters

Segment Name =	ENTRY CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	10.00 deg
Segment Length =	523.60 ft	**Center Displacement =**	11.42 ft

Segment Force Components

Normal Force =	71,787 lb
Drag Force =	23,687 lb
Friction Force =	21,536 lb
Segment Weight =	-7,128 lb
Tension =	268,218 lb
Average Tension =	238,403 lb
Segment Force =	59,631 lb
Cumulative Force =	**268,218 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,615 psi	
Cumulative Axial Stress =	7,266 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,727 psi	7,537 psi
Combined Stress =	0.5168	< 1.0
Total Stress =	0.3173	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 5 of 5**

Segment Parameters

Segment Name =	ENTRY TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	402.29 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	18,199 lb
Friction Force =	18,566 lb
Segment Weight =	-10,912 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	25,853 lb
Cumulative Force =	**294,071 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	700 psi	
Cumulative Axial Stress =	7,966 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,045 psi	7,537 psi
Combined Stress =	0.1915	< 1.0
Total Stress =	0.0661	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 3 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	2,891 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	23.83 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 1 of 5**

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	609.31 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	27,564 lb
Friction Force =	4,314 lb
Segment Weight =	-2,021 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	29,857 lb
Cumulative Force =	**29,857 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	809 psi	
Cumulative Axial Stress =	809 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	408 psi	7,537 psi
Combined Stress =	0.0194	< 1.0
Total Stress =	0.0036	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	-375 lb
Drag Force =	18,950 lb
Friction Force =	113 lb
Segment Weight =	-696 lb
Tension =	48,336 lb
Average Tension =	39,097 lb
Segment Force =	18,479 lb
Cumulative Force =	**48,336 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	501 psi	
Cumulative Axial Stress =	1,309 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	541 psi	7,537 psi
Combined Stress =	0.3736	< 1.0
Total Stress =	0.1223	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	936.99 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	42,388 lb
Friction Force =	6,699 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	49,087 lb
Cumulative Force =	**97,423 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,330 psi	
Cumulative Axial Stress =	2,639 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	541 psi	7,537 psi
Combined Stress =	0.0634	< 1.0
Total Stress =	0.0109	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	5,859 lb
Drag Force =	23,687 lb
Friction Force =	1,758 lb
Segment Weight =	1,088 lb
Tension =	125,713 lb
Average Tension =	111,568 lb
Segment Force =	28,290 lb
Cumulative Force =	**125,713 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	766 psi	
Cumulative Axial Stress =	3,406 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	541 psi	7,537 psi
Combined Stress =	0.4240	< 1.0
Total Stress =	0.1594	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	402.29 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	18,199 lb
Friction Force =	2,832 lb
Segment Weight =	1,665 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	22,696 lb
Cumulative Force =	**148,409 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	615 psi	
Cumulative Axial Stress =	4,020 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	334 psi	7,537 psi
Combined Stress =	0.0966	< 1.0
Total Stress =	0.0130	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 3 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	2,891 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	246.76 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	0.00 lb/ft

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy — Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	609.31 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	27,564 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	27,564 lb
Cumulative Force =	**27,564 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	747 psi	
Cumulative Axial Stress =	747 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,129 psi	7,537 psi
Combined Stress =	0.0180	< 1.0
Total Stress =	0.0228	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	5,718 lb
Drag Force =	18,950 lb
Friction Force =	1,715 lb
Segment Weight =	0 lb
Tension =	49,945 lb
Average Tension =	38,754 lb
Segment Force =	22,380 lb
Cumulative Force =	**49,945 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	606 psi	
Cumulative Axial Stress =	1,353 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,511 psi	7,537 psi
Combined Stress =	0.3746	< 1.0
Total Stress =	0.1742	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	936.99 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	42,388 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	42,388 lb
Cumulative Force =	**92,333 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,148 psi	
Cumulative Axial Stress =	2,501 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,511 psi	7,537 psi
Combined Stress =	0.0601	< 1.0
Total Stress =	0.0470	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	12,827 lb
Drag Force =	23,687 lb
Friction Force =	3,848 lb
Segment Weight =	0 lb
Tension =	123,716 lb
Average Tension =	108,025 lb
Segment Force =	31,383 lb
Cumulative Force =	**123,716 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	850 psi	
Cumulative Axial Stress =	3,351 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,511 psi	7,537 psi
Combined Stress =	0.4227	< 1.0
Total Stress =	0.2122	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	402.29 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	18,199 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	18,199 lb
Cumulative Force =	**141,915 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	493 psi	
Cumulative Axial Stress =	3,845 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	914 psi	7,537 psi
Combined Stress =	0.0924	< 1.0
Total Stress =	0.0273	< 1.0

APPENDIX F
HDD-4

APPENDIX F
HDD-4

General

This appendix provides GeoEngineers' HDD design recommendations for proposed HDD-4 along the proposed North Mist Pipeline alignment located in Columbia County, Oregon. The general site plan and profile is provided in Figure F-1 of this appendix. A full size construction drawing showing the design profile is provided in the attached Drawing No. HDD-4. The design drawing includes the necessary geometric information required to complete the pilot hole.

Project Description and Basis of Design

The proposed HDD installation will be a 24-inch-diameter steel pipeline crossing Beaver Slough, a drainage canal, a blueberry field and Collins Road 2. The proposed pipeline alignment is oriented south-north (entry to exit), as shown in Figure F-1. The HDD design was completed based on the parameters presented below in Table F-1.

TABLE F-1. BASIS OF DESIGN FOR THE 24-INCH-DIAMETER HDD-4

Carrier Pipe Data	Design Parameter
Carrier Pipe Specifications	24 inches x 0.500 inches w.t.[1] API-5L X-52 steel pipe
Horizontal Crossing Length	3,685 feet
Maximum Allowable Operating Pressure	809 psig[2]
Maximum Operating Temperature	55 degrees F
Assumed Tie-In Temperature	55 degrees F

Notes:
[1] w.t. – wall thickness
[2] psig – pounds per square inch gauge

SITE DESCRIPTION

Surface Conditions

Topography along the proposed HDD alignment generally consists of a relatively flat alluvial valley that is cut by Beaver Slough. The ground surface along the proposed HDD alignment is currently occupied by a tree farm and blueberry farm. The proposed HDD begins on the south at an elevation of about 4.4 feet MSL, traverses a relatively flat Poplar tree farm and then crosses Beaver Slough roughly 460 feet north of the entry point. Beaver Sough is approximately 140 feet wide and 18 feet deep measured from the top of the northern levee. Bathymetric data obtained by Westlake Consultants, Inc., in August 2015 places the mudline of Beaver slough at a minimum elevation of approximately -13.5 feet MSL along the HDD alignment. After crossing Beaver Slough, the alignment continues northward across blueberry farm property for an additional approximately 2,800 feet, crosses an approximately 5 to 8-foot-wide by 3-foot deep drainage ditch and then crosses Collins Road 2 before reaching the exit point, which is situated in Poplar tree farm property roughly 150 feet north of Collins Road 2. The exit point is situated at an elevation of about 2.6 feet MSL. At the time of our reconnaissance, the Poplar trees within the proposed exit workspace were roughly 10 feet tall. The proposed pipe stringing and fabrication workspace extends southward away from the entry workspace across a Poplar tree farm.

Subsurface Conditions

We completed four borings (B-9, B-10, B-11 and B-12) and one CPT (CPT-1) along or near the proposed HDD alignment in the locations shown in Figure E-1.

In general, subsurface conditions encountered in the explorations consisted of very soft to medium stiff elastic silt, soft to medium stiff silt, very stiff to hard lean clay with wood fragments, and medium dense sand with varying amounts of silt. Subsurface conditions encountered in each exploration are described in more detail below.

Boring B-9 was drilled near the proposed exit workspace, approximately 250 feet north of Collins Road 2. The boring generally encountered approximately 13 feet of very soft silt with clay and wood fragments overlying interbedded loose to medium dense silty sand and sand with silt that extended to approximately 39 feet bgs. Below 39 feet bgs, the boring encountered medium dense silty sand to 65 feet bgs, at which point the sand was interbedded with 1 to 3-foot-thick layers of stiff to very stiff lean clay to 71 feet bgs. Medium stiff silt was observed in the sampler below 71 feet bgs. The silt extended to 71.5 feet bgs, the maximum depth explored.

B-10 was drilled approximately 1,575 feet north of Beaver Slough and about 30 feet west of the proposed alignment. The boring generally encountered 28 feet of very soft organic silt overlying interbedded soft to medium stiff elastic silt and very soft to stiff silt that extended to approximately 215 feet bgs. Below 215 feet bgs, the boring encountered dense sand with occasional silt that extended to 231.5 feet, the maximum depth explored.

Boring B-11 was completed approximately 80 feet north of Beaver Slough, and about 25 feet east of the proposed alignment. Boring B-11 generally encountered approximately 8 feet of very soft elastic silt overlying very soft organic silt that extended to about 29 feet bgs and was overlying layered very soft elastic silt, very soft to very stiff silt and loose silty sand that extended to about 94 feet bgs. Below 94 feet bgs, the boring encountered medium dense sand that extended to approximately 168 feet bgs. Below 168 feet bgs, the boring encountered stiff to very stiff silt that extended to 196.5 feet bgs, the maximum depth explored.

Boring B-12 was drilled near the proposed entry point, approximately 400 feet south of Beaver Slough and approximately 25 feet west of the proposed alignment. In general, boring B-12 encountered approximately 60 feet of very soft to medium stiff elastic silt with varying amounts of sand overlying an approximately 3-foot-thick layer of very stiff lean clay that extended to about 63 feet bgs. Below about 63 feet bgs, the boring encountered soft silt with sand and wood fragments to 71.5 feet, the maximum depth explored.

CPT-1 was completed between borings B-10 and B-11 roughly 900 feet north of Beaver Slough, and about 30 feet east of the proposed alignment. CPT-1 encountered similar materials as those observed in borings B-10 and B-11. However, the CPT met practical refusal at a depth of 60 feet bgs.

Subsurface conditions encountered in our borings are shown graphically in Figure F-1, and are described in detail in the boring logs in Appendix A.

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE EVALUATION

Model Input Parameters

The HDD geometry used for our analyses of HDD-4 is shown in Figure F-1, and in the HDD Design Drawing HDD-4 in this appendix. Based on the results of the exploration program and subsequent laboratory-testing program, the soil properties used in the evaluation are presented in Table F-2 below.

TABLE F-2. ESTIMATED SOIL PROPERTIES

Soil Description	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Soft Silt with Clay and Soft Elastic Silt	90	0	50
Medium Stiff Elastic Silt	100	20	0
Medium Stiff to V Stiff Lean Clay	105-110	20-23	0
Loose to M. Dense Silty Sand	100-120	26-32	0

Based on available information and common HDD construction procedures, the tool dimensions and rheological properties used in the evaluation are summarized in Table F-3. Because these parameters are dependent upon the HDD contractor's means and methods, the hydraulic fracture and drilling fluid surface release evaluation should be refined during construction of the HDD installations.

TABLE F-3. ESTIMATED TOOL DIMENSIONS AND RHEOLOGICAL PROPERTIES

Parameter	Value
Pilot Hole Bit Diameter	12.25 inches
Drill Pipe Diameter	6.625 inches
Drilling Fluid Weight	9.5 ppg
Plastic Viscosity	12 CP
Yield Point	24 lb/100 sf

Notes:
ppg = pounds per gallon; CP = centipoise; lb/100 sf = pounds per 100 square feet

Results of Hydraulic Fracture and Drilling Fluid Surface Release Evaluation

The results of the hydraulic fracture evaluation are presented in Figures F-2 and F-3. Figure F-2 shows the calculated formation limit pressure (green line) and the estimated drilling fluid pressure shown as the red line, which represents the drilling fluid pressure along the HDD profile based on the anticipated drilling fluid properties shown in Table F-3.

When evaluating the risk of hydraulic fracture and drilling fluid surface releases, the analysis computes two types of factors of safety. These are:

- Factor of Safety against localized hydraulic fracture; and
- Factor of Safety against drilling fluid surface release.

Local Hydraulic Fracture: The factor of safety against hydraulic fracture is the ratio of the formation limit pressure to the estimated drilling fluid pressure along the profile, shown as the green line in Figure F-3. This represents the factor of safety against hydraulic fracture of the soil immediately surrounding the HDD profile and is a localized condition.

Drilling Fluid Surface Release: The factors of safety against drilling fluid surface release considers the strength of the soil column above the HDD profile that resists drilling fluid migrating to the ground surface. It is computed by comparing the formation limit pressure of the soil units above a specific location along the planned HDD alignment to the anticipated drilling fluid pressure at the same location. The factors of safety against drilling fluid surface releases are shown in Figure F-3 at selected points shown as red triangles.

The model indicates that the risk of localized hydraulic fracture and drilling fluid surface releases is generally low (factors of safety between 2.5 and 5.0) from the proposed entry point, below Beaver Slough and adjacent levees, to about midway through the HDD profile, where safety factors gradually drop below 2.0 and the risk increases to moderate until about 100 feet of the exit point where the risk becomes high to very high, as would be expected for typical HDD installations.

INSTALLATION LOADS AND OPERATING STRESSES

Installation Loads

The analyses of installation loads and operational stresses are based on the product pipe being installed along the designed drill path using the BMPs of the HDD industry. The addition of water into the product pipe is the standard method that contractors typically use to control buoyancy of the product pipe during the installation procedure. The proposed 24-inch-diameter product pipe will be positively buoyant in the anticipated drilling fluid weights. The HDD Contractor may choose to add water to the product pipe to try and achieve neutral buoyancy during pullback and reduce the required pull force during installation of the product pipe. Thus, our analyses include a range of cases with differing levels of buoyancy control. The following table presents a summary of the calculated installation loads for the HDD.

TABLE F-4. INSTALLATION LOADS FOR THE 24-INCH-DIAMETER HDD-4[1]

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Effective Pipe Weight[2] (lb/ft)	Pullback Force[3] (lb)
9.5	Empty	-97	301,000
9.5	Full	83	247,000
12	Empty	-156	373,000
12	Full	24	194,000
10.5	Neutral	0	180,000

Notes:
[1] See the HDD Design Summary and Calculations summaries provided in this appendix for detailed calculations.
[2] Negative values indicate upward force (positive buoyancy).
[3] Assumes a fully open drilled hole.
[4] Assumes a minimum pipeline radius of 2,400 feet.

Because the HDD contractor might utilize a relatively large drill rig to complete the installation, the drill rig may have a pullback capacity capable of causing damage to the product pipe during installation. While the estimated installation forces provided in Table F-4 suggest that the pullback forces should be less than 373,000 pounds, improper preparation of the hole prior to pullback operations or delays during pullback operations may cause pullback forces to exceed those estimated in the calculations.

Operating Stresses

For our operating stresses analysis, the installation and operating temperatures were assumed to be 55 degrees Fahrenheit. We can further evaluate different installation and operating temperatures, if requested. The following table presents a summary of the operating stresses for the product pipe specifications proposed for the HDD.

TABLE F-5. SUMMARY OF OPERATING STRESSES FOR THE 24-INCH-DIAMETER HDD-4

Stress Component	Stress (psi)	Percent SMYS[1] (%)	Maximum Allowable Percent SMYS (%)
Longitudinal Bending Stress	12,324	24	-
Hoop Stress	18,272	35	50[2]
Longitudinal Tensile Stress from Hoop Stress	5,482	11	-
Longitudinal Stress from Thermal Expansion	0	0	90[3]
Maximum Net Longitudinal Stress	17,806	34	90[4]
Maximum Shear Stress	12,557	24	45[5]
Maximum Combined Effective Stress	25,115	48	90[6]

Notes:
[1] Specified Minimum Yield Stress.
[2] Limited by design factor from DOT regulations, Title 49 CFR Part 192.111 for gas.
[3] Limited by Section 402.3.2 of ASME B31.4.
[4] Limited by Section 833.3 of ASME B31.8 for gas.
[5] Limited by Section 402.3.1 of ASME B31.4.
[6] Limited by Section 833.4 of ASME B31.8 for gas.

CONCLUSIONS AND RECOMMENDATIONS

HDD-4 crosses beneath Beaver Slough and its adjacent levees that are pending certification by the USACE. As such HDD-4 will be subject to the requirements for HDD crossings under levees by the USACE. Among others, the USACE will require that the calculated factor of safety against hydraulic fracture under the levees by at least 1.5 and possibly 2.0. Based on the current subsurface data and the current design profile, provided the HDD profile is drilled from the south to north (entry to exit), safety factors beneath Beaver Slough and the adjacent levees are greater than 2.0 as further discussed in the "Hydraulic Fracture and Drilling Fluid Surface Releases" section below. Therefore, we recommend that the HDD profile be drilled from the south towards the north to reduce the risk of hydraulic fracture and drilling fluid surface releases to Beaver Slough. Because the pipe fabrication and stringing area is on the south side of the HDD alignment, the drill rig will have to be moved to the north side of the HDD prior to pullback.

Boring B-12 encountered very soft to soft elastic silt in the upper 55 feet of the soil profile. The softer zones of these soils may present steering difficulties during construction. The contractor should be prepared to encounter steering difficulties, particularly on the south side of the HDD profile.

Cuttings Removal

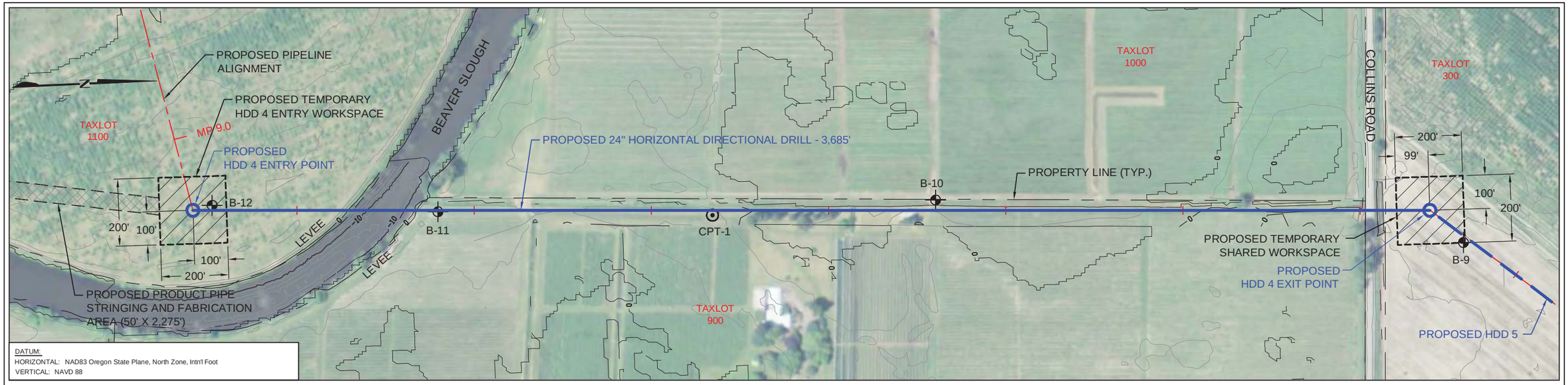
The proposed HDD profile will likely encounter elastic silt and clay soils that may present difficulty removing cuttings. The contractor should consider the soils observed in the borings completed along the alignment and utilize strategies to facilitate cuttings removal. Refer to Section 5.1.6 of this report for further discussion on cuttings removal within clay/elastic silt soils.

Hydraulic Fracture and Drilling Fluid Surface Release

Based on our analyses, there is generally a low to moderate risk of hydraulic fracture and drilling fluid surface release along most of the proposed HDD profile. As is typical with HDD installations, we expect that the risk is generally high within 100 feet of the entry and exit points.

Assuming the levees associated with Beaver Slough are under the USACE jurisdiction, the contractor will be required to complete the HDD in accordance with the requirements of the USACE, examples of which are included in the "Conclusions and Recommendations" section of the main body of this report. It will be extremely important for the contractor to maintain drilling fluid returns at all times, and monitor the alignment for drilling fluid surface releases during construction. The contractor should stage an employee near the slough to visually observe the surface for indications of drilling fluid releases at all times during construction.

We recommend that the contractor establish a contingency and mitigation plan in the event that drilling fluid surface releases occur; these plans should be reviewed and approved by the project team prior to the start of construction.

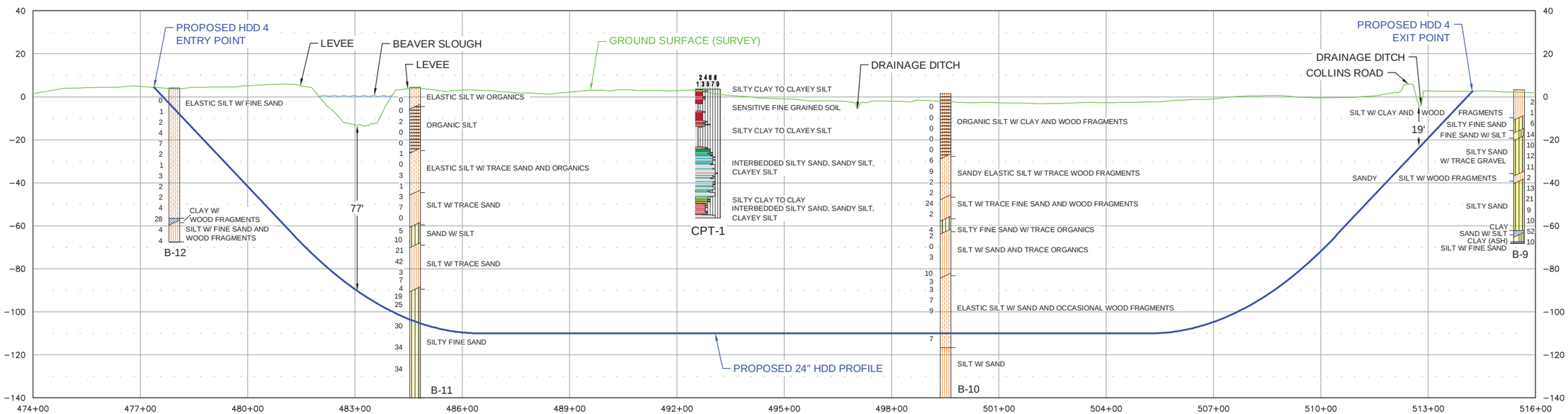


BCR : BTL

NOT FOR CONSTRUCTION:
THE HDD DESIGN DRAWING IS INCLUDED AS HDD 4 IN APPENDIX F.

PLAN
300' 0 300'
SCALE IN FEET

Major Contour Interval = 10'
Minor Contour Interval = 2'



PROFILE
300' 0 300'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Refer to the borings logs in the accompanying report for more detailed soil descriptions.
4. GeoEngineers, Inc. has not verified the field location of the existing utilities.

Reference: Ground surface DEM (1/9 arc second) and aerial photos downloaded from http://nationalmap.gov. Base files provided by NorthWest Natural. Ground surface and bathymetric data provided by Westlake Consultants, Inc., obtained August 2015.

LEGEND:

TYPE OF SOIL — SPT (N)

Boring Location

SITE PLAN AND PROFILE
HDD 4

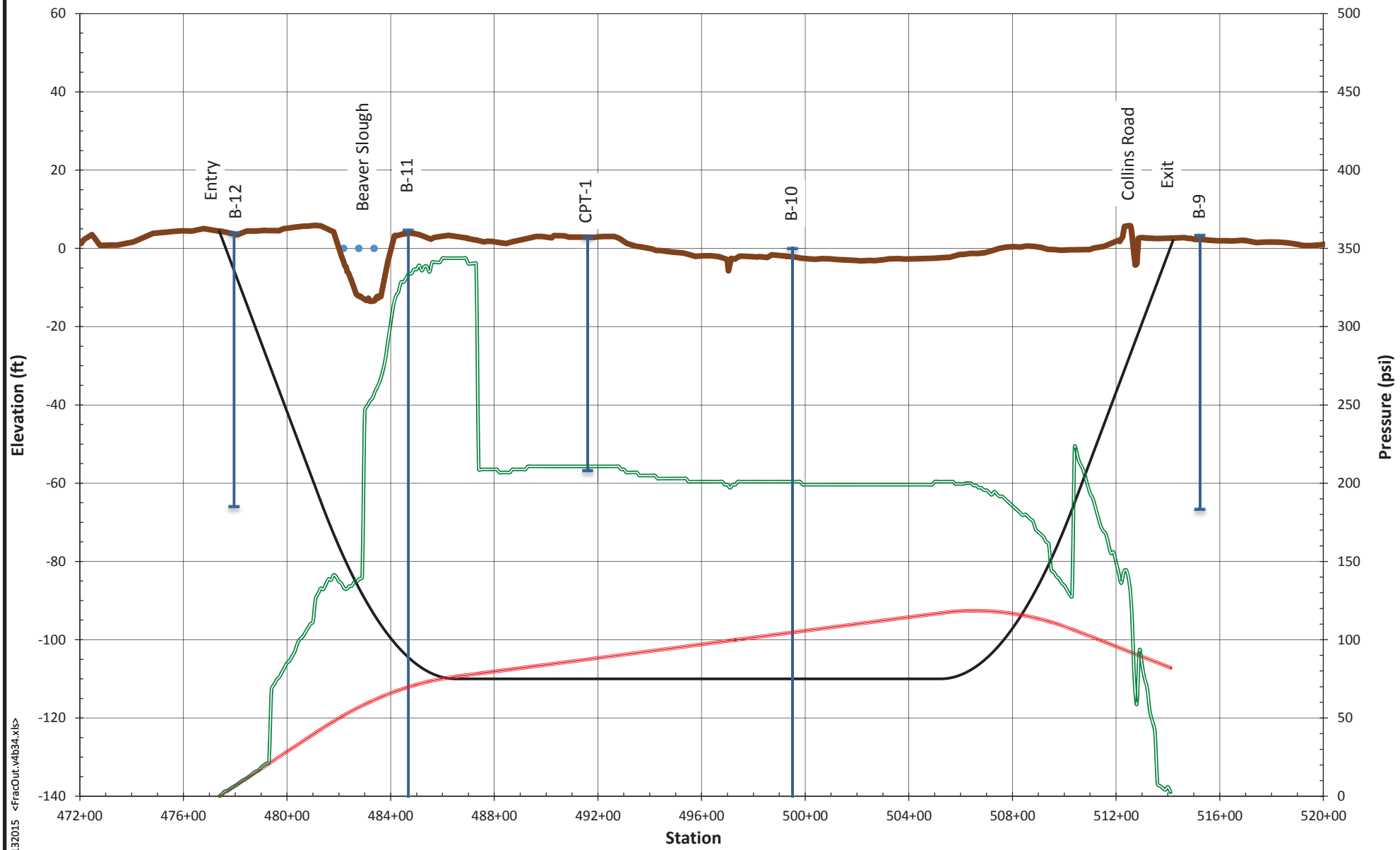
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

GEOENGINEERS

FIGURE F-1

P:\6\0024157\04\CAD\Figure F-1.dwg\TAB:Figure F-1 modified on Sep 14, 2015 - 1:02pm

NW NATURAL - NORTH MIST PIPELINE HDD 4



Crossing Length (ft)	3685
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	12
Yield Point (lb/100 ft)	24

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Estimated Annular Drilliing Fluid Pressure (psi) for Pilot Hole
- Formation Limit Pressure (psi)

ESTIMATED ANNULAR DRILLING FLUID AND FORMATION LIMIT PRESSURES

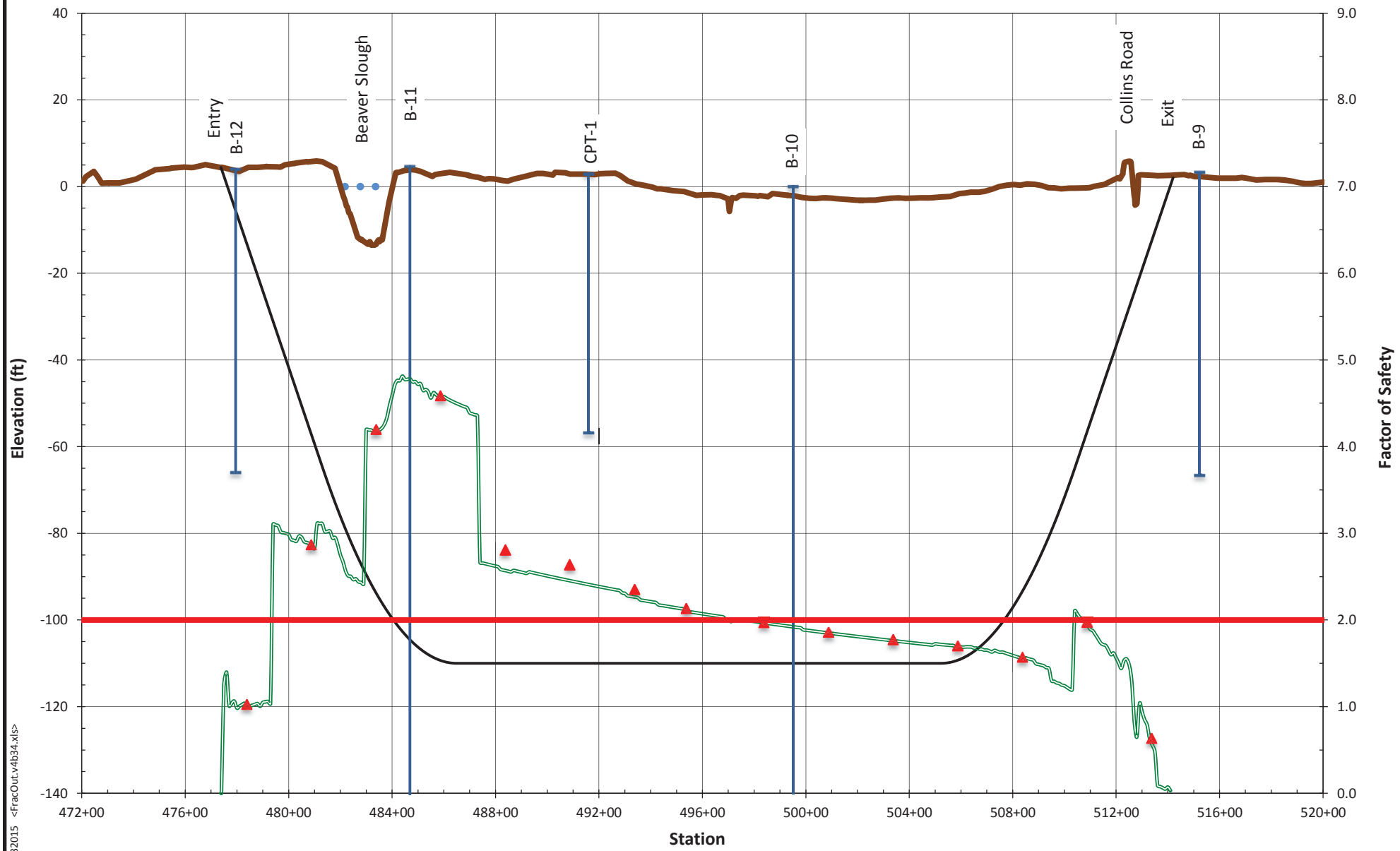
NW NATURAL - NORTH MIST PIPELINE HDD 4

GEOENGINEERS

FIGURE F-2

06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>

NW NATURAL - NORTH MIST PIPELINE HDD 4



Crossing Length (ft)	3685
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Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	12
Yield Point (lb/100 ft)	24

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Drilling Fluid Surface Release Factor of Safety for Pilot Hole
- Hydraulic Fracture Factor of Safety for Pilot Hole
- Factor of Safety = 2

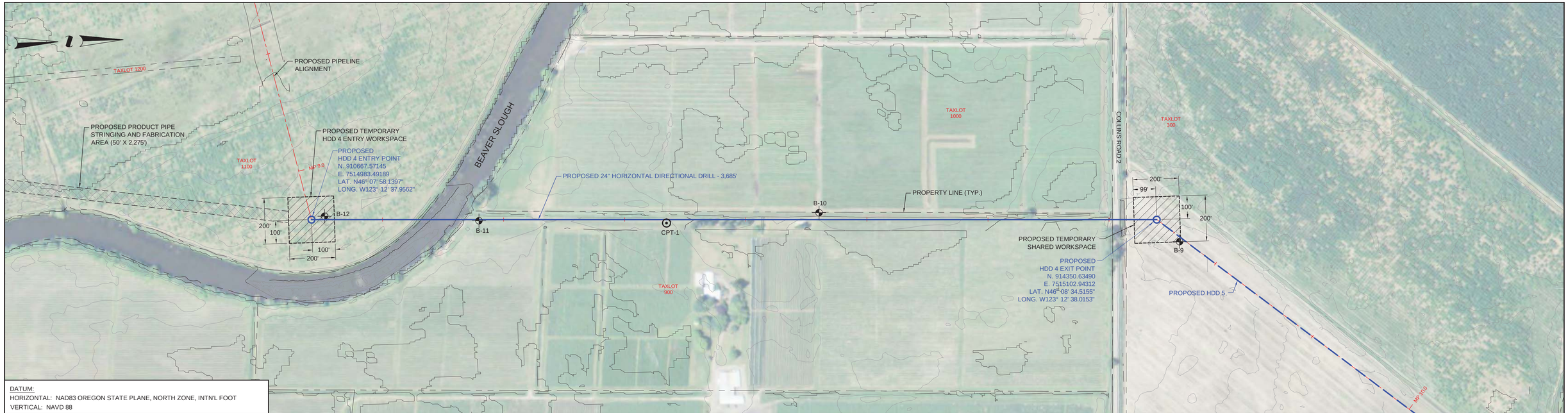
HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE FACTORS OF SAFETY

NW NATURAL - NORTH MIST PIPELINE HDD 4

GEOENGINEERS

FIGURE F-3

06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>

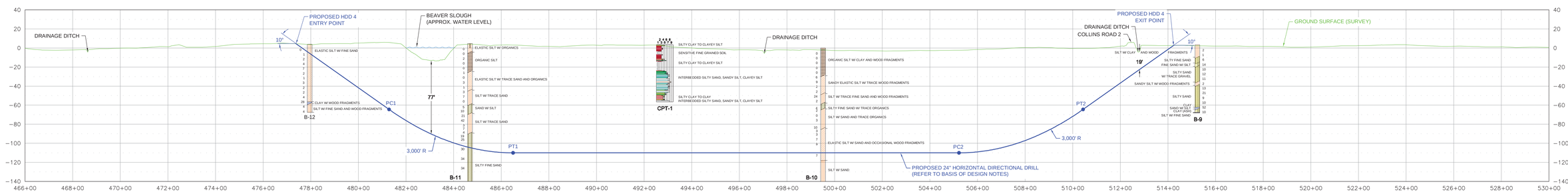


DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

200' 0 200'
SCALE IN FEET

MAJOR CONTOUR INTERVAL = 10'
MINOR CONTOUR INTERVAL = 2'



PROFILE

200' 0 200'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

DIRECTIONAL DRILL DATA HDD 4		
DESCRIPTION	STATION (FT)	ELEVATION (FT)
ENTRY @ 10°	477+38.46	4.41
P C 1 (10.00° @ 3.000 FT R.)	481+28.81	-64.42
P T 1	486+49.75	-110.00
P C 2 (10.00° @ 3.000 FT R.)	505+22.22	-110.00
P T 2	510+43.17	-64.42
EXIT @ 10°	514+23.46	2.63
HORIZONTAL DISTANCE = 3,685.00 FT		
DIRECTIONAL DRILL PIPE LENGTH = 3,702.20 FT		

RECOMMENDED TOLERANCES	
ITEM	TOLERANCE
PILOT HOLE ENTRY ANGLE	INCREASE ANGLE UP TO 1° (STEEPER), BUT NO DECREASE IN ANGLE ALLOWED.
PILOT HOLE ENTRY LOCATION	AS PER COORDINATES PROVIDED BY COMPANY WITH NO CHANGES WITHOUT COMPANY APPROVAL.
PILOT HOLE EXIT ANGLE	INCREASE ANGLE UP TO 1° (STEEPER) OR DECREASE UP TO 2° (FLATTER).
PILOT HOLE EXIT LOCATION	UP TO 20 FEET BEYOND OR 10 FEET SHORT OF THE EXIT STAKE. BETWEEN 5 FEET LEFT AND 5 FEET RIGHT OF CENTERLINE.
PILOT HOLE DEPTH	UP TO 2 FEET ABOVE THE DESIGN DRILL PROFILE ALLOWED. UP TO 10 FEET BELOW THE DESIGN DRILL PROFILE ALLOWED.
PILOT HOLE ALIGNMENT	SHALL REMAIN WITHIN 5 FEET LEFT OR RIGHT OF THE HDD ALIGNMENT.

LEGEND:

TYPE OF SOIL — SPT (N)

BORING LOCATION

FINAL

NOTES

1. ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT–OF–WAY OR FROM APPROVED ACCESS ROADS.
2. WORK SPACE: MAXIMUM WORK SPACE LIMITS ARE DEPICTED. RESTRICT CLEARING TO THE WORK SPACE INDICATED AT THE ENTRY AND EXIT POINTS AND PRODUCT PIPE STRINGING AND FABRICATION AREA ALONG THE CONSTRUCTION RIGHT–OF–WAY. CLEARING BETWEEN THE ENTRY AND EXIT POINTS REQUIRES PRIOR APPROVAL FROM THE ENVIRONMENTAL INSPECTOR AND IS LIMITED TO THE AMOUNT NECESSARY TO STRING SURVEY WIRES AND INSTALL PUMPS AND PIPING TO OBTAIN WATER (WHERE APPROVED).
3. WATER SOURCE: DRILL WATER AND HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE.
4. HYDROSTATIC TEST: PRE–INSTALLATION AND POST–INSTALLATION HYDROSTATIC TESTS SHALL BE CONDUCTED IN ACCORDANCE WITH THE HYDROSTATIC TEST PLAN. TEST WATER SHALL BE SAMPLED AND TESTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE TEST WATER SHALL BE DISCHARGED IN AN UPLAND AREA INTO AN EROSION CONTROL STRUCTURE OF STRAW BALES AND/OR SILT FENCES, GEOTEXTILE FILTER BAG, OR COLLECTED IN A TRUCK AND HAULED TO AN APPROVED DISPOSAL SITE. UPON COMPLETION OF DEWATERING AND DRYING, A CALIPER PIG SURVEY SHALL BE COMPLETED IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
5. SPILL–PREVENTION: REFUELING OF ALL EQUIPMENT SHALL BE COMPLETED IN ACCORDANCE WITH THE SPCC PLAN.
6. EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE APPROVED CONSTRUCTION RIGHT–OF–WAY AT THE DRILL EXIT POINT AS SHOWN. AFTER THE PILOT HOLE IS COMPLETE, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO NORTHWEST NATURAL FOR APPROVAL. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULL BACK.
8. DRILLING FLUID DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING FLUID AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING FLUID WHICH INADVERTENTLY SURFACES AT POINTS OTHER THAN THE ENTRY OR EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.
9. CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN THE CLEAN–UP AND RESTORATION REQUIREMENTS.
10. GEOTECHNICAL DATA: BORE HOLES ARE OFFSET FROM THE PIPELINE CENTERLINE AS SHOWN ON THE PLAN VIEW. THE GEOTECHNICAL INFORMATION PROVIDED ON THIS DRAWING IS A GENERAL SUMMARY. REFER TO THE APPLICABLE GEOTECHNICAL REPORT IN THE CONTRACT DOCUMENTS FOR MORE DETAILED INFORMATION.
11. IF THE TERRAIN ALLOWS AND ACCESS IS PERMITTED, CONTRACTOR SHALL UTILIZE LOW GROUND PRESSURE EQUIPMENT OR OTHER EQUIPMENT APPROVED BY OWNER, TO FACILITATE CONTAINMENT AND CLEAN–UP OF ANY INADVERTENT RETURNS THAT OCCUR DURING THE HDD INSTALLATION PROCESS.
12. THE MINIMUM ALLOWABLE THREE JOINT RADIUS SHALL NOT BE LESS THAN 2,400 FEET.
13. AERIAL PHOTOS DOWNLOADED FROM HTTP://VIEWER.NATIONALMAP.GOV/VIEWER/. BASE FILES PROVIDED NORTHWEST NATURAL. GROUND SURFACE AND BATHYMETRIC SURVEY DATA PROVIDED BY WESTLAKE CONSULTANTS, INC., OBTAINED AUGUST 2015.
14. CONTRACTOR IS RESPONSIBLE FOR CALLING OREGON ONE–CALL AND PHYSICALLY LOCATING ALL UNDERGROUND UTILITIES PRIOR TO BEGINNING CONSTRUCTION. IF ANY UTILITY IS LOCATED WITHIN 15 FEET OF THE DESIGNED HDD PROFILE AND ALIGNMENT, CONTRACTOR SHALL OBTAIN APPROVAL FROM NORTHWEST NATURAL PRIOR TO INITIATING HDD OPERATIONS.
15. A SITE SPECIFIC SURVEY DOCUMENTING EXISTING UTILITIES HAS NOT BEEN CONDUCTED ALONG THE PROPOSED PIPELINE ALIGNMENT. A SITE SPECIFIC TOPOGRAPHIC AND UTILITY SURVEY SHOULD BE COMPLETED PRIOR TO FINAL ISSUANCE OF THESE PLANS. DURING CONSTRUCTION, IT IS THE CONTRACTORS RESPONSIBILITY TO IDENTIFY AND PROTECT ANY UTILITY THAT MAY BE AFFECTED BY THE HDD OPERATIONS.
16. CONTRACTOR SHALL ADHERE TO THE SPECIFICATIONS AND REQUIREMENTS PER NORTHWEST NATURAL SPECIFICATIONS, CONTRACT DOCUMENTS, AND SPECIAL PERMIT CONDITIONS, EXCEPT AS NOTED ON THIS DRAWING.

BASIS OF DESIGN:

1. PRODUCT PIPE WILL CONSIST OF 24" O.D. X 0.500" W.T., API–5L X–52 PIPE WITH 14–16 MILS OF FUSION BONDED EPOXY (FBE) AND A MINIMUM OF 40 MILS OF ABRASION RESISTANT OVERLAY (ARO).
2. MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) = 809 psi

NOTE: THIS IS A FULL SIZE DRAWING THAT IS INTENDED TO BE PRINTED ON A 24" X 36" SHEET OF PAPER.

REFERENCE DRAWINGS	
DRAWING NO.	TITLE

REVISIONS						
NO.	DATE	BY	DESCRIPTION	W.O.NO.	CHK.	APP.
A	07/02/14	MWC	ISSUED AS DRAFT		BCR	TNH
B	04/20/15	BTL	ISSUED AS DRAFT (24–INCH REDESIGN)		BCR	TNH
C	09/15/15	BTL	ISSUED FOR FINAL		BCR	TNH

GEOENGINEERS
1200 NW NAITO PARKWAY, SUITE 180
PORTLAND, OREGON 97209
TELEPHONE: (503) 624-9274
FAX: (503) 620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
STATION 466+00 TO 530+00
HDD 4
COLUMBIA COUNTY, OREGON

NW Natural

DRAWN BY: MWC	DATE: 06/03/14	ISSUED FOR BID:	SCALE: AS NOTED
CHECKED BY: BCR	DATE: 06/03/14	ISSUED FOR CONSTRUCTION:	
APPROVED BY:	DATE:	DRAWING NUMBER: HDD 4	SHEET 1
WO:		TIME: 02:30 PM DATE: 09/09/15 PATH: P:\0\60243570\CAD\HDD 4_FINAL_Rev C.dwg	OF 1

HDD Design Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 4 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe Diameter = 24.000 in

Pipe Material = Steel

Yield Stress = 52,000 psi

Wall Thickness = 0.5 in

Assumed Installation Temp = 55 °F

Assumed Operating Temp= 55 °F

Design Factor = 0.5

MAOP = 809 psi

Drill Data Box

Point	Station (ft)	Elevation (ft)
ENTRY @ 10°	47,738.46	4.41
P C 1 (10.00° @ 3,000 ft R.)	48,128.81	-64.42
P T 1	48,649.75	-110.00
P C 2 (10.00° @ 3,000 ft R.)	50,522.22	-110.00
P T 2	51,043.17	-64.42
EXIT @ 10°	51,423.46	2.63

Horizontal Alignment Length = 3,685.00 ft

Profile Segment Information

Segment Name	Segment Type	Segment Length (ft)
ENTRY TANGENT	Straight	396.37
ENTRY CURVE	Vertical Curve	523.60
BOTTOM TANGENT	Straight	1,872.47
EXIT CURVE	Vertical Curve	523.60
EXIT TANGENT	Straight	386.16

Pipe Length = 3,702.20 ft

Installation Load Summary

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Buoyancy Control (lb/ft)	Effective Pipe Weight (lb/ft)	Total Installation Force (lb)
9.50	Empty	0.00	-97.46	301,000
9.50	Full	180.04	82.58	247,000
12.00	Empty	0.00	-156.21	373,000
12.00	Full	180.04	23.83	194,000
10.50	Neutral	120.96	0.00	180,000

GeoEngineers

Minimum Radius Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 4 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters:

Pipe Diameter = 24.000 in **MAOP =** 809 psi **Factor of Safety =** 2.00

Wall Thickness = 0.500 in **SMYS =** 52,000 psi

D/t Ratio = 48.00 **Modulus of Elasticity (E) =** 2.96E+007 psi

Hoop Stress:

Calculated Hoop Stress = (MAOP * Pipe Diameter) / (2 * Wall Thickness) = 19,416 psi

Longitudinal Stress:

Calculated Longitudinal Stress = Hoop Stress / 2 = 9,708 psi

Allowable Stress:

Calculated Allowable Stress = SMYS / Factor of Safety = 26,000 psi

Bending Stress:

Calculated Bending Stress = Allowable Stress - Longitudinal Stress = 16,292 psi

Minimum Radius:

Calculated Minimum Radius = (E * Pipe Diameter) / (2 * Bending Stress) = 1,817 ft

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 4 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe diameter =	24.000 in	**Minimum Radius of Curvature =**	2,400 ft
Wall Thickness =	0.500 in	**Coefficient of Thermal Expansion =**	6.5E-06 in/in/°F
SMYS =	52,000 psi	**Assumed Installation Temperature =**	55 °F
MAOP =	809 psi	**Assumed Operating Temperature =**	55 °F
Poissons's Ratio =	0.30	**Temperature Derating Factor =**	1.00
Young's Modulus (E) =	2.96E+007 psi	**Groundwater Table Head =**	110.00 ft
Design Factor =	0.5		

Stress Analyses

Longitudinal Stress from Bending =	12,324 psi	
Percent SMYS =	23.70 %	
Hoop Stress =	18,272 psi	
Percent SMYS =	35.14 %	Limited by Design Factor (0.5) according to 49 CFR 192.111
Longitudinal Tensile Stress from Hoop Stress =	5,482 psi	
Percent SMYS =	10.54 %	
Longitudinal Stress from Thermal Expansion =	0 psi	
Percent SMYS =	0.00 %	Limited to 90% SMYS by ASME/ANSI B31.4 section 402.3.2
Net Longitudinal Stress (Comp. side of Curve) =	-6,843 psi	
Percent SMYS =	13.16 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Net Longitudinal Stress (Tension side of Curve) =	17,806 psi	
Percent SMYS =	34.24 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Maximum Shear Stress =	12,557 psi	
Percent SMYS =	24.15 %	Limited to 45% SMYS by ASME/ANSI B31.4 section 402.3.1
Combined BiaxialSress Check =	25,115 psi	
Percent SMYS =	48.30 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.4

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 4 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 4 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,702 ft
Moment of Inertia =	2,549 in^4
Pipe Face Area =	36.91 in^2
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft^3
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft^3
Pipe Exterior Volume =	3.14 ft^3/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft^3/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft^3
Effective Weight of Pipe =	-97.46 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty — Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	386.16 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	17,469 lb
Friction Force =	11,119 lb
Segment Weight =	6,535 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	35,123 lb
Cumulative Force =	**35,123 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	951 psi	
Cumulative Axial Stress =	951 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	815 psi	7,537 psi
Combined Stress =	0.0229	< 1.0
Total Stress =	0.0127	< 1.0

GeoEngineers

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	10.00 deg
Segment Length =	523.60 ft	**Center Displacement =**	11.42 ft

Segment Force Components

Normal Force =	38,725 lb
Drag Force =	23,687 lb
Friction Force =	11,618 lb
Segment Weight =	4,447 lb
Tension =	86,492 lb
Average Tension =	60,808 lb
Segment Force =	51,370 lb
Cumulative Force =	**86,492 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,392 psi	
Cumulative Axial Stress =	2,343 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,355 psi	7,537 psi
Combined Stress =	0.3984	< 1.0
Total Stress =	0.1819	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	1,872.47 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	84,709 lb
Friction Force =	54,745 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	139,453 lb
Cumulative Force =	**225,946 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	3,778 psi	
Cumulative Axial Stress =	6,121 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,355 psi	7,537 psi
Combined Stress =	0.1471	< 1.0
Total Stress =	0.0636	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	55,331 lb
Drag Force =	23,687 lb
Friction Force =	16,599 lb
Segment Weight =	-4,447 lb
Tension =	278,384 lb
Average Tension =	252,165 lb
Segment Force =	52,439 lb
Cumulative Force =	**278,384 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,421 psi	
Cumulative Axial Stress =	7,541 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,355 psi	7,537 psi
Combined Stress =	0.5234	< 1.0
Total Stress =	0.2951	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	396.37 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	17,931 lb
Friction Force =	11,412 lb
Segment Weight =	-6,708 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	22,636 lb
Cumulative Force =	**301,021 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	613 psi	
Cumulative Axial Stress =	8,155 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	815 psi	7,537 psi
Combined Stress =	0.1960	< 1.0
Total Stress =	0.0585	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 4 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,702 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	82.58 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	386.16 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	17,469 lb
Friction Force =	9,422 lb
Segment Weight =	-5,538 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	21,354 lb
Cumulative Force =	**21,354 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	578 psi	
Cumulative Axial Stress =	578 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	118 psi	7,537 psi
Combined Stress =	0.0139	< 1.0
Total Stress =	0.0005	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	10.00 deg
Segment Length =	523.60 ft	**Center Displacement =**	11.42 ft

Segment Force Components

Normal Force =	-20,380 lb
Drag Force =	23,687 lb
Friction Force =	6,114 lb
Segment Weight =	-3,769 lb
Tension =	53,500 lb
Average Tension =	37,427 lb
Segment Force =	32,146 lb
Cumulative Force =	**53,500 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	871 psi	
Cumulative Axial Stress =	1,449 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	184 psi	7,537 psi
Combined Stress =	0.3770	< 1.0
Total Stress =	0.1137	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	1,872.47 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	84,709 lb
Friction Force =	46,391 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	131,099 lb
Cumulative Force =	**184,599 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	3,552 psi	
Cumulative Axial Stress =	5,001 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	184 psi	7,537 psi
Combined Stress =	0.1202	< 1.0
Total Stress =	0.0162	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	-3,018 lb
Drag Force =	23,687 lb
Friction Force =	905 lb
Segment Weight =	3,769 lb
Tension =	213,865 lb
Average Tension =	199,232 lb
Segment Force =	29,266 lb
Cumulative Force =	**213,865 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	793 psi	
Cumulative Axial Stress =	5,794 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	184 psi	7,537 psi
Combined Stress =	0.4814	< 1.0
Total Stress =	0.1949	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	396.37 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	17,931 lb
Friction Force =	9,671 lb
Segment Weight =	5,684 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	33,286 lb
Cumulative Force =	**247,152 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	902 psi	
Cumulative Axial Stress =	6,695 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	118 psi	7,537 psi
Combined Stress =	0.1609	< 1.0
Total Stress =	0.0272	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 4 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,702 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	-156.21 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 1 of 5**

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	386.16 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	17,469 lb
Friction Force =	17,821 lb
Segment Weight =	10,475 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	45,765 lb
Cumulative Force =	**45,765 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,240 psi	
Cumulative Axial Stress =	1,240 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,030 psi	7,537 psi
Combined Stress =	0.0298	< 1.0
Total Stress =	0.0204	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	58,499 lb
Drag Force =	23,687 lb
Friction Force =	17,550 lb
Segment Weight =	7,128 lb
Tension =	111,680 lb
Average Tension =	78,723 lb
Segment Force =	65,915 lb
Cumulative Force =	**111,680 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,786 psi	
Cumulative Axial Stress =	3,025 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,712 psi	7,537 psi
Combined Stress =	0.4148	< 1.0
Total Stress =	0.2206	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	1,872.47 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	84,709 lb
Friction Force =	87,748 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	172,457 lb
Cumulative Force =	**284,137 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	4,672 psi	
Cumulative Axial Stress =	7,697 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,712 psi	7,537 psi
Combined Stress =	0.1850	< 1.0
Total Stress =	0.1010	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 4 of 5**

Segment Parameters

Segment Name =	ENTRY CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	10.00 deg
Segment Length =	523.60 ft	**Center Displacement =**	11.42 ft

Segment Force Components

Normal Force =	78,542 lb
Drag Force =	23,687 lb
Friction Force =	23,563 lb
Segment Weight =	-7,128 lb
Tension =	347,821 lb
Average Tension =	315,979 lb
Segment Force =	63,684 lb
Cumulative Force =	**347,821 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,725 psi	
Cumulative Axial Stress =	9,423 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,712 psi	7,537 psi
Combined Stress =	0.5686	< 1.0
Total Stress =	0.3724	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 5 of 5**

Segment Parameters

Segment Name =	ENTRY TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	396.37 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	17,931 lb
Friction Force =	18,293 lb
Segment Weight =	-10,752 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	25,472 lb
Cumulative Force =	**373,293 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	690 psi	
Cumulative Axial Stress =	10,113 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,030 psi	7,537 psi
Combined Stress =	0.2431	< 1.0
Total Stress =	0.0908	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 4 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,702 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	23.83 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 1 of 5**

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	386.16 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	17,469 lb
Friction Force =	2,719 lb
Segment Weight =	-1,598 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	18,590 lb
Cumulative Force =	**18,590 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	504 psi	
Cumulative Axial Stress =	504 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	332 psi	7,537 psi
Combined Stress =	0.0121	< 1.0
Total Stress =	0.0022	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	10.00 deg
Segment Length =	523.60 ft	**Center Displacement =**	11.42 ft

Segment Force Components

Normal Force =	-2,440 lb
Drag Force =	23,687 lb
Friction Force =	732 lb
Segment Weight =	-1,088 lb
Tension =	42,654 lb
Average Tension =	30,622 lb
Segment Force =	24,063 lb
Cumulative Force =	**42,654 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	652 psi	
Cumulative Axial Stress =	1,155 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	540 psi	7,537 psi
Combined Stress =	0.3699	< 1.0
Total Stress =	0.1198	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	1,872.47 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	84,709 lb
Friction Force =	13,387 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	98,096 lb
Cumulative Force =	**140,750 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	2,657 psi	
Cumulative Axial Stress =	3,813 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	540 psi	7,537 psi
Combined Stress =	0.0917	< 1.0
Total Stress =	0.0161	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	10,180 lb
Drag Force =	23,687 lb
Friction Force =	3,054 lb
Segment Weight =	1,088 lb
Tension =	171,632 lb
Average Tension =	156,191 lb
Segment Force =	30,883 lb
Cumulative Force =	**171,632 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	837 psi	
Cumulative Axial Stress =	4,650 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	540 psi	7,537 psi
Combined Stress =	0.4539	< 1.0
Total Stress =	0.1838	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	396.37 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	17,931 lb
Friction Force =	2,791 lb
Segment Weight =	1,640 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	22,362 lb
Cumulative Force =	**193,995 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	606 psi	
Cumulative Axial Stress =	5,255 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	332 psi	7,537 psi
Combined Stress =	0.1263	< 1.0
Total Stress =	0.0201	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 4 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,702 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	246.76 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	0.00 lb/ft

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 1 of 5**

Segment Parameters			
Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	386.16 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	17,469 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	17,469 lb
Cumulative Force =	**17,469 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	473 psi	
Cumulative Axial Stress =	473 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	901 psi	7,537 psi
Combined Stress =	0.0114	< 1.0
Total Stress =	0.0143	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	5,210 lb
Drag Force =	23,687 lb
Friction Force =	1,563 lb
Segment Weight =	0 lb
Tension =	44,282 lb
Average Tension =	30,876 lb
Segment Force =	26,813 lb
Cumulative Force =	**44,282 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	726 psi	
Cumulative Axial Stress =	1,200 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,498 psi	7,537 psi
Combined Stress =	0.3710	< 1.0
Total Stress =	0.1706	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	1,872.47 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	84,709 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	84,709 lb
Cumulative Force =	**128,991 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	2,295 psi	
Cumulative Axial Stress =	3,494 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	1,498 psi	7,537 psi
Combined Stress =	0.0840	< 1.0
Total Stress =	0.0517	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	16,384 lb
Drag Force =	23,687 lb
Friction Force =	4,915 lb
Segment Weight =	0 lb
Tension =	162,508 lb
Average Tension =	145,749 lb
Segment Force =	33,517 lb
Cumulative Force =	**162,508 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	908 psi	
Cumulative Axial Stress =	4,402 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	1,498 psi	7,537 psi
Combined Stress =	0.4479	< 1.0
Total Stress =	0.2330	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	396.37 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	17,931 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	17,931 lb
Cumulative Force =	**180,440 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	486 psi	
Cumulative Axial Stress =	4,888 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	901 psi	7,537 psi
Combined Stress =	0.1175	< 1.0
Total Stress =	0.0333	< 1.0

APPENDIX G
HDD-5

APPENDIX G
HDD-5

General

This appendix provides GeoEngineers' HDD design recommendations for HDD-5 along the proposed North Mist Pipeline alignment located in Columbia County, Oregon. The general site plan and profile is provided in Figure G-1 of this appendix. A full size construction drawing showing the design profile is provided in the attached Drawing No. HDD-5. The design drawing includes the necessary geometric information required to complete the pilot hole.

Project Description and Basis of Design

The proposed HDD installation will be a 24-inch-diameter steel pipeline crossing tree farm properties, Larson Slough, drainage ditches and Lewis Road. The proposed pipeline alignment is oriented southwest-northeast (entry to exit), as shown in Figure G-1. The HDD design was completed based on the parameters presented below in Table G-1.

TABLE G-1. BASIS OF DESIGN FOR THE 24-INCH-DIAMETER HDD-5

Carrier Pipe Data	Design Parameter
Carrier Pipe Specifications	24 inches x 0.500 inches w.t.[1] API-5L X-52 steel pipe
Horizontal Crossing Length	3,750 feet
Maximum Allowable Operating Pressure	809 psig[2]
Maximum Operating Temperature	55 degrees F
Assumed Tie-In Temperature	55 degrees F

Notes:
[1] w.t. – wall thickness
[2] psig – pounds per square inch gauge

SITE DESCRIPTION

Surface Conditions

Topography along the proposed HDD alignment generally consists of a relatively flat alluvial valley that is cut by Larson Slough and two relatively small drainage canals. The ground surface along the proposed HDD alignment is currently occupied by Poplar tree farms. The proposed HDD begins approximately 150 feet north of Collins Road 2. Larson Slough is located roughly in the center of the proposed HDD. The slough is approximately 60 feet wide and 9 feet deep measured from the tops of the approximately 4.5-foot high levees situated on either side. Based on survey completed by Westlake Consultants in August 2015, the mudline of Larson Slough is situated at an elevation of approximately -4 feet MSL> Approximately 1,000 feet northeast of Larson Slough the proposed alignment crosses an approximately 8-foot-wide by 5-foot-deep drainage ditch. Approximately 1,475 feet northeast of Larson Slough the alignment crosses Lewis Road, which is bounded by approximately 10-foot-wide by 5-foot to 7-foot-deep drainage ditches. The HDD exit workspace is situated in a relatively flat Poplar tree farm approximately 275 feet northeast of Lewis Road.

Subsurface Conditions

We completed three borings (B-2, B-8 and B-9) along or near the proposed HDD alignment at the locations shown in Figure G-1. In general, subsurface conditions encountered in the borings consisted of interbedded very soft to medium stiff elastic silt with sand, very soft to soft lean clay with trace sand and medium dense to dense sand and silty sand. Subsurface conditions encountered in each boring are described in more detail below.

Boring B-2 was located roughly in the center of the proposed alignment, approximately 140 feet south of Larson Slough and approximately 225 feet south of the proposed alignment. This boring was completed during a previous phase of the project when the proposed alignment was located south of the currently proposed alignment. Boring B-2 generally encountered about 3 feet of silt fill with gravel and organics overlying very soft lean clay with trace sand that was in turn overlying very soft silt with fine sand to a depth of approximately 38 feet bgs. Below 38 feet bgs, the boring encountered medium dense to dense silty sand that extended to 71.5 feet bgs, the maximum depth explored.

Boring B-8 was located near the proposed exit point, approximately 60 feet northeast of Lewis Road and roughly 25 feet southwest of the proposed alignment. Boring B-8 generally encountered approximately 40 feet of very soft to medium stiff silt with sand and some wood fragments overlying loose to medium dense sand with silt that extended to 71.5 feet bgs, the maximum depth explored.

Boring B-9 was located near the proposed entry point about 275 feet northeast of Collins Road 2, and about 30 feet southwest of the proposed alignment. Boring B-9 encountered approximately 13 feet of very soft silt with wood fragments overlying loose to medium dense sand with varying amounts of silt that extended to approximately 39 feet bgs. Below 39 feet bgs, the boring encountered an approximately 5-foot-thick layer of soft sandy silt overlying loose to medium dense silty sand interbedded with very stiff silt and clay layers to a depth of 71.5 feet bgs, the maximum depth explored.

Subsurface conditions encountered in our borings are shown graphically in Figure G-1, and are described in detail in the boring logs in Appendix A.

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE EVALUATION

Model Input Parameters

The HDD geometry used for our analyses of HDD-5 is shown in Figure G-1, and in the HDD Design Drawing HDD-5 in this appendix. Based on the results of the exploration program and subsequent laboratory-testing program, the soil properties used in the evaluation are presented in Table G-2 below.

TABLE G-2. ESTIMATED SOIL PROPERTIES

Soil Description	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Very Soft Silt	90	0	50 to 100
Very Soft Clay	100	0	200
Medium Stiff Silt	110	0	500

Soil Description	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Loose to Medium Dense Silty Sand/Sand with Silt	100-120	28 -32	0
Very Stiff Lean Clay	125	0	1,000

Based on available information and common HDD construction procedures, the tool dimensions and rheological properties used in the evaluation are summarized in Table G-3. Because these parameters are dependent upon the HDD contractor's means and methods, the hydraulic fracture and drilling fluid surface release evaluation should be refined during construction of the HDD installations.

TABLE G-3. ESTIMATED TOOL DIMENSIONS AND RHEOLOGICAL PROPERTIES

Parameter	Value
Pilot Hole Bit Diameter	12.25 inches
Drill Pipe Diameter	6.625 inches
Drilling Fluid Weight	9.5 ppg
Plastic Viscosity	14 CP
Yield Point	26 lb/100 sf

Notes:
ppg = pounds per gallon; CP = centipoise; lb/100 sf = pounds per 100 square feet

Results of Hydraulic Fracture and Drilling Fluid Surface Release Evaluation

The results of the hydraulic fracture evaluation are presented in Figures G-2 and G-3. Figure G-2 shows the calculated formation limit pressure (green line) and the estimated drilling fluid pressure shown as the red line, which represents the drilling fluid pressure along the HDD profile based on the anticipated drilling fluid properties shown in Table G-3.

When evaluating the risk of hydraulic fracture and drilling fluid surface releases, the analysis computes two types of factors of safety. These are:

- Factor of Safety against localized hydraulic fracture; and
- Factor of Safety against drilling fluid surface release.

Local Hydraulic Fracture: The factor of safety against hydraulic fracture is the ratio of the formation limit pressure to the estimated drilling fluid pressure along the profile, shown as the green line in Figure G-3. This represents the factor of safety against hydraulic fracture of the soil immediately surrounding the HDD profile and is a localized condition.

Drilling Fluid Surface Release: The factors of safety against drilling fluid surface release considers the strength of the soil column above the HDD profile that resists drilling fluid migrating to the ground surface. It is computed by comparing the formation limit pressure of the soil units above a specific location along the planned HDD alignment to the anticipated drilling fluid pressure at the same location. The factors of

safety against drilling fluid surface releases are shown in Figure G-3 at selected points shown as red triangles.

The model indicates that the risk of localized hydraulic fracture and drilling fluid surface releases is generally low, with safety factors greater than 2 because the HDD path is expected to be within medium dense silty sand and sand with silt. However, the factors of safety against hydraulic fracture and drilling fluid surface releases drop significantly on the north side of Lewis Road and extending about 300 feet to the exit point where subsurface conditions are expected to generally consist of very soft silt.

INSTALLATION LOADS AND OPERATING STRESSES

Installation Loads

The analyses of installation loads and operational stresses are based on the product pipe being installed along the designed drill path using the BMPs of the HDD industry. The addition of water into the product pipe is the standard method that contractors typically use to control buoyancy of the product pipe during the installation procedure. The proposed 24-inch-diameter product pipe will be positively buoyant in the anticipated drilling fluid weights. The HDD Contractor may choose to add water to the product pipe to try and achieve neutral buoyancy during pullback and reduce the required pull force during installation of the product pipe. Thus, our analyses include a range of cases with differing levels of buoyancy control. The following table presents a summary of the calculated installation loads for the HDD.

TABLE G-4. INSTALLATION LOADS FOR THE 24-INCH-DIAMETER HDD-5[1]

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Effective Pipe Weight[2] (lb/ft)	Pullback Force[3] (lb)
9.5	Empty	-97	305,000
9.5	Full	83	250,000
12	Empty	-156	378,000
12	Full	24	199,000
10.5	Neutral	0	183,000

Notes:
[1] See the HDD Design Summary and Calculations summaries provided in this appendix for detailed calculations.
[2] Negative values indicate upward force (positive buoyancy).
[3] Assumes a fully open drilled hole.
[4] Assumes a minimum pipeline radius of 2,400 feet.

Because the HDD contractor might utilize a relatively large drill rig to complete the installation, the drill rig may have a pullback capacity capable of causing damage to the product pipe during installation. While the estimated installation forces provided in Table G-4 suggest that the pullback forces should be less than 378,000 pounds, improper preparation of the hole prior to pullback operations or delays during pullback operations may cause pullback forces to exceed those estimated in the calculations.

Operating Stresses

For our operating stresses analysis, the installation and operating temperatures were assumed to be 55 degrees Fahrenheit. We can further evaluate different installation and operating temperatures, if

requested. The following table presents a summary of the operating stresses for the product pipe specifications proposed for the HDD.

TABLE G-5. SUMMARY OF OPERATING STRESSES FOR THE 24-INCH-DIAMETER HDD-5

Stress Component	Stress (psi)	Percent SMYS[1] (%)	Maximum Allowable Percent SMYS (%)
Longitudinal Bending Stress	12,324	24	-
Hoop Stress	18,792	36	50[2]
Longitudinal Tensile Stress from Hoop Stress	5,638	11	-
Longitudinal Stress from Thermal Expansion	0	0	90[3]
Maximum Net Longitudinal Stress	17,962	35	90[4]
Maximum Shear Stress	12,739	25	45[5]
Maximum Combined Effective Stress	25,479	49	90[6]

Notes:
[1] Specified Minimum Yield Stress.
[2] Limited by design factor from DOT regulations, Title 49 CFR Part 192.111 for gas.
[3] Limited by Section 402.3.2 of ASME B31.4.
[4] Limited by Section 833.3 of ASME B31.8 for gas.
[5] Limited by Section 402.3.1 of ASME B31.4.
[6] Limited by Section 833.4 of ASME B31.8 for gas.

CONCLUSIONS AND RECOMMENDATIONS

HDD-5 crosses beneath Larson Slough and its adjacent levees that are pending certification by the USACE. As such HDD-5 will be subject to the requirements for HDD crossings under levees by the USACE. Among others, the USACE will require that the calculated factor of safety against hydraulic fracture under the levees by at least 1.5 and possibly 2.0. Our analysis shows calculated safety factors of 2 or greater where the profile passes beneath Larson Slough and the levees as discussed further in the report.

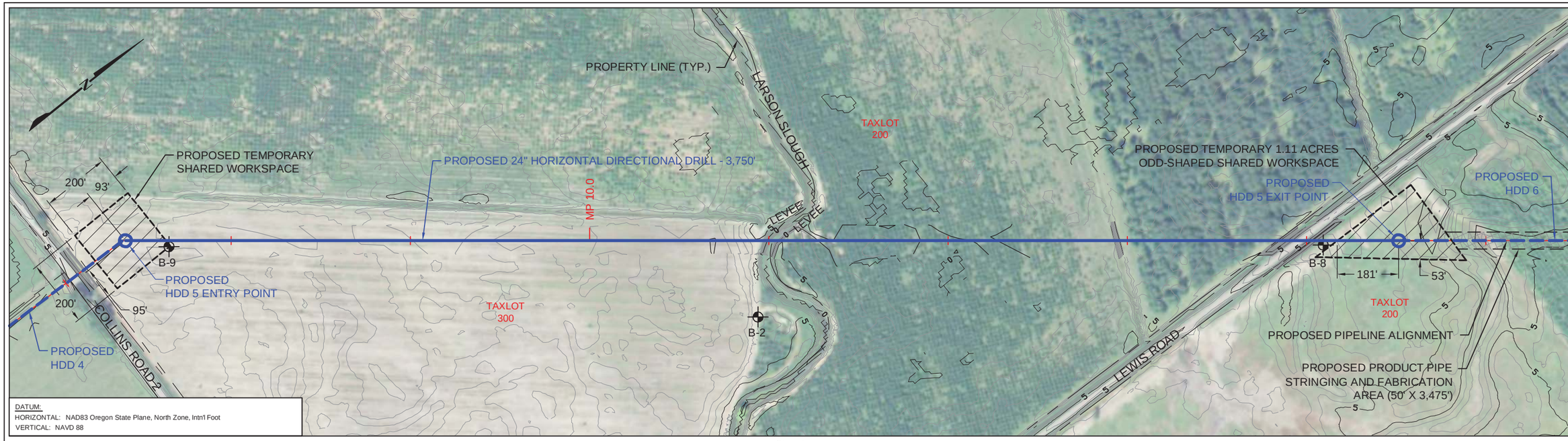
Each of the three borings completed along or near the proposed alignment encountered very soft to soft elastic silt in the upper portion of the soil profile. The softer zones of these soils may present steering difficulties during construction, particularly within the entry and exit tangents where very soft silt is expected to be encountered during HDD operations. The contractor should be prepared to encounter steering difficulties within the softer soils encountered in the upper portion of the soil profile. In addition, the soft soils observed in boring B-9 between the surface and approximately 15 feet bgs likely will not provide adequate drill rod support to advance the pilot hole along the relatively long HDD.

We recommend that the contractor consider installing casing along the entry tangent to provide a reaction mass for allowing a greater transfer of axial loads through the drill pipe string to the drill bit during pilot hole drilling. The casing maintains hole uniformity and prevents the drill pipe string from being pushed into the soil formation while trying to advance the drill bit. Upon completion of the pilot hole, or prior to reaming the cased section of the hole, the casing is typically removed.

Hydraulic Fracture and Drilling Fluid Surface Release

Based on our analyses, there is a low risk of hydraulic fracture and drilling fluid surface releases along the majority of HDD-5. Although, there is a very high potential for drilling fluid surface release within approximately 300 feet of the exit point where the HDD is expected to pass through very soft silt within the upper 25 feet.

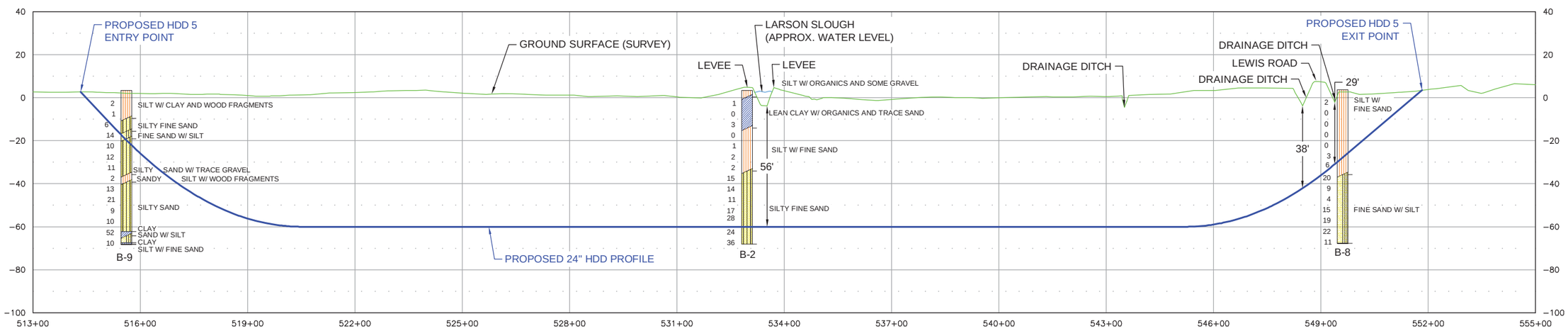
We recommend that the contractor establish a contingency and mitigation plan in the event that drilling fluid surface releases occur; these plans should be reviewed and approved by the project team prior to the start of construction. It will be important for the contractor to maintain drilling fluid returns at all times, and monitor the last 300 feet of the HDD alignment for drilling fluid surface releases during construction.



NOT FOR CONSTRUCTION:
THE HDD DESIGN DRAWING IS INCLUDED AS HDD 5 IN APPENDIX G.

PLAN
300' 0 300'
SCALE IN FEET

Major Contour Interval = 5'
Minor Contour Interval = 1'



PROFILE
300' 0 300'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Refer to the borings logs in the accompanying report for more detailed soil descriptions.
4. GeoEngineers, Inc. has not verified the field location of the existing utilities.

Reference: Ground surface DEM (1/9 arc second) and aerial photos downloaded from http://nationalmap.gov. Base files provided by NorthWest Natural. Ground surface and bathymetric survey data provided by Westlake Consultants, Inc., obtained August 2015.

LEGEND:

SPT (N) — TYPE OF SOIL

Boring Location

SITE PLAN AND PROFILE
HDD 5

NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

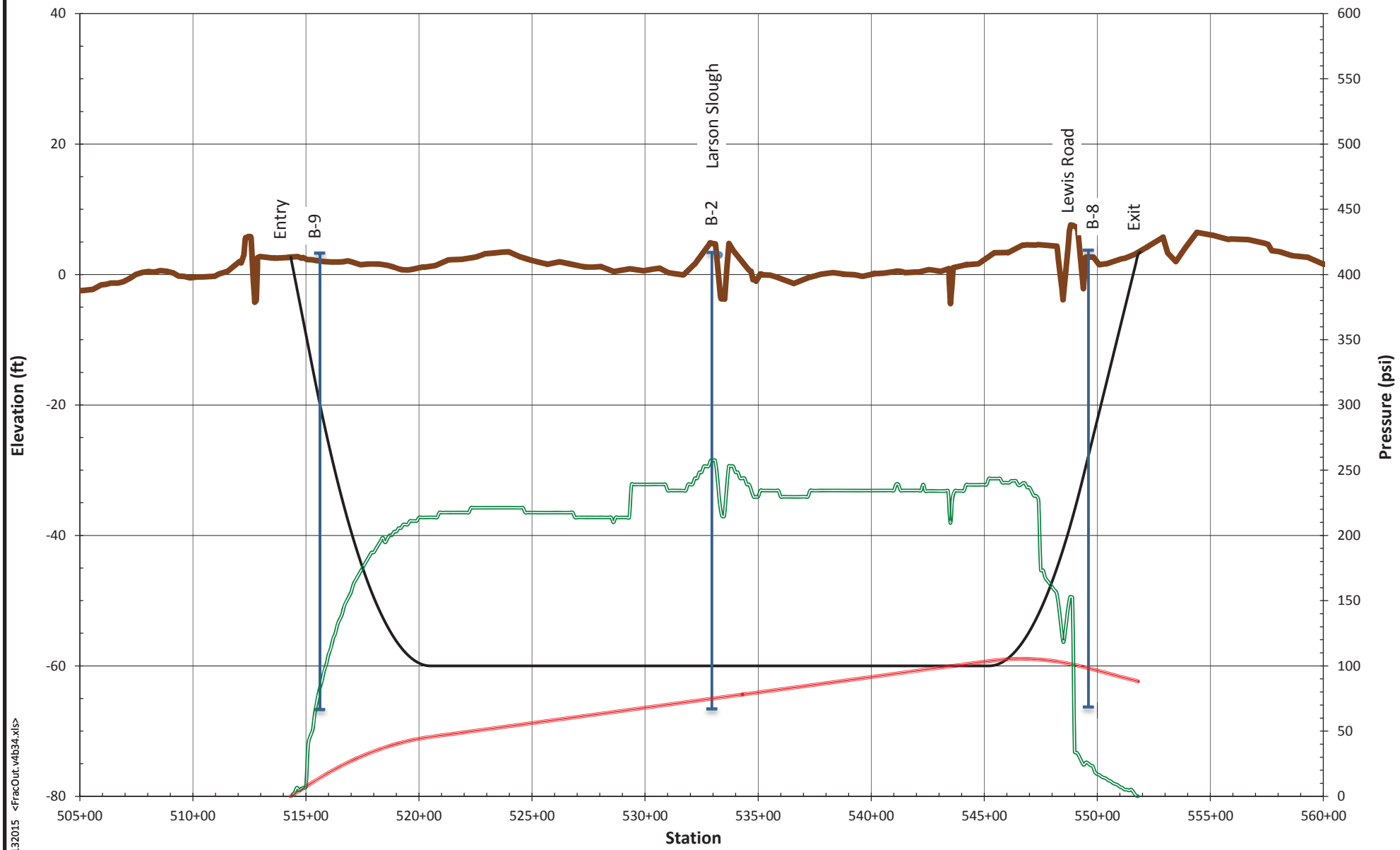
GEOENGINEERS

FIGURE G-1

BCR : BTL

P:\\6602415704\CAD\Figure G-1.dwg\TAB:Figure G-1 modified on Sep 14, 2015 - 2:04pm

NW NATURAL - NORTH MIST PIPELINE HDD 5



Crossing Length (ft)	3750
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	14
Yield Point (lb/100 ft)	26

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Estimated Annular Drilliing Fluid Pressure (psi) for Pilot Hole
- Formation Limit Pressure (psi)

ESTIMATED ANNULAR DRILLING FLUID AND FORMATION LIMIT PRESSURES

NW NATURAL - NORTH MIST PIPELINE HDD 5

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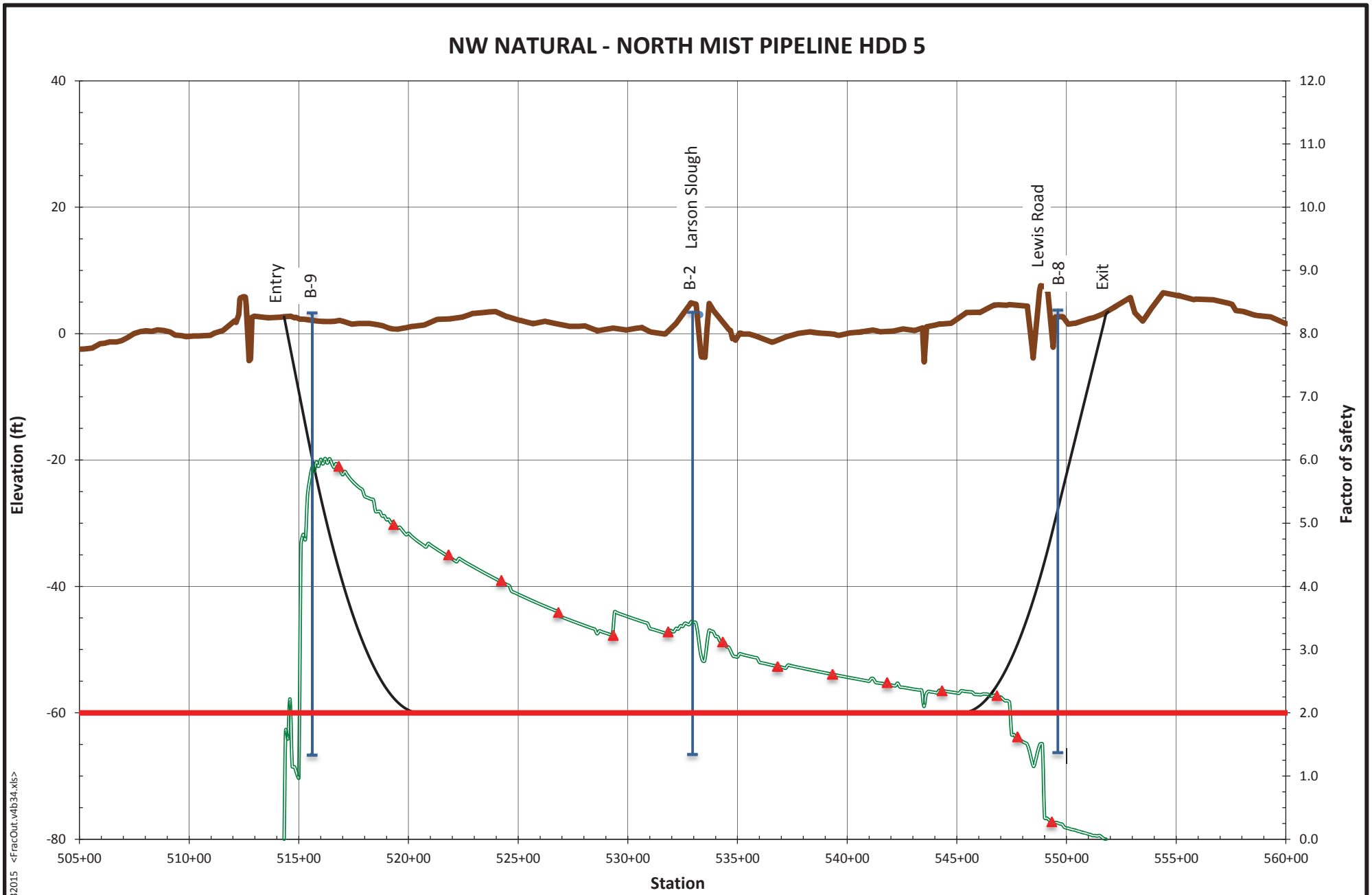
FIGURE G-2

06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>



Crossing Length (ft)	3750
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	14
Yield Point (lb/100 ft)	26

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Drilling Fluid Surface Release Factor of Safety for Pilot Hole
- Hydraulic Fracture Factor of Safety for Pilot Hole
- Factor of Safety = 2

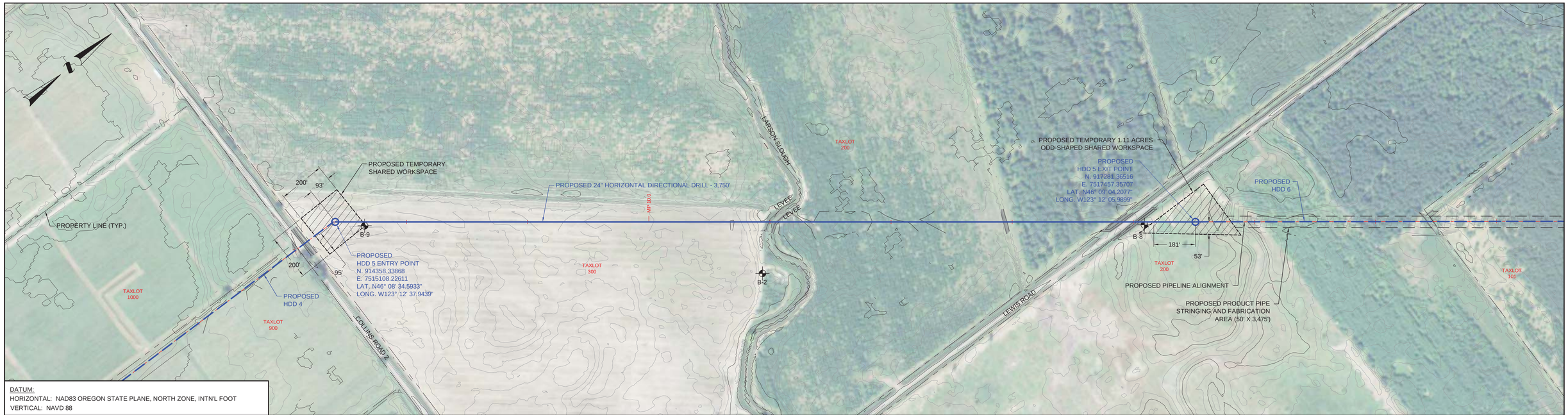
HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE FACTORS OF SAFETY

NW NATURAL - NORTH MIST PIPELINE HDD 5

GEOENGINEERS

FIGURE G-3

06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>

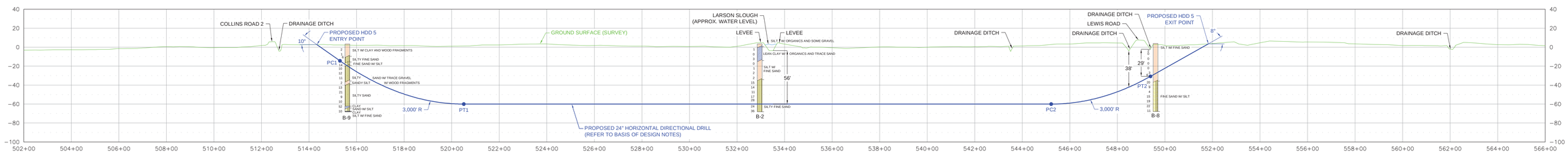


DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

200' 0 200'
SCALE IN FEET

MAJOR CONTOUR INTERVAL = 5'
MINOR CONTOUR INTERVAL = 1'



PROFILE

200' 0 200'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

DIRECTIONAL DRILL DATA HDD 5		
DESCRIPTION	STATION (FT)	ELEVATION (FT)
ENTRY @ 10°	514+33.01	2.66
P C 1 (10.00° @ 3,000 FT R.)	515+29.91	-14.42
P T 1	520+50.86	-60.00
P C 2 (8.00° @ 3,000 FT R.)	545+21.74	-60.00
P T 2	549+39.26	-30.80
EXIT @ 8°	551+83.01	3.45
HORIZONTAL DISTANCE = 3,750.00 FT		
DIRECTIONAL DRILL PIPE LENGTH = 3,757.90 FT		

RECOMMENDED TOLERANCES	
ITEM	TOLERANCE
PILOT HOLE ENTRY ANGLE	INCREASE ANGLE UP TO 1° (STEEPER), BUT NO DECREASE IN ANGLE ALLOWED.
PILOT HOLE ENTRY LOCATION	AS PER COORDINATES PROVIDED BY COMPANY WITH NO CHANGES WITHOUT COMPANY APPROVAL.
PILOT HOLE EXIT ANGLE	INCREASE ANGLE UP TO 1° (STEEPER) OR DECREASE UP TO 2° (FLATTER).
PILOT HOLE EXIT LOCATION	UP TO 20 FEET BEYOND OR 10 FEET SHORT OF THE EXIT STAKE. BETWEEN 5 FEET LEFT AND 5 FEET RIGHT OF CENTERLINE.
PILOT HOLE DEPTH	UP TO 2 FEET ABOVE THE DESIGN DRILL PROFILE ALLOWED. UP TO 10 FEET BELOW THE DESIGN DRILL PROFILE ALLOWED.
PILOT HOLE ALIGNMENT	SHALL REMAIN WITHIN 5 FEET LEFT OR RIGHT OF THE HDD ALIGNMENT.

LEGEND:

SPT (N) — TYPE OF SOIL

BORING LOCATION

FINAL

NOTES

1. ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT-OF-WAY OR FROM APPROVED ACCESS ROADS.
2. WORK SPACE: MAXIMUM WORK SPACE LIMITS ARE DEPICTED. RESTRICT CLEARING TO THE WORK SPACE INDICATED AT THE ENTRY AND EXIT POINTS AND PRODUCT PIPE STRINGING AND FABRICATION AREA ALONG THE CONSTRUCTION RIGHT-OF-WAY. CLEARING BETWEEN THE ENTRY AND EXIT POINTS REQUIRES PRIOR APPROVAL FROM THE ENVIRONMENTAL INSPECTOR AND IS LIMITED TO THE AMOUNT NECESSARY TO STRING SURVEY WIRES AND INSTALL PUMPS AND PIPING TO OBTAIN WATER (WHERE APPROVED).
3. WATER SOURCE: DRILL WATER AND HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE.
4. HYDROSTATIC TEST: PRE-INSTALLATION AND POST-INSTALLATION HYDROSTATIC TESTS SHALL BE CONDUCTED IN ACCORDANCE WITH THE HYDROSTATIC TEST PLAN. TEST WATER SHALL BE SAMPLED AND TESTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE TEST WATER SHALL BE DISCHARGED IN AN UPLAND AREA INTO AN EROSION CONTROL STRUCTURE OF STRAW BALES AND/OR SILT FENCES, GEOTEXTILE FILTER BAG, OR COLLECTED IN A TRUCK AND HAULED TO AN APPROVED DISPOSAL SITE. UPON COMPLETION OF DEWATERING AND DRYING, A CALIPER PIG SURVEY SHALL BE COMPLETED IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
5. SPILL-PREVENTION: REFUELING OF ALL EQUIPMENT SHALL BE COMPLETED IN ACCORDANCE WITH THE SPCC PLAN.
6. EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE APPROVED CONSTRUCTION RIGHT-OF-WAY AT THE DRILL EXIT POINT AS SHOWN. AFTER THE PILOT HOLE IS COMPLETE, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO NORTHWEST NATURAL FOR APPROVAL. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULL BACK.
8. DRILLING FLUID DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING FLUID AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING FLUID WHICH INADVERTENTLY SURFACES AT POINTS OTHER THAN THE ENTRY OR EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.
9. CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN THE CLEAN-UP AND RESTORATION REQUIREMENTS.
10. GEOTECHNICAL DATA: BORE HOLES ARE OFFSET FROM THE PIPELINE CENTERLINE AS SHOWN ON THE PLAN VIEW. THE GEOTECHNICAL INFORMATION PROVIDED ON THIS DRAWING IS A GENERAL SUMMARY. REFER TO THE APPLICABLE GEOTECHNICAL REPORT IN THE CONTRACT DOCUMENTS FOR MORE DETAILED INFORMATION.
11. IF THE TERRAIN ALLOWS AND ACCESS IS PERMITTED, CONTRACTOR SHALL UTILIZE LOW GROUND PRESSURE EQUIPMENT OR OTHER EQUIPMENT APPROVED BY OWNER, TO FACILITATE CONTAINMENT AND CLEAN-UP OF ANY INADVERTENT RETURNS THAT OCCUR DURING THE HDD INSTALLATION PROCESS.
12. THE MINIMUM ALLOWABLE THREE JOINT RADIUS SHALL NOT BE LESS THAN 2,400 FEET.
13. AERIAL PHOTOS AND GROUND SURFACE DEM (1/9 ARC SECOND) DOWNLOADED FROM HTTP://VIEWER.NATIONALMAP.GOV/VIEWER/. BASE FILES PROVIDED BY NORTHWEST NATURAL. GROUND SURFACE AND BAYTHMETRIC SURVEY DATA PROVIDED BY WESTLAKE CONSULTANTS, INC., OBTAINED AUGUST 2015.
14. CONTRACTOR IS RESPONSIBLE FOR CALLING OREGON ONE-CALL AND PHYSICALLY LOCATING ALL UNDERGROUND UTILITIES PRIOR TO BEGINNING CONSTRUCTION. IF ANY UTILITY IS LOCATED WITHIN 15 FEET OF THE DESIGNED HDD PROFILE AND ALIGNMENT, CONTRACTOR SHALL OBTAIN APPROVAL FROM NORTHWEST NATURAL PRIOR TO INITIATING HDD OPERATIONS.
15. A SITE SPECIFIC SURVEY DOCUMENTING EXISTING UTILITIES HAS NOT BEEN CONDUCTED ALONG THE PROPOSED PIPELINE ALIGNMENT. A SITE SPECIFIC TOPOGRAPHIC AND UTILITY SURVEY SHOULD BE COMPLETED PRIOR TO FINAL ISSUANCE OF THESE PLANS. DURING CONSTRUCTION, IT IS THE CONTRACTORS RESPONSIBILITY TO IDENTIFY AND PROTECT ANY UTILITY THAT MAY BE AFFECTED BY THE HDD OPERATIONS.
16. CONTRACTOR SHALL ADHERE TO THE SPECIFICATIONS AND REQUIREMENTS PER NORTHWEST NATURAL SPECIFICATIONS, CONTRACT DOCUMENTS, AND SPECIAL PERMIT CONDITIONS, EXCEPT AS NOTED ON THIS DRAWING.

BASIS OF DESIGN:

1. PRODUCT PIPE WILL CONSIST OF 24" O.D. X 0.500" W.T., API-5L X-52 PIPE WITH 14-16 MILS OF FUSION BONDED EPOXY (FBE) AND A MINIMUM OF 40 MILS OF ABRASION RESISTANT OVERLAY (ARO).
2. MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) = 809 psi

NOTE: THIS IS A FULL SIZE DRAWING THAT IS INTENDED TO BE PRINTED ON A 24" X 36" SHEET OF PAPER.

REFERENCE DRAWINGS	
DRAWING NO.	TITLE

REVISIONS						
NO.	DATE	BY	DESCRIPTION	W.O.NO.	CHK.	APP.
A	07/02/14	MWC	ISSUED AS DRAFT		BCR	TNH
B	04/20/15	MWC	ISSUED AS DRAFT (24-INCH REDESIGN)		BCR	TNH
C	09/15/15	BTL	ISSUED FOR FINAL		BCR	TNH

GEOENGINEERS
1200 NW NAITO PARKWAY, SUITE 180
PORTLAND, OREGON 97209
TELEPHONE: (503) 624-9274
FAX: (503) 620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
STATION 502+00 TO 566+00
HDD 5
COLUMBIA COUNTY, OREGON

NW Natural

DRAWN BY: MWC	DATE: 06/04/14	ISSUED FOR BID:	SCALE: AS NOTED
CHECKED BY: BCR	DATE: 06/04/14	ISSUED FOR CONSTRUCTION:	
APPROVED BY:	DATE:	DRAWING NUMBER: HDD 5	SHEET 1
WO:		TIME: 04:09 PM DATE: 09/09/15 PATH: P:\60224157\04\CAD\HDD\5_FINAL_Rev\C.dwg	OF 1

HDD Design Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 5 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe Diameter = 24.000 in

Pipe Material = Steel

Yield Stress = 52,000 psi

Wall Thickness = 0.5 in

Assumed Installation Temp = 55 °F

Assumed Operating Temp= 55 °F

Design Factor = 0.5

MAOP = 809 psi

Drill Data Box

Point	Station (ft)	Elevation (ft)
ENTRY @ 10°	51,433.01	2.66
P C 1 (10.00° @ 3,000 ft R.)	51,529.91	-14.42
P T 1	52,050.86	-60.00
P C 2 (8.00° @ 3,000 ft R.)	54,521.74	-60.00
P T 2	54,939.26	-30.80
EXIT @ 8°	55,183.01	3.45

Horizontal Alignment Length = 3,750.00 ft

Profile Segment Information

Segment Name	Segment Type	Segment Length (ft)
ENTRY TANGENT	Straight	98.40
ENTRY CURVE	Vertical Curve	523.60
BOTTOM TANGENT	Straight	2,470.88
EXIT CURVE	Vertical Curve	418.88
EXIT TANGENT	Straight	246.15

Pipe Length = 3,757.90 ft

Installation Load Summary

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Buoyancy Control (lb/ft)	Effective Pipe Weight (lb/ft)	Total Installation Force (lb)
9.50	Empty	0.00	-97.46	305,000
9.50	Full	180.04	82.58	250,000
12.00	Empty	0.00	-156.21	378,000
12.00	Full	180.04	23.83	199,000
10.50	Neutral	120.96	0.00	183,000

GeoEngineers

Minimum Radius Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 5 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters:

Pipe Diameter = 24.000 in **MAOP =** 809 psi **Factor of Safety =** 2.00

Wall Thickness = 0.500 in **SMYS =** 52,000 psi

D/t Ratio = 48.00 **Modulus of Elasticity (E) =** 2.96E+007 psi

Hoop Stress:

Calculated Hoop Stress = (MAOP * Pipe Diameter) / (2 * Wall Thickness) = 19,416 psi

Longitudinal Stress:

Calculated Longitudinal Stress = Hoop Stress / 2 = 9,708 psi

Allowable Stress:

Calculated Allowable Stress = SMYS / Factor of Safety = 26,000 psi

Bending Stress:

Calculated Bending Stress = Allowable Stress - Longitudinal Stress = 16,292 psi

Minimum Radius:

Calculated Minimum Radius = (E * Pipe Diameter) / (2 * Bending Stress) = 1,817 ft

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 5 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe diameter =	24.000 in	**Minimum Radius of Curvature =**	2,400 ft
Wall Thickness =	0.500 in	**Coefficient of Thermal Expansion =**	6.5E-06 in/in/°F
SMYS =	52,000 psi	**Assumed Installation Temperature =**	55 °F
MAOP =	809 psi	**Assumed Operating Temperature =**	55 °F
Poissons's Ratio =	0.30	**Temperature Derating Factor =**	1.00
Young's Modulus (E) =	2.96E+007 psi	**Groundwater Table Head =**	60.00 ft
Design Factor =	0.5		

Stress Analyses

Longitudinal Stress from Bending =	12,324 psi	
Percent SMYS =	23.70 %	
Hoop Stress =	18,792 psi	
Percent SMYS =	36.14 %	Limited by Design Factor (0.5) according to 49 CFR 192.111
Longitudinal Tensile Stress from Hoop Stress =	5,638 psi	
Percent SMYS =	10.84 %	
Longitudinal Stress from Thermal Expansion =	0 psi	
Percent SMYS =	0.00 %	Limited to 90% SMYS by ASME/ANSI B31.4 section 402.3.2
Net Longitudinal Stress (Comp. side of Curve) =	-6,687 psi	
Percent SMYS =	12.86 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Net Longitudinal Stress (Tension side of Curve) =	17,962 psi	
Percent SMYS =	34.54 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Maximum Shear Stress =	12,739 psi	
Percent SMYS =	24.50 %	Limited to 45% SMYS by ASME/ANSI B31.4 section 402.3.1
Combined BiaxialSress Check =	25,479 psi	
Percent SMYS =	49.00 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.4

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 5 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 5 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,758 ft
Moment of Inertia =	2,549 in^4
Pipe Face Area =	36.91 in^2
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft^3
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft^3
Pipe Exterior Volume =	3.14 ft^3/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft^3/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft^3
Effective Weight of Pipe =	-97.46 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	246.15 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	11,135 lb
Friction Force =	7,127 lb
Segment Weight =	3,339 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	21,601 lb
Cumulative Force =	**21,601 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	585 psi	
Cumulative Axial Stress =	585 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	406 psi	7,537 psi
Combined Stress =	0.0141	< 1.0
Total Stress =	0.0033	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	30,891 lb
Drag Force =	18,950 lb
Friction Force =	9,267 lb
Segment Weight =	2,848 lb
Tension =	61,933 lb
Average Tension =	41,767 lb
Segment Force =	40,332 lb
Cumulative Force =	**61,933 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,093 psi	
Cumulative Axial Stress =	1,678 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	752 psi	7,537 psi
Combined Stress =	0.3824	< 1.0
Total Stress =	0.1370	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	2,470.88 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	111,780 lb
Friction Force =	72,240 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	184,020 lb
Cumulative Force =	**245,953 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	4,985 psi	
Cumulative Axial Stress =	6,663 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	752 psi	7,537 psi
Combined Stress =	0.1602	< 1.0
Total Stress =	0.0418	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	57,232 lb
Drag Force =	23,687 lb
Friction Force =	17,170 lb
Segment Weight =	-4,447 lb
Tension =	299,532 lb
Average Tension =	272,742 lb
Segment Force =	53,579 lb
Cumulative Force =	**299,532 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,451 psi	
Cumulative Axial Stress =	8,114 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	752 psi	7,537 psi
Combined Stress =	0.5372	< 1.0
Total Stress =	0.2716	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	98.40 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,451 lb
Friction Force =	2,833 lb
Segment Weight =	-1,665 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	5,619 lb
Cumulative Force =	**305,151 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	152 psi	
Cumulative Axial Stress =	8,267 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	212 psi	7,537 psi
Combined Stress =	0.1987	< 1.0
Total Stress =	0.0426	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 5 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,758 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	82.58 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	246.15 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	11,135 lb
Friction Force =	6,039 lb
Segment Weight =	-2,829 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	14,345 lb
Cumulative Force =	**14,345 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	389 psi	
Cumulative Axial Stress =	389 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	49 psi	7,537 psi
Combined Stress =	0.0093	< 1.0
Total Stress =	0.0002	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	-16,491 lb
Drag Force =	18,950 lb
Friction Force =	4,947 lb
Segment Weight =	-2,413 lb
Tension =	40,776 lb
Average Tension =	27,561 lb
Segment Force =	26,431 lb
Cumulative Force =	**40,776 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	716 psi	
Cumulative Axial Stress =	1,105 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	92 psi	7,537 psi
Combined Stress =	0.3687	< 1.0
Total Stress =	0.1061	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	2,470.88 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	111,780 lb
Friction Force =	61,216 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	172,996 lb
Cumulative Force =	**213,773 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	4,687 psi	
Cumulative Axial Stress =	5,791 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	92 psi	7,537 psi
Combined Stress =	0.1392	< 1.0
Total Stress =	0.0202	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	-231 lb
Drag Force =	23,687 lb
Friction Force =	69 lb
Segment Weight =	3,769 lb
Tension =	241,367 lb
Average Tension =	227,570 lb
Segment Force =	27,594 lb
Cumulative Force =	**241,367 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	748 psi	
Cumulative Axial Stress =	6,539 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	92 psi	7,537 psi
Combined Stress =	0.4993	< 1.0
Total Stress =	0.2083	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	98.40 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,451 lb
Friction Force =	2,401 lb
Segment Weight =	1,411 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	8,263 lb
Cumulative Force =	**249,630 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	224 psi	
Cumulative Axial Stress =	6,763 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	26 psi	7,537 psi
Combined Stress =	0.1626	< 1.0
Total Stress =	0.0267	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 5 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,758 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	-156.21 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 1 of 5**

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	246.15 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	11,135 lb
Friction Force =	11,423 lb
Segment Weight =	5,351 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	27,909 lb
Cumulative Force =	**27,909 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	756 psi	
Cumulative Axial Stress =	756 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	513 psi	7,537 psi
Combined Stress =	0.0182	< 1.0
Total Stress =	0.0053	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	46,695 lb
Drag Force =	18,950 lb
Friction Force =	14,009 lb
Segment Weight =	4,564 lb
Tension =	79,441 lb
Average Tension =	53,675 lb
Segment Force =	51,531 lb
Cumulative Force =	**79,441 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,396 psi	
Cumulative Axial Stress =	2,152 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	949 psi	7,537 psi
Combined Stress =	0.3938	< 1.0
Total Stress =	0.1547	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	2,470.88 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	111,780 lb
Friction Force =	115,791 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	227,571 lb
Cumulative Force =	**307,012 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	6,165 psi	
Cumulative Axial Stress =	8,317 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	949 psi	7,537 psi
Combined Stress =	0.1999	< 1.0
Total Stress =	0.0657	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	80,393 lb
Drag Force =	23,687 lb
Friction Force =	24,118 lb
Segment Weight =	-7,128 lb
Tension =	371,806 lb
Average Tension =	339,409 lb
Segment Force =	64,795 lb
Cumulative Force =	**371,806 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,755 psi	
Cumulative Axial Stress =	10,072 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	949 psi	7,537 psi
Combined Stress =	0.5842	< 1.0
Total Stress =	0.3336	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty — **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	98.40 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,451 lb
Friction Force =	4,541 lb
Segment Weight =	-2,669 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	6,324 lb
Cumulative Force =	**378,130 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	171 psi	
Cumulative Axial Stress =	10,244 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	267 psi	7,537 psi
Combined Stress =	0.2462	< 1.0
Total Stress =	0.0655	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 5 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,758 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	23.83 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 1 of 5**

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	246.15 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	11,135 lb
Friction Force =	1,743 lb
Segment Weight =	-816 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	12,062 lb
Cumulative Force =	**12,062 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	327 psi	
Cumulative Axial Stress =	327 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	156 psi	7,537 psi
Combined Stress =	0.0079	< 1.0
Total Stress =	0.0005	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	-1,847 lb
Drag Force =	18,950 lb
Friction Force =	554 lb
Segment Weight =	-696 lb
Tension =	31,423 lb
Average Tension =	21,742 lb
Segment Force =	19,361 lb
Cumulative Force =	**31,423 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	525 psi	
Cumulative Axial Stress =	851 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	289 psi	7,537 psi
Combined Stress =	0.3626	< 1.0
Total Stress =	0.1070	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	2,470.88 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	111,780 lb
Friction Force =	17,666 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	129,446 lb
Cumulative Force =	**160,869 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	3,507 psi	
Cumulative Axial Stress =	4,358 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	289 psi	7,537 psi
Combined Stress =	0.1048	< 1.0
Total Stress =	0.0141	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	12,237 lb
Drag Force =	23,687 lb
Friction Force =	3,671 lb
Segment Weight =	1,088 lb
Tension =	192,985 lb
Average Tension =	176,927 lb
Segment Force =	32,117 lb
Cumulative Force =	**192,985 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	870 psi	
Cumulative Axial Stress =	5,228 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	289 psi	7,537 psi
Combined Stress =	0.4678	< 1.0
Total Stress =	0.1864	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	98.40 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,451 lb
Friction Force =	693 lb
Segment Weight =	407 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	5,552 lb
Cumulative Force =	**198,537 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	150 psi	
Cumulative Axial Stress =	5,378 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	82 psi	7,537 psi
Combined Stress =	0.1293	< 1.0
Total Stress =	0.0174	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 5 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,758 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	246.76 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	0.00 lb/ft

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 1 of 5**

Segment Parameters			
Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	246.15 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	11,135 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	11,135 lb
Cumulative Force =	**11,135 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	302 psi	
Cumulative Axial Stress =	302 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	448 psi	7,537 psi
Combined Stress =	0.0073	< 1.0
Total Stress =	0.0036	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	4,337 lb
Drag Force =	18,950 lb
Friction Force =	1,301 lb
Segment Weight =	0 lb
Tension =	32,688 lb
Average Tension =	21,911 lb
Segment Force =	21,552 lb
Cumulative Force =	**32,688 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	584 psi	
Cumulative Axial Stress =	886 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	831 psi	7,537 psi
Combined Stress =	0.3634	< 1.0
Total Stress =	0.1272	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	2,470.88 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	111,780 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	111,780 lb
Cumulative Force =	**144,467 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	3,028 psi	
Cumulative Axial Stress =	3,914 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	831 psi	7,537 psi
Combined Stress =	0.0941	< 1.0
Total Stress =	0.0248	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	17,948 lb
Drag Force =	23,687 lb
Friction Force =	5,385 lb
Segment Weight =	0 lb
Tension =	178,924 lb
Average Tension =	161,696 lb
Segment Force =	34,456 lb
Cumulative Force =	**178,924 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	933 psi	
Cumulative Axial Stress =	4,847 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	831 psi	7,537 psi
Combined Stress =	0.4586	< 1.0
Total Stress =	0.2012	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	98.40 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,451 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	4,451 lb
Cumulative Force =	**183,375 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	121 psi	
Cumulative Axial Stress =	4,968 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	234 psi	7,537 psi
Combined Stress =	0.1194	< 1.0
Total Stress =	0.0167	< 1.0

APPENDIX H
HDD-6

APPENDIX H
HDD-6

General

This appendix provides GeoEngineers' HDD design recommendations for proposed HDD-6 along the North Mist Pipeline alignment located in Columbia County, Oregon. The general site plan and profile is provided in Figure H-1 of this appendix. A full size construction drawing showing the design profile is provided in the attached Drawing No. HDD-6. The design drawing includes the necessary geometric information required to complete the pilot hole.

Project Description and Basis of Design

The proposed HDD installation will be a 24-inch-diameter steel pipeline crossing Collins Road 1, several drainage ditches and tree farm properties. The proposed pipeline alignment is oriented southwest-northeast (entry to exit), as shown in Figure H-1. The HDD design was completed based on the parameters presented below in Table H-1.

TABLE H-1. BASIS OF DESIGN FOR THE 24-INCH-DIAMETER HDD-6

Carrier Pipe Data	Design Parameter
Carrier Pipe Specifications	24 inches x 0.500 inches w.t.[1] API-5L X-52 steel pipe
Horizontal Crossing Length	3,900 feet
Maximum Allowable Operating Pressure	809 psig[2]
Maximum Operating Temperature	55 degrees F
Assumed Tie-In Temperature	55 degrees F

Notes:
[1] w.t. – wall thickness
[2] psig – pounds per square inch gauge

SITE DESCRIPTION

Surface Conditions

Surface conditions along the proposed alignment consist of a relatively flat, alluvial valley that is cut by three drainage ditches. The proposed entry point and entry workspace are situated just northeast of Lewis Road within a poplar tree farm property, at an elevation of approximately 3.5 feet MSL. The alignment crosses an approximately 36-foot wide and 5-foot-deep drainage canal approximately 1,025 feet northeast of the entry point. Approximately 2,700 feet northeast of the entry point, the alignment crosses Collins Road 1 and two approximately 20 to 30-foot-wide by 4 to 7-foot-deep drainage canals. The proposed exit point and exit workspace are situated on a relatively flat poplar tree farm property at an approximate elevation of zero feet MSL. The proposed pipe stringing and fabrication workspace extends approximately 4,000 feet northeast of the proposed exit point across poplar tree farms and crosses two drainage canals that are approximately 15 to 30 feet wide by 5 feet deep.

Subsurface Conditions

We completed three borings (B-7, B-8 and B-18) along or near the proposed HDD alignment in the locations shown in Figure H-1. Subsurface conditions encountered in the borings generally consisted of between approximately 39 and 43 feet of very soft to medium stiff silt with sand overlying loose to medium dense sand with varying amounts of silt that extended to 71.5 feet, the maximum depth explored.

Subsurface conditions encountered in the borings are shown graphically in Figure H-1, and are described in detail in boring logs in Appendix A.

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE EVALUATION

Model Input Parameters

The HDD geometry used for our analyses of HDD-6 is shown in Figure H-1, and in the HDD Design Drawing No. HDD-6 in this appendix. Based on the results of the subsurface exploration program and subsequent laboratory-testing program, the soil properties used in the evaluation are presented in Table H-2 below.

TABLE H-2. ESTIMATED SOIL PROPERTIES

Soil Description	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Very Soft Silt	90-100	0	50
Soft Silt with Sand	100-110	0	250-500
Loose Silty Sand	110	28	0
Medium Dense Sand with Silt	120	32	0

Based on available information and common HDD construction procedures, the tool dimensions and rheological properties used in the evaluation are summarized in Table H-3. Because these parameters are dependent upon the HDD contractor's means and methods, the hydraulic fracture and drilling fluid surface release evaluation should be refined during construction of the HDD installations.

TABLE H-3. ESTIMATED TOOL DIMENSIONS AND RHEOLOGICAL PROPERTIES

Parameter	Value
Pilot Hole Bit Diameter	12.25 inches
Drill Pipe Diameter	6.625 inches
Drilling Fluid Weight	9.5 ppg
Plastic Viscosity	14 CP
Yield Point	26 lb/100 sf

Notes:
ppg = pounds per gallon; CP = centipoise; lb/100 sf = pounds per 100 square feet

Results of Hydraulic Fracture and Drilling Fluid Surface Release Evaluation

The results of the hydraulic fracture evaluation are presented in Figures H-2 and H-3. Figure H-2 shows the calculated formation limit pressure (green line) and the estimated drilling fluid pressure shown as the red line, which represents the drilling fluid pressure along the HDD profile based on the anticipated drilling fluid properties shown in Table H-3.

When evaluating the risk of hydraulic fracture and drilling fluid surface releases, the analysis computes two types of factors of safety. These are:

- Factor of Safety against localized hydraulic fracture; and
- Factor of Safety against drilling fluid surface release.

Local Hydraulic Fracture: The factor of safety against hydraulic fracture is the ratio of the formation limit pressure to the estimated drilling fluid pressure along the profile, shown as the green line in Figure H-3. This represents the factor of safety against hydraulic fracture of the soil immediately surrounding the HDD profile and is a localized condition.

Drilling Fluid Surface Release: The factors of safety against drilling fluid surface release considers the strength of the soil column above the HDD profile that resists drilling fluid migrating to the ground surface. It is computed by comparing the formation limit pressure of the soil units above a specific location along the planned HDD alignment to the anticipated drilling fluid pressure at the same location. The factors of safety against drilling fluid surface releases are shown in Figure H-3 at selected points shown as red triangles.

The model indicates that the risk of localized hydraulic fracture and drilling fluid surface releases is generally low, with safety factors greater than 2 because the HDD path is generally expected to be within or below medium dense sand. However, the factors of safety against hydraulic fracture and drilling fluid surface releases drop significantly along the last approximately 300 feet where subsurface conditions are expected to generally consist of very soft silt. In addition, as shown in the model and based on our experience, there is typically a high risk of drilling fluid surface releases within the first 150 feet of the HDD due to relatively little depth of cover.

INSTALLATION LOADS AND OPERATING STRESSES

Installation Loads

The analyses of installation loads and operational stresses are based on the product pipe being installed along the designed drill path using the BMPs of the HDD industry. The addition of water into the product pipe is the standard method that contractors typically use to control buoyancy of the product pipe during the installation procedure. The proposed 24-inch-diameter product pipe will be buoyant in the anticipated drilling fluid weights. The HDD Contractor may choose to add water to the product pipe to try and achieve neutral buoyancy during pullback and reduce the required pull force during installation of the product pipe. Thus, our analyses include a range of cases with differing levels of buoyancy control. The following table presents a summary of the calculated installation loads for the HDD.

TABLE H-4. INSTALLATION LOADS FOR THE 24-INCH-DIAMETER HDD-6[1]

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Effective Pipe Weight[2] (lb/ft)	Pullback Force[3] (lb)
9.5	Empty	-97	316,000
9.5	Full	83	261,000
12	Empty	-156	392,000
12	Full	24	207,000
10.5	Neutral	0	190,000

Notes:
[1] See the HDD Design Summary and Calculations summaries provided in this appendix for detailed calculations.
[2] Negative values indicate upward force (positive buoyancy).
[3] Assumes a fully open drilled hole.
[4] Assumes a minimum pipeline radius of 2,400 feet.

Because the HDD contractor might utilize a relatively large drill rig to complete the installation, the drill rig may have a pullback capacity capable of causing damage to the product pipe during installation. While the estimated installation forces provided in Table H-4 suggest that the pullback forces should be less than 392,000 pounds, improper preparation of the hole prior to pullback operations or delays during pullback operations may cause pullback forces to exceed those estimated in the calculations.

Operating Stresses

For our operating stresses analysis, the installation and operating temperatures were assumed to be 55 degrees Fahrenheit. We can further evaluate different installation and operating temperatures, if requested. The following table presents a summary of the operating stresses for the product pipe specifications proposed for the HDD.

TABLE H-5. SUMMARY OF OPERATING STRESSES FOR THE 24-INCH-DIAMETER HDD-6

Stress Component	Stress (psi)	Percent SMYS[1] (%)	Maximum Allowable Percent SMYS (%)
Longitudinal Bending Stress	12,324	24	-
Hoop Stress	18,813	36	50[2]
Longitudinal Tensile Stress from Hoop Stress	5,644	11	-
Longitudinal Stress from Thermal Expansion	0	0	90[3]
Maximum Net Longitudinal Stress	17,968	35	90[4]
Maximum Shear Stress	12,747	25	45[5]
Maximum Combined Effective Stress	25,493	49	90[6]

Notes:
[1] Specified Minimum Yield Stress.
[2] Limited by design factor from DOT regulations, Title 49 CFR Part 192.111 for gas.
[3] Limited by Section 402.3.2 of ASME B31.4.
[4] Limited by Section 833.3 of ASME B31.8 for gas.
[5] Limited by Section 402.3.1 of ASME B31.4.
[6] Limited by Section 833.4 of ASME B31.8 for gas.

CONCLUSIONS AND RECOMMENDATIONS

Each of the three borings completed along or near the proposed alignment encountered very soft to soft silt in the upper portion of the soil profile. The softer zones of these soils may present steering difficulties during construction. The contractor should be prepared to encounter steering difficulties within the softer soils encountered in the upper portion of the soil profile. In addition, the soft soils likely will not provide adequate drill rod support to advance the pilot hole along the relatively long HDD.

We recommend that the contractor consider installing casing along the entry tangent to provide a reaction mass for allowing a greater transfer of axial loads through the drill pipe string to the drill bit during pilot hole drilling. The casing maintains hole uniformity and prevents the drill pipe string from being pushed into the soil formation while trying to advance the drill bit. Upon completion of the pilot hole, or prior to reaming the cased section of the hole, the casing is typically removed.

Drilling Fluid Surface Release

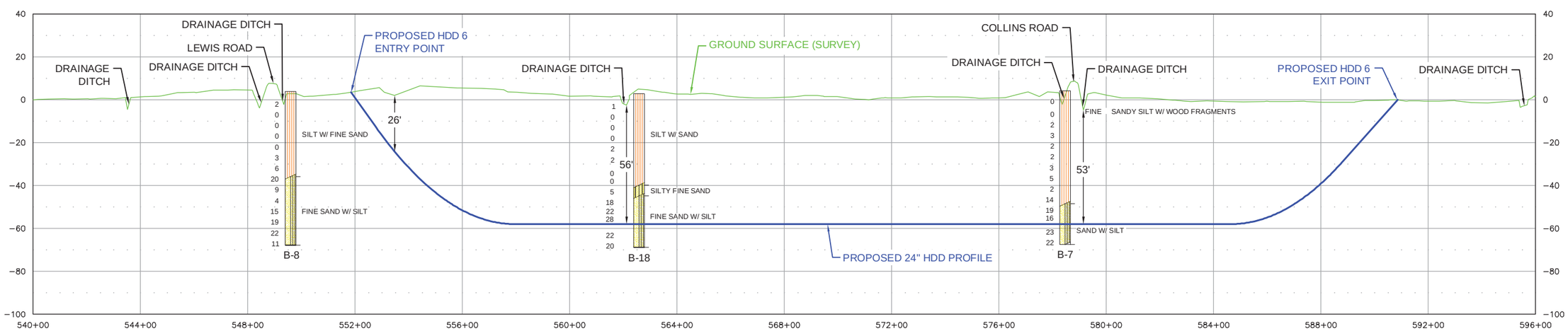
Based on our analyses, there is a low risk of drilling fluid surface releases along the majority of HDD-6. Although, there is a very high potential for drilling fluid surface release within approximately the first 150 feet of entry and within 300 feet of the exit point where the HDD is passing through very soft silt within the upper 25 feet.

We recommend that the contractor establish a contingency and mitigation plan in the event that drilling fluid surface releases occur; these plans should be reviewed and approved by the project team prior to the start of construction. It will be important for the contractor to maintain drilling fluid returns at all times, and monitor the first 150 feet and last 300 feet of the HDD alignment for drilling fluid surface releases during construction.

NOT FOR CONSTRUCTION:
THE HDD DESIGN DRAWING IS INCLUDED AS HDD 6 IN APPENDIX H.

PLAN
400' 0 400'
SCALE IN FEET

Major Contour Interval = 10'
Minor Contour Interval = 2'



PROFILE
400' 0 400'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Refer to the borings logs in the accompanying report for more detailed soil descriptions.
4. GeoEngineers, Inc. has not verified the field location of the existing utilities.

Reference: Ground surface DEM (1/9 arc second) and aerial photos downloaded from http://nationalmap.gov. Base files provided by NorthWest Natural. Ground surface and bathymetric survey data provided by Westlake Consultants, Inc., obtained August 2015.

LEGEND:

SPT (N) — TYPE OF SOIL

Boring Location

SITE PLAN AND PROFILE
HDD 6

NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

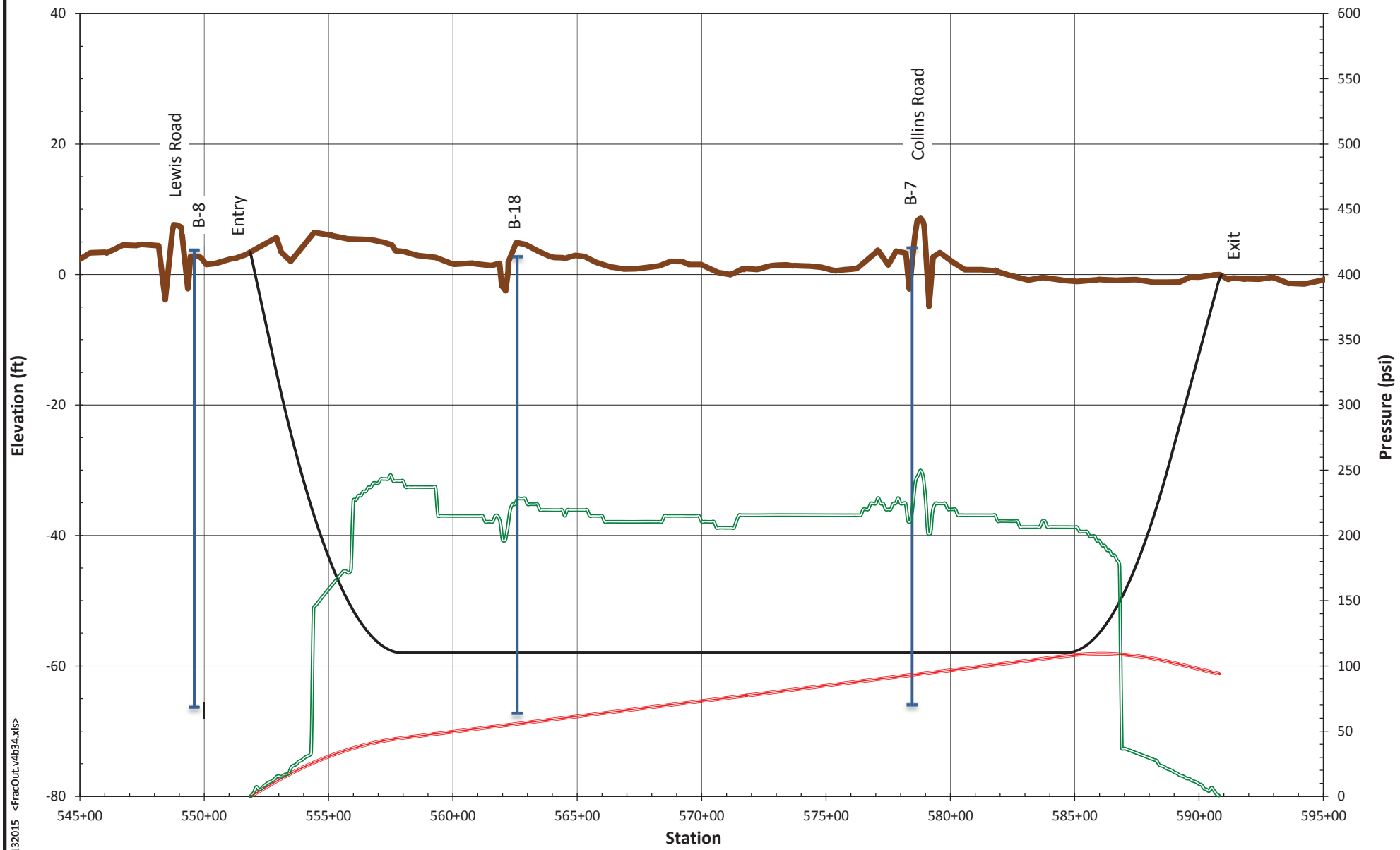
GEOENGINEERS

FIGURE H-1

BCR : BTL

P:\6\0241570\04\CAD\Figure H-1.dwg\TAB:Figure H-1 modified on Sep 14, 2015 - 1:57pm

NW NATURAL - NORTH MIST PIPELINE HDD 6



Crossing Length (ft)	3900
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	14
Yield Point (lb/100 ft)	26

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Estimated Annular Drilliing Fluid Pressure (psi) for Pilot Hole
- Formation Limit Pressure (psi)

ESTIMATED ANNULAR DRILLING FLUID AND FORMATION LIMIT PRESSURES

NW NATURAL - NORTH MIST PIPELINE HDD 6

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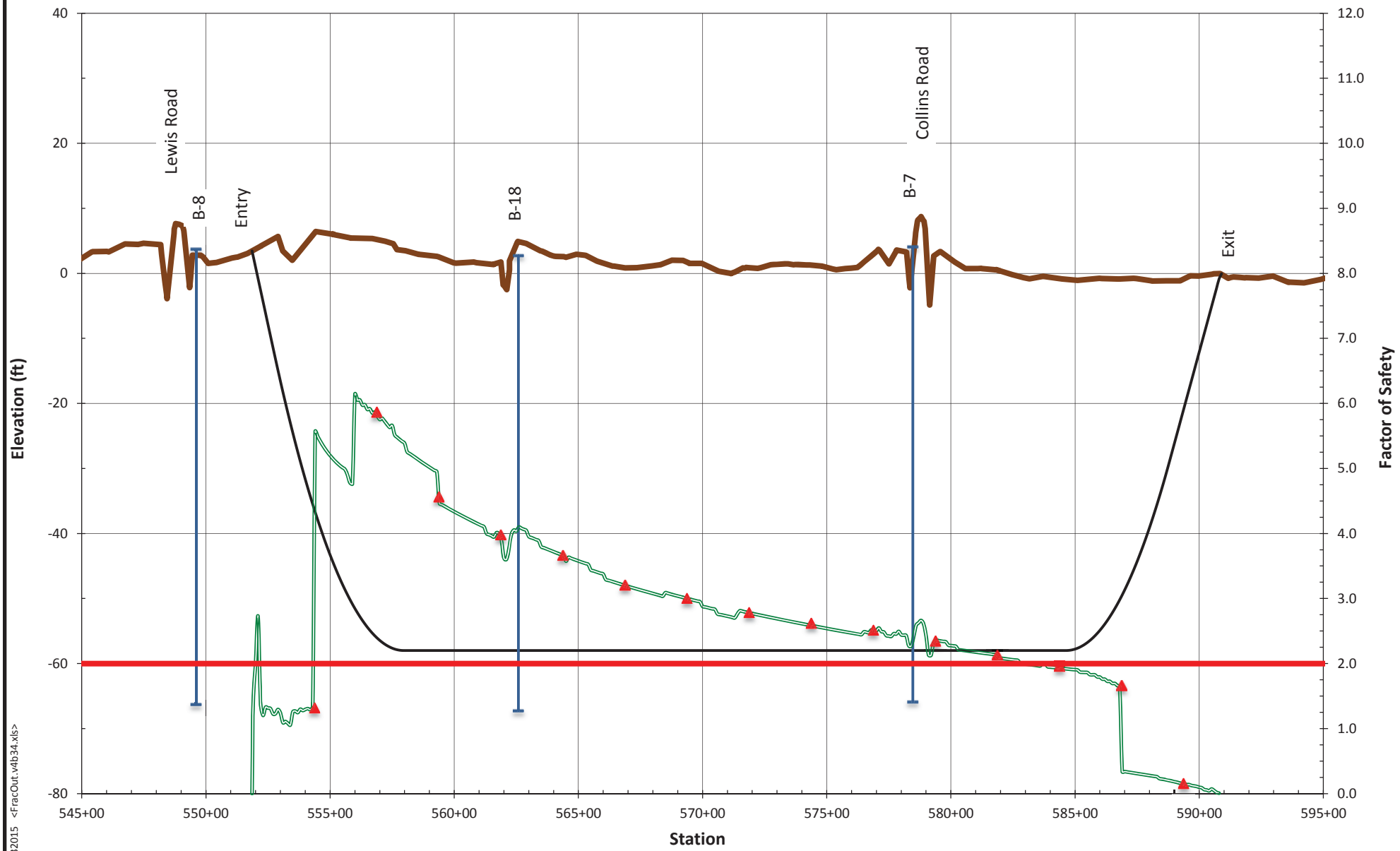
FIGURE H-2

06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>

NW NATURAL - NORTH MIST PIPELINE HDD 6



Crossing Length (ft)	3900
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	14
Yield Point (lb/100 ft)	26

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Drilling Fluid Surface Release Factor of Safety for Pilot Hole
- Hydraulic Fracture Factor of Safety for Pilot Hole
- Factor of Safety = 2

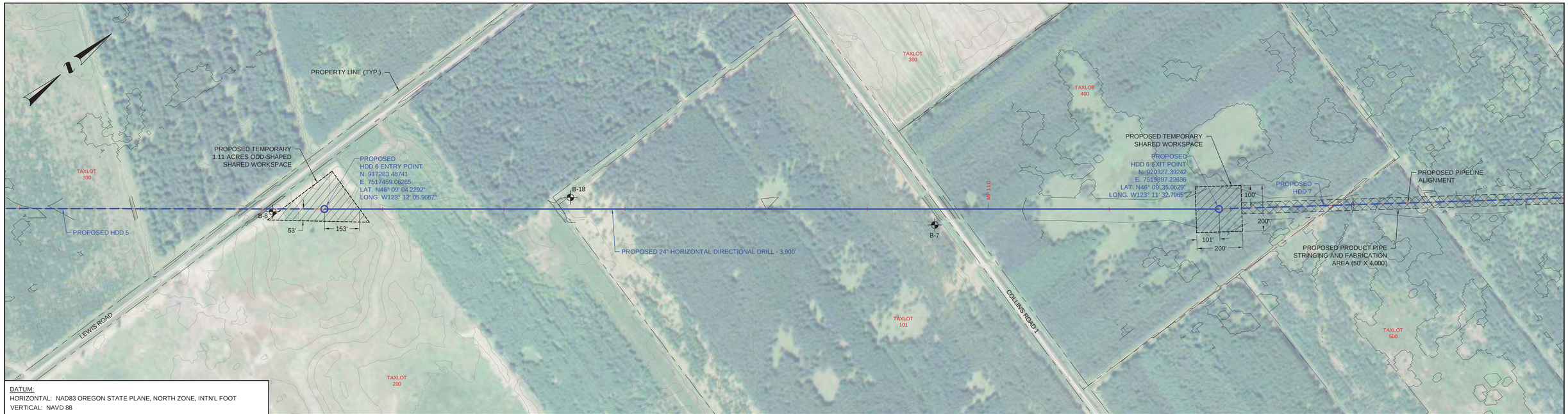
HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE FACTORS OF SAFETY

NW NATURAL - NORTH MIST PIPELINE HDD 6

GEOENGINEERS

FIGURE H-3

06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>

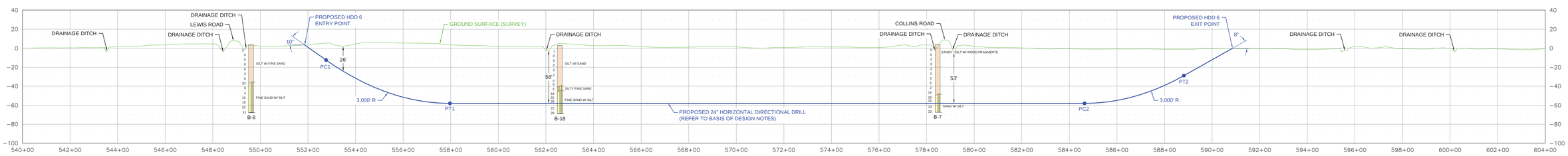


DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

200' 0 200'
SCALE IN FEET

MAJOR CONTOUR INTERVAL = 10'
MINOR CONTOUR INTERVAL = 2'



PROFILE

200' 0 200'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

DIRECTIONAL DRILL DATA HDD 6		
DESCRIPTION	STATION (FT)	ELEVATION (FT)
ENTRY @ 10°	551+85.73	3.45
P C 1 (10.00° @ 3,000 FT R.)	552+75.76	-12.42
P T 1	557+96.70	-58.00
P C 2 (8.00° @ 3,000 FT R.)	584+63.75	-58.00
P T 2	588+81.27	-28.80
EXIT @ 8°	590+85.73	-0.07
HORIZONTAL DISTANCE = 3,900.00 FT		
DIRECTIONAL DRILL PIPE LENGTH = 3,907.41 FT		

RECOMMENDED TOLERANCES	
ITEM	TOLERANCE
PILOT HOLE ENTRY ANGLE	INCREASE ANGLE UP TO 1º (STEEPER), BUT NO DECREASE IN ANGLE ALLOWED.
PILOT HOLE ENTRY LOCATION	AS PER COORDINATES PROVIDED BY COMPANY WITH NO CHANGES WITHOUT COMPANY APPROVAL.
PILOT HOLE EXIT ANGLE	INCREASE ANGLE UP TO 1º (STEEPER) OR DECREASE UP TO 2º (FLATTER).
PILOT HOLE EXIT LOCATION	UP TO 20 FEET BEYOND OR 10 FEET SHORT OF THE EXIT STAKE. BETWEEN 5 FEET LEFT AND 5 FEET RIGHT OF CENTERLINE.
PILOT HOLE DEPTH	UP TO 2 FEET ABOVE THE DESIGN DRILL PROFILE ALLOWED. UP TO 10 FEET BELOW THE DESIGN DRILL PROFILE ALLOWED.
PILOT HOLE ALIGNMENT	SHALL REMAIN WITHIN 5 FEET LEFT OR RIGHT OF THE HDD ALIGNMENT.

LEGEND:

SPT (N) — TYPE OF SOIL

BORING LOCATION

FINAL

NOTES

1. ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT-OF-WAY OR FROM APPROVED ACCESS ROADS.
2. WORK SPACE: MAXIMUM WORK SPACE LIMITS ARE DEPICTED. RESTRICT CLEARING TO THE WORK SPACE INDICATED AT THE ENTRY AND EXIT POINTS AND PRODUCT PIPE STRINGING AND FABRICATION AREA ALONG THE CONSTRUCTION RIGHT-OF-WAY. CLEARING BETWEEN THE ENTRY AND EXIT POINTS REQUIRES PRIOR APPROVAL FROM THE ENVIRONMENTAL INSPECTOR AND IS LIMITED TO THE AMOUNT NECESSARY TO STRING SURVEY WIRES AND INSTALL PUMPS AND PIPING TO OBTAIN WATER (WHERE APPROVED).
3. WATER SOURCE: DRILL WATER AND HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE.
4. HYDROSTATIC TEST: PRE-INSTALLATION AND POST-INSTALLATION HYDROSTATIC TESTS SHALL BE CONDUCTED IN ACCORDANCE WITH THE HYDROSTATIC TEST PLAN. TEST WATER SHALL BE SAMPLED AND TESTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE TEST WATER SHALL BE DISCHARGED IN AN UPLAND AREA INTO AN EROSION CONTROL STRUCTURE OF STRAW BALES AND/OR SILT FENCES, GEOTEXTILE FILTER BAG, OR COLLECTED IN A TRUCK AND HAULED TO AN APPROVED DISPOSAL SITE. UPON COMPLETION OF DEWATERING AND DRYING, A CALIPER PIG SURVEY SHALL BE COMPLETED IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
5. SPILL-PREVENTION: REFUELING OF ALL EQUIPMENT SHALL BE COMPLETED IN ACCORDANCE WITH THE SPCC PLAN.
6. EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE APPROVED CONSTRUCTION RIGHT-OF-WAY AT THE DRILL EXIT POINT AS SHOWN. AFTER THE PILOT HOLE IS COMPLETE, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO NORTHWEST NATURAL FOR APPROVAL. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULL BACK.
8. DRILLING FLUID DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING FLUID AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING FLUID WHICH INADVERTENTLY SURFACES AT POINTS OTHER THAN THE ENTRY OR EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.
9. CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN THE CLEAN-UP AND RESTORATION REQUIREMENTS.
10. GEOTECHNICAL DATA: BORE HOLES ARE OFFSET FROM THE PIPELINE CENTERLINE AS SHOWN ON THE PLAN VIEW. THE GEOTECHNICAL INFORMATION PROVIDED ON THIS DRAWING IS A GENERAL SUMMARY. REFER TO THE APPLICABLE GEOTECHNICAL REPORT IN THE CONTRACT DOCUMENTS FOR MORE DETAILED INFORMATION.
11. IF THE TERRAIN ALLOWS AND ACCESS IS PERMITTED, CONTRACTOR SHALL UTILIZE LOW GROUND PRESSURE EQUIPMENT OR OTHER EQUIPMENT APPROVED BY OWNER, TO FACILITATE CONTAINMENT AND CLEAN-UP OF ANY INADVERTENT RETURNS THAT OCCUR DURING THE HDD INSTALLATION PROCESS.
12. THE MINIMUM ALLOWABLE THREE JOINT RADIUS SHALL NOT BE LESS THAN 2,400 FEET.
13. AERIAL PHOTOS AND GROUND SURFACE DEM (1/9 ARC SECOND) DOWNLOADED FROM HTTP://VIEWER.NATIONALMAP.GOV/VIEWER/. BASE FILES PROVIDED BY NORTHWEST NATURAL. GROUND SURFACE AND BATHYMETRIC SURVEY DATA PROVIDED BY WESTLAKE CONSULTANTS, INC., OBTAINED AUGUST 2015.
14. CONTRACTOR IS RESPONSIBLE FOR CALLING OREGON ONE-CALL AND PHYSICALLY LOCATING ALL UNDERGROUND UTILITIES PRIOR TO BEGINNING CONSTRUCTION. IF ANY UTILITY IS LOCATED WITHIN 15 FEET OF THE DESIGNED HDD PROFILE AND ALIGNMENT, CONTRACTOR SHALL OBTAIN APPROVAL FROM NORTHWEST NATURAL PRIOR TO INITIATING HDD OPERATIONS.
15. A SITE SPECIFIC SURVEY DOCUMENTING EXISTING UTILITIES HAS NOT BEEN CONDUCTED ALONG THE PROPOSED PIPELINE ALIGNMENT. A SITE SPECIFIC TOPOGRAPHIC AND UTILITY SURVEY SHOULD BE COMPLETED PRIOR TO FINAL ISSUANCE OF THESE PLANS. DURING CONSTRUCTION, IT IS THE CONTRACTORS RESPONSIBILITY TO IDENTIFY AND PROTECT ANY UTILITY THAT MAY BE AFFECTED BY THE HDD OPERATIONS.
16. CONTRACTOR SHALL ADHERE TO THE SPECIFICATIONS AND REQUIREMENTS PER NORTHWEST NATURAL SPECIFICATIONS, CONTRACT DOCUMENTS, AND SPECIAL PERMIT CONDITIONS, EXCEPT AS NOTED ON THIS DRAWING.

BASIS OF DESIGN:

1. PRODUCT PIPE WILL CONSIST OF 24" O.D. X 0.500" W.T., API-5L X-52 PIPE WITH 14-16 MILS OF FUSION BONDED EPOXY (FBE) AND A MINIMUM OF 40 MILS OF ABRASION RESISTANT OVERLAY (ARO).
2. MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) = 809 psi

NOTE: THIS IS A FULL SIZE DRAWING THAT IS INTENDED TO BE PRINTED ON A 24" X 36" SHEET OF PAPER.

REFERENCE DRAWINGS	
DRAWING NO.	TITLE

REVISIONS						
NO.	DATE	BY	DESCRIPTION	W.O.NO.	CHK.	APP.
A	07/02/14	MWC	ISSUED AS DRAFT		BCR	TNH
B	04/20/15	MWC	ISSUED AS DRAFT (24-INCH REDESIGN)		BCR	TNH
C	09/15/15	BTL	ISSUED FOR FINAL		BCR	TNH

GEOENGINEERS
1200 NW NAITO PARKWAY, SUITE 180
PORTLAND, OREGON 97209
TELEPHONE: (503) 624-9274
FAX: (503) 620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
STATION 540+00 TO 604+00
HDD 6
COLUMBIA COUNTY, OREGON

NW Natural

DRAWN BY: MWC	DATE: 06/05/14	ISSUED FOR BID:	SCALE: AS NOTED
CHECKED BY: BCR	DATE: 06/05/14	ISSUED FOR CONSTRUCTION:	
APPROVED BY:	DATE:	DRAWING NUMBER: HDD 6	SHEET 1
WO:		TIME: 01:53 PM DATE: 09/14/15 PATH: P:\60024157\5\6\CAD\HDD 6_FINAL Rev C.dwg	OF 1

HDD Design Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 6 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe Diameter = 24.000 in

Pipe Material = Steel

Yield Stress = 52,000 psi

Wall Thickness = 0.5 in

Assumed Installation Temp = 55 °F

Assumed Operating Temp= 55 °F

Design Factor = 0.5

MAOP = 809 psi

Drill Data Box

Point	Station (ft)	Elevation (ft)
ENTRY @ 10°	55,185.73	3.45
P C 1 (10.00° @ 3,000 ft R.)	55,275.76	-12.42
P T 1	55,796.70	-58.00
P C 2 (8.00° @ 3,000 ft R.)	58,463.75	-58.00
P T 2	58,881.27	-28.80
EXIT @ 8°	59,085.73	-0.07

Horizontal Alignment Length = 3,900.00 ft

Profile Segment Information

Segment Name	Segment Type	Segment Length (ft)
ENTRY TANGENT	Straight	91.41
ENTRY CURVE	Vertical Curve	523.60
BOTTOM TANGENT	Straight	2,667.05
EXIT CURVE	Vertical Curve	418.88
EXIT TANGENT	Straight	206.47

Pipe Length = 3,907.41 ft

Installation Load Summary

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Buoyancy Control (lb/ft)	Effective Pipe Weight (lb/ft)	Total Installation Force (lb)
9.50	Empty	0.00	-97.46	316,000
9.50	Full	180.04	82.58	261,000
12.00	Empty	0.00	-156.21	392,000
12.00	Full	180.04	23.83	207,000
10.50	Neutral	120.96	0.00	190,000

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Minimum Radius Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 6 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters:

Pipe Diameter = 24.000 in **MAOP =** 809 psi **Factor of Safety =** 2.00

Wall Thickness = 0.500 in **SMYS =** 52,000 psi

D/t Ratio = 48.00 **Modulus of Elasticity (E) =** 2.96E+007 psi

Hoop Stress:

Calculated Hoop Stress = (MAOP * Pipe Diameter) / (2 * Wall Thickness) = 19,416 psi

Longitudinal Stress:

Calculated Longitudinal Stress = Hoop Stress / 2 = 9,708 psi

Allowable Stress:

Calculated Allowable Stress = SMYS / Factor of Safety = 26,000 psi

Bending Stress:

Calculated Bending Stress = Allowable Stress - Longitudinal Stress = 16,292 psi

Minimum Radius:

Calculated Minimum Radius = (E * Pipe Diameter) / (2 * Bending Stress) = 1,817 ft

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 6 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe diameter =	24.000 in	**Minimum Radius of Curvature =**	2,400 ft
Wall Thickness =	0.500 in	**Coefficient of Thermal Expansion =**	6.5E-06 in/in/°F
SMYS =	52,000 psi	**Assumed Installation Temperature =**	55 °F
MAOP =	809 psi	**Assumed Operating Temperature =**	55 °F
Poissons's Ratio =	0.30	**Temperature Derating Factor =**	1.00
Young's Modulus (E) =	2.96E+007 psi	**Groundwater Table Head =**	58.00 ft
Design Factor =	0.5		

Stress Analyses

Longitudinal Stress from Bending =	12,324 psi	
Percent SMYS =	23.70 %	
Hoop Stress =	18,813 psi	
Percent SMYS =	36.18 %	Limited by Design Factor (0.5) according to 49 CFR 192.111
Longitudinal Tensile Stress from Hoop Stress =	5,644 psi	
Percent SMYS =	10.85 %	
Longitudinal Stress from Thermal Expansion =	0 psi	
Percent SMYS =	0.00 %	Limited to 90% SMYS by ASME/ANSI B31.4 section 402.3.2
Net Longitudinal Stress (Comp. side of Curve) =	-6,680 psi	
Percent SMYS =	12.85 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Net Longitudinal Stress (Tension side of Curve) =	17,968 psi	
Percent SMYS =	34.55 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Maximum Shear Stress =	12,747 psi	
Percent SMYS =	24.51 %	Limited to 45% SMYS by ASME/ANSI B31.4 section 402.3.1
Combined BiaxialSress Check =	25,493 psi	
Percent SMYS =	49.03 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.4

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 6 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 6 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,907 ft
Moment of Inertia =	2,549 in^4
Pipe Face Area =	36.91 in^2
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft^3
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft^3
Pipe Exterior Volume =	3.14 ft^3/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft^3/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft^3
Effective Weight of Pipe =	-97.46 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	206.47 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	9,341 lb
Friction Force =	5,978 lb
Segment Weight =	2,800 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	18,119 lb
Cumulative Force =	**18,119 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	491 psi	
Cumulative Axial Stress =	491 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	382 psi	7,537 psi
Combined Stress =	0.0118	< 1.0
Total Stress =	0.0028	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	30,639 lb
Drag Force =	18,950 lb
Friction Force =	9,192 lb
Segment Weight =	2,848 lb
Tension =	58,300 lb
Average Tension =	38,209 lb
Segment Force =	40,181 lb
Cumulative Force =	**58,300 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,089 psi	
Cumulative Axial Stress =	1,579 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	728 psi	7,537 psi
Combined Stress =	0.3801	< 1.0
Total Stress =	0.1343	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	2,667.05 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	120,654 lb
Friction Force =	77,976 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	198,630 lb
Cumulative Force =	**256,930 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	5,381 psi	
Cumulative Axial Stress =	6,960 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	728 psi	7,537 psi
Combined Stress =	0.1673	< 1.0
Total Stress =	0.0437	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	58,252 lb
Drag Force =	23,687 lb
Friction Force =	17,476 lb
Segment Weight =	-4,447 lb
Tension =	311,121 lb
Average Tension =	284,025 lb
Segment Force =	54,191 lb
Cumulative Force =	**311,121 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,468 psi	
Cumulative Axial Stress =	8,428 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	728 psi	7,537 psi
Combined Stress =	0.5447	< 1.0
Total Stress =	0.2782	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	91.41 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,135 lb
Friction Force =	2,632 lb
Segment Weight =	-1,547 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	5,220 lb
Cumulative Force =	**316,341 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	141 psi	
Cumulative Axial Stress =	8,570 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	188 psi	7,537 psi
Combined Stress =	0.2060	< 1.0
Total Stress =	0.0452	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 6 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,907 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	82.58 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	206.47 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	9,341 lb
Friction Force =	5,066 lb
Segment Weight =	-2,373 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	12,033 lb
Cumulative Force =	**12,033 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	326 psi	
Cumulative Axial Stress =	326 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	83 psi	7,537 psi
Combined Stress =	0.0078	< 1.0
Total Stress =	0.0002	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	-16,698 lb
Drag Force =	18,950 lb
Friction Force =	5,009 lb
Segment Weight =	-2,413 lb
Tension =	38,588 lb
Average Tension =	25,311 lb
Segment Force =	26,555 lb
Cumulative Force =	**38,588 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	719 psi	
Cumulative Axial Stress =	1,045 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	125 psi	7,537 psi
Combined Stress =	0.3672	< 1.0
Total Stress =	0.1059	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	2,667.05 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	120,654 lb
Friction Force =	66,077 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	186,731 lb
Cumulative Force =	**225,319 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	5,059 psi	
Cumulative Axial Stress =	6,104 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	125 psi	7,537 psi
Combined Stress =	0.1467	< 1.0
Total Stress =	0.0228	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	873 lb
Drag Force =	23,687 lb
Friction Force =	262 lb
Segment Weight =	3,769 lb
Tension =	253,299 lb
Average Tension =	239,309 lb
Segment Force =	27,980 lb
Cumulative Force =	**253,299 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	758 psi	
Cumulative Axial Stress =	6,862 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	125 psi	7,537 psi
Combined Stress =	0.5071	< 1.0
Total Stress =	0.2164	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	91.41 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,135 lb
Friction Force =	2,230 lb
Segment Weight =	1,311 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	7,677 lb
Cumulative Force =	**260,976 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	208 psi	
Cumulative Axial Stress =	7,070 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	60 psi	7,537 psi
Combined Stress =	0.1699	< 1.0
Total Stress =	0.0295	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 6 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,907 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	-156.21 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	206.47 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	9,341 lb
Friction Force =	9,582 lb
Segment Weight =	4,489 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	23,411 lb
Cumulative Force =	**23,411 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	634 psi	
Cumulative Axial Stress =	634 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	483 psi	7,537 psi
Combined Stress =	0.0152	< 1.0
Total Stress =	0.0046	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	46,396 lb
Drag Force =	18,950 lb
Friction Force =	13,919 lb
Segment Weight =	4,564 lb
Tension =	74,763 lb
Average Tension =	49,087 lb
Segment Force =	51,352 lb
Cumulative Force =	**74,763 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,391 psi	
Cumulative Axial Stress =	2,025 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	919 psi	7,537 psi
Combined Stress =	0.3908	< 1.0
Total Stress =	0.1510	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	2,667.05 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	120,654 lb
Friction Force =	124,984 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	245,638 lb
Cumulative Force =	**320,401 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	6,654 psi	
Cumulative Axial Stress =	8,680 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	919 psi	7,537 psi
Combined Stress =	0.2086	< 1.0
Total Stress =	0.0684	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	81,613 lb
Drag Force =	23,687 lb
Friction Force =	24,484 lb
Segment Weight =	-7,128 lb
Tension =	385,927 lb
Average Tension =	353,164 lb
Segment Force =	65,526 lb
Cumulative Force =	**385,927 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,775 psi	
Cumulative Axial Stress =	10,455 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	919 psi	7,537 psi
Combined Stress =	0.5934	< 1.0
Total Stress =	0.3423	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	91.41 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,135 lb
Friction Force =	4,219 lb
Segment Weight =	-2,480 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	5,875 lb
Cumulative Force =	**391,802 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	159 psi	
Cumulative Axial Stress =	10,614 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	237 psi	7,537 psi
Combined Stress =	0.2551	< 1.0
Total Stress =	0.0694	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 6 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,907 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	23.83 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 1 of 5**

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	206.47 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	9,341 lb
Friction Force =	1,462 lb
Segment Weight =	-685 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	10,118 lb
Cumulative Force =	**10,118 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	274 psi	
Cumulative Axial Stress =	274 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	184 psi	7,537 psi
Combined Stress =	0.0066	< 1.0
Total Stress =	0.0007	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	-2,009 lb
Drag Force =	18,950 lb
Friction Force =	603 lb
Segment Weight =	-696 lb
Tension =	29,576 lb
Average Tension =	19,847 lb
Segment Force =	19,458 lb
Cumulative Force =	**29,576 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	527 psi	
Cumulative Axial Stress =	801 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	317 psi	7,537 psi
Combined Stress =	0.3614	< 1.0
Total Stress =	0.1069	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	2,667.05 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	120,654 lb
Friction Force =	19,068 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	139,723 lb
Cumulative Force =	**169,299 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	3,785 psi	
Cumulative Axial Stress =	4,586 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	317 psi	7,537 psi
Combined Stress =	0.1102	< 1.0
Total Stress =	0.0158	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	13,086 lb
Drag Force =	23,687 lb
Friction Force =	3,926 lb
Segment Weight =	1,088 lb
Tension =	201,925 lb
Average Tension =	185,612 lb
Segment Force =	32,626 lb
Cumulative Force =	**201,925 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	884 psi	
Cumulative Axial Stress =	5,470 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	317 psi	7,537 psi
Combined Stress =	0.4736	< 1.0
Total Stress =	0.1924	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	91.41 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,135 lb
Friction Force =	644 lb
Segment Weight =	378 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	5,157 lb
Cumulative Force =	**207,082 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	140 psi	
Cumulative Axial Stress =	5,610 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	109 psi	7,537 psi
Combined Stress =	0.1349	< 1.0
Total Stress =	0.0192	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 6 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,907 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	246.76 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	0.00 lb/ft

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy — Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	206.47 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	9,341 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	9,341 lb
Cumulative Force =	**9,341 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	253 psi	
Cumulative Axial Stress =	253 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	422 psi	7,537 psi
Combined Stress =	0.0061	< 1.0
Total Stress =	0.0032	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	4,186 lb
Drag Force =	18,950 lb
Friction Force =	1,256 lb
Segment Weight =	0 lb
Tension =	30,802 lb
Average Tension =	20,071 lb
Segment Force =	21,461 lb
Cumulative Force =	**30,802 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	581 psi	
Cumulative Axial Stress =	834 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	804 psi	7,537 psi
Combined Stress =	0.3622	< 1.0
Total Stress =	0.1252	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	2,667.05 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	120,654 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	120,654 lb
Cumulative Force =	**151,456 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	3,269 psi	
Cumulative Axial Stress =	4,103 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	804 psi	7,537 psi
Combined Stress =	0.0986	< 1.0
Total Stress =	0.0250	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	18,643 lb
Drag Force =	23,687 lb
Friction Force =	5,593 lb
Segment Weight =	0 lb
Tension =	186,329 lb
Average Tension =	168,893 lb
Segment Force =	34,873 lb
Cumulative Force =	**186,329 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	945 psi	
Cumulative Axial Stress =	5,048 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	804 psi	7,537 psi
Combined Stress =	0.4635	< 1.0
Total Stress =	0.2041	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	91.41 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,135 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	4,135 lb
Cumulative Force =	**190,465 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	112 psi	
Cumulative Axial Stress =	5,160 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	208 psi	7,537 psi
Combined Stress =	0.1240	< 1.0
Total Stress =	0.0175	< 1.0

APPENDIX I
HDD-7

APPENDIX I
HDD-7

General

This appendix provides GeoEngineers' HDD design recommendations for proposed HDD-7 along the North Mist Pipeline alignment located in Columbia County, Oregon. The general site plan and profile is provided in Figure I-1 of this appendix. A full size construction drawing showing the design profile is provided in the attached Drawing No. HDD-7. The design drawing includes the necessary geometric information required to complete the pilot hole.

Project Description and Basis of Design

The proposed HDD installation will be a 24-inch-diameter steel pipeline crossing Hermo Road, a poplar tree farm, other agricultural properties, and several drainage canals. The proposed pipeline alignment is oriented northeast-southwest (entry to exit), as shown in Figure I-1. The HDD design was completed based on the parameters presented below in Table I-1.

TABLE I-1. BASIS OF DESIGN FOR THE 24-INCH-DIAMETER HDD-7

Carrier Pipe Data	Design Parameter
Carrier Pipe Specifications	24 inches x 0.500 inches w.t.[1] API-5L X-52 steel pipe
Horizontal Crossing Length	3,570 feet
Maximum Allowable Operating Pressure	809 psig[2]
Maximum Operating Temperature	55 degrees F
Assumed Tie-In Temperature	55 degrees F

Notes:
[1] w.t. – wall thickness
[2] psig – pounds per square inch gauge

SITE DESCRIPTION

Surface Conditions

Surface conditions along the proposed alignment consist of a relatively flat alluvial valley occupied by a Poplar tree farm and other agricultural land properties. The crossing area is drained by several drainage ditches that are approximately 5 to 8-feet wide. The depths of the drainage ditches from approximately pipeline station 6+10 to Hermo Road (approximate pipeline station 6+25) are unknown, but assumed to be less than 8 feet. The proposed entry workspace is situated northeast of Hermo Road at an elevation of approximately 6.4 feet MSL. The alignment crosses a drainage canal and Hermo Road approximately 100 feet southwest of the entry point, and then crosses an agricultural field that is cut by several relatively small drainage canals. Survey data obtained by Westlake Consultants, Inc. August 2015 indicates the alignment crosses two drainage ditches located approximately 2,650 feet and 3,100 feet southwest of the entry point. These two drainage ditches are approximately 15 feet wide by 4 feet deep and 30 feet wide by 4 feet deep respectively. The proposed HDD exits within a poplar tree farm property at an approximate elevation of 0.5 feet MSL. The proposed pipe stringing and fabrication workspace extends 3,600 feet southwest of the proposed exit workspace, crossing tree farm properties and Collins Road 1.

Subsurface Conditions

We completed three borings (B-4, B-5 and B-6) along the proposed HDD alignment at the locations shown in Figure I-1. Subsurface conditions encountered in the borings consisted of interbedded very soft to soft elastic silt, very soft to soft silt with varying amounts of sand and soft to very stiff lean clay with varying amounts of sand and wood fragments. These interbedded silts and clays extended to 71.5 feet bgs, the maximum depth explored.

Subsurface conditions encountered in the borings are shown graphically in Figure I-1, and are described in detail in the boring logs in Appendix A.

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE EVALUATION

Model Input Parameters

The HDD geometry used for our analyses of HDD-7 is shown in Figure I-1, and in the HDD Design Drawing, Drawing No. HDD-7 in this appendix. Based on the results of the exploration program and subsequent laboratory-testing program, the soil properties used in the evaluation are presented in Table I-2 below.

TABLE I-2. ESTIMATED SOIL PROPERTIES

Soil Description	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Very Soft Silt and Elastic Silt	90-100	0	200
Soft Lean Clay, Silt, and Elastic Silt	100-105	10	250
Soft Silt with Sand	105	20	0
Medium Stiff to Stiff Silt	100	23	300

Based on available information and common HDD construction procedures, the tool dimensions and rheological properties used in the evaluation are summarized in Table I-3. Because these parameters are dependent upon the HDD contractor's means and methods, the hydraulic fracture and drilling fluid surface release evaluation should be refined during construction of the HDD installations.

TABLE I-3. ESTIMATED TOOL DIMENSIONS AND RHEOLOGICAL PROPERTIES

Parameter	Value
Pilot Hole Bit Diameter	12.25 inches
Drill Pipe Diameter	6.625 inches
Drilling Fluid Weight	9.5 ppg
Plastic Viscosity	10 CP
Yield Point	20 lb/100 sf

Notes:
ppg = pounds per gallon; CP = centipoise; lb/100 sf = pounds per 100 square feet

Results of Hydraulic Fracture and Drilling Fluid Surface Release Evaluation

The results of the hydraulic fracture evaluation are presented in Figures I-2 and I-3. Figure I-2 shows the calculated formation limit pressure (green line) and the estimated drilling fluid pressure shown as the red line, which represents the drilling fluid pressure along the HDD profile based on the anticipated drilling fluid properties shown in Table I-3.

When evaluating the risk of hydraulic fracture and drilling fluid surface releases, the analysis computes two types of factors of safety. These are:

- Factor of Safety against localized hydraulic fracture; and
- Factor of Safety against drilling fluid surface release.

Local Hydraulic Fracture: The factor of safety against hydraulic fracture is the ratio of the formation limit pressure to the estimated drilling fluid pressure along the profile, shown as the green line in Figure I-3. This represents the factor of safety against hydraulic fracture of the soil immediately surrounding the HDD profile and is a localized condition.

Drilling Fluid Surface Release: The factors of safety against drilling fluid surface release considers the strength of the soil column above the HDD profile that resists drilling fluid migrating to the ground surface. It is computed by comparing the formation limit pressure of the soil units above a specific location along the planned HDD alignment to the anticipated drilling fluid pressure at the same location. The factors of safety against drilling fluid surface releases are shown in Figure I-3 at selected points shown as red triangles.

As shown in Figure I-3, the safety factor against hydraulic fracture generally remains above 2.0 from the entry point to about station 617+00 where it drops to below 1.0 and remains below 1.0 to the exit. The model indicates that the safety factor against drilling fluid surface releases is greater than 2.0 from the entry point to about station 622+00, then drops to between 1.0 and 1.5 between stations 613+00 and 605+00. Beyond station 615+00 and to the exit point, the factor of safety against drilling fluid surface release is less than 1.0.

INSTALLATION LOADS AND OPERATING STRESSES

Installation Loads

The analyses of installation loads and operational stresses are based on the product pipe being installed along the designed drill path using the BMPs of the HDD industry. The addition of water into the product pipe is the standard method that contractors typically use to control buoyancy of the product pipe during the installation procedure. The proposed 24-inch-diameter product pipe will be positively buoyant in the anticipated drilling fluid weights. The HDD Contractor may choose to add water to the product pipe to try and achieve neutral buoyancy during pullback and reduce the required pull force during installation of the product pipe. Thus, our analyses include a range of cases with differing levels of buoyancy control. The following table presents a summary of the calculated installation loads for the HDD.

TABLE I-4. INSTALLATION LOADS FOR THE 24-INCH-DIAMETER HDD-7[1]

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Effective Pipe Weight[2] (lb/ft)	Pullback Force[3] (lb)
9.5	Empty	-97	287,000
9.5	Full	83	241,000
12	Empty	-156	356,000
12	Full	24	188,000
10.5	Neutral	0	173,000

Notes:
[1] See the HDD Design Summary and Calculations summaries provided in this appendix for detailed calculations.
[2] Negative values indicate upward force (positive buoyancy).
[3] Assumes a fully open drilled hole.
[4] Assumes a minimum pipeline radius of 2,400 feet.

Because the HDD contractor might utilize a relatively large drill rig to complete the installation, the drill rig may have a pullback capacity capable of causing damage to the product pipe during installation. While the estimated installation forces provided in Table I-4 suggest that the pullback forces should be less than 356,000 pounds, improper preparation of the hole prior to pullback operations or delays during pullback operations may cause pullback forces to exceed those estimated in the calculations.

Operating Stresses

For our operating stresses analysis, the installation and operating temperatures were assumed to be 55 degrees Fahrenheit. We can further evaluate different installation and operating temperatures, if requested. The following table presents a summary of the operating stresses for the product pipe specifications proposed for the HDD.

TABLE I-5. SUMMARY OF OPERATING STRESSES FOR THE 24-INCH-DIAMETER HDD-7

Stress Component	Stress (psi)	Percent SMYS[1] (%)	Maximum Allowable Percent SMYS (%)
Longitudinal Bending Stress	12,324	24	-
Hoop Stress	18,792	36	50[2]
Longitudinal Tensile Stress from Hoop Stress	5,638	11	-
Longitudinal Stress from Thermal Expansion	0	0	90[3]
Maximum Net Longitudinal Stress	17,962	35	90[4]
Maximum Shear Stress	12,739	25	45[5]
Maximum Combined Effective Stress	25,479	49	90[6]

Notes:
[1] Specified Minimum Yield Stress.
[2] Limited by design factor from DOT regulations, Title 49 CFR Part 192.111 for gas.
[3] Limited by Section 402.3.2 of ASME B31.4.
[4] Limited by Section 833.3 of ASME B31.8 for gas.
[5] Limited by Section 402.3.1 of ASME B31.4.
[6] Limited by Section 833.4 of ASME B31.8 for gas.

CONCLUSIONS AND RECOMMENDATIONS

The very soft to soft soils encountered in the borings may present steering difficulties during construction. The contractor should be prepared to encounter steering difficulties along the proposed HDD profile, and choose their means and methods appropriately. In addition, the soft soils likely will not provide adequate drill rod support to advance the pilot hole along the relatively long HDD.

We recommend that the contractor consider installing casing along the entry tangent (or entry and exit tangent if the pilot hole intersect method is utilized) to provide a reaction mass for allowing a greater transfer of axial loads through the drill pipe string to the drill bit during pilot hole drilling. The casing maintains hole uniformity and prevents the drill pipe string from being pushed into the soil formation while trying to advance the drill bit. Upon completion of the pilot hole, or prior to reaming the cased section of the hole, the casing is typically removed.

Drilling Fluid Surface Release

Based on our analyses, there is a very high risk of drilling fluid surface release from approximately station 615+00 to the exit. We recommend that NW Natural consider potential design changes and other mitigation measures that can be planned to reduce the risk of drilling fluid releases. Design changes could include reconfiguring the HDD sections to be shorter and deeper through the HDD-7 area in order to decrease drilling fluid pressures while increasing formation limit pressures. Alternatively, the crossing could be completed using pilot hole intersect methods. By jetting the pilot hole from both sides of the HDD, the pumping pressures required to move drilling fluid back to the drill rig would be reduced, which would in turn reduce the risk of drilling fluid surface releases along the proposed HDD alignment.

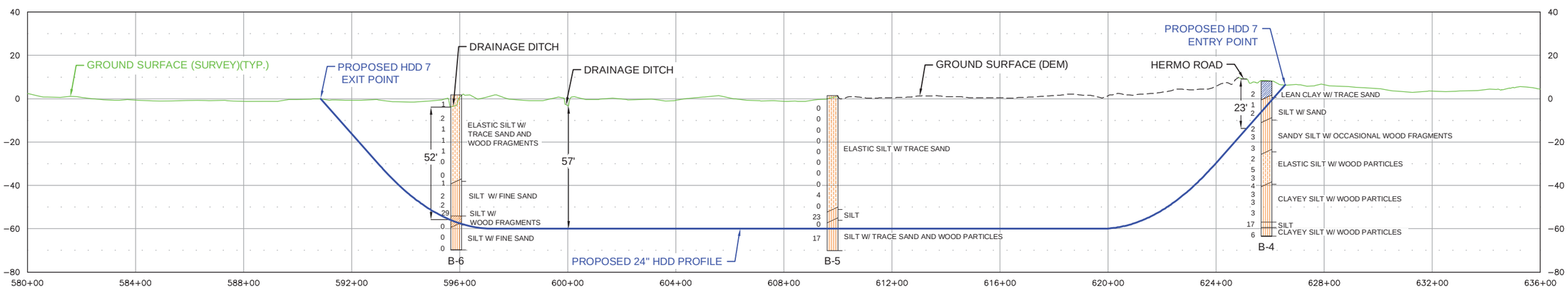
In either case, it will be extremely important for the contractor to maintain drilling fluid returns at all times, and monitor the ground surface for drilling fluid surface releases during construction.

We recommend that the contractor establish a contingency and mitigation plan in the event that drilling fluid surface releases occur; these plans should be reviewed and approved by the project team prior to the start of construction.

NOT FOR CONSTRUCTION:
THE HDD DESIGN DRAWING IS INCLUDED AS HDD 7 IN APPENDIX I.

PLAN
400' 0 400'
SCALE IN FEET

Major Contour Interval = 10'
Minor Contour Interval = 2'



PROFILE
400' 0 400'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Refer to the borings logs in the accompanying report for more detailed soil descriptions.
4. GeoEngineers, Inc. has not verified the field location of the existing utilities.

Reference: Ground surface DEM (1/9 arc second) and aerial photos downloaded from http://nationalmap.gov. Base files provided by NorthWest Natural. Ground surface and bathymetric survey data provided by Westlake Consultants, Inc., obtained August 2015.

LEGEND:

SPT (N) — TYPE OF SOIL

Boring Location

SITE PLAN AND PROFILE
HDD 7

NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

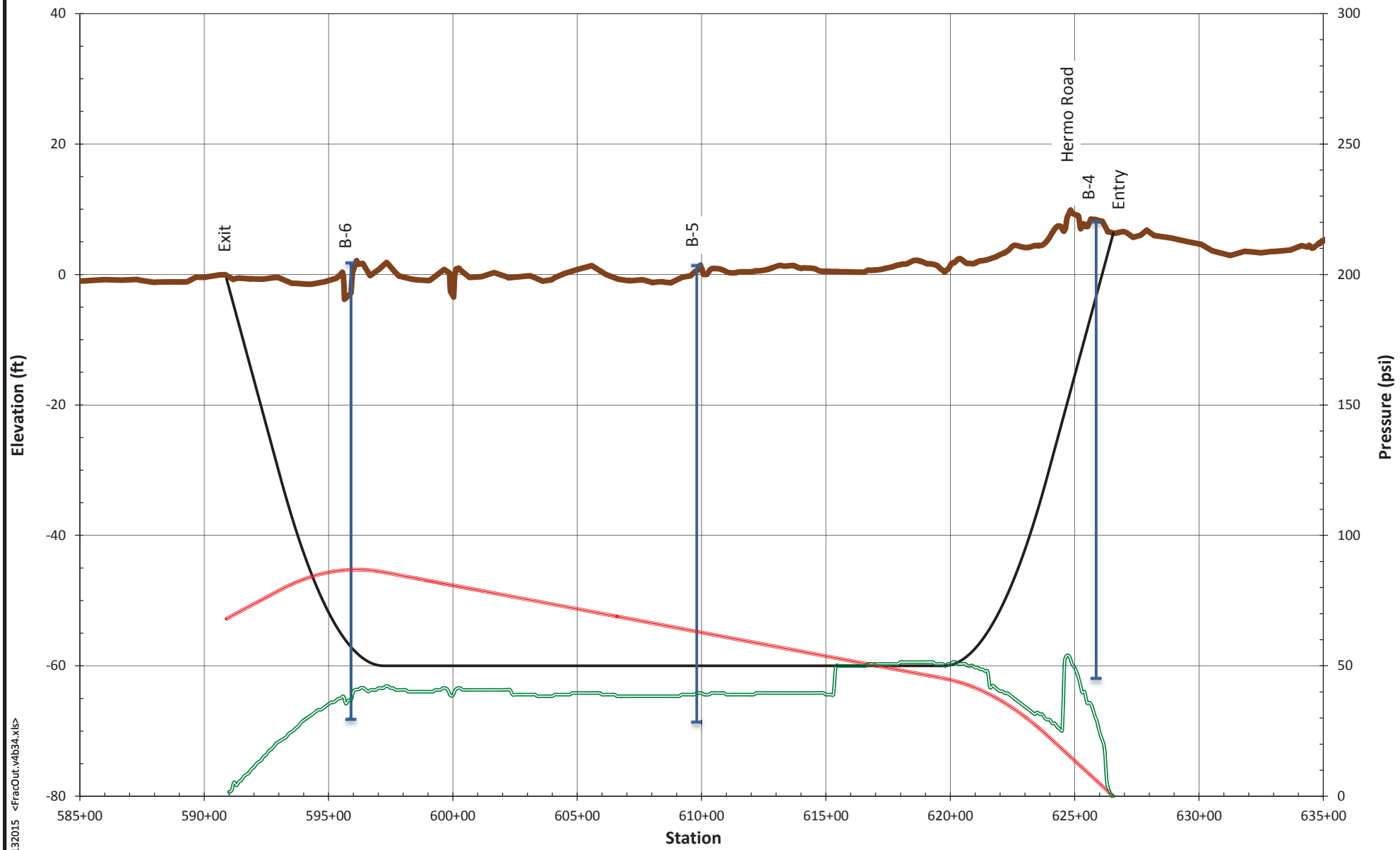
GEOENGINEERS

FIGURE I-1

BCR : BTL

P:\6\0241570\04\CAD\Figure I-1.dwg\TAB:Figure I-1 modified on Sep 14, 2015 - 4:05pm

NW NATURAL - NORTH MIST PIPELINE HDD 7



Crossing Length (ft)	3570
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	10
Yield Point (lb/100 ft)	20

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Estimated Annular Drilliing Fluid Pressure (psi) for Pilot Hole
- Formation Limit Pressure (psi)

ESTIMATED ANNULAR DRILLING FLUID AND FORMATION LIMIT PRESSURES

NW NATURAL - NORTH MIST PIPELINE HDD 7

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FIGURE I-2

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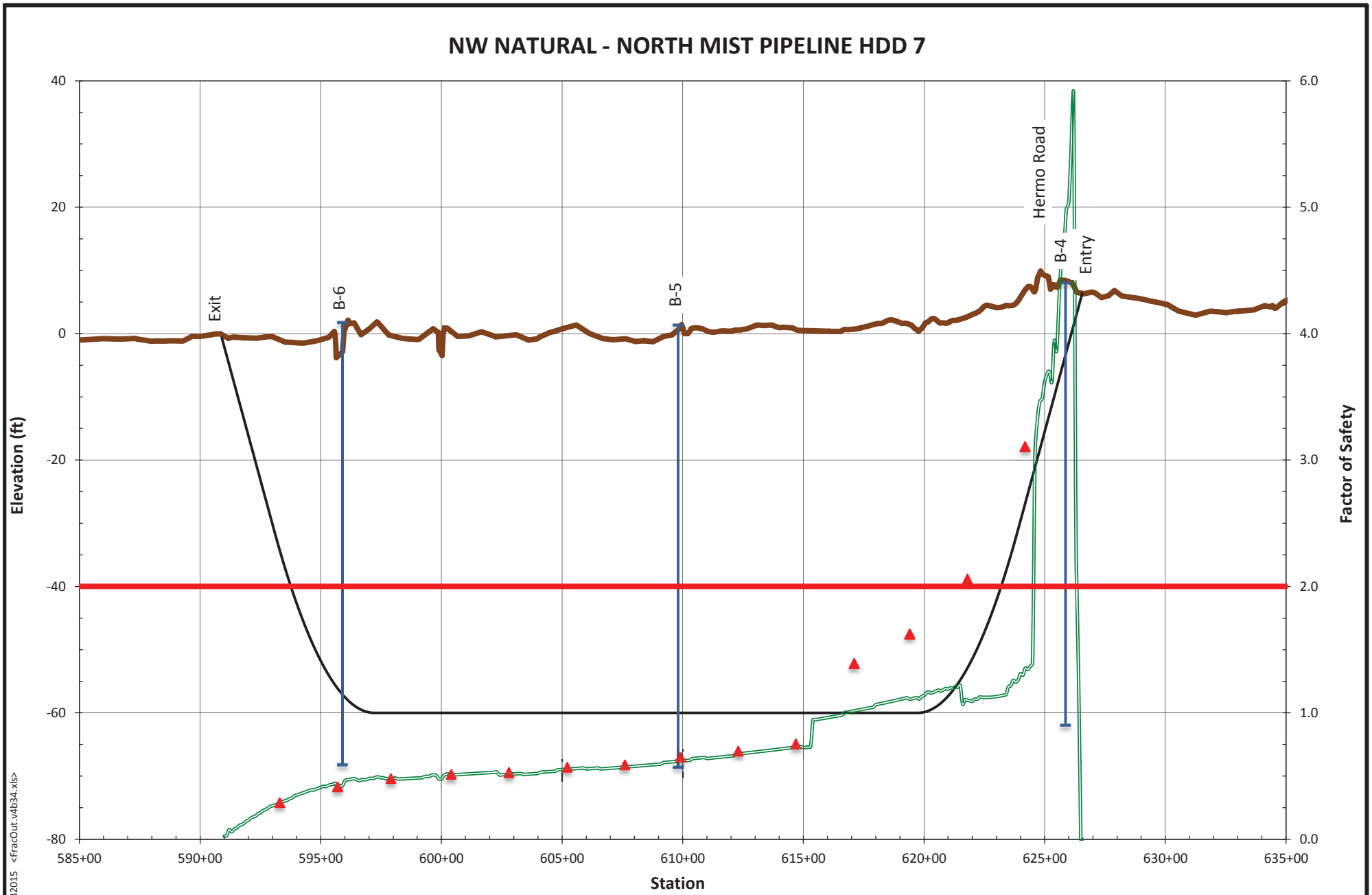

Crossing Length (ft)	3570
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	10
Yield Point (lb/100 ft)	20

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Drilling Fluid Surface Release Factor of Safety for Pilot Hole
- Hydraulic Fracture Factor of Safety for Pilot Hole
- Factor of Safety = 2

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE FACTORS OF SAFETY

NW NATURAL - NORTH MIST PIPELINE HDD 7

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FIGURE I-3

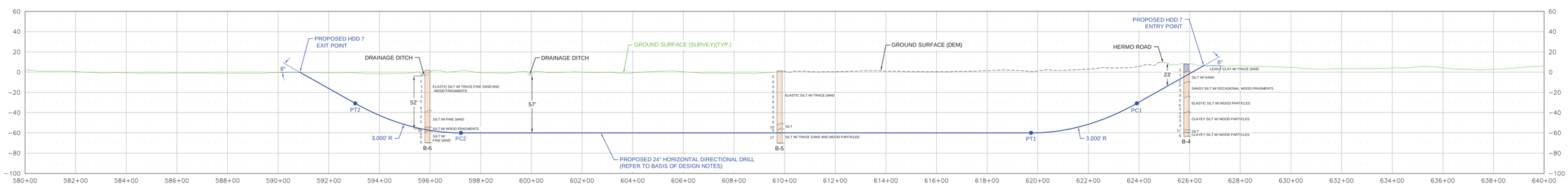
06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>

DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

200' 0 200'
SCALE IN FEET

MAJOR CONTOUR INTERVAL = 10'
MINOR CONTOUR INTERVAL = 2'



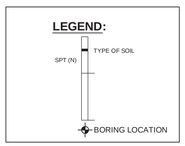
PROFILE

200' 0 200'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

DIRECTIONAL DRILL DATA HDD 7		
DESCRIPTION	STATION (FT)	ELEVATION (FT)
ENTRY @ 8°	626+55.73	6.36
P C 1 (8.00° @ 3,000 FT R.)	623+91.29	-30.80
P T 1	619+73.77	-60.00
P C 2 (8.00° @ 3,000 FT R.)	597+21.94	-60.00
P T 2	593+04.42	-30.80
EXIT @ 8°	590+85.73	-0.07
HORIZONTAL DISTANCE = 3,570.00 FT		
DIRECTIONAL DRILL PIPE LENGTH = 3,577.47 FT		

RECOMMENDED TOLERANCES	
ITEM	TOLERANCE
PILOT HOLE ENTRY ANGLE	INCREASE ANGLE UP TO 1° (STEEPER), BUT NO DECREASE IN ANGLE ALLOWED.
PILOT HOLE ENTRY LOCATION	AS PER COORDINATES PROVIDED BY COMPANY WITH NO CHANGES WITHOUT COMPANY APPROVAL.
PILOT HOLE EXIT ANGLE	INCREASE ANGLE UP TO 1° (STEEPER) OR DECREASE UP TO 2° (FLATTER).
PILOT HOLE EXIT LOCATION	UP TO 20 FEET BEYOND OR 10 FEET SHORT OF THE EXIT STAKE. BETWEEN 5 FEET LEFT AND 5 FEET RIGHT OF CENTERLINE.
PILOT HOLE DEPTH	UP TO 2 FEET ABOVE THE DESIGN DRILL PROFILE ALLOWED. UP TO 10 FEET BELOW THE DESIGN DRILL PROFILE ALLOWED.
PILOT HOLE ALIGNMENT	SHALL REMAIN WITHIN 5 FEET LEFT OR RIGHT OF THE HDD ALIGNMENT.

LEGEND:



FINAL

NOTES

1. ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT-OF-WAY OR FROM APPROVED ACCESS ROADS.
2. WORK SPACE: MAXIMUM WORK SPACE LIMITS ARE DEPICTED. RESTRICT CLEARING TO THE WORK SPACE INDICATED AT THE ENTRY AND EXIT POINTS AND PRODUCT PIPE STRINGING AND FABRICATION AREA ALONG THE CONSTRUCTION RIGHT-OF-WAY. CLEARING BETWEEN THE ENTRY AND EXIT POINTS REQUIRES PRIOR APPROVAL FROM THE ENVIRONMENTAL INSPECTOR AND IS LIMITED TO THE AMOUNT NECESSARY TO STRING SURVEY WIRES AND INSTALL PUMPS AND PIPING TO OBTAIN WATER (WHERE APPROVED).
3. WATER SOURCE: DRILL WATER AND HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE.
4. HYDROSTATIC TEST: PRE-INSTALLATION AND POST-INSTALLATION HYDROSTATIC TESTS SHALL BE CONDUCTED IN ACCORDANCE WITH THE HYDROSTATIC TEST PLAN. TEST WATER SHALL BE SAMPLED AND TESTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE TEST WATER SHALL BE DISCHARGED IN AN UPLAND AREA INTO AN EROSION CONTROL STRUCTURE OF STRAW BALES AND/OR SILT FENCES, GEOTEXTILE FILTER BAG, OR COLLECTED IN A TRUCK AND HAULED TO AN APPROVED DISPOSAL SITE. UPON COMPLETION OF DEWATERING AND DRYING, A CALIPER PIG SURVEY SHALL BE COMPLETED IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
5. SPILL-PREVENTION: REFUELING OF ALL EQUIPMENT SHALL BE COMPLETED IN ACCORDANCE WITH THE SPCC PLAN.
6. EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE APPROVED CONSTRUCTION RIGHT-OF-WAY AT THE DRILL EXIT POINT AS SHOWN. AFTER THE PILOT HOLE IS COMPLETE, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO NORTHWEST NATURAL FOR APPROVAL. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULL BACK.
8. DRILLING FLUID DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING FLUID AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING FLUID WHICH INADVERTENTLY SURFACES AT POINTS OTHER THAN THE ENTRY OR EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.
9. CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN THE CLEAN-UP AND RESTORATION REQUIREMENTS.
10. GEOTECHNICAL DATA: BORE HOLES ARE OFFSET FROM THE PIPELINE CENTERLINE AS SHOWN ON THE PLAN VIEW. THE GEOTECHNICAL INFORMATION PROVIDED ON THIS DRAWING IS A GENERAL SUMMARY. REFER TO THE APPLICABLE GEOTECHNICAL REPORT IN THE CONTRACT DOCUMENTS FOR MORE DETAILED INFORMATION.
11. IF THE TERRAIN ALLOWS AND ACCESS IS PERMITTED, CONTRACTOR SHALL UTILIZE LOW GROUND PRESSURE EQUIPMENT OR OTHER EQUIPMENT APPROVED BY OWNER, TO FACILITATE CONTAINMENT AND CLEAN-UP OF ANY INADVERTENT RETURNS THAT OCCUR DURING THE HDD INSTALLATION PROCESS.
12. THE MINIMUM ALLOWABLE THREE JOINT RADIUS SHALL NOT BE LESS THAN 2,400 FEET.
13. AERIAL PHOTOS AND GROUND SURFACE DEM (1/9 ARC SECOND) DOWNLOADED FROM HTTP://VIEWER.NATIONALMAP.GOV/VIEWER/. BASE FILES PROVIDED BY NORTHWEST NATURAL. GROUND SURFACE AND BATHYMETRIC SURVEY DATA PROVIDED BY WESTLAKE CONSULTANTS, INC., OBTAINED AUGUST 2015.
14. CONTRACTOR IS RESPONSIBLE FOR CALLING OREGON ONE-CALL AND PHYSICALLY LOCATING ALL UNDERGROUND UTILITIES PRIOR TO BEGINNING CONSTRUCTION. IF ANY UTILITY IS LOCATED WITHIN 15 FEET OF THE DESIGNED HDD PROFILE AND ALIGNMENT, CONTRACTOR SHALL OBTAIN APPROVAL FROM NORTHWEST NATURAL PRIOR TO INITIATING HDD OPERATIONS.
15. A SITE SPECIFIC SURVEY DOCUMENTING EXISTING UTILITIES HAS NOT BEEN CONDUCTED ALONG THE PROPOSED PIPELINE ALIGNMENT. A SITE SPECIFIC TOPOGRAPHIC AND UTILITY SURVEY SHOULD BE COMPLETED PRIOR TO FINAL ISSUANCE OF THESE PLANS. DURING CONSTRUCTION, IT IS THE CONTRACTORS RESPONSIBILITY TO IDENTIFY AND PROTECT ANY UTILITY THAT MAY BE AFFECTED BY THE HDD OPERATIONS.
16. CONTRACTOR SHALL ADHERE TO THE SPECIFICATIONS AND REQUIREMENTS PER NORTHWEST NATURAL SPECIFICATIONS, CONTRACT DOCUMENTS, AND SPECIAL PERMIT CONDITIONS, EXCEPT AS NOTED ON THIS DRAWING.

BASIS OF DESIGN:

1. PRODUCT PIPE WILL CONSIST OF 24" O.D. X 0.500" W.T., API-5L X-52 PIPE WITH 14-16 MILS OF FUSION BONDED EPOXY (FBE) AND A MINIMUM OF 40 MILS OF ABRASION RESISTANT OVERLAY (ARO).
2. MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) = 809 psi

NOTE: THIS IS A FULL SIZE DRAWING THAT IS INTENDED TO BE PRINTED ON A 24" X 36" SHEET OF PAPER.

REFERENCE DRAWINGS	
DRAWING NO.	TITLE

REVISIONS						
NO.	DATE	BY	DESCRIPTION	W.O.NO.	CHK.	APP.
A	07/02/14	MWC	ISSUED AS DRAFT		BCR	TNH
B	04/20/15	TJB	ISSUED AS DRAFT (24-INCH REDESIGN)		BCR	TNH
C	09/15/15	BTL	ISSUED FOR FINAL		BCR	TNH

GEOENGINEERS
1200 NW NAITO PARKWAY, SUITE 180
PORTLAND, OREGON 97209
TELEPHONE: (503) 624-9274
FAX: (503) 620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
STATION 580+00 TO 640+00
HDD 7
COLUMBIA COUNTY, OREGON

NW Natural

DRAWN BY: MWC	DATE: 06/05/14	ISSUED FOR BID:	SCALE: AS NOTED
CHECKED BY: BCR	DATE: 06/05/14	ISSUED FOR CONSTRUCTION:	
APPROVED BY:	DATE:	DRAWING NUMBER: HDD 7	SHEET 1
WO:		TIME: 08:58 AM DATE: 09/10/15 PATH: P:\B0024157\04\CAD\HDD 7_FINAL Rev\C.dwg	OF 1

HDD Design Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 7 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe Diameter = 24.000 in
Pipe Material = Steel
Yield Stress = 52,000 psi
Wall Thickness = 0.5 in
Assumed Installation Temp = 55 °F
Assumed Operating Temp= 55 °F
Design Factor = 0.5
MAOP = 809 psi

Drill Data Box

Point	Station (ft)	Elevation (ft)
ENTRY @ 8°	62,655.73	6.36
P C 1 (8.00° @ 3,000 ft R.)	62,391.29	-30.80
P T 1	61,973.77	-60.00
P C 2 (8.00° @ 3,000 ft R.)	59,721.94	-60.00
P T 2	59,304.42	-30.80
EXIT @ 8°	59,085.73	-0.07

Horizontal Alignment Length = 3,570.00 ft

Profile Segment Information

Segment Name	Segment Type	Segment Length (ft)
ENTRY TANGENT	Straight	267.04
ENTRY CURVE	Vertical Curve	418.88
BOTTOM TANGENT	Straight	2,251.83
EXIT CURVE	Vertical Curve	418.88
EXIT TANGENT	Straight	220.84

Pipe Length = 3,577.47 ft

Installation Load Summary

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Buoyancy Control (lb/ft)	Effective Pipe Weight (lb/ft)	Total Installation Force (lb)
9.50	Empty	0.00	-97.46	287,000
9.50	Full	180.04	82.58	241,000
12.00	Empty	0.00	-156.21	356,000
12.00	Full	180.04	23.83	188,000
10.50	Neutral	120.96	0.00	173,000

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Minimum Radius Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 7 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters:

Pipe Diameter = 24.000 in **MAOP =** 809 psi **Factor of Safety =** 2.00

Wall Thickness = 0.500 in **SMYS =** 52,000 psi

D/t Ratio = 48.00 **Modulus of Elasticity (E) =** 2.96E+007 psi

Hoop Stress:

Calculated Hoop Stress = (MAOP * Pipe Diameter) / (2 * Wall Thickness) = 19,416 psi

Longitudinal Stress:

Calculated Longitudinal Stress = Hoop Stress / 2 = 9,708 psi

Allowable Stress:

Calculated Allowable Stress = SMYS / Factor of Safety = 26,000 psi

Bending Stress:

Calculated Bending Stress = Allowable Stress - Longitudinal Stress = 16,292 psi

Minimum Radius:

Calculated Minimum Radius = (E * Pipe Diameter) / (2 * Bending Stress) = 1,817 ft

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 7 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe diameter =	24.000 in	**Minimum Radius of Curvature =**	2,400 ft
Wall Thickness =	0.500 in	**Coefficient of Thermal Expansion =**	6.5E-06 in/in/°F
SMYS =	52,000 psi	**Assumed Installation Temperature =**	55 °F
MAOP =	809 psi	**Assumed Operating Temperature =**	55 °F
Poissons's Ratio =	0.30	**Temperature Derating Factor =**	1.00
Young's Modulus (E) =	2.96E+007 psi	**Groundwater Table Head =**	60.00 ft
Design Factor =	0.5		

Stress Analyses

Longitudinal Stress from Bending =	12,324 psi	
Percent SMYS =	23.70 %	
Hoop Stress =	18,792 psi	
Percent SMYS =	36.14 %	Limited by Design Factor (0.5) according to 49 CFR 192.111
Longitudinal Tensile Stress from Hoop Stress =	5,638 psi	
Percent SMYS =	10.84 %	
Longitudinal Stress from Thermal Expansion =	0 psi	
Percent SMYS =	0.00 %	Limited to 90% SMYS by ASME/ANSI B31.4 section 402.3.2
Net Longitudinal Stress (Comp. side of Curve) =	-6,687 psi	
Percent SMYS =	12.86 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Net Longitudinal Stress (Tension side of Curve) =	17,962 psi	
Percent SMYS =	34.54 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Maximum Shear Stress =	12,739 psi	
Percent SMYS =	24.50 %	Limited to 45% SMYS by ASME/ANSI B31.4 section 402.3.1
Combined BiaxialSress Check =	25,479 psi	
Percent SMYS =	49.00 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.4

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 7 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 7 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,577 ft
Moment of Inertia =	2,549 in^4
Pipe Face Area =	36.91 in^2
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft^3
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft^3
Pipe Exterior Volume =	3.14 ft^3/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft^3/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft^3
Effective Weight of Pipe =	-97.46 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty — Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	220.84 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	9,991 lb
Friction Force =	6,394 lb
Segment Weight =	2,995 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	19,380 lb
Cumulative Force =	**19,380 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	525 psi	
Cumulative Axial Stress =	525 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	440 psi	7,537 psi
Combined Stress =	0.0126	< 1.0
Total Stress =	0.0037	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	30,731 lb
Drag Force =	18,950 lb
Friction Force =	9,219 lb
Segment Weight =	2,848 lb
Tension =	59,615 lb
Average Tension =	39,498 lb
Segment Force =	40,236 lb
Cumulative Force =	**59,615 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,090 psi	
Cumulative Axial Stress =	1,615 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	786 psi	7,537 psi
Combined Stress =	0.3809	< 1.0
Total Stress =	0.1374	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	2,251.83 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	101,870 lb
Friction Force =	65,836 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	167,706 lb
Cumulative Force =	**227,322 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	4,543 psi	
Cumulative Axial Stress =	6,158 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	786 psi	7,537 psi
Combined Stress =	0.1480	< 1.0
Total Stress =	0.0388	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	45,776 lb
Drag Force =	18,950 lb
Friction Force =	13,733 lb
Segment Weight =	-2,848 lb
Tension =	270,889 lb
Average Tension =	249,106 lb
Segment Force =	43,567 lb
Cumulative Force =	**270,889 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,180 psi	
Cumulative Axial Stress =	7,338 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	786 psi	7,537 psi
Combined Stress =	0.5185	< 1.0
Total Stress =	0.2546	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	267.04 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	12,080 lb
Friction Force =	7,731 lb
Segment Weight =	-3,622 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	16,190 lb
Cumulative Force =	**287,079 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	439 psi	
Cumulative Axial Stress =	7,777 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	440 psi	7,537 psi
Combined Stress =	0.1869	< 1.0
Total Stress =	0.0428	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 7 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,577 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	82.58 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	220.84 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	9,991 lb
Friction Force =	5,418 lb
Segment Weight =	-2,538 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	12,871 lb
Cumulative Force =	**12,871 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	349 psi	
Cumulative Axial Stress =	349 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	121 psi	7,537 psi
Combined Stress =	0.0084	< 1.0
Total Stress =	0.0004	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	-16,623 lb
Drag Force =	18,950 lb
Friction Force =	4,987 lb
Segment Weight =	-2,413 lb
Tension =	39,381 lb
Average Tension =	26,126 lb
Segment Force =	26,510 lb
Cumulative Force =	**39,381 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	718 psi	
Cumulative Axial Stress =	1,067 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	163 psi	7,537 psi
Combined Stress =	0.3678	< 1.0
Total Stress =	0.1071	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	2,251.83 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	101,870 lb
Friction Force =	55,789 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	157,660 lb
Cumulative Force =	**197,040 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	4,271 psi	
Cumulative Axial Stress =	5,338 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	163 psi	7,537 psi
Combined Stress =	0.1283	< 1.0
Total Stress =	0.0181	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters

Segment Name =	ENTRY CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	-1,014 lb
Drag Force =	18,950 lb
Friction Force =	304 lb
Segment Weight =	2,413 lb
Tension =	219,012 lb
Average Tension =	208,026 lb
Segment Force =	21,971 lb
Cumulative Force =	**219,012 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	595 psi	
Cumulative Axial Stress =	5,933 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	163 psi	7,537 psi
Combined Stress =	0.4847	< 1.0
Total Stress =	0.1972	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters

Segment Name =	ENTRY TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	267.04 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	12,080 lb
Friction Force =	6,552 lb
Segment Weight =	3,069 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	21,701 lb
Cumulative Force =	**240,713 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	588 psi	
Cumulative Axial Stress =	6,521 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	121 psi	7,537 psi
Combined Stress =	0.1568	< 1.0
Total Stress =	0.0259	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 7 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,577 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	-156.21 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	220.84 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	9,991 lb
Friction Force =	10,248 lb
Segment Weight =	4,801 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	25,040 lb
Cumulative Force =	**25,040 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	678 psi	
Cumulative Axial Stress =	678 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	556 psi	7,537 psi
Combined Stress =	0.0163	< 1.0
Total Stress =	0.0060	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	46,505 lb
Drag Force =	18,950 lb
Friction Force =	13,951 lb
Segment Weight =	4,564 lb
Tension =	76,457 lb
Average Tension =	50,749 lb
Segment Force =	51,417 lb
Cumulative Force =	**76,457 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,393 psi	
Cumulative Axial Stress =	2,071 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	993 psi	7,537 psi
Combined Stress =	0.3919	< 1.0
Total Stress =	0.1556	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	2,251.83 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	101,870 lb
Friction Force =	105,526 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	207,396 lb
Cumulative Force =	**283,853 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	5,618 psi	
Cumulative Axial Stress =	7,690 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	993 psi	7,537 psi
Combined Stress =	0.1848	< 1.0
Total Stress =	0.0609	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	64,326 lb
Drag Force =	18,950 lb
Friction Force =	19,298 lb
Segment Weight =	-4,564 lb
Tension =	336,834 lb
Average Tension =	310,344 lb
Segment Force =	52,981 lb
Cumulative Force =	**336,834 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,435 psi	
Cumulative Axial Stress =	9,125 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	993 psi	7,537 psi
Combined Stress =	0.5615	< 1.0
Total Stress =	0.3111	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	267.04 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	12,080 lb
Friction Force =	12,392 lb
Segment Weight =	-5,805 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	18,667 lb
Cumulative Force =	**355,502 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	506 psi	
Cumulative Axial Stress =	9,631 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	556 psi	7,537 psi
Combined Stress =	0.2315	< 1.0
Total Stress =	0.0659	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 7 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,577 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	23.83 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 1 of 5**

Segment Parameters			
Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	220.84 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	9,991 lb
Friction Force =	1,564 lb
Segment Weight =	-732 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	10,822 lb
Cumulative Force =	**10,822 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	293 psi	
Cumulative Axial Stress =	293 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	236 psi	7,537 psi
Combined Stress =	0.0070	< 1.0
Total Stress =	0.0011	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	-1,950 lb
Drag Force =	18,950 lb
Friction Force =	585 lb
Segment Weight =	-696 lb
Tension =	30,245 lb
Average Tension =	20,533 lb
Segment Force =	19,423 lb
Cumulative Force =	**30,245 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	526 psi	
Cumulative Axial Stress =	819 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	370 psi	7,537 psi
Combined Stress =	0.3618	< 1.0
Total Stress =	0.1087	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	2,251.83 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	101,870 lb
Friction Force =	16,100 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	117,970 lb
Cumulative Force =	**148,215 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	3,196 psi	
Cumulative Axial Stress =	4,015 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	370 psi	7,537 psi
Combined Stress =	0.0965	< 1.0
Total Stress =	0.0136	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	9,506 lb
Drag Force =	18,950 lb
Friction Force =	2,852 lb
Segment Weight =	696 lb
Tension =	173,564 lb
Average Tension =	160,890 lb
Segment Force =	25,349 lb
Cumulative Force =	**173,564 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	687 psi	
Cumulative Axial Stress =	4,702 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	370 psi	7,537 psi
Combined Stress =	0.4551	< 1.0
Total Stress =	0.1784	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	267.04 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	12,080 lb
Friction Force =	1,891 lb
Segment Weight =	886 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	14,857 lb
Cumulative Force =	**188,421 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	402 psi	
Cumulative Axial Stress =	5,104 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	236 psi	7,537 psi
Combined Stress =	0.1227	< 1.0
Total Stress =	0.0176	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 7 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	3,577 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	246.76 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	0.00 lb/ft

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 1 of 5**

Segment Parameters			
Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	220.84 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	9,991 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	9,991 lb
Cumulative Force =	**9,991 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	271 psi	
Cumulative Axial Stress =	271 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	487 psi	7,537 psi
Combined Stress =	0.0065	< 1.0
Total Stress =	0.0042	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	4,241 lb
Drag Force =	18,950 lb
Friction Force =	1,272 lb
Segment Weight =	0 lb
Tension =	31,485 lb
Average Tension =	20,738 lb
Segment Force =	21,494 lb
Cumulative Force =	**31,485 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	582 psi	
Cumulative Axial Stress =	853 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	869 psi	7,537 psi
Combined Stress =	0.3626	< 1.0
Total Stress =	0.1284	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	2,251.83 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	101,870 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	101,870 lb
Cumulative Force =	**133,355 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	2,760 psi	
Cumulative Axial Stress =	3,613 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	869 psi	7,537 psi
Combined Stress =	0.0868	< 1.0
Total Stress =	0.0244	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	14,301 lb
Drag Force =	18,950 lb
Friction Force =	4,290 lb
Segment Weight =	0 lb
Tension =	160,885 lb
Average Tension =	147,120 lb
Segment Force =	27,530 lb
Cumulative Force =	**160,885 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	746 psi	
Cumulative Axial Stress =	4,358 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	869 psi	7,537 psi
Combined Stress =	0.4469	< 1.0
Total Stress =	0.1930	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	267.04 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	12,080 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	12,080 lb
Cumulative Force =	**172,966 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	327 psi	
Cumulative Axial Stress =	4,686 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	487 psi	7,537 psi
Combined Stress =	0.1126	< 1.0
Total Stress =	0.0197	< 1.0

APPENDIX J
HDD-8

APPENDIX J
HDD-8

General

This appendix provides GeoEngineers' HDD design recommendations for proposed HDD-8 along the proposed North Mist Pipeline alignment located in Columbia County, Oregon. The general site plan and profile is provided in Figure J-1 of this appendix. A full size construction drawing showing the design profile is provided in the attached Drawing No. HDD-8. The design drawing includes the necessary geometric information required to complete the pilot hole.

Project Description and Basis of Design

The proposed HDD installation will be a 24-inch-diameter steel pipeline crossing an organic mint farm and a drainage canal. The proposed pipeline alignment is oriented southwest-northeast (entry to exit), as shown in Figure J-1. The HDD design was completed based on the parameters presented below in Table J-1.

TABLE J-1. BASIS OF DESIGN FOR THE 24-INCH-DIAMETER HDD-8

Carrier Pipe Data	Design Parameter
Carrier Pipe Specifications	24 inches x 0.500 inches w.t.[1] API-5L X-52 steel pipe
Horizontal Crossing Length	1,985 feet
Maximum Allowable Operating Pressure	809 psig[2]
Maximum Operating Temperature	55 degrees F
Assumed Tie-In Temperature	55 degrees F

Notes:
[1] w.t. – wall thickness
[2] psig – pounds per square inch gauge

SITE DESCRIPTION

Surface Conditions

Surface conditions along the proposed alignment generally consist of a relatively flat, organic mint farm within an alluvial valley that is cut by an approximately 5 to 8-foot-wide and 5-foot deep drainage ditch. The proposed entry point and entry workspace are situated just northeast of Hermo Road at an elevation of approximately 6.3 feet MSL. Northeast of the entry point, the alignment crosses an organic mint farm and then passes beneath a drainage ditch approximately 870 feet northeast of the entry point. After crossing the drainage ditch, the alignment continues across an organic mint farm and crosses a gravel road approximately 1,760 feet northeast of the entry point. After crossing this gravel road, the alignment crosses a field vegetated with grasses and a few deciduous trees, and then exits within a Portland General Electric facility at an elevation of approximately 11.3 feet MSL.

Subsurface Conditions

We completed two borings (B-1 and B-4) along the proposed HDD alignment at the locations shown in Figure J-1. We proposed to complete another boring within the organic mint farm roughly in the center of the HDD, but permission for this boring was not granted by the landowners. Subsurface conditions encountered in the borings consisted of interbedded very soft to soft elastic silt and silt on the southwest

side of the proposed alignment and interbedded loose to medium dense sand, soft lean clay and soft silt on the northeastern side of the alignment. Subsurface conditions encountered in each boring are described in more detail below.

Boring B-1 was drilled on a gravel road approximately 225 feet southwest of the proposed exit point. The boring encountered approximately 3 to 4 feet of soft organic silt overlying loose sand with varying amounts of silt that extended to approximately 14 feet bgs. Below 14 feet bgs, the boring encountered soft silt with sand to about 24 feet bgs overlying soft clay with varying amounts of sand and organic material to about 39 feet bgs. Below 39 feet bgs, the boring encountered an approximately 3-foot-thick layer of soft silt overlying medium dense sand with silt that extended to 71.5 feet bgs, the maximum depth explored.

Boring B-4 was drilled near the proposed entry point, approximately 75 feet northeast of Hermo Road. The boring generally encountered interbedded very soft to soft lean clay, silt and elastic silt with varying amounts of sand and organic material that extended to 71.5 feet, the maximum depth explored. An approximately 3-foot-thick layer of very stiff silt was encountered between about 65 and 68 feet bgs.

Subsurface conditions encountered in the borings are shown graphically in Figure J-1, and are described in detail in the boring logs in Appendix A.

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE EVALUATION

Model Input Parameters

The HDD geometry used for our analyses of HDD-7 is shown in Figure J-1, and in the HDD design drawing, Drawing No. HDD-8 in this appendix. Based on the results of the exploration program and subsequent laboratory-testing program, the soil properties used in the evaluation are presented in Table J-2 below.

TABLE J-2. ESTIMATED SOIL PROPERTIES

Soil Description	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Soft Lean Clay with Trace Sand	100	0	300
Very Soft to Soft Sandy Silt with Occasional Wood Fragments	105	12	250
Soft to Medium Stiff Elastic Silt with Wood Particles	100	10	200
Soft Clayey Silt with Wood Particles	105	0	200
Stiff to Very Stiff Silt	100	20	250
Very Loose to Loose Fine Sand with Silt	105	26	0
Soft Silt with Sand and Lean Clay with Sand and Occasional Organics	100	18	100
Medium Dense Fine Sand with Silt	120	32	0

Based on available information and common HDD construction procedures, the tool dimensions and rheological properties used in the evaluation are summarized in Table J-3. Because these parameters are

dependent upon the HDD contractor's means and methods, the hydraulic fracture and drilling fluid surface release evaluation should be refined during construction of the HDD installations.

TABLE J-3. ESTIMATED TOOL DIMENSIONS AND RHEOLOGICAL PROPERTIES

Parameter	Value
Pilot Hole Bit Diameter	12.25 inches
Drill Pipe Diameter	6.625 inches
Drilling Fluid Weight	9.5 ppg
Plastic Viscosity	10 CP
Yield Point	20 lb/100 sf

Notes:
ppg = pounds per gallon; CP = centipoise; lb/100 sf = pounds per 100 square feet

Results of Hydraulic Fracture and Drilling Fluid Surface Release Evaluation

The results of the hydraulic fracture evaluation are presented in Figures J-2 and J-3. Figure J-3 shows the calculated formation limit pressure (green line) and the estimated drilling fluid pressure shown as the red line, which represents the drilling fluid pressure along the HDD profile based on the anticipated drilling fluid properties shown in Table J-3.

When evaluating the risk of hydraulic fracture and drilling fluid surface releases, the analysis computes two types of factors of safety. These are:

- Factor of Safety against localized hydraulic fracture; and
- Factor of Safety against drilling fluid surface release.

Local Hydraulic Fracture: The factor of safety against hydraulic fracture is the ratio of the formation limit pressure to the estimated drilling fluid pressure along the profile, shown as the green line in Figure J-3. This represents the factor of safety against hydraulic fracture of the soil immediately surrounding the HDD profile and is a localized condition.

Drilling Fluid Surface Release: The factors of safety against drilling fluid surface release considers the strength of the soil column above the HDD profile that resists drilling fluid migrating to the ground surface. It is computed by comparing the formation limit pressure of the soil units above a specific location along the planned HDD alignment to the anticipated drilling fluid pressure at the same location. The factors of safety against drilling fluid surface releases are shown in Figure J-3 at selected points shown as red triangles.

The model indicates that the risk of localized hydraulic fracture is generally low from the entry point to station 628+00 and from station 635+00 to station 642+75, moderate to high between stations 628+00 and 635+00, and high to very high between station 643+00 and the exit point at station 646+45.

The model also indicates that the risk of drilling fluid surface release is relatively low between the entry point and approximately station 631+00 and between stations 635+00 and 642+75, moderate between station s 631+00 and 635+00, and high to very high between station 642+75 and the exit point at station 646+45.

INSTALLATION LOADS AND OPERATING STRESSES

Installation Loads

The analyses of installation loads and operational stresses are based on the product pipe being installed along the designed drill path using the BMPs of the HDD industry. The addition of water into the product pipe is the standard method that contractors typically use to control buoyancy of the product pipe during the installation procedure. The proposed 24-inch-diameter product pipe will be positively buoyant in the anticipated drilling fluid weights. The HDD Contractor may choose to add water to the product pipe to try and achieve neutral buoyancy during pullback and reduce the required pull force during installation of the product pipe. Thus, our analyses include a range of cases with differing levels of buoyancy control. The following table presents a summary of the calculated installation loads for the HDD.

TABLE J-4. INSTALLATION LOADS FOR THE 24-INCH-DIAMETER HDD-8[1]

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Effective Pipe Weight[2] (lb/ft)	Pullback Force[3] (lb)
9.5	Empty	-97	167,000
9.5	Full	83	133,000
12	Empty	-156	208,000
12	Full	24	100,000
10.5	Neutral	0	99,000

Notes:
[1] See the HDD Design Summary and Calculations summaries provided in this appendix for detailed calculations.
[2] Negative values indicate upward force (positive buoyancy).
[3] Assumes a fully open drilled hole.
[4] Assumes a minimum pipeline radius of 2,400 feet.

Because the HDD contractor might utilize a relatively large drill rig to complete the installation, the drill rig may have a pullback capacity capable of causing damage to the product pipe during installation. While the estimated installation forces provided in Table J-4 suggest that the pullback forces should be less than 208,000 pounds, improper preparation of the hole prior to pullback operations or delays during pullback operations may cause pullback forces to exceed those estimated in the calculations.

Operating Stresses

For our operating stresses analysis, the installation and operating temperatures were assumed to be 55 degrees Fahrenheit. We can further evaluate different installation and operating temperatures, if requested. The following table presents a summary of the operating stresses for the product pipe specifications proposed for the HDD.

TABLE J-5. SUMMARY OF OPERATING STRESSES FOR THE 24-INCH-DIAMETER HDD-8

Stress Component	Stress (psi)	Percent SMYS[1] (%)	Maximum Allowable Percent SMYS (%)
Longitudinal Bending Stress	12,324	24	-
Hoop Stress	18,844	36	50[2]
Longitudinal Tensile Stress from Hoop Stress	5,653	11	-
Longitudinal Stress from Thermal Expansion	0	0	90[3]
Maximum Net Longitudinal Stress	17,977	35	90[4]
Maximum Shear Stress	12,757	25	45[5]
Maximum Combined Effective Stress	25,515	49	90[6]

Notes:
[1] Specified Minimum Yield Stress.
[2] Limited by design factor from DOT regulations, Title 49 CFR Part 192.111 for gas.
[3] Limited by Section 402.3.2 of ASME B31.4.
[4] Limited by Section 833.3 of ASME B31.8 for gas.
[5] Limited by Section 402.3.1 of ASME B31.4.
[6] Limited by Section 833.4 of ASME B31.8 for gas.

CONCLUSIONS AND RECOMMENDATIONS

The proposed alignment crosses a U.S. Department of Agriculture certified organic mint farm. During drilling of exploratory boring B-5, which is located within this organic mint farm property, the organic mint farmer had very strict requirements and procedures for work to be conducted within the organic mint farm property. As such, the consequence of drilling fluid surface releases within this organic mint farm may be of relatively high concern. NW Natural should be prepared to negotiate a drilling fluid surface release and clean up procedure/agreement with the organic mint farmer prior to construction, and communicate that procedure/agreement to the HDD contractor. In addition, full time observation of the HDD contractor by NW Natural's environmental inspector should be conducted to verify that the contractor follows any and all negotiated procedures/agreements within the mint farm property.

The very soft to soft soils encountered in boring B-4 may present steering difficulties during construction. The contractor should be prepared to encounter steering difficulties along the proposed HDD profile, and choose their means and methods appropriately. In addition, the soft soils likely will not provide adequate drill rod support to advance the pilot hole along the relatively long HDD.

We recommend that the contractor install casing along the entry tangent (and exit tangent if the pilot hole intersect method is utilized) to provide a reaction mass for allowing a greater transfer of axial loads through the drill pipe string to the drill bit during pilot hole drilling. The casing maintains hole uniformity and prevents the drill pipe string from being pushed into the soil formation while trying to advance the drill bit. Upon completion of the pilot hole, or prior to reaming the cased section of the hole, the casing is typically removed.

Cuttings Removal

The proposed HDD profile will likely encounter elastic silt soils that may present difficulty with removing cuttings. The contractor should consider the soils observed in the borings completed along the alignment and utilize strategies to facilitate cuttings removal. Refer to Section 5.1.6 of this report for further discussion on cuttings removal within clay/elastic silt soils.

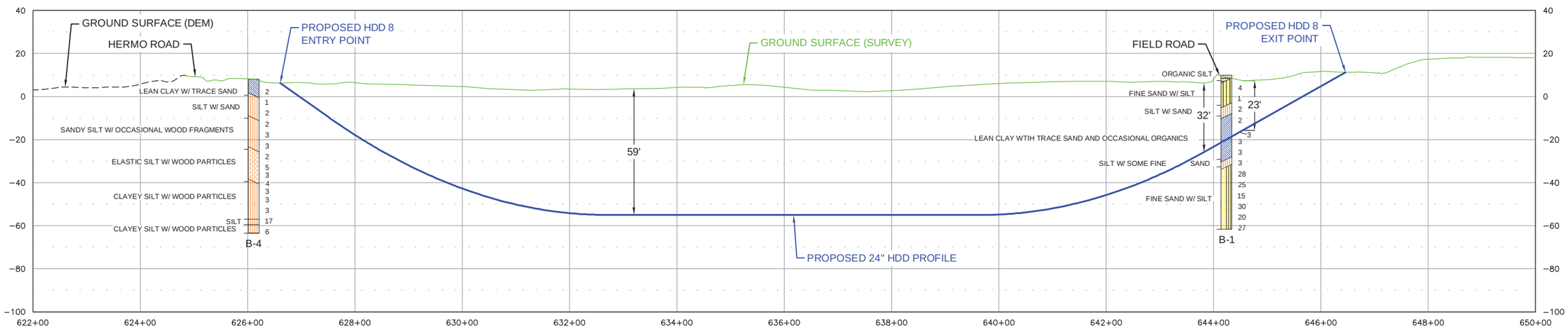
Drilling Fluid Surface Release

The risk of localized hydraulic fracture and drilling fluid surface release is relatively high to very high in the northeastern 350 feet of the proposed HDD profile between stations 643+00 and the exit point at station 646+46 because the pilot hole is expected to encounter relatively low strength silt and clay without a significant amount of overlying higher strength sand to limit upward migration of drilling fluid. This risk could be potentially be mitigated by completing the pilot hole using pilot hole intersect methods and maintaining drilling fluid returns at all times during construction.

NOT FOR CONSTRUCTION:
THE HDD DESIGN DRAWING IS INCLUDED AS HDD 8 IN APPENDIX J.

PLAN
200' 0 200'
SCALE IN FEET

Major Contour Interval = 10'
Minor Contour Interval = 2'



PROFILE
200' 0 200'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Refer to the borings logs in the accompanying report for more detailed soil descriptions.
4. GeoEngineers, Inc. has not verified the field location of the existing utilities.

Reference: Ground surface DEM (1/9 arc second) and aerial photos downloaded from http://nationalmap.gov. Base files provided by NorthWest Natural. Ground surface and bathymetric survey data provided by Westlake Consultants, Inc., obtained August 2015.

LEGEND:

TYPE OF SOIL — SPT (N)

Boring Location

SITE PLAN AND PROFILE
HDD 8

NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

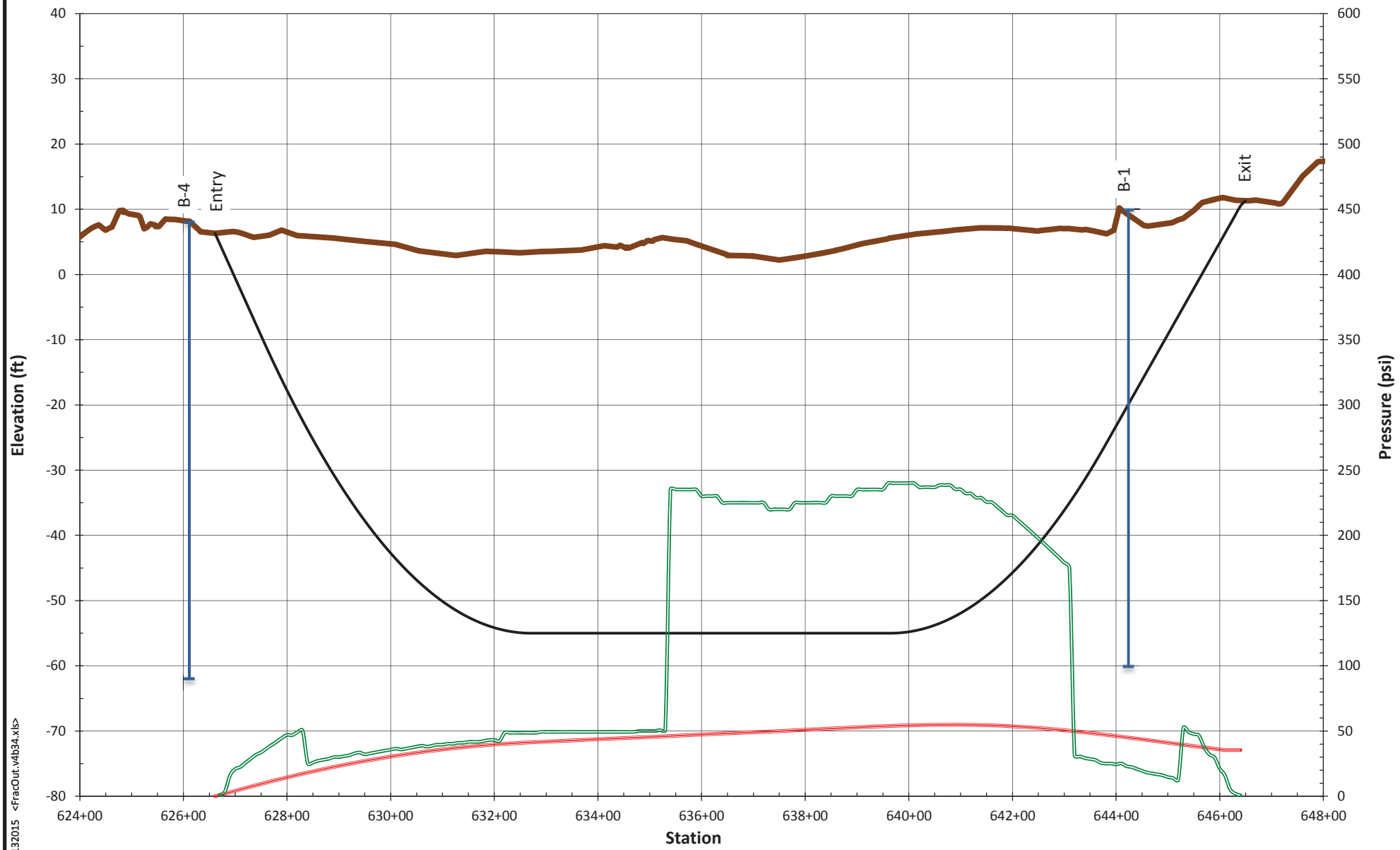
GEOENGINEERS

FIGURE J-1

BCR : BTL

P:\6\0241570\04\CAD\Figure J-1.dwg\TAB:Figure J-1 modified on Sep 14, 2015 - 4:01pm

NW NATURAL - NORTH MIST PIPELINE HDD 8



Crossing Length (ft)	1985
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	10
Yield Point (lb/100 ft)	20

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Estimated Annular Drilliing Fluid Pressure (psi) for Pilot Hole
- Formation Limit Pressure (psi)

ESTIMATED ANNULAR DRILLING FLUID AND FORMATION LIMIT PRESSURES

NW NATURAL - NORTH MIST PIPELINE HDD 8

GEOENGINEERS

FIGURE J-2

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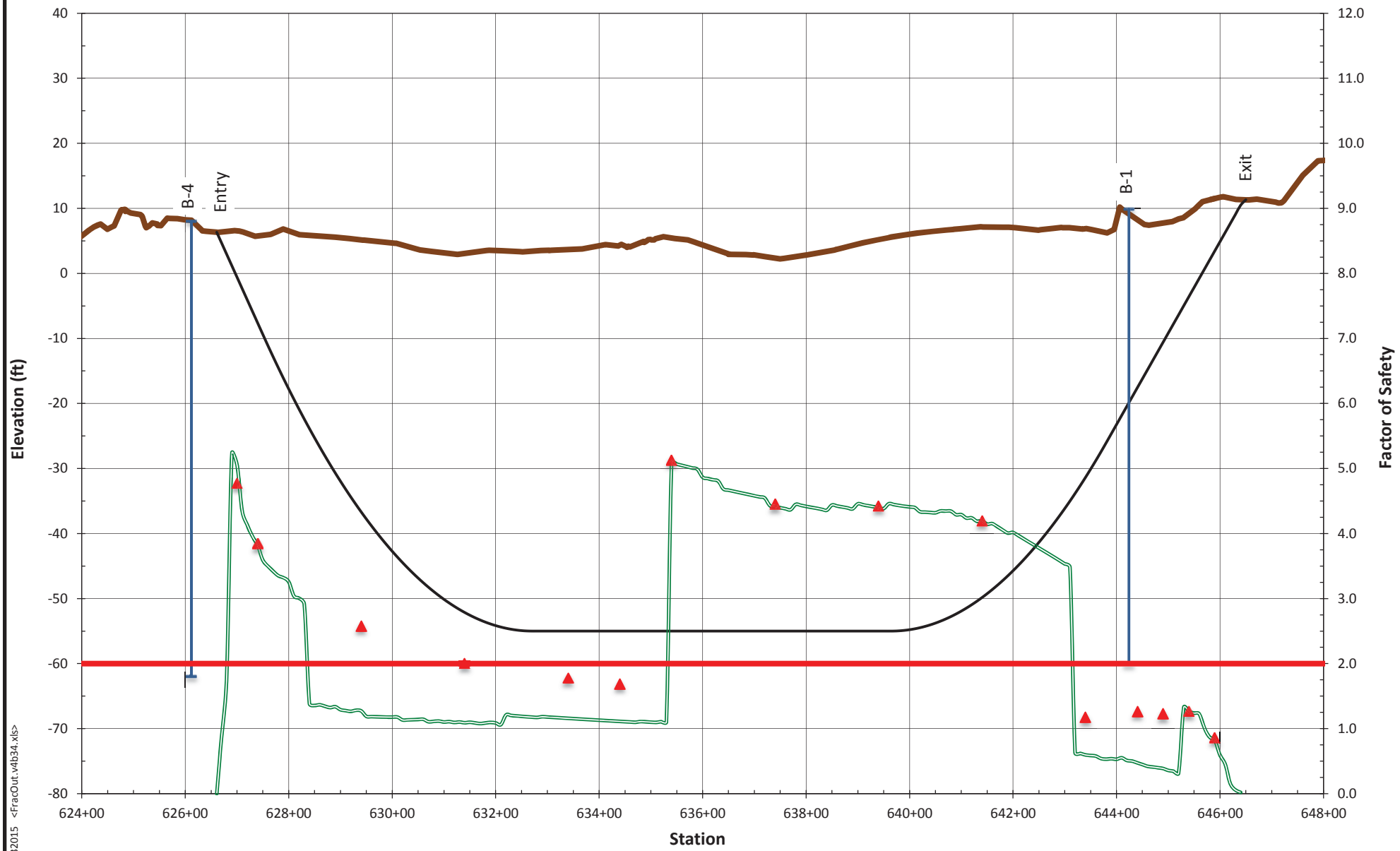
NW NATURAL - NORTH MIST PIPELINE HDD 8



Crossing Length (ft)	1985
Hole Diameter (in)	12.250
Drill Pipe O.D. (in)	6.625
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (CP)	10
Yield Point (lb/100 ft)	20

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Drilling Fluid Surface Release Factor of Safety for Pilot Hole
- Hydraulic Fracture Factor of Safety for Pilot Hole
- Factor of Safety = 2

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE FACTORS OF SAFETY

NW NATURAL - NORTH MIST PIPELINE HDD 8

GEOENGINEERS

FIGURE J-3

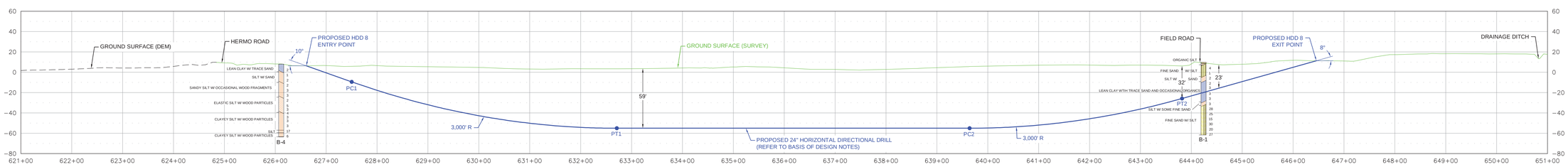
06024-157-03 JAH/AES 09132015 <FracOut.v4b34.xls>

DATUM:
HORIZONTAL: NAD83 OREGON STATE PLANE, NORTH ZONE, INTN'L FOOT
VERTICAL: NAVD 88

PLAN

100' 0 100'
SCALE IN FEET

MAJOR CONTOUR INTERVAL = 10'
MINOR CONTOUR INTERVAL = 2'



PROFILE

100' 0 100'
HORIZONTAL SCALE IN FEET
50' 0 50'
VERTICAL SCALE IN FEET

DIRECTIONAL DRILL DATA HDD 8		
DESCRIPTION	STATION (FT)	ELEVATION (FT)
ENTRY @ 10°	626+60.88	6.32
P C 1 (10.00° @ 3,000 FT R.)	627+50.16	-9.42
P T 1	632+71.10	-55.00
P C 2 (8.00° @ 3,000 FT R.)	639+64.25	-55.00
P T 2	643+81.77	-25.80
EXIT @ 8°	646+45.88	11.31
HORIZONTAL DISTANCE = 1,985.00 FT		
DIRECTIONAL DRILL PIPE LENGTH = 1,992.99 FT		

RECOMMENDED TOLERANCES	
ITEM	TOLERANCE
PILOT HOLE ENTRY ANGLE	INCREASE ANGLE UP TO 1° (STEEPER), BUT NO DECREASE IN ANGLE ALLOWED.
PILOT HOLE ENTRY LOCATION	AS PER COORDINATES PROVIDED BY COMPANY WITH NO CHANGES WITHOUT COMPANY APPROVAL.
PILOT HOLE EXIT ANGLE	INCREASE ANGLE UP TO 1° (STEEPER) OR DECREASE UP TO 2° (FLATTER).
PILOT HOLE EXIT LOCATION	UP TO 20 FEET BEYOND OR 10 FEET SHORT OF THE EXIT STAKE. BETWEEN 5 FEET LEFT AND 5 FEET RIGHT OF CENTERLINE.
PILOT HOLE DEPTH	UP TO 2 FEET ABOVE THE DESIGN DRILL PROFILE ALLOWED. UP TO 10 FEET BELOW THE DESIGN DRILL PROFILE ALLOWED.
PILOT HOLE ALIGNMENT	SHALL REMAIN WITHIN 5 FEET LEFT OR RIGHT OF THE HDD ALIGNMENT.

LEGEND:

TYPE OF SOIL — SPT (N)

BORING LOCATION

FINAL

NOTES

1. ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT–OF–WAY OR FROM APPROVED ACCESS ROADS.
2. WORK SPACE: MAXIMUM WORK SPACE LIMITS ARE DEPICTED. RESTRICT CLEARING TO THE WORK SPACE INDICATED AT THE ENTRY AND EXIT POINTS AND PRODUCT PIPE STRINGING AND FABRICATION AREA ALONG THE CONSTRUCTION RIGHT–OF–WAY. CLEARING BETWEEN THE ENTRY AND EXIT POINTS REQUIRES PRIOR APPROVAL FROM THE ENVIRONMENTAL INSPECTOR AND IS LIMITED TO THE AMOUNT NECESSARY TO STRING SURVEY WIRES AND INSTALL PUMPS AND PIPING TO OBTAIN WATER (WHERE APPROVED).
3. WATER SOURCE: DRILL WATER AND HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE.
4. HYDROSTATIC TEST: PRE–INSTALLATION AND POST–INSTALLATION HYDROSTATIC TESTS SHALL BE CONDUCTED IN ACCORDANCE WITH THE HYDROSTATIC TEST PLAN. TEST WATER SHALL BE SAMPLED AND TESTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE TEST WATER SHALL BE DISCHARGED IN AN UPLAND AREA INTO AN EROSION CONTROL STRUCTURE OF STRAW BALES AND/OR SILT FENCES, GEOTEXTILE FILTER BAG, OR COLLECTED IN A TRUCK AND HAULED TO AN APPROVED DISPOSAL SITE. UPON COMPLETION OF DEWATERING AND DRYING, A CALIPER PIG SURVEY SHALL BE COMPLETED IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
5. SPILL–PREVENTION: REFUELING OF ALL EQUIPMENT SHALL BE COMPLETED IN ACCORDANCE WITH THE SPCC PLAN.
6. EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE APPROVED CONSTRUCTION RIGHT–OF–WAY AT THE DRILL EXIT POINT AS SHOWN. AFTER THE PILOT HOLE IS COMPLETE, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO NORTHWEST NATURAL FOR APPROVAL. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULL BACK.
8. DRILLING FLUID DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING FLUID AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING FLUID WHICH INADVERTENTLY SURFACES AT POINTS OTHER THAN THE ENTRY OR EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.
9. CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN THE CLEAN–UP AND RESTORATION REQUIREMENTS.
10. GEOTECHNICAL DATA: BORE HOLES ARE OFFSET FROM THE PIPELINE CENTERLINE AS SHOWN ON THE PLAN VIEW. THE GEOTECHNICAL INFORMATION PROVIDED ON THIS DRAWING IS A GENERAL SUMMARY. REFER TO THE APPLICABLE GEOTECHNICAL REPORT IN THE CONTRACT DOCUMENTS FOR MORE DETAILED INFORMATION.
11. IF THE TERRAIN ALLOWS AND ACCESS IS PERMITTED, CONTRACTOR SHALL UTILIZE LOW GROUND PRESSURE EQUIPMENT OR OTHER EQUIPMENT APPROVED BY OWNER, TO FACILITATE CONTAINMENT AND CLEAN–UP OF ANY INADVERTENT RETURNS THAT OCCUR DURING THE HDD INSTALLATION PROCESS.
12. THE MINIMUM ALLOWABLE THREE JOINT RADIUS SHALL NOT BE LESS THAN 2,400 FEET.
13. AERIAL PHOTOS AND GROUND SURFACE DEM (1/9 ARC SECOND) DOWNLOADED FROM HTTP://VIEWER.NATIONALMAP.GOV/VIEWER/. BASE FILES PROVIDED BY NORTHWEST NATURAL. GROUND SURFACE AND BATHYMETRIC SURVEY DATA PROVIDED BY WESTLAKE CONSULTANTS, INC., OBTAINED AUGUST 2015.
14. CONTRACTOR IS RESPONSIBLE FOR CALLING OREGON ONE–CALL AND PHYSICALLY LOCATING ALL UNDERGROUND UTILITIES PRIOR TO BEGINNING CONSTRUCTION. IF ANY UTILITY IS LOCATED WITHIN 15 FEET OF THE DESIGNED HDD PROFILE AND ALIGNMENT, CONTRACTOR SHALL OBTAIN APPROVAL FROM NORTHWEST NATURAL PRIOR TO INITIATING HDD OPERATIONS.
15. A SITE SPECIFIC SURVEY DOCUMENTING EXISTING UTILITIES HAS NOT BEEN CONDUCTED ALONG THE PROPOSED PIPELINE ALIGNMENT. A SITE SPECIFIC TOPOGRAPHIC AND UTILITY SURVEY SHOULD BE COMPLETED PRIOR TO FINAL ISSUANCE OF THESE PLANS. DURING CONSTRUCTION, IT IS THE CONTRACTORS RESPONSIBILITY TO IDENTIFY AND PROTECT ANY UTILITY THAT MAY BE AFFECTED BY THE HDD OPERATIONS.
16. CONTRACTOR SHALL ADHERE TO THE SPECIFICATIONS AND REQUIREMENTS PER NORTHWEST NATURAL SPECIFICATIONS, CONTRACT DOCUMENTS, AND SPECIAL PERMIT CONDITIONS, EXCEPT AS NOTED ON THIS DRAWING.

BASIS OF DESIGN:

1. PRODUCT PIPE WILL CONSIST OF 24" O.D. X 0.500" W.T., API–5L X–52 PIPE WITH 14–16 MILS OF FUSION BONDED EPOXY (FBE) AND A MINIMUM OF 40 MILS OF ABRASION RESISTANT OVERLAY (ARO).
2. MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) = 809 psi

NOTE: THIS IS A FULL SIZE DRAWING THAT IS INTENDED TO BE PRINTED ON A 24" X 36" SHEET OF PAPER.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

NO.	DATE	BY	DESCRIPTION	W.O.NO.	CHK.	APP.
A	07/02/14	MWC	ISSUED AS DRAFT		BCR	TNH
B	04/20/15	TJB	ISSUED AS DRAFT (24–INCH REDESIGN)		BCR	TNH
C	09/15/15	BTL	ISSUED FOR FINAL		BCR	TNH

GEOENGINEERS
1200 NW NAITO PARKWAY, SUITE 180
PORTLAND, OREGON 97209
TELEPHONE: (503) 624-9274
FAX: (503) 620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
STATION 621+00 TO 651+00
HDD 8
COLUMBIA COUNTY, OREGON

NW Natural

DRAWN BY: MWC	DATE: 06/05/14	ISSUED FOR BID:	SCALE: AS NOTED
CHECKED BY: BCR	DATE: 06/05/14	ISSUED FOR CONSTRUCTION:	
APPROVED BY:	DATE:	DRAWING NUMBER: HDD 8	SHEET 1
WO:		TIME: 09:41 AM DATE: 09/10/15 PATH: P:\0\60243570\FICAD\HDD\E_FINAL Rev\C.dwg	OF 1

HDD Design Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 8 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe Diameter = 24.000 in

Pipe Material = Steel

Yield Stress = 52,000 psi

Wall Thickness = 0.5 in

Assumed Installation Temp = 55 °F

Assumed Operating Temp= 55 °F

Design Factor = 0.5

MAOP = 809 psi

Drill Data Box

Point	Station (ft)	Elevation (ft)
ENTRY @ 10°	62,660.88	6.32
P C 1 (10.00° @ 3,000 ft R.)	62,750.16	-9.42
P T 1	63,271.10	-55.00
P C 2 (8.00° @ 3,000 ft R.)	63,964.25	-55.00
P T 2	64,381.77	-25.80
EXIT @ 8°	64,645.88	11.31

Horizontal Alignment Length = 1,985.00 ft

Profile Segment Information

Segment Name	Segment Type	Segment Length (ft)
ENTRY TANGENT	Straight	90.65
ENTRY CURVE	Vertical Curve	523.60
BOTTOM TANGENT	Straight	693.15
EXIT CURVE	Vertical Curve	418.88
EXIT TANGENT	Straight	266.71

Pipe Length = 1,992.99 ft

Installation Load Summary

Drilling Fluid Weight (lb/gal)	Buoyancy Condition	Buoyancy Control (lb/ft)	Effective Pipe Weight (lb/ft)	Total Installation Force (lb)
9.50	Empty	0.00	-97.46	167,000
9.50	Full	180.04	82.58	133,000
12.00	Empty	0.00	-156.21	208,000
12.00	Full	180.04	23.83	100,000
10.50	Neutral	120.96	0.00	99,000

GeoEngineers

Minimum Radius Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 8 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters:

Pipe Diameter = 24.000 in **MAOP =** 809 psi **Factor of Safety =** 2.00

Wall Thickness = 0.500 in **SMYS =** 52,000 psi

D/t Ratio = 48.00 **Modulus of Elasticity (E) =** 2.96E+007 psi

Hoop Stress:

Calculated Hoop Stress = (MAOP * Pipe Diameter) / (2 * Wall Thickness) = 19,416 psi

Longitudinal Stress:

Calculated Longitudinal Stress = Hoop Stress / 2 = 9,708 psi

Allowable Stress:

Calculated Allowable Stress = SMYS / Factor of Safety = 26,000 psi

Bending Stress:

Calculated Bending Stress = Allowable Stress - Longitudinal Stress = 16,292 psi

Minimum Radius:

Calculated Minimum Radius = (E * Pipe Diameter) / (2 * Bending Stress) = 1,817 ft

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 8 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Design Parameters

Pipe diameter =	24.000 in	**Minimum Radius of Curvature =**	2,400 ft
Wall Thickness =	0.500 in	**Coefficient of Thermal Expansion =**	6.5E-06 in/in/°F
SMYS =	52,000 psi	**Assumed Installation Temperature =**	55 °F
MAOP =	809 psi	**Assumed Operating Temperature =**	55 °F
Poissons's Ratio =	0.30	**Temperature Derating Factor =**	1.00
Young's Modulus (E) =	2.96E+007 psi	**Groundwater Table Head =**	55.00 ft
Design Factor =	0.5		

Stress Analyses

Longitudinal Stress from Bending =	12,324 psi	
Percent SMYS =	23.70 %	
Hoop Stress =	18,844 psi	
Percent SMYS =	36.24 %	Limited by Design Factor (0.5) according to 49 CFR 192.111
Longitudinal Tensile Stress from Hoop Stress =	5,653 psi	
Percent SMYS =	10.87 %	
Longitudinal Stress from Thermal Expansion =	0 psi	
Percent SMYS =	0.00 %	Limited to 90% SMYS by ASME/ANSI B31.4 section 402.3.2
Net Longitudinal Stress (Comp. side of Curve) =	-6,671 psi	
Percent SMYS =	12.83 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Net Longitudinal Stress (Tension side of Curve) =	17,977 psi	
Percent SMYS =	34.57 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.3
Maximum Shear Stress =	12,757 psi	
Percent SMYS =	24.53 %	Limited to 45% SMYS by ASME/ANSI B31.4 section 402.3.1
Combined BiaxialSress Check =	25,515 psi	
Percent SMYS =	49.07 %	Limited to 90% SMYS by ASME/ANSI B31.8 section 833.4

GeoEngineers

Operating Stress Summary

Project Name: North Mist Expansion Project **HDD Name:** HDD 8 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 8 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	1,993 ft
Moment of Inertia =	2,549 in^4
Pipe Face Area =	36.91 in^2
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft^3
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft^3
Pipe Exterior Volume =	3.14 ft^3/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft^3/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft^3
Effective Weight of Pipe =	-97.46 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty — Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	266.71 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	12,066 lb
Friction Force =	7,722 lb
Segment Weight =	3,617 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	23,405 lb
Cumulative Force =	**23,405 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	634 psi	
Cumulative Axial Stress =	634 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	440 psi	7,537 psi
Combined Stress =	0.0152	< 1.0
Total Stress =	0.0039	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	31,022 lb
Drag Force =	18,950 lb
Friction Force =	9,307 lb
Segment Weight =	2,848 lb
Tension =	63,815 lb
Average Tension =	43,610 lb
Segment Force =	40,411 lb
Cumulative Force =	**63,815 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,095 psi	
Cumulative Axial Stress =	1,729 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	785 psi	7,537 psi
Combined Stress =	0.3837	< 1.0
Total Stress =	0.1394	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	693.15 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	31,357 lb
Friction Force =	20,265 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	51,623 lb
Cumulative Force =	**115,438 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	1,398 psi	
Cumulative Axial Stress =	3,127 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	785 psi	7,537 psi
Combined Stress =	0.0752	< 1.0
Total Stress =	0.0193	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	45,454 lb
Drag Force =	23,687 lb
Friction Force =	13,636 lb
Segment Weight =	-4,447 lb
Tension =	161,950 lb
Average Tension =	138,694 lb
Segment Force =	46,512 lb
Cumulative Force =	**161,950 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,260 psi	
Cumulative Axial Stress =	4,387 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	785 psi	7,537 psi
Combined Stress =	0.4476	< 1.0
Total Stress =	0.1895	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	90.65 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,101 lb
Friction Force =	2,610 lb
Segment Weight =	-1,534 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	5,177 lb
Cumulative Force =	**167,127 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	140 psi	
Cumulative Axial Stress =	4,528 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	246 psi	7,537 psi
Combined Stress =	0.1088	< 1.0
Total Stress =	0.0143	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 8 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	1,993 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	223.26 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	82.58 lb/ft

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	266.71 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	12,066 lb
Friction Force =	6,543 lb
Segment Weight =	-3,065 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	15,544 lb
Cumulative Force =	**15,544 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	421 psi	
Cumulative Axial Stress =	421 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	54 psi	7,537 psi
Combined Stress =	0.0101	< 1.0
Total Stress =	0.0002	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	-16,383 lb
Drag Force =	18,950 lb
Friction Force =	4,915 lb
Segment Weight =	-2,413 lb
Tension =	41,910 lb
Average Tension =	28,727 lb
Segment Force =	26,367 lb
Cumulative Force =	**41,910 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	714 psi	
Cumulative Axial Stress =	1,135 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	96 psi	7,537 psi
Combined Stress =	0.3694	< 1.0
Total Stress =	0.1067	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	693.15 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	31,357 lb
Friction Force =	17,173 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	48,530 lb
Cumulative Force =	**90,440 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,315 psi	
Cumulative Axial Stress =	2,450 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	96 psi	7,537 psi
Combined Stress =	0.0589	< 1.0
Total Stress =	0.0039	< 1.0

Installation Load Calculations

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	-12,443 lb
Drag Force =	23,687 lb
Friction Force =	3,733 lb
Segment Weight =	3,769 lb
Tension =	125,362 lb
Average Tension =	107,901 lb
Segment Force =	34,922 lb
Cumulative Force =	**125,362 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	946 psi	
Cumulative Axial Stress =	3,396 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	96 psi	7,537 psi
Combined Stress =	0.4238	< 1.0
Total Stress =	0.1451	< 1.0

Installation:9.50 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	90.65 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,101 lb
Friction Force =	2,212 lb
Segment Weight =	1,300 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	7,613 lb
Cumulative Force =	**132,975 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	206 psi	
Cumulative Axial Stress =	3,602 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	30 psi	7,537 psi
Combined Stress =	0.0866	< 1.0
Total Stress =	0.0077	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 8 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Product Pipe Parameters

Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	1,993 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations

Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	-156.21 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	266.71 ft	Center Displacement =	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	12,066 lb
Friction Force =	12,377 lb
Segment Weight =	5,798 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	30,241 lb
Cumulative Force =	**30,241 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	819 psi	
Cumulative Axial Stress =	819 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	555 psi	7,537 psi
Combined Stress =	0.0197	< 1.0
Total Stress =	0.0062	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	46,851 lb
Drag Force =	18,950 lb
Friction Force =	14,055 lb
Segment Weight =	4,564 lb
Tension =	81,865 lb
Average Tension =	56,053 lb
Segment Force =	51,624 lb
Cumulative Force =	**81,865 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,399 psi	
Cumulative Axial Stress =	2,218 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	992 psi	7,537 psi
Combined Stress =	0.3954	< 1.0
Total Stress =	0.1582	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	693.15 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	31,357 lb
Friction Force =	32,483 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	63,840 lb
Cumulative Force =	**145,705 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,729 psi	
Cumulative Axial Stress =	3,947 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	992 psi	7,537 psi
Combined Stress =	0.0949	< 1.0
Total Stress =	0.0308	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	66,272 lb
Drag Force =	23,687 lb
Friction Force =	19,882 lb
Segment Weight =	-7,128 lb
Tension =	202,027 lb
Average Tension =	173,866 lb
Segment Force =	56,322 lb
Cumulative Force =	**202,027 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	1,526 psi	
Cumulative Axial Stress =	5,473 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	992 psi	7,537 psi
Combined Stress =	0.4737	< 1.0
Total Stress =	0.2233	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Empty **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	90.65 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,101 lb
Friction Force =	4,184 lb
Segment Weight =	-2,459 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	5,826 lb
Cumulative Force =	**207,852 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	158 psi	
Cumulative Axial Stress =	5,631 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	310 psi	7,537 psi
Combined Stress =	0.1354	< 1.0
Total Stress =	0.0223	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 8 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	1,993 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	282.01 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	23.83 lb/ft

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	266.71 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	12,066 lb
Friction Force =	1,888 lb
Segment Weight =	-885 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	13,069 lb
Cumulative Force =	**13,069 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	354 psi	
Cumulative Axial Stress =	354 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	169 psi	7,537 psi
Combined Stress =	0.0085	< 1.0
Total Stress =	0.0006	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 2 of 5**

Segment Parameters			
Segment Name =	EXIT CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	8.00 deg
Segment Length =	418.88 ft	Center Displacement =	7.31 ft

Segment Force Components	
Normal Force =	-1,782 lb
Drag Force =	18,950 lb
Friction Force =	535 lb
Segment Weight =	-696 lb
Tension =	32,392 lb
Average Tension =	22,731 lb
Segment Force =	19,322 lb
Cumulative Force =	**32,392 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	523 psi	
Cumulative Axial Stress =	878 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	302 psi	7,537 psi
Combined Stress =	0.3632	< 1.0
Total Stress =	0.1077	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full **Segment 3 of 5**

Segment Parameters			
Segment Name =	BOTTOM TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	693.15 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	31,357 lb
Friction Force =	4,956 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	36,313 lb
Cumulative Force =	**68,705 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	984 psi	
Cumulative Axial Stress =	1,861 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	302 psi	7,537 psi
Combined Stress =	0.0447	< 1.0
Total Stress =	0.0043	< 1.0

Installation Load Calculations

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	2,817 lb
Drag Force =	23,687 lb
Friction Force =	845 lb
Segment Weight =	1,088 lb
Tension =	95,169 lb
Average Tension =	81,937 lb
Segment Force =	26,465 lb
Cumulative Force =	**95,169 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	717 psi	
Cumulative Axial Stress =	2,578 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	302 psi	7,537 psi
Combined Stress =	0.4041	< 1.0
Total Stress =	0.1360	< 1.0

Installation:12.00 lb/gal Drilling Fluid With the Pipe Annulus Full — **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	90.65 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,101 lb
Friction Force =	638 lb
Segment Weight =	375 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	5,114 lb
Cumulative Force =	**100,284 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	139 psi	
Cumulative Axial Stress =	2,717 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	95 psi	7,537 psi
Combined Stress =	0.0653	< 1.0
Total Stress =	0.0048	< 1.0

Installation Load Calculations

Project Name: North Mist Expansion Project **HDD Name:** HDD 8 **Owner:** NW Natural

Project No: 6024-157-03 **By:** BCR **Ck'd By:** TNH **Location:** Columbia County, OR. **Date:** Thursday, September 17, 2015

Installation Case:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy

Product Pipe Parameters	
Pipe Diameter =	24.000 in
Wall Thickness =	0.500 in
SMYS =	52,000 psi
Young's Modulus =	2.96E+007 psi
Total Pipe Length =	1,993 ft
Moment of Inertia =	2,549 in⁴
Pipe Face Area =	36.91 in²
D/t Ratio =	48.00
Poisson Ratio =	0.30
Coefficient of Soil Friction =	0.30
Fluid Drag Coefficient =	0.05

Effective Weight Calculations	
Total Empty Pipe Weight In Air=	125.80 lb/ft
Pipe Interior Volume =	2.89 ft³
Coating Thickness =	0.00 in
Coating Density =	0.00 lb/ft³
Pipe Exterior Volume =	3.14 ft³/ft
Displaced Fluid Weight =	246.76 lb/ft
B.C. Line(s) Weight =	0.00 lb/ft
B.C. Line(s) Volume =	0.00 ft³/ft
Unit Weight of B.C. Fluid =	62.40 lb/ft³
Effective Weight of Pipe =	0.00 lb/ft

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy

Segment 1 of 5

Segment Parameters

Segment Name =	EXIT TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	266.71 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	12,066 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	12,066 lb
Cumulative Force =	**12,066 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	327 psi	
Cumulative Axial Stress =	327 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	486 psi	7,537 psi
Combined Stress =	0.0079	< 1.0
Total Stress =	0.0042	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 2 of 5**

Segment Parameters

Segment Name =	EXIT CURVE	**Radius of Curvature =**	3,000 ft
Segment Type =	Vertical Curve	**Angle Turned =**	8.00 deg
Segment Length =	418.88 ft	**Center Displacement =**	7.31 ft

Segment Force Components

Normal Force =	4,416 lb
Drag Force =	18,950 lb
Friction Force =	1,325 lb
Segment Weight =	0 lb
Tension =	33,665 lb
Average Tension =	22,865 lb
Segment Force =	21,599 lb
Cumulative Force =	**33,665 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	585 psi	
Cumulative Axial Stress =	912 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	868 psi	7,537 psi
Combined Stress =	0.3640	< 1.0
Total Stress =	0.1294	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 3 of 5**

Segment Parameters

Segment Name =	BOTTOM TANGENT	**Radius of Curvature =**	0 ft
Segment Type =	Straight	**Angle Turned =**	0.00 deg
Segment Length =	693.15 ft	**Center Displacement =**	0.00 ft

Segment Force Components

Normal Force =	0 lb
Drag Force =	31,357 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	31,357 lb
Cumulative Force =	**65,022 lb**

Segment Installation Stress Checks

Stress Component	Calculated	Allowable
Segment Axial Stress =	849 psi	
Cumulative Axial Stress =	1,761 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	868 psi	7,537 psi
Combined Stress =	0.0423	< 1.0
Total Stress =	0.0165	< 1.0

Installation Load Calculations

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 4 of 5**

Segment Parameters			
Segment Name =	ENTRY CURVE	Radius of Curvature =	3,000 ft
Segment Type =	Vertical Curve	Angle Turned =	10.00 deg
Segment Length =	523.60 ft	Center Displacement =	11.42 ft

Segment Force Components	
Normal Force =	10,001 lb
Drag Force =	23,687 lb
Friction Force =	3,000 lb
Segment Weight =	0 lb
Tension =	94,710 lb
Average Tension =	79,866 lb
Segment Force =	29,688 lb
Cumulative Force =	**94,710 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	804 psi	
Cumulative Axial Stress =	2,566 psi	41,600 psi
Bending Stress =	12,333 psi	36,050 psi
Hoop Stress =	868 psi	7,537 psi
Combined Stress =	0.4038	< 1.0
Total Stress =	0.1582	< 1.0

Installation:10.50 lb/gal Drilling Fluid With Neutral Pipe Buoyancy **Segment 5 of 5**

Segment Parameters			
Segment Name =	ENTRY TANGENT	Radius of Curvature =	0 ft
Segment Type =	Straight	Angle Turned =	0.00 deg
Segment Length =	90.65 ft	Center Displacement =	0.00 ft

Segment Force Components	
Normal Force =	0 lb
Drag Force =	4,101 lb
Friction Force =	0 lb
Segment Weight =	0 lb
Tension =	0 lb
Average Tension =	0 lb
Segment Force =	4,101 lb
Cumulative Force =	**98,811 lb**

Segment Installation Stress Checks		
Stress Component	Calculated	Allowable
Segment Axial Stress =	111 psi	
Cumulative Axial Stress =	2,677 psi	41,600 psi
Bending Stress =	0 psi	36,050 psi
Hoop Stress =	271 psi	7,537 psi
Combined Stress =	0.0643	< 1.0
Total Stress =	0.0063	< 1.0

APPENDIX K
HDD Specifications

HORIZONTAL DIRECTIONAL DRILLING SPECIFICATIONS

NW Natural

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REVISION HISTORY			
REV.	DATE	DESCRIPTION OF REVISION	APPROVED BY
0	04/15/13	Original Issue of Specifications	

1.0 DEFINITIONS

- CONTRACTOR – The HDD contractor, all subcontractors, suppliers, vendors, or other parties required by CONTRACTOR to complete work defined herein.
- COMPANY – NW Natural and their representatives, inspectors and environmental staff.

2.0 SCOPE OF WORK

- CONTRACTOR shall furnish all supervision, labor, equipment, materials and supplies to perform the work necessary to install pipe by horizontal directional drilling (HDD) in accordance with COMPANY Drawings, Specifications, Contract Documents, and this specification.
- For the purposes of this specification CONTRACTOR shall include all subcontractors, suppliers, vendors, or other parties required by CONTRACTOR to complete work defined herein.

3.0 GENERAL REQUIREMENTS

- CONTRACTOR shall not proceed with Work before COMPANY approves its supervisor, personnel, subcontractors, vendors, drilling plan and schedule. CONTRACTOR shall provide all required documentation, as requested herein, with the Contract Bid Proposal.
- COMPANY will provide workspace for drilling sites in addition to pipeline right of way (ROW) as shown on the Drawings. CONTRACTOR work activities shall remain within the provided workspace and ROW. CONTRACTOR may not occupy, cross or utilize any areas outside COMPANY provided workspace. All work associated with the preparation of the drilling sites (entry / exit points) and pullback area, including clearing, brush hogging, top soil segregation, grading / filling, fill dirt, gravel, flume pipes, geotextile fabric and timber mats, final grading and clean up, will be at CONTRACTOR'S expense unless otherwise specified by COMPANY.
- CONTRACTOR shall be responsible for constructing, maintaining, clean up and restoration for all means of temporary access to the designated work sites, including all temporary fill dirt, gravel, flume pipes, and geotextile fabric and / or timber mats; and shall include all costs in the bid price, unless otherwise specified by COMPANY, bid documents or contract. CONTRACTOR shall be liable for all damages to roads and any other property by heavy trucks and equipment accessing the work sites. CONTRACTOR shall only use those access roads identified and approved by the COMPANY.
- CONTRACTOR shall comply with all requirements of permits obtained by COMPANY for construction of the pipeline facilities and drilling operations.
- COMPANY will identify water sources and will obtain any required permits for water withdrawal.
- CONTRACTOR shall be responsible for all work necessary for withdrawing and transporting water to the job site, and shall be responsible for all costs associated with the water usage.
- CONTRACTOR shall provide personnel with radios to monitor water bodies and ground surface for drilling fluid release or surface settlement along the full length of the drill path at all times during drilling operation.
- CONTRACTOR personnel shall monitor facilities and other sensitive areas within 500 feet of the drill path for drilling fluid migration and release. Inspection shall be performed twice daily or more often if drilling fluid ceases returning to the entry/exit pits or if fluid migration is detected. COMPANY may designate certain facilities such as highways or sensitive natural areas for full time monitoring by CONTRACTOR during drilling operations. A full time monitoring crew will be required if specified in Contract. CONTRACTOR shall be responsible for all costs of personnel and equipment required for monitoring.
- CONTRACTOR shall install safety fence or provide other COMPANY approved barrier to prevent equipment, vehicle or pedestrian traffic from crossing over drill path in areas subject to surface collapse or bore hole collapse or in other areas deemed necessary by the COMPANY. Project specific requirements may be attached in the scope of work or depicted on the drawings.

4.0 DRILLING OPERATIONS

4.1 Radio Communication and Access to Instruments

- COMPANY shall have access inside the drill cab and to all instruments and their readings at all times including authorized third party representatives. CONTRACTOR shall provide conversion factors to convert instrument read-outs of travel and rotary motors to force and torque units according to the motor manufacturer's specifications.
- Upon request, CONTRACTOR shall provide 2 two-way radios on CONTRACTOR frequency with battery chargers to COMPANY prior to commencement of drilling operations.

4.2 Contractor Personnel and Subcontractors

- CONTRACTOR shall provide, in the Contract Bid Proposal, resumes of key personnel and a list of subcontractors that will be working on the project and provide any updates to the list should it change either prior to or during construction. COMPANY has the right to reject any personnel or subcontractors proposed by CONTRACTOR.
- CONTRACTOR shall provide adequate personnel to supervise all aspects of the directional drilling process. COMPANY has the right to reject any supervisory personnel changes during construction. CONTRACTOR shall submit 72-hour notification of any supervisory personnel changes during construction to COMPANY for approval.

4.3 Drilling Schedule

- CONTRACTOR shall submit a drilling schedule with its bid for COMPANY approval. The schedule shall be job specific and comply with the schedule specified in the Contract. The schedule shall be updated weekly during drilling operations. Contractor's plan shall address continuity of supervision, quality management, and communication between shifts to address completion of tasks and processes begun in previous shifts or to be undertaken in subsequent shifts.
- The following shall be included in the schedule:
    - Dates for mobilization, rig-up drill start, pullback completion, rig-down, demobilization;
    - Dates for fabrication and hydrostatic pre-testing of pullback pipe (if required by contract documents);
    - Mobilization and set up durations;
    - Pilot drill duration;
    - Reaming steps with duration for each pass;
    - Final hole preparation and pullback duration;
    - Dates for final hydrostatic testing and internal inspection; and
    - Clean up, restoration and move out duration.
    - Any other site specific activities required for the particular crossing project
    - Daily work schedule for all phases of the project -- i.e. 12 or 24 hour work-days and number of shifts.
    - Personnel (supervisor and work crews) schedule for the various work shifts and phases.

- CONTRACTOR shall submit a 72-hour notification prior to any changes in schedule or shutdowns (including holidays) to COMPANY for approval. The schedule change or shutdown will not occur without COMPANY approval.

4.4 Drilling Plan

- CONTRACTOR shall submit a drilling plan with its bid for COMPANY approval. Approval of drilling plan by COMPANY does not relieve CONTRACTOR of any responsibility or liability for safety, damages, compliance with permits and regulations, accuracy, adequacy of the plan for execution of the project. Any operational deviation from the submitted plan, including, but not limited to, change in reaming size, shall be presented to COMPANY's Authorized Representative in written form. COMPANY'S Engineering Department shall review and approve any deviations to the drilling plan prior to implementation by the CONTRACTOR.
- The Drilling Plan shall be site specific and shall be updated during drilling operations. CONTRACTOR'S drilling plan shall not override or change requirements of Drawings, Specifications, Contract Documents or this specification without written approval from COMPANY. The following shall be included in the plan; if requested, CONTRACTOR shall provide supporting data, calculations and/or other information for each item:
    - Size of drilling rig, including torque and pulling capacities;
    - Type of rig, including size of motors;
    - Type of survey tracking equipment to be utilized and its stated accuracy;
    - Pilot survey equipment with sketch of tracking cable layout;
    - Pilot hole size, each reaming step size, and final hole size;
    - Diameter, type, grade of drill pipe;
    - Most recent inspection records for drill pipe to be used for this project
    - Type of pilot hole bits (include diameter and type);
    - Type of hole opening tools (include diameter and type);
    - Anticipated and maximum penetration rates to be maintained for the anticipated soil and groundwater conditions for this project.
    - Equipment (pumps, etc.) required to obtain water;
    - Quantity of water required for drilling operations with estimated maximum daily rate to be consumed;
    - Drilling fluid system, including recycle plans (if applicable);
    - Drilling fluid composition and additives including all Material Safety Data Sheets;
    - Drilling fluid and hole cuttings disposal method and location;
    - Disposal location permit status and/or authorization to dispose fluid and cuttings or other project wastes;
    - Contingency plan for inadvertent drilling fluid migration and release;
    - Inventory of equipment and material to be on site for fluid release;
    - Roller spacing, if different from Contract;
    - Buoyancy mitigation plan;
    - Spare equipment and parts inventory;
    - If applicable, plan for pipe fabrication and pullback support (if in contract). Number and size(s) of pullback equipment (i.e. number of side boom pipe layers, cranes, and

other support equipment);

- Pneumatic Ram and Pull Assistance Contingency Plan. This contingency plan will only be considered if the pipe string becomes lodged during the pullback. CONTRACTOR shall provide detailed description of the proposed equipment, procedures, methods, monitoring and engineering calculations for any pneumatic ramming or pull assistance equipment. Written authorization from the COMPANY will be required before the CONTRACTOR implements this contingency plan;
- Plan for site grading and access road preparation including support mats;
- On-site equipment required to continuously monitor highways or sensitive natural areas during drilling operations; and
- Sample of daily report.

4.5 Reporting of Drilling Status

- CONTRACTOR shall submit daily reports to COMPANY at end of each work shift. CONTRACTOR shall submit daily reports on COMPANY approved form and shall include the following information:

  - Supervisor on site, crew members on site, shifts/time worked;
  - Description of work, tools in use, footage completed;
  - Daily total of Bentonite used and total to date;
  - Drilling fluid additives in use;
  - Loss of drilling fluid circulation and duration;
  - Quantity of drilling fluid lost or released and disposition of the fluid released in regard to clean-up;
  - Pilot drill deviations and corrections made;
  - Maximum torque values on each pilot or reaming joint;
  - Penetration rates for each pilot or reaming joint;
  - Calculation of 3-joint radius for the days footage;
  - Copy of directional survey report and report from pilot hole tracking (ParaTrack or equal) system(s);
  - Provide data to calculate minimum radius of each 3 joint segment of pilot hole;
  - Disposal quantities of drilling mud and cuttings;
  - Disposal bill of lading/trip ticket and lab sample results;
  - Drilling schedule updates;
  - Drilling plan updates;
  - Drilling fluid system updates; and
  - Drilling fluid properties report.

5.0 DRILLING FLUID SYSTEM

5.1 Instrumentation

- CONTRACTOR shall provide and maintain instrumentation that will accurately measure drilling fluid discharge rate and pressure. COMPANY shall have access to these instruments and their readings at all times.

5.2 Drilling Fluid Pressures and Circulation

- CONTRACTOR shall take necessary precautions to insure the drilling fluid pressure in the drilled hole does not exceed what can be contained by the overburden soil to prevent any migration into waterbodies, wetlands, utilities, foundations, structures, road/railroad right of ways, or any other facilities.
- CONTRACTOR shall make every effort to maintain circulation and recycle the drilling fluid throughout the drilling process.

5.3 Drilling Fluid Containment

- CONTRACTOR shall provide metal fluid tanks on both sides of the crossing sufficient to contain all drilling fluids resulting from the drilling operation. CONTRACTOR shall insure that all drilling fluids are contained within the drilled hole, the drill pit or the fluid tanks.

5.4 Plan for Drilling Fluid System

- CONTRACTOR shall submit a job specific plan of the proposed drilling fluid mixing system, cleaning system, and mud pumping capabilities and shall provide the plan with its bid. The plan shall include the following information:
  - Total volume of mixing tank – (BBLS);
  - Total volume of cleaning tank – (BBLS);
  - Scalping shakers – quantity;
  - Scalping shakers – mesh size;
  - Desander cones – quantity;
  - Desander cleaning ability – GPM;
  - Desander shakers – mesh size;
  - Desilter cones – quantity;
  - Desilter cleaning ability – GPM;
  - Desilter shakers – mesh size;
  - Centrifuge(s) – quantity;
  - Centrifuge(s) cleaning ability – GPM;
  - Mud pump(s) capabilities (entry side): name brand, liner size, maximum pressure, maximum flow rate (GPM) and gallons per stroke);
  - Mud pump(s) capabilities (exit side): name brand, liner size, maximum pressure, maximum flow rate (GPM) and gallons per stroke);
  - Anticipated mud pump volumes (GPM) to be maintained on each reaming pass in clay, sand, silt, rock and gravel; and
  - Anticipated daily water usage.

6.0 DRILLING FLUID COMPOSITION

6.1 Drilling Fluid Engineer

- CONTRACTOR shall provide a certified and COMPANY approved drilling fluid engineer on-site during all phases of the drilling process. CONTRACTOR shall provide a resume for the proposed drilling fluid engineer in its bid. CONTRACTOR will be responsible for these costs. For HDD installations less than 8-inches in diameter and less than 1,000 feet in length, COMPANY may modify or waive the requirement to provide a full-time drilling fluid engineer.

6.2 Drilling Fluid Composition

- CONTRACTOR shall provide a plan with its bid describing the drilling fluid composition to be used on this project.
- The drilling fluid plan shall include the following information:
  - Anticipated mud composition with MSDS sheets;
  - Anticipated additives with MSDS sheets;
  - Minimum and maximum viscosities that will be maintained in sand, silt, clay, rock and gravel;
  - Proposed ideal and maximum percentage of solids (sand content) to be maintained during the drilling process. Describe the process that will be implemented should the percentage of solids exceed the proposed maximum; and
  - Sample drilling fluid daily report
- CONTRACTOR shall submit MSDS sheets for any changes to the drilling fluid composition or use of additives during construction for COMPANY approval. COMPANY shall approve any changes prior to use of the new drilling fluid composition.
- Any additives not included in the plan will NOT be allowed on-site or used without prior COMPANY approval.

6.3 Reporting of Drilling Fluid Properties

- CONTRACTOR shall check drilling fluid properties at least once every two hours during drilling operations. The results of these tests shall be recorded during each shift and a copy of the report shall be given to COMPANY at the end of each shift. The report shall include the following (with suggested testing procedure indicated (latest edition) or as otherwise approved by COMPANY:
  - Density ('mud weight', per API RP 13B-1);
  - Viscosity (including apparent viscosity, plastic viscosity and yield point per API RP 13B-1);
  - Funnel Viscosity (using Marsh funnel, per API RP 13B-1);
  - Gel Strength (per API RP 13B-1);
  - Solids and Sand Content (per API RP 13B-1);
  - Water loss (filtration, per API RP 13B-1); and
  - Chemical quality of make-up water and drilling fluid (e.g., pH, chlorides, hardness, per API RP 13B-1).

7.0 DISPOSAL OF DRILLING FLUID AND CUTTINGS

7.1 General

- CONTRACTOR shall promptly remove all drilling fluids and associated cuttings from job site and haul to a COMPANY approved facility for proper disposal. All costs of disposal of both drilling fluids and associated cuttings, including hauling, shall be at CONTRACTOR'S expense. At its discretion, COMPANY may obtain use of private property to land farm drilling fluid and associated cuttings if specified elsewhere in the contract. CONTRACTOR shall be responsible for all work necessary for land farming, including any improvements to the property and including improvements necessary for ingress and egress to the site. CONTRACTOR shall be responsible for all work necessary to clean up and restore property used for land farming. CONTRACTOR shall bear all costs to clear additional disposal sites requested by the CONTRACTOR.

7.2 Disposal Plan for Drilling Fluids and Cuttings

- CONTRACTOR shall include a disposal management plan for drilling fluid and cuttings in its bid for approval by COMPANY. CONTRACTOR shall notify COMPANY and submit list with any changes in plan for COMPANY approval prior to work starting. The plan shall include:
  - Description of CONTRACTOR'S plans for disposal of the drilling fluid and cuttings;
  - Names, addresses and telephone numbers of subcontractors to be performing any portion of the disposal activities
  - Anticipated drilling fluid composition with MSDS sheets;
  - Anticipated additives with MSDS sheets;
  - Anticipated intervals of disposing of the drilling fluid (duration between loads and volume per load);
  - Disposal hauler; and
  - Estimated quantities to be disposed.

7.3 Disposal Reporting

- CONTRACTOR shall submit daily reports to COMPANY including the following:
  - Quantity of drilling fluid and cuttings hauled from drill sites;
  - Bill of lading / trip ticket for each truckload;
  - CONTRACTOR shall maintain a steady supply of trucks to keep up with the volume of drilling fluid disposal (mud, soil and cuttings); and
  - Lab sample results in accordance with disposal permit.

8.0 DRILLING FLUID MIGRATION AND RELEASE

8.1 General

- CONTRACTOR shall immediately cease drilling and notify COMPANY upon detection of drilling fluid/mud release to the ground surface or water body, or detection of drilling fluid/mud migration under pavement, foundation, utilities or other structure. Operations shall not resume without COMPANY approval.
- CONTRACTOR shall have adequate spill containment measures and collection equipment on site at all times to contain and collect any release of drilling fluids to the ground surface, wetlands, or waterbodies.
- All areas contaminated by drilling fluid migration and release shall be cleaned up and restored to the original condition, agency requirements, or as accepted by the COMPANY at CONTRACTOR's expense.
- CONTRACTOR shall be responsible for damages to structures, foundations, pavements, utilities or other facilities affected by drilling fluid migration.
- CONTRACTOR shall be responsible for fluid migration that effects any domestic or agricultural water supply. All activities in this event must be documented and submitted to the Company by end of business day. A mitigation plan must be communicated to the Company.

8.2 Contingency Plan for Drilling Fluid Migration and Release

- CONTRACTOR shall submit a plan for containing, collecting and cleaning up after drilling fluid releases. The plan shall include detailed descriptions of all equipment and materials to be utilized, and an inventory of equipment and materials to be on site.

8.3 Reporting of Drilling Fluid Migration and Releases

- CONTRACTOR shall submit a report of quantity of drilling fluid released, location, and clean up activity.

9.0 PILOT DRILLING, TRACKING AND SURVEY

9.1 General

- The pilot hole shall be drilled within COMPANY tolerances along the path shown on the plan and profile drawing. The position of the drill string shall be monitored by CONTRACTOR with precise downhole survey instruments and verified with surface location equipment (i.e., ParaTrack2, TruTracker or equal, or as approved in writing by COMPANY).
- CONTRACTOR shall provide a description of its downhole survey instruments and surface location equipment and provide a sketch of the cable layout with its drilling plan for COMPANY approval. There shall be no gap in cable coverage over accessible ground surfaces for the entire length of drill path. CONTRACTOR shall install cable over roads and highways where COMPANY has obtained a permit for cable installation.
- CONTRACTOR shall compute the position in the X, Y and Z-axis relative to ground surface from down-hole survey data a minimum of once per length of each drill pipe (approximately 30 foot interval). Upon exit of the pilot hole bit, CONTRACTOR shall take the final survey with the survey probe at the ground elevation. This survey shall be tied-in to the existing exit survey stake.

9.2 Entry/Exit Angle, Horizontal Alignment and Depth

- The entry and exit points will be staked on the ground as shown on plan and profile drawings and shall be located by COMPANY using traditional survey methods. If site grading is required at entry or exit, COMPANY will provide new coordinates for entry or exit point.
- Pilot drill shall follow the path shown on the Drawings within the following tolerances, unless otherwise stated in Contract documents.

Item	Tolerance
Pilot Hole Entry Angle	Increase up to 1° (deeper), but not decrease in angle allowed
Pilot Hole Entry Location	As per coordinates provided by COMPANY, or as staked by COMPANY, with no changes without COMPANY approval
Pilot Hole Exit Angle	Increase angle up to 1° (higher) or Decrease up to 2° (flatter)
Pilot Hole Exit Location	Up to 20 feet longer or 10 feet shorter than exit stake unless otherwise specified by contract documents. Between 5 feet left and 5 feet right of COMPANY survey centerline.
Pilot Hole Depth	Up to 2 feet above the design drill profile allowed. Up to 10 feet below the design drill profile allowed
Pilot Hole Alignment	shall remain within 5 feet left or right of COMPANY centerline survey

9.3 Pilot Drill Radius

- The pilot hole shall be drilled at a radius equal to or greater than that shown on the plan and profile drawing. Pilot drill deviations and corrections made along the drill path shall not exceed the absolute minimum radius, over a three joint range, as shown on drawings and/or Contract documents.
- CONTRACTOR shall calculate the drilled radius over all consecutive three joint segments using the following formula (assuming range 2 drill pipe):

$$R_{drilled} = (L_{drilled}/A_{avg}) * 57.32$$

Where:

$R_{drilled}$ = drilled radius over $L_{drilled}$

$L_{drilled}$ = length drilled, approximately 90 feet

A_{avg} = total change in angle over $L_{drilled}$

9.4 Pilot Drill Survey Reporting

- Horizontal and vertical Tolerance deviations between the recorded position of the drill string and the plan and profile drawing, and/or radius violations shall be documented and immediately brought to the attention of COMPANY.
- CONTRACTOR shall provide in its daily report to COMPANY, the computer printout of the directional survey and the ParaTrack2, TruTracker or equivalent reports generated by the downhole survey tools. Report data shall be in a format suitable for independent calculation of the pilot hole profile. COMPANY reserves the right to request this information at any time or during any shift. CONTRACTOR shall supply this information, for independent calculation, with no additional cost to COMPANY should the pilot drilling operation be halted to supply this information.
- CONTRACTOR shall also furnish the following to COMPANY in its daily report:
  - Maximum torque values read on each pilot joint or reaming joint run. CONTRACTOR shall note reasoning for any excessive torque value beyond normal operating conditions; and
  - Survey information on the minimum radius of each three (3) joint segment of the pilot hole.
- CONTRACTOR shall notify COMPANY's Authorized Representative of any drill profile failing to meet the specifications, and correction for this shall be at CONTRACTOR's sole expense.

9.5 Pilot Drill Corrections

- CONTRACTOR shall redrill or pullback and correct the pilot hole and provide documentation that the pilot hole is within COMPANY specifications. CONTRACTOR will be responsible for all costs associated with re-drilling of any portion of the pilot hole, including grouting of the old pilot hole.

10.0 HOLE REAMING AND PREPARATION FOR PIPE PULLBACK

10.1 Pilot Hole Acceptance

- CONTRACTOR shall meet with COMPANY representative and review pilot data before the hole-opening process begins. Contractor may not proceed with hole opening until meeting has occurred, or approval to proceed is provided by COMPANY.

10.2 Lost or Lodged Tools

- Any tools or other metal object lost or lodged downhole shall be reported to the Authorized Company Representative. Metal objects shall be fully recovered prior to pipe pullback operation unless specifically approved otherwise by COMPANY. Failure to recover metal objects lost or lodged downhole within a reasonable time period constitute just cause for rejection of the drill hole.

11.0 PIPE FABRICATION AND PULLBACK

11.1 Pipe and Coatings

- COMPANY will furnish pipe as shown on drawings and/or in Contract documents.
- Unless previously agreed to in the contract documents, CONTRACTOR shall furnish all necessary and required equipment and material to apply external coatings to field joints on the pipe section fabricated for pullback into the reamed hole and any pipe coating repairs. CONTRACTOR shall comply with COMPANY's Coating Specification for surface preparation, applying field joint coating and all pipe coating repairs.
- External coating shall be inspected with an approved electrical holiday detector during fabrication, after field joints are coated, and immediately prior to pipe being pulled back into the drill hole.

11.2 Pipe Fabrication and Testing Prior to Pullback

- CONTRACTOR shall fabricate pipe for pullback into reamed hole, including installing and removing COMPANY furnished test manifolds or test caps. CONTRACTOR shall hydrostatically test fabricated pipe section(s) at pressures and duration as specified in the Design and Pressure Test Documentation. Unless otherwise stated in Contract documents, a 1hour pre-test is required on all pipe segments used for the pullback section(s). If required by the COMPANY, CONTRACTOR shall keep 24-hour security on the pullback section. CONTRACTOR may install pull heads and associated equipment after dewatering. Water source for the hydrostatic test shall be at COMPANY approved locations. CONTRACTOR shall be responsible for all costs (labor, equipment and material) associated with hauling, filling and dewatering of pipe section(s). COMPANY will take samples during fill and dewatering operations.
- Pipe may be hydrostatically pre-tested on skids or rollers; however, if pipe is placed on rollers or skids for pretest, CONTRACTOR shall perform the pretest in accordance with the following requirements:
  - All pipe in the test section shall be as specified on the drawings on in the Contract documents;
  - The test medium shall be water;
  - The maximum support spacing shall be 50 feet and/or as shown on the drawings and/or Contract documents for fabrication and hydrostatic testing.
  - The minimum and maximum test pressures shall be as shown on drawings and/or Contract documents; and
  - Each support shall have a weight capacity sufficient to hold up the water filled pipe with an appropriate safety factor.
- Supports shall be arranged such that they are loaded approximately equally. Supports located in low areas shall be raised to keep the drill section as straight as possible. Additional supports or timber pads (under supports) or other means shall be used to provide firm support so that sinkage is minimized in areas where the ground is soft, at no additional cost to COMPANY. Supports shall closely conform to the shape of the pipe (e.g. rollers, chocks, notched out timber, etc.).

- During pullback, the exposed pipe shall be supported on rollers. All rollers shall be in good mechanical and physical condition. COMPANY shall have the right, in its sole judgment, to stop work, on CONTRACTOR'S account, if insufficient rollers are being used.

11.3 Pipe PullBack

- CONTRACTOR shall provide and maintain instrumentation that will accurately measure drill string axial and torsional loads. COMPANY shall have access to these instruments and their readings at all times. COMPANY maximum permissible tensile load imposed on the pull section shall be calculated using the following formula:

  Max Pull Load (pounds) = (SMYS * Pipe Area) * 0.8

  Where:

  SMYS = specifies minimum yield strength of pipe (psi)
  Pipe Area = area of pipe section(s) (square inches)

- If more than one value is involved for a given pull section, the lesser shall govern. Pulling force exerted on pipe during pullback shall not exceed 1,000,000 pounds without prior consent of COMPANY.
- CONTRACTOR shall not use any hammering or ramming device to aid in the installation of the pipeline. CONTRACTOR may submit a Pneumatic Ram and Pull Assistance Contingency Plan for COMPANY engineering analysis and management approval. This contingency plan will only be considered if the pipe string becomes lodged during pullback and all other means for completing the drill have been exhausted. All costs associated with this contingency plan shall be included in the Contract Bid Proposal, at no additional cost to the COMPANY. Written authorization from the COMPANY will be required before the CONTRACTOR implements this contingency plan.
- Approval of the Pneumatic Ram and Pull Assistance Contingency Plan by the COMPANY does not relieve the CONTRACTOR of any responsibility or liability for safety, damages, accuracy or compliance with the execution of the Contract. Final acceptance of the drilled pipeline crossing will be as outlined in Section 12.3. The Pneumatic Ram and Pull Assistance Contingency Plan should include a description of the equipment, procedures, methods or monitoring to be used; and engineering calculations to verify the pipe will not be overstressed or the pipe dimensions impacted by using a pneumatic rammer or pulling device/s. The maximum ramming force/s should be specified in the plan. CONTRACTOR shall install thinner wall sacrificial pipe between the pneumatic rammer and the carrier pipe. A full penetration weld will be required between the sacrificial pipe and carrier pipe. COMPANY will inspect the pipeline sections at the entry and exit points for visual damage. NDT will be performed on all exposed girth welds to demonstrate that no weld cracking has occurred in the rammed or pulled sections of the carrier pipe. The COMPANY may require material test coupons for material inspection. Ultimate approval will be based on the successful hydro test, gauging tool survey, ovality checks and material inspections. CONTRACTOR shall comply with all applicable regulations.
- To minimize torsional stress imposed on the pull section, CONTRACTOR shall use a swivel assembly to connect the pull section.

- CONTRACTOR shall install the pipeline in one continuous string with no tie-in welds unless stated otherwise in COMPANY approved drilling plan. CONTRACTOR shall begin the pullback operation immediately after the final swab pass has been completed. Once CONTRACTOR begins pullback operations, installation shall not cease until pullback operations are completed.
- CONTRACTOR shall provide buoyancy modification as required and/or when conditions necessitate.
- During the pullback operation, CONTRACTOR shall monitor roller operation and shall use side boom pipe layers or cranes if required to assist movement of the pipe. Situations that cause coating damage shall be corrected immediately. CONTRACTOR shall repair coating damage to COMPANY Coating Specifications before pulling operations resume. COMPANY reserves the right to stop pullback operation if coating damage cannot be corrected to COMPANY's satisfaction, at no additional cost to COMPANY.
- CONTRACTOR shall utilize equipment necessary to lift the pullback section up to reach the proper entry angle and safely support the pipeline in the break over area. CONTRACTOR shall submit an equipment list and procedures in the Drilling Plan.
- If the pipe becomes lodged in the drill hole during pullback and cannot be recovered, CONTRACTOR shall seal the pipe and existing drilled hole, as specified by COMPANY.
- CONTRACTOR shall repeat efforts to successfully install the drilled sections beginning with the re-drilling of a pilot hole. Unless otherwise specified in the contract documents, CONTRACTOR shall bear all costs of re-drilling, furnishing coated pipe, welding, coating of joints and hydro testing to replace any pipe that is not retrieved from an unsuccessful pullback.

12.0 HYDROSTATIC TESTING, INSPECTIONS AND ACCEPTANCE

12.1 Hydrostatic Testing of Installed Pipe

- CONTRACTOR shall perform an 8-hour hydrostatic test of the installed pipe at test pressures and procedures as specified in the Design and Pressure Test Documentation. This hydrostatic test is required for COMPANY approval and acceptance of HDD installation.
- CONTRACTOR shall install and remove COMPANY furnished launchers, test manifolds or test caps. Water source for the hydrostatic test shall be at COMPANY approved locations. CONTRACTOR shall be responsible for all costs (labor, equipment and material) associated with hauling, filling and dewatering of pipe section(s). COMPANY may take samples during fill and dewatering operations.
- CONTRACTOR shall de-water the crossing pipe and run a pig with a sizing plate (if required) made to COMPANY specifications to check for ovality, buckles or dents.

12.2 Internal Inspection of Installed Pipe

- COMPANY will make arrangements for internal inspection of installed pipe unless otherwise specified. CONTRACTOR shall allow COMPANY adequate time to analyze the caliper/deformation tool data.
- CONTRACTOR will assist COMPANY with internal inspection tools, including:
  - Installing launcher and receiver on each end of crossing pipe
  - Furnishing and operating air compressors to push tool
  - Loading and unloading tool
  - Remove launchers / receivers
- CONTRACTOR shall include this assistance and time in the costs to install the pipeline.
  - The caliper/deformation survey will be considered acceptable if results indicate no sharp anomalies (e.g., dents, buckles, gouges, or internal obstructions) greater than ¼" in pipe 12 ¾" and less in outside diameter. In pipe greater than 12 ¾" in outside diameter, the anomalies can be no larger than 2% of the nominal pipe diameter. The depth of a dent shall be measured as the gap between the lowest point of the dent and the original contour of the pipe.

    Pipe ovality will be considered unacceptable if results indicate ovality greater than 2.5% of the nominal pipe diameter. Pipe ovality shall be measured as the percent difference between the maximum and minimum pipe diameters within a span of 5 feet.

12.3 Acceptance of Installation

- COMPANY will review results of the drill profile survey information, hydrostatic test data, sizing plate run data (if required), internal pipeline inspection report, and any material inspection data; and then determine the acceptability of installed HDD crossing. COMPANY shall notify the CONTRACTOR of the final results.
- Unless otherwise specified in the Compensation Section of the Contract Agreement,

payment for the Horizontal Directionally Drilled Crossing shall be made in lump sum payment upon successful pullback, gauging tool investigation and hydrostatic test acceptance. There will be no partial payment or progress payment made for the HDD operations.

- Footage for the HDD work shall be omitted from the eligible length of pipeline sections related to per foot progress payments or lump sum payments in the pipeline Compensation Section of the Contract. Footage calculated for the lump sum payment shall be from entry point station to exit point station, as measured along pipeline survey stationing. No additional compensation will be allowed for contractor's adjustment to the profile depth or length, or that length which is outside the tolerances specified in these specifications, unless approved by Company.

12.4 Preparation of Pipe Ends, Nitrogen and Final Tie-In to Pipeline

- The HDD crossing pipe ends shall be installed at depth and angle suitable for final tie-in to the proposed and/or existing pipeline. Depending on the project schedule and construction plan, the final tie-ins for HDD crossing may be scheduled at a later date.
- CONTRACTOR shall install weld caps on the crossing pipe ends if tie-ins to the pipeline are delayed. Buried pipe ends shall be marked for future location by the contractor.
- If the HDD crossing is installed in advance of the tie-ins to adjacent pipeline, a nitrogen purge and 15-psig pack/fill will be required to eliminate the possibility of internal corrosion.

12.5 Final Reporting

- CONTRACTOR shall furnish to COMPANY a copy of the complete computer printout of the directional survey report (ParaTrack2, TruTracker or equal) made during the drilling operation and an as-built map of the horizontally drilled section showing the "x", "y", and "z" coordinates of the final location of the pipeline. All coordinates shall be in State Plane Coordinate system. As-built map to be overlaid on an aerial photo. The maximum spacing between coordinate points shall be every joint of drill pipe (approx. 30 feet).
- CONTRACTOR shall furnish the as-built drawing within 15 days after the pulled back pipe has been installed.

13.0 SITE CLEAN UP AND RESTORATION

13.1 Grouting and Sealing of Annulus and Abandoned Holes

- If requested in the contract documents, CONTRACTOR shall furnish and inject grout into annulus at entry and exit of the completed HDD. The minimum extent of the grouting will be to completely seal and fill the upper 30 feet of hole entirely with grout with the top 5 feet filled with soil compacted to match surrounding soil conditions. More extensive grouting may be required to prevent ground subsidence, comply with permit or other job conditions included elsewhere in this contract, all of which shall be the responsibility of the CONTRACTOR.
- CONTRACTOR shall fill abandoned drill holes with grout to completely seal and fill the upper 30 feet of hole entirely with grout and shall place compacted soil in the top 5 feet of the hole. COMPANY may require more extensive grouting up to and including grouting of entire abandoned pilot holes to prevent ground subsidence, hydraulic fracture of adjacent HDD paths, or to comply with permit or other job conditions included elsewhere in this contract, all of which are the responsibility of the CONTRACTOR.

13.2 Remediation of Ground Subsidence and Voids

- CONTRACTOR shall check for voids along all attempted drills and final drill corridor. CONTRACTOR shall fill voids and compact subsoil along installed pipeline and along any abandoned drill path. CONTRACTOR shall restore ground above drill corridor to original contours and condition including furnishing and installing COMPANY approved fill material, topsoil or pavements; at no additional cost to COMPANY. In the event the COMPANY has to seek permitting variances to place soil in environmentally sensitive areas such as wetlands or waterbodies, CONTRACTOR will not be relieved of these responsibilities.

13.3 Clean Up and Restoration

- CONTRACTOR shall remove all equipment, materials and trash and then perform final clean up and restore all work areas. Restoration shall include temporary and permanent revegetation as specified in the Drawings and Contract Documents.

End of HDD Specifications

APPENDIX L
Report Limitations and Guidelines for Use

APPENDIX L
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for the exclusive use of NW Natural and their authorized agents. This report is not intended for use by others, and the information contained herein is not applicable to other sites.

GeoEngineers structures our services to meet the specific needs of our clients. For example, a geotechnical or geologic study conducted for a civil engineer or architect may not fulfill the needs of a construction contractor or even another civil engineer or architect that are involved in the same project. Because each geotechnical or geologic study is unique, each geotechnical engineering or geologic report is unique, prepared solely for the specific client and project site. Our report is prepared for the exclusive use of our Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. This report should not be applied for any purpose or project except the one originally contemplated.

A Geotechnical Engineering or Geologic Report Is Based on a Unique Set of Project-specific Factors

This report has been prepared for NW Natural for HDD-1 through HDD-8 associated with the North Mist Expansion Project in Columbia County, Oregon. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, do not rely on this report if it was:

- not prepared for you.
- not prepared for your project.
- not prepared for the specific site explored.
- completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure.
- elevation, configuration, location, orientation or weight of the proposed structure.
- composition of the design team.
- project ownership.

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

If important changes are made after the date of this report, GeoEngineers should be given the opportunity to review our interpretations and recommendations and provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by manmade events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. Always contact GeoEngineers before applying a report to determine if it remains applicable.

Most Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied our professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

Do not over-rely on the preliminary construction recommendations included in this report. These recommendations are not final, because they were developed principally from GeoEngineers' professional judgment and opinion. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for this report's recommendations if we do not perform construction observation.

Sufficient observation, testing and consultation by GeoEngineers should be provided during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. You could lower that risk by having GeoEngineers confer with appropriate members of the design team after submitting the report. Also, retain GeoEngineers to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering or geologic report. Reduce that risk by having GeoEngineers participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design

drawings. Only photographic or electronic reproduction is acceptable, but recognize that separating logs from the report can elevate risk.

Give Contractors a Complete Report and Guidance

Some owners and design professionals believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering or geologic report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might an owner be in a position to give contractors the best information available, while requiring them to at least share the financial responsibilities stemming from unanticipated conditions. Further, a contingency for unanticipated conditions should be included in your project budget and schedule.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and to adjacent properties.

Read These Provisions Closely

Some clients, design professionals and contractors may not recognize that the geoscience practices (geotechnical engineering or geology) are far less exact than other engineering and natural science disciplines. This lack of understanding can create unrealistic expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory "limitations" provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you are unclear how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical, Geologic and Environmental Reports Should Not Be Interchanged

The equipment, techniques and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding a specific project.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings, or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants and no conclusions or inferences should be drawn regarding Biological Pollutants, as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria, and viruses, and/or any of their byproducts.

If Client desires these specialized services, they should be obtained from a consultant who offers services in this specialized field.

Have we delivered World Class Client Service?

Please let us know by visiting **www.geoengineers.com/feedback**.

GeoEngineers

Exhibit I - Soil Evaluation

North Mist Expansion Project
Columbia County, Oregon

for
NW Natural

November 19, 2015

GeoEngineers
Earth Science + Technology

Exhibit I – Soil Evaluation

North Mist Expansion Project
Columbia County, Oregon

for
NW Natural

November 19, 2015

GeoEngineers

1200 NW Naito Parkway, Suite 180
Portland, Oregon 97209
503.624.9274

Exhibit I – Soil Evaluation

North Mist Expansion Project
Columbia County, Oregon

File No. 6024-157-03

November 19, 2015

Prepared for:

NW Natural
220 NW 2nd Avenue, Suite 300
Portland, Oregon 97209

Attention: Mike Hayward

Prepared by:

GeoEngineers, Inc.
1200 NW Naito Parkway, Suite 180
Portland, Oregon 97209
503.624.9274

REGISTERED
OREGON
BRIAN C. RANNEY
No. G1947
GEOLOGIST

EXP 11-30-2015

Brian C. Ranney, CEG
Senior Geologist

Trevor Hoyles, PE
Principal

BCR:TNH:cje

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GEOENGINEERS

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APPENDIX I-A. EROSION CONTROL PLANS

I.1 INTRODUCTION

I.1.1 General

This report presents the results of GeoEngineers' soil evaluation for the proposed North Mist Expansion Project. The project location is shown with respect to the surrounding area in Figure I-1. We performed this evaluation to meet the Energy Facility Siting Council (EFSC) certificate application requirements for Exhibit I as presented in Oregon Administrative Rule (OAR) 345-021-0010(1)(i). The section headers of this report refer to the applicable elements of the EFSC Division 21 Application for Site Certificate administrative rules that are addressed in that section.

The information used in this evaluation included available geologic maps and the U.S. Department of Agriculture Natural Resources Conservation Survey (NRCS) soil maps.

I.1.2 Project Description

As described in Request for Amendment No. 11, NW Natural proposes to amend the Mist Facility's Site Certificate to expand the site boundary to develop new underground gas storage capacity through the development of the Adams reservoir, including construction of a new compressor station facility and new pipeline capacity.

Table I-1 below summarizes the proposed lengths of the pipelines, including the HDD segments and the shared trench.

TABLE I-1. PROPOSED PIPELINE LENGTHS

Name	Length (feet)
North Mist Expansion Pipeline	**68,753 (total length)**
North Mist Expansion Pipeline – HDD Installation	24,498
North Mist Expansion Pipeline – Open Trench Installation	44,255
Utility Conduit Trench	**11,564 (total length)**
Utility Conduit installed in non-shared open trench	9,118
Utility Conduit installed in open trench shared with the 24-inch pipeline.	2,446

In order to minimize impacts to natural resources and agricultural lands, a significant portion of the transmission pipeline will be installed utilizing horizontal directional drilling (HDD) methods. Approximately 36 percent of the North Mist Expansion Pipeline is proposed to be installed by HDD method, with a total of nine bore pads within the Columbia River flood plain area. As the pipeline emerges from the agricultural area near the Columbia River, the final bore pad is proposed for location within the PGE's PWIP property. The proposed pipeline, utility conduit and compressor station site are shown with respect to topography and the surrounding area in the attached Vicinity Map, Figure I-1.

I.2 SOIL CONDITIONS [OAR 345-021-0010(1)(I)(A)]

We identified shallow subsurface soil conditions in the proposed project site vicinity using the NRCS website soil maps (NRCS, 2014) and the Soil Conservation Service (SCS) Soil Survey of Columbia County (Smythe, 1986). The survey describes soil conditions in the upper 5 feet of the subsurface profile and classifies land use. Thirteen soil units were identified by the NRCS within the area of the proposed construction for the North Mist Expansion Project. A general description of each soil unit mapped in the project area is provided in Table I-2 below. Soils defined as "protected" are protected against flooding by either a dike or dredge material. Figure I-2 provides the NRCS soil unit index for the project vicinity and Figures I-3 through I-6 show the proposed facilities and pipeline relative to the NRCS soil map units.

TABLE I-2. SOIL UNIT DESCRIPTIONS

Soil Unit	Setting Within Project Area	Approximate Thickness	Formation Setting	Permeability	Runoff	Hazard for Erosion
Alstony Gravelly Loam	Moderate to steep slopes at higher elevations near ridge tops	2 feet	Colluvium derived from volcanic rocks and ash	Moderate	Very Rapid	High
Anunde Silt Loam	Gentle to moderate, stable, convex slopes	At least 5 feet	Colluvium derived from siltstone mixed with volcanic ash	Moderate	Rapid	High
Braun-Scaponia Silt Loam	Gentle to steep, active and stable, convex slopes	2.5 feet	Colluvium derived from siltstone	Moderate	Medium to rapid	High
Caterl Gravelly Silt	Moderate slopes	3.5 feet	Colluvium derived from igneous rock mixed with volcanic ash	Moderate	Rapid	High
Crims Silt Loam, Protected	Concave areas of low flood plains of the Columbia River	At least 5 feet	Partially decomposed plant material	Moderate	Slow	Slight
Locoda Silt Loam, Protected	Flood plains of the Columbia River	1 foot	Alluvium from mixed sources	Moderately slow	Slow	Slight
Murnen Silt Loam	Gentle to moderate, ridge tops and side slopes	4 feet	Colluvium and residuum derived from basalt mixed with volcanic ash	Moderate to high	Medium to rapid	Moderate to high
Scaponia-Braun Silt Loam	Active north and south convex slopes	3 to 5 feet	Colluvium derived dominantly from siltstone.	Moderate	Very rapid	High

Soil Unit	Setting Within Project Area	Approximate Thickness	Formation Setting	Permeability	Runoff	Hazard for Erosion
Tolke Silt Loam	Broad stable ridge tops and on gentle to moderate side slopes	5 feet	Volcanic ash and colluvium derived from siltstone and shale	Moderate	Medium to rapid	Moderate to high
Udipsamments, Protected	Flood plains of the Columbia River	At least 5 feet	Sandy dredge material	Rapid to very rapid	Slow	Slight to moderate
Wauld Very Gravelly Loam	Moderate to steep active side slopes	3 feet	Colluvium derived from basalt	Moderate	Rapid	High
Wauna Silt Loam, Protected	On flood plains of the Columbia River	At least 5 feet	Alluvium from mixed sources	Moderately slow	Slow to ponded	Slight
Wauna-Locoda Silt Loam	Flood plains of the Columbia River	At least 5 feet	Alluvium from mixed sources	Moderately slow	Slow to ponded	Slight

I.3 GROUNDWATER

Regional groundwater is located from fewer than 10 feet below the ground surface (bgs) in the Columbia River valley north of Highway 30 to hundreds of feet bgs in mountainous terrain south of Highway 30. Elevations within the project area range between about Elevation 0 feet above mean sea level (MSL) and 1,750 feet MSL. A well log obtained from the Oregon Water Resources Department for a water well drilled at the Miller Station compressor station indicated a static groundwater level of 188 feet beneath the surface (ORWD, 2009). Miller Station is located roughly 3 miles south of southern end of the project area, at an elevation of roughly 1,050 feet MSL. Localized perched groundwater may exist in the upland area of the project site. However, no specific indicators of perched groundwater such as springs or seeps have been mapped at the site.

We encountered groundwater within our borings completed for the trenchless (HDD) portion of the pipeline in the Columbia River valley at depths ranging from approximately 2 to 14 feet bgs, which generally correlates with the approximate elevation of the nearby Columbia River. However, during flooding conditions on the Columbia River, or during heavy prolonged precipitation, groundwater can rise to the ground surface within the valley north of Highway 30. We did not encounter groundwater in borings completed at the compressor station site. We anticipate that groundwater levels will fluctuate with precipitation, site utilization and other factors.

I.4 LAND USE [OAR 345-021-0010(1)(I)(B)]

Land use in the northern area of the project area (north of Highway 30), within the Columbia River valley, consists of pasture, blueberry and mint crops, tree farms and wildlife habitat.

Land use within the southern, upland portion of the project area south of Highway 30, includes managed timberlands, forested wildlife habitat and natural gas production. Timber harvesting has required construction of a network of skid roads and haul roads for operation and maintenance activities. Gravel roads have also been constructed for operation of the existing natural gas energy facilities in the area, for injection wells, and for pipelines. Native plant species and some non-native intrusive species currently grow in the harvest units of the project area, and where gravel roads are not maintained.

I.5 POTENTIAL ADVERSE IMPACTS TO SOIL [OAR 345-021-0010(1)(I)(C)]

The following section summarizes the potential impacts to soil from construction of the proposed North Mist Expansion Project.

I.5.1 Construction

Construction activities can introduce the potential for increased erosion due to soil disturbance, loss of vegetation, compaction and changes to surface drainage patterns. Erosion can be caused by increasing exposure to wind or water. Wind erosion is influenced by the wind intensity, vegetative cover, soil texture, soil moisture, grain-size of unprotected soil surface, topography, and by the frequency of soil disturbance. Wind erosion is not a significant concern in the project area because of the cohesive surface soils, moisture content of the soil in the northern region of the alignment, tree cover along and adjacent to the southern region of the alignment, and the erosion control measures that will be implemented to mitigate erosion potential. Water erosion is a function of primarily soil type, vegetative cover, precipitation, and slope inclination. If left unmitigated, erosion from rainfall will be a hazard during construction.

The runoff potential and water erosion hazard for the identified soils at the site range from slight to high with higher erosion potentials associated with steeper slopes. The NRCS reports that the site vicinity receives approximately 50 to 70 inches of rainfall per year. The erosion potential and available precipitation, therefore, make site soils sensitive to water erosion during much of the year, particularly where slopes are steep.

The proposed construction will disturb soil where grading and excavations will be required for preparation of the compressor station site, and pipeline installation. Specifically, the proposed construction areas include an 80-foot-wide easement along the pipeline and utility conduit alignments where they are not located along existing gravel roads, an approximately 40-foot-wide easement (or the width of the gravel road) where the pipeline and utility conduit are located within gravel roads and the approximately 10-acre North Mist Pipeline Compressor Station site. A number of temporary workspace, staging and storage areas are proposed along the 200-foot pipeline study corridor, with four other locations outside of the corridor, as depicted in the erosion control plans included in Appendix A. In addition, temporary workspaces and pipe stringing areas during HDD construction will disturb soil. The temporary entry and exit workspaces and pipe stringing areas for HDD installation will range from approximately 0.6 to 1.11 acres each. Construction of the pipeline in roadway areas will primarily involve trenching, associated stock piling of excavation spoils, placing pipe and backfilling the trenches. Vegetation removal will occur along overland pipeline segments and at the proposed North Mist Compressor Station. If not mitigated, the disturbed construction areas can modify drainage patterns by capturing, concentrating and rerouting surface water runoff. Such modifications can lead to increased erosion.

I.5.1.1 Drilling Fluids

The drilling fluids for HDD operations typically consist of a water and bentonite clay mixture that is prepared and contained in a mixing tank on the drilling fluid recycling system. In some instances, specialized polymers may be used to control fluid loss, prevent binding of clay particles or swelling of clays, or to control loss of drilling fluid circulation. Typical polymers used during HDD operations do not meet the definition of a "hazardous chemical" given in 29 CFR Part 1910.1200 (OSHA) and therefore do not present a risk of soil contamination during construction. The specific products used during construction will depend on the contractor's means and methods, and hole conditions encountered during construction. NW Natural will not allow any hazardous chemicals to be added to drilling fluids. Therefore, the drilling fluid will not present a risk of soil contamination.

The inadvertent release of drilling fluids in an undesired or unexpected location at the ground surface is commonly referred to as an inadvertent return, or a drilling fluid surface release. The unexpected release of drilling fluids typically occurs when the drilling fluid pressure exceeds the overburden pressure of the soil above the drill profile. The likelihood of drilling fluid surface releases is typically higher near the HDD entry/exit points where soil cover is comparatively thin (i.e., within 100 feet [measured horizontally] from the entry/exit points). Drilling fluid surface release mitigation measures are discussed in Section 1.6.1.6 of this exhibit.

Drilling fluids are managed by pumping drilling fluid that returns through the annulus of the drilled hole to a drilling fluid recycling system where the cuttings are separated from the fluid and the fluid is then pumped again downhole through the drill pipe. There will be secondary containment (plastic sheeting/sand bag berms) constructed beneath the drilling fluid recycling system. Upon conclusion of the HDD operations, the drilling fluid is collected in Vacuum trucks or tanker trucks and hauled off site to an approved dump location for disposal.

A more comprehensive description of the overall HDD operation is presented as Attachment F to Exhibit J.

I.5.2 Operations

Operations activities will be limited to those areas directly related to the North Mist Expansion Project. Other parts of the project area will not be affected.

Along overland sections of the pipeline and conduit corridor, vegetation will be reestablished in accordance with the mitigation strategy described in Exhibit K, and will be maintained to provide access for monitoring during operations. Where the pipeline and utility corridor follow existing gravel roads, no vegetation management is anticipated. Existing gravel roads will be used to access major components of the proposed project. We do not anticipate that significant soil disturbance or erosion will result from typical operations. The proposed compressor station site will be covered with gravel and/or pavement that will have a low susceptibility to wind and water erosion.

Some stormwater will be shed from graveled surfaces and structures during periods of precipitation. There will be no land application of liquid wastes, and no hazardous liquid materials will be produced during operations. However, chemical spills during construction could potentially adversely impact soils adjacent to the North Mist Compressor Station if these spills migrate offsite. In addition, chemical spills could adversely impact soil if the chemicals were to percolate through gravel portions of the site, and into the underlying soils. Impact to the soils would generally include chemical contamination of the soils from

operational products such as oil or water/oil mixtures. Soils impacted by chemical spills would be removed and disposed of properly, and replaced with clean soils of similar composition.

I.5.3 Retirement

Retirement will consist of abandoning the pipelines (including the injection/withdrawal (I/W) and transmission pipelines) and leaving them in place, and removing equipment at the compressor station. Erosion hazards during decommissioning of the pipelines will be minimal. Potential erosion hazards during retirement of the compressor station will be similar to those occurring during construction.

I.6 MITIGATION OF POTENTIAL ADVERSE IMPACTS [OAR 345-021-0010(1)(I)(D)]

Potential adverse impacts to soil from construction, operations and retirement of the proposed pipeline, utility conduit and compressor station should be mitigated by adhering to appropriate erosion and sediment control Best Management Practices (BMPs) during construction and operations. Specific mitigation measures are included in the following sections.

I.6.1 Construction

1.6.1.1 General

Restoration and revegetation of disturbed areas that is not necessary for operations will be completed following construction. Roadway areas will be restored to their original grades, drainage condition and rock surface. Exposed soil in overland segments that are affected by construction will be seeded when there is adequate soil moisture, and reseeded in the spring if a healthy cover crop does not grow. Straw mulch will be placed over the seeded areas to stabilize the soil surface until permeant vegetation is established. Sediment fences and check dams will remain in place and be maintained until the affected areas are well vegetated.

Overland corridors will be constructed with waterbars adequately spaced so that surface drainage continues to natural drainage patterns, with minimal diversions through ditches and culverts. Regular maintenance of drainage facilities will be conducted to ensure continued proper operation.

Possible contamination from construction equipment or supplies such as lubricant and fuel will be controlled in accordance with the applicant's spill prevention and management plan. Sanitary wastes generated during construction will be limited to portable toilets, which will be serviced regularly by a qualified sewage disposal vendor.

Soils at the project area will be susceptible to water erosion. However, where the proposed pipeline alignment follows existing roadways, water erosion will be minimal because of surface water drainage systems and crushed rock road surfacing that are already in place. In overland segments, the pipeline alignment will be relatively narrow and will be protected from erosion using current erosion control BMPs. A project-specific Erosion and Sediment Control Plan (ESCP) was completed to fulfill requirements of the National Pollutant Discharge Elimination System (NPDES) permit 1200-C. The ESCP is included as Appendix A of this report. Erosion control measures to be employed during construction will include, but not necessarily be limited to the following:

1.6.1.2 Forested Areas

The proposed pipeline will be installed in an open trench within forested areas. A portion of the alignment is situated cross country on densely forested lands, while a portion is located within existing roadways. Mitigation measures within forested lands will include:

- Stripping topsoil to a minimum depth of 12 inches, and stockpiling topsoil for replacement after pipeline installation to promote vegetation growth. Stripping topsoil will occur after logging operations to remove large trees, and grubbing operations to remove tree stumps.
- Installing sediment fence or other approved BMPs at downslope sides of excavations and disturbed areas.
- Installing check dams along areas of concentrated water flow runoff, particularly in roadside ditches.
- Placing straw mulching, erosion control fabric, and/or hydroseed with tacifier on all soils disturbed by construction. In general, erosion control fabric will be placed over mulch where slopes exceed 40 percent, on stream adjacent banks, or within drainage channels restored after construction.
- Providing temporary sediment traps downstream of intermittent stream crossings.
- In collaboration with agricultural and commercial timber operators, planting designated seed mixes and seedlings within affected areas to reestablish permanent vegetative cover and to restore commercial timber.
- Construction and maintenance of waterbars (essentially small interceptor dikes) in sloping overland segments of the pipeline alignment.
- Leaving vegetative buffers where practical.

1.6.1.3 Agricultural Areas

Within agricultural lands, the proposed pipeline will be installed by a series of HDDs connected to each other by relatively short tie-in trenches. Installing the pipeline in this manner across agricultural land will limit the areas of disturbance primarily to the HDD entry and exit workspace where excavation will be required to contain drilling fluid, and short open trench installation segments between the HDDs. No vegetation removal or excavation will be required within the temporary pipe stringing and fabrication work areas. The following mitigation measures are intended to be applied to all agricultural lands, including those that are fallow.

- Stripping topsoil to a minimum depth of 18 inches, and stockpiling topsoil within entry and exit workspaces and open trench segments for replacement after pipeline installation to promote vegetation growth.
- Placing straw mulching over applied seed. Straw mulch will be applied at 4,000 pounds per acre, or a functional equivalent. Mulch will not be applied within wetland boundaries.
- Installing orange sediment fence to identify construction limits and limit off-site migration of soils.
- Replace stockpiled topsoil, and reseed with approved seed mixes, or in accordance with landowner agreements
- Leaving vegetative buffers in areas where excavation is not required to install the pipeline.
- Providing temporary sediment traps downstream of intermittent stream crossings.

- Planting designated seed mixes within affected areas.
- Placing load dispersing timber mat roads within pipe stringing and fabrication workspaces, and particularly where these workspace cross mapped wetlands, to reduce soil compaction and disturbance.
- Decompaction of the topsoil and subsoil: NW Natural will relieve soil compaction using an agricultural subsoiler or similar piece of equipment to loosen compacted soils. Where topsoil had been stripped and stockpiled prior to installation of the pipeline, the subsoil will be relieved of compaction prior to placement of the topsoil and final grading of the topsoil. Where topsoil is not stripped (i.e. pipe stringing areas), NW Natural will conduct deep tillage to relieve soil compaction, if necessary. Weather and soil conditions permitting, NW Natural will conduct soil decompaction when soil moisture levels allow for effective soil shattering. Decompaction equipment will not be operated on soils that are too wet, such that a greater level of disturbance might result.

1.6.1.4 Wetland Areas

Wetland areas along the proposed pipeline are limited to those identified within the agricultural lands. In addition, to the mitigation measures described above, the following mitigation measures will be completed within designated wetland areas.

- Placing load dispersing timber mat roads within pipe stringing and fabrication workspaces to reduce soil compaction and disturbance.
- Segregating and replacing hydric soils to match preconstruction conditions

1.6.1.6 Drilling Fluid Surface Release (Inadvertent Returns)

Measures will be implemented to reduce the risk of drilling fluid surface release adversely impacting soils or public safety. Drilling fluid surface release prevention measures will include the contractor and/or NW Natural environmental representatives closely monitoring drilling fluid returns to the entry/exit points; a reduction or loss of returns indicates a drilling fluid surface release may have occurred. Furthermore, the contractor or NW Natural will provide an employee designated as a “look out” to observe the ground surface within approximately 150 feet of the entry/exit point for signs of drilling fluid surface releases any time drilling fluid is being circulated.

In the event of a drilling fluid surface release, the contractor will immediately disengage drilling fluid pumps and drilling will be temporarily halted. These actions should result in relatively low amounts of drilling fluid being released to the ground surface. The contractor will then immediately contain the fluid, typically using silt fencing, hay bales or straw wattles. The fluid will be cleaned from the ground surface using hand tools and a vacuum truck, and transported to the entry point for cleaning and reuse, or hauled off site for disposal. The drilling fluid release area will be continuously monitored and any additional drilling fluid that surfaces will be immediately removed from the surface as drilling progresses. However, it is common for a drilling fluid release conduit to be plugged with soil cuttings such that no additional drilling fluid surfaces at that location. The contractor will have the following supplies/BPMs and equipment ready to deploy at all times when drilling fluid is being circulated:

- Portable pumps
- Hand tools (shovels, pulaski axes, rubber long-handle squeegee)

- Silt fence
- Hay bales
- Straw wattles
- Vacuum trucks
- Other heavy equipment such as backhoes

A more comprehensive inadvertent drilling fluid returns plan is presented as Attachment F to Exhibit J.

Upon completion of each HDD installation, the drilling fluid will be hauled offsite for disposal. NW Natural expects that the above noted drilling fluid surface release prevention measures, and the immediate containment and removal of any drilling fluid surface release that may occur, will result in a relatively low risk of the drilling fluid adversely affecting soils.

1.6.1.6 Chemical Spills during Construction

NW Natural will require the selected contractors to develop a spill prevention and management plan prior to construction. NW Natural expects that the spill prevention and management plan will incorporate BMPs such as drip pans, secondary containment for all stationary equipment (such as drill rigs, drilling fluid pumps, centrifugal pumps, mobile fluid storage tanks [“Baker Tanks”]). NW Natural will require spill kits to be readily accessible at all active construction areas, and will limit fueling of equipment onsite or within approximately 100 feet of a water body of wetland. Drip pans will be used to catch relatively small quantities of fluids during equipment maintenance. Secondary containment may range from heavy plastic circular swimming pools for equipment such as centrifugal pumps or trash pumps, to thick plastic sheeting that is incorporated with a sand bag berm that will enclose areas beneath a drill rig, drilling fluid recycling system and mobile fluid storage tanks. Only commonly used lubricants for construction operations will be stored onsite during construction (i.e. Hydraulic oil, grease), and these materials will be stored in designated enclosed areas to provide secondary containment. No fuel or other hazardous liquids will be stored onsite. Spill kits will be staged within all active construction areas so in the event that a spill does occur, clean up can begin immediately to mitigate the risk of adverse impacts to the soils. Spill kits will typically include absorbent pads and granules, shovels, plastic for emergency containment, universal containment socks, nitrile gloves and disposal bags. In the event that spill kits are used, the waste products will be handled in accordance with Exhibit G. In some instances, equipment such as excavators and drill rigs may need to be fueled onsite. Construction vehicles such as tool vans, equipment service vehicles and personal vehicles will be fueled offsite. All equipment will be fueled a minimum of 100 feet away from water bodies or delineated wetlands. Spill kits will be staged on fueling equipment in the unlikely event that a fuel spill occurs during equipment fueling. These measures should adequately mitigate the risk of adverse impacts to soil or the risk of public health and safety resulting from potential spills during construction.

I.6.2 Operations and Maintenance [OAR 345-021-0010(1)(I)(E)]

Operation and maintenance of the proposed expansion project will not have a significant impact on the soils because soil disturbance is not anticipated. Consequently, no measures to mitigate adverse impacts to the soil are necessary. However, monitoring of the system will be completed annually by NW Natural staff as part of an in-house regular maintenance program. If problem areas are observed,

appropriate mitigation and remediation measures will be implemented specific to the problem at that time.

NW Natural will develop a Spill Prevention and Management Plan, or similar document(s) as required by state and federal regulations, for the North Mist Compressor Station facility. BMPs that may be implemented to avoid or mitigate adverse impacts to soils resulting from chemical spills during operation of the North Mist Compressor Station may include (but are not limited to) the following:

- Containment diking – temporary or permanent polyurethane or plastic berms, concrete berms, or retaining walls designed to hold chemical spills.
- Curbing – a barrier that surrounds and area of concern and prevents spills or leaks from being released to the environment bout routing runoff to treatment or control areas.
- Drip pans – Pans used to contain very small volumes of leaks, drips, and spills.
- Absorbent socks – tubular wrapped absorbent material used to contain, and to some degree to clean up, a relatively small spill.
- Absorbent granules – a granulated or powder substance with absorbent properties that absorb liquids on contact and turns the spilled liquids into a solid that can be easily disposed.

The final design of the North Mist Compressor Station is not complete. The above discussion is intended to present a broad range of BMPs that may be implemented. The actual BMPs used for operation will be decided during final design of the North Mist Compressor Station.

I.6.3 Retirement

The erosion hazard will be minimal during decommissioning of the pipelines; adequate erosion control measures will be implemented where necessary. Similar erosion control BMPs presented in Section I.6 should be implemented to prevent erosion during retirement of the North Mist Pipeline Compressor Station.

I.7 LIMITATIONS

We have prepared this report for use by NW Natural and other members of the design team involved with this project. The report is not intended for use by others, and the information contained herein is not applicable to other sites. The data and report should be provided to prospective contractors, but our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions. The conclusions and recommendations in this report should be applied in their entirety.

Variations in subsurface conditions from those found during our research are possible. Subsurface conditions may also vary with time. A contingency for unanticipated conditions should be included in the project budget and schedule for such an occurrence. We recommend that sufficient monitoring, testing and consultation be provided by GeoEngineers during construction to confirm that the conditions encountered are consistent with those indicated by our research, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork and pipeline installation activities comply with contract plans and specifications.

The scope of our services does not include services related to construction safety precautions. Our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No warranty or other conditions, express or implied, should be understood.

I.8 REFERENCES

Natural Resources Conservation Service, U.S. Department of Agriculture Web Soil Survey, http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. Accessed December 1, 2014.

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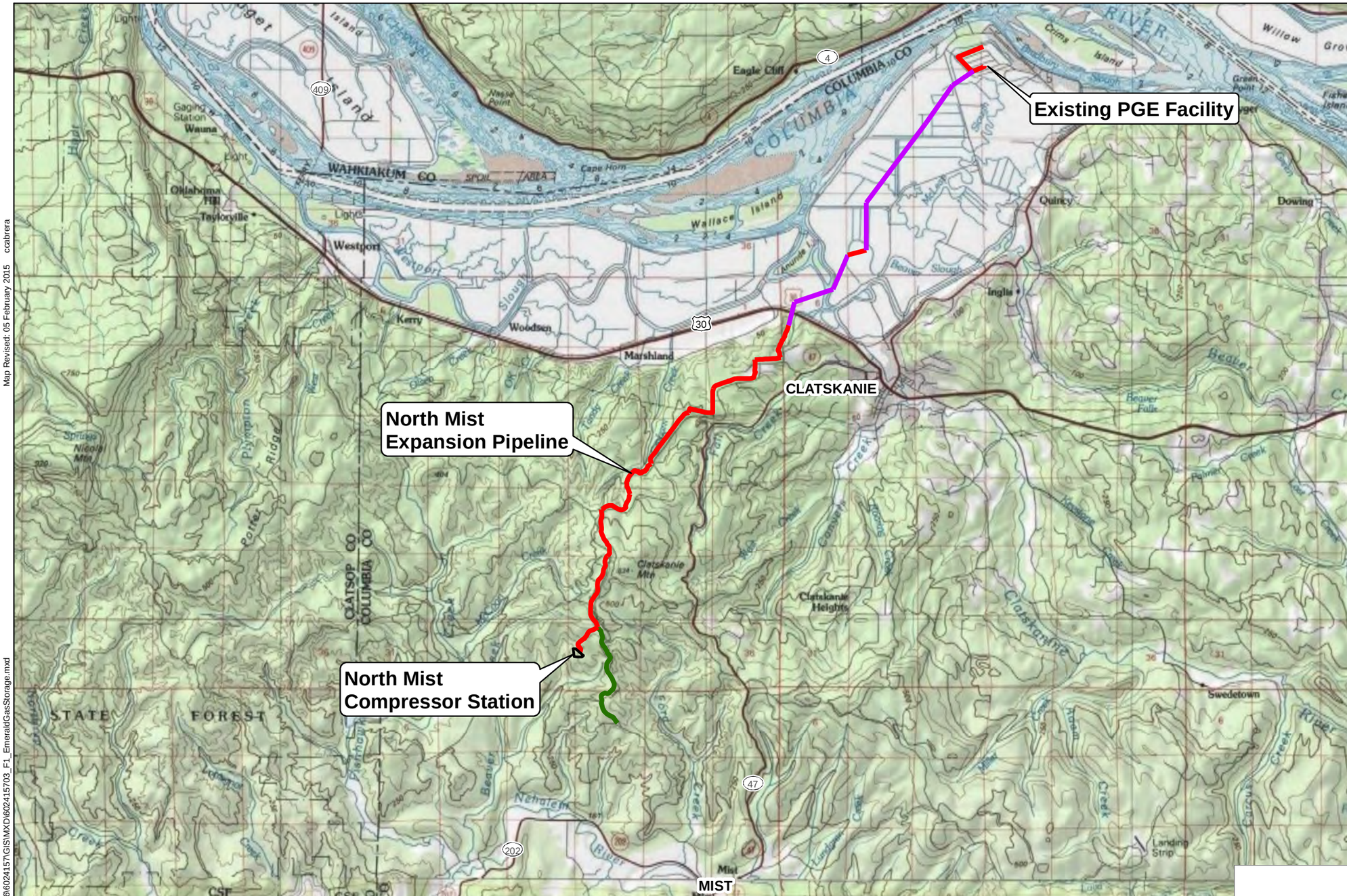

Reference:
ESRI Data & Maps, Street Maps 2008
Topo map obtained from NGS_Topo_US_2D, http://server.arcgisonline.com/arcgis/services

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Vicinity Map

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure I-1

Map Revised: 05 February 2015 ccabrera

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Office: PORT

- 3E - Alstony gravelly loam, 30 to 60 percent north slopes
- 3F - Alstony gravelly loam, 60 to 90 percent north slopes
- 4E - Alstony gravelly loam, 30 to 60 percent south slopes
- 5D - Anunde silt loam, 3 to 30 percent slopes
- 6D - Bacona silt loam, 3 to 30 percent slopes
- 7D - Braun-Scaponia silt loams, 5 to 30 percent slopes
- 8F - Braun-Scaponia silt loams, 60 to 90 percent north slopes
- 9F - Braun-Scaponia silt loams, 60 to 90 percent south slopes
- 11E - Caterl gravelly silt loam, 30 to 60 percent north slopes
- 12E - Caterl gravelly silt loam, 30 to 60 percent south slopes
- 15 - Crims silt loam, protected
- 18E - Dowde silt loam, 0 to 60 percent north slopes
- 19E - Dowde silt loam, 30 to 60 percent south slopes
- 23C - Goble silt loam, warm, 3 to 15 percent slopes
- 23D - Goble silt loam, warm, 15 to 30 percent slopes
- 24 - Hapludalfs-Udifluvents complex
- 26C - Kenusky silty clay loam, 0 to 15 percent slopes
- 28 - Locoda silt loam
- 29 - Locoda silt loam, protected
- 30D - Mayger silt loam, 3 to 30 percent slopes
- 35B - Multnomah variant loam, 0 to 8 percent slopes
- 36D - Murnen silt loam, 3 to 30 percent slopes
- 44D - Rinearson silt loam, 3 to 30 percent slopes
- 44E - Rinearson silt loam, 30 to 60 percent slopes
- 49E - Scaponia-Braun silt loams, 30 to 60 percent north slopes
- 50E - Scaponia-Braun silt loams, 30 to 60 percent south slopes
- 53D - Tolany loam, 3 to 30 percent slopes
- 56D - Tolke silt loam, 5 to 30 percent slopes
- 57D - Tolke-Alstony complex, 5 to 30 percent slopes
- 58 - Treharne silt loam
- 59 - Udifluvents-Dystrochrepts complex
- 60 - Udipsamments, nearly level
- 61 - Udipsamments, nearly level, protected
- 64E - Wauld very gravelly loam, 30 to 70 percent slopes
- 65D - Wauld-Rock outcrop complex, 5 to 30 percent slopes
- 66 - Wauna silt loam, protected
- 67 - Wauna-Locoda silt loams
- 68 - Wauna-Locoda silt loams, protected
- Water

Data Source: NRCS Soils data from USDA, websoilsurvey.nrcs.usda.gov/.

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Projection: NAD 1983 UTM Zone 10N

NRCS Soils Index

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure I-2

December 08, 2014 ccabrera
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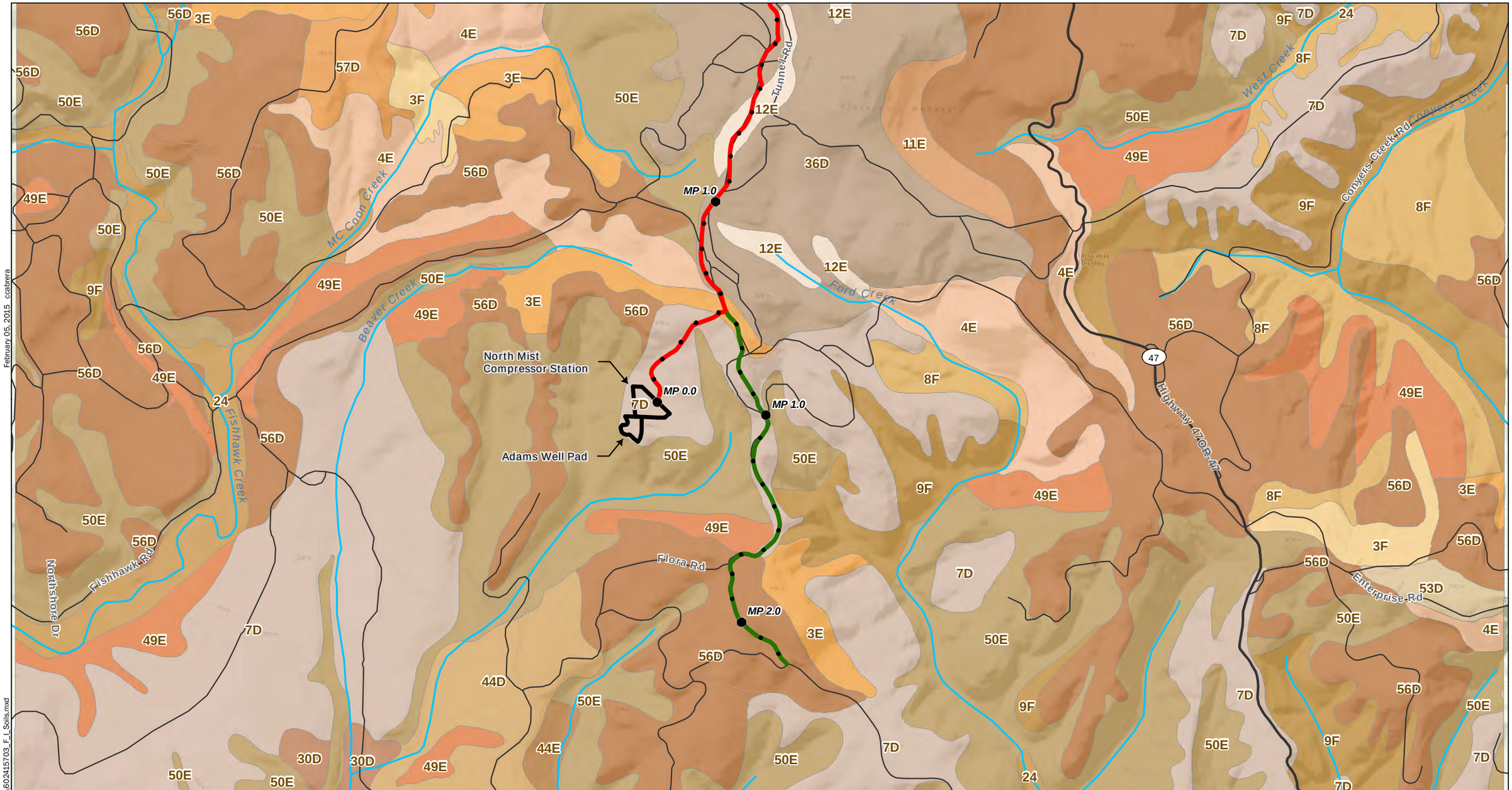

February 05, 2015 ccabrera

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Data Source: NRCS Soils data from USDA, websoilsurvey.nrcs.usda.gov/.
Hillshade base and 2013 Street data from ESRI Data Online.

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Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

N W E S

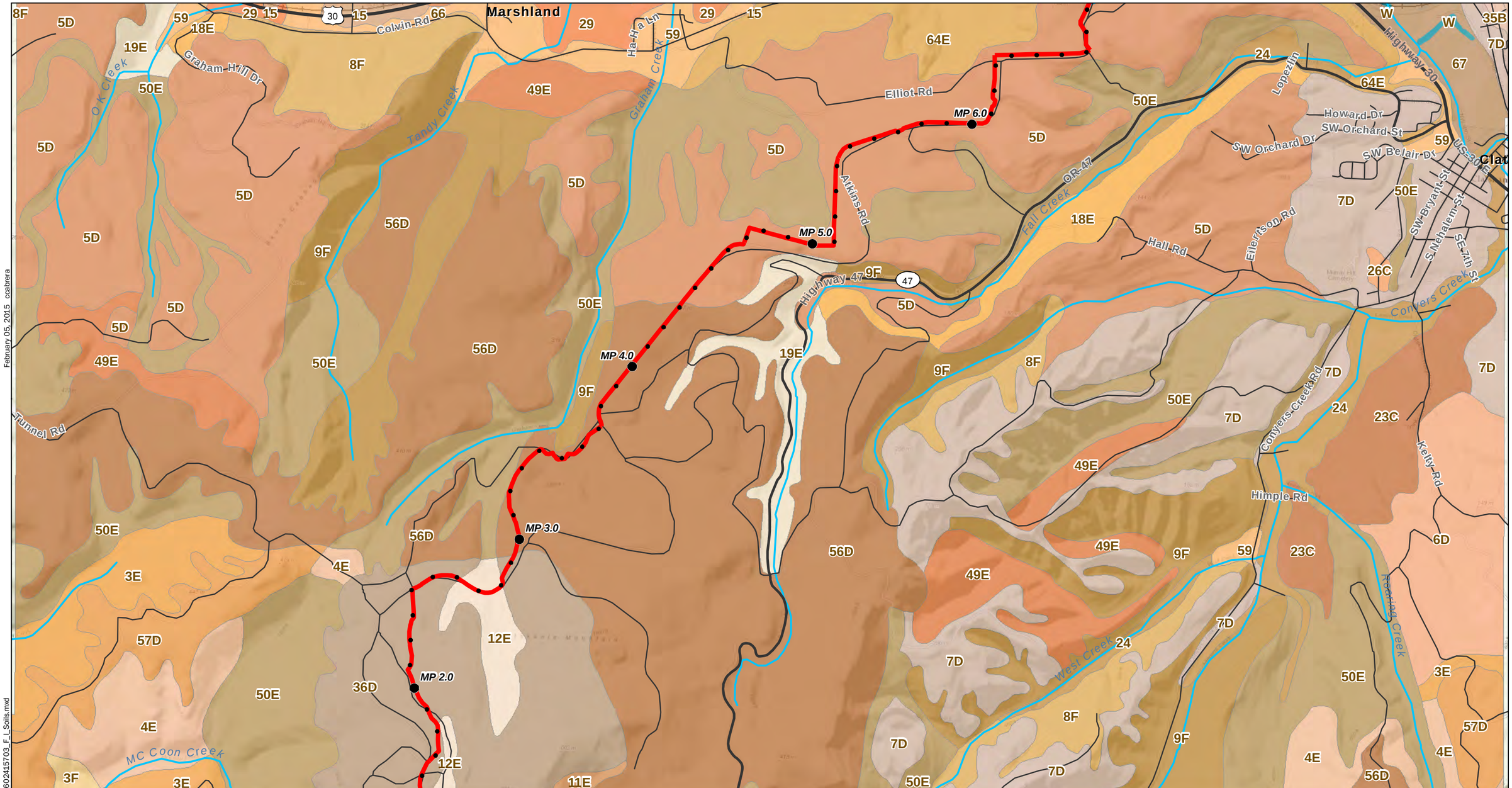
2,000 0 2,000
Feet

Soils Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure I-3



Data Source: NRCS Soils data from USDA, websoilsurvey.nrcs.usda.gov/.
Hillshade base and 2013 Street data from ESRI Data Online.

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Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

N W E S

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Feet

Soils Map

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure I-4

February 05, 2015 ccabrera

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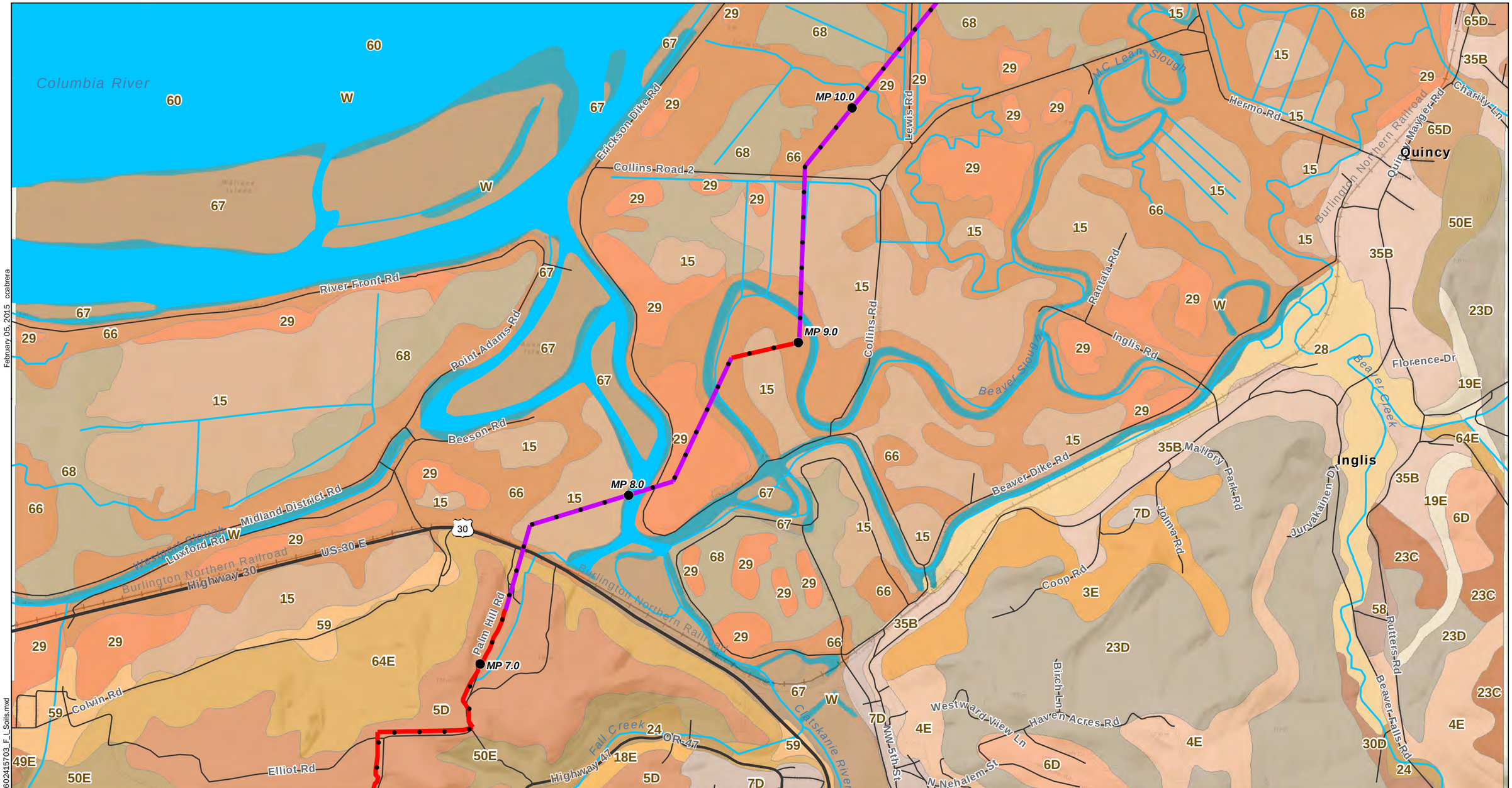

Data Source: NRCS Soils data from USDA, websoilsurvey.nrcs.usda.gov/.
Hillshade base and 2013 Street data from ESRI Data Online.

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Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

N W E S

2,000 0 2,000
Feet

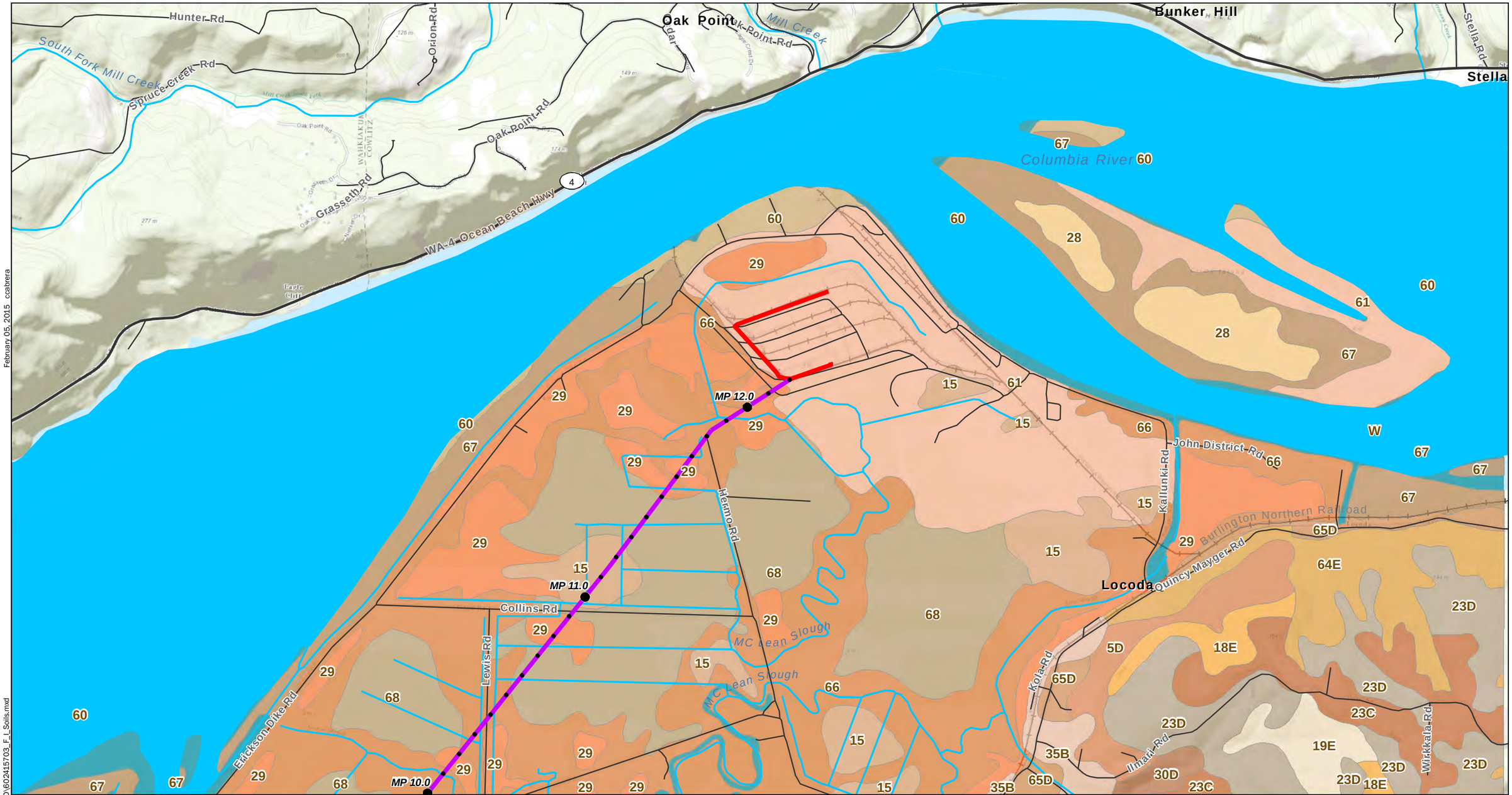
Soils Map

North Mist Expansion Project
Columbia County, Oregon

GeoEngineers

Figure I-5

Office: PORT Path: P:\6\6024157\GIS\MXD\602415703_F_I_Soils.mxd February 05, 2015 ccabrera



Data Source: NRCS Soils data from USDA, websoilsurvey.nrcs.usda.gov/.
Hillshade base and 2013 Street data from ESRI Data Online.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601

Legend

- North Mist Expansion Pipeline Open Trench
- North Mist Expansion Pipeline HDD Installation
- Utility Conduit Route
- Milepost

N W E S

2,000 0 2,000
Feet

Soils Map

North Mist Expansion Project
Columbia County, Oregon

GEOENGINEERS

Figure I-6

February 05, 2015 ccabrera

Path: P:\6\6024157\GIS\MXD\6024157\03_F_I_Soils.mxd

Office: PORT

APPENDIX I-A
Erosion Control Plans

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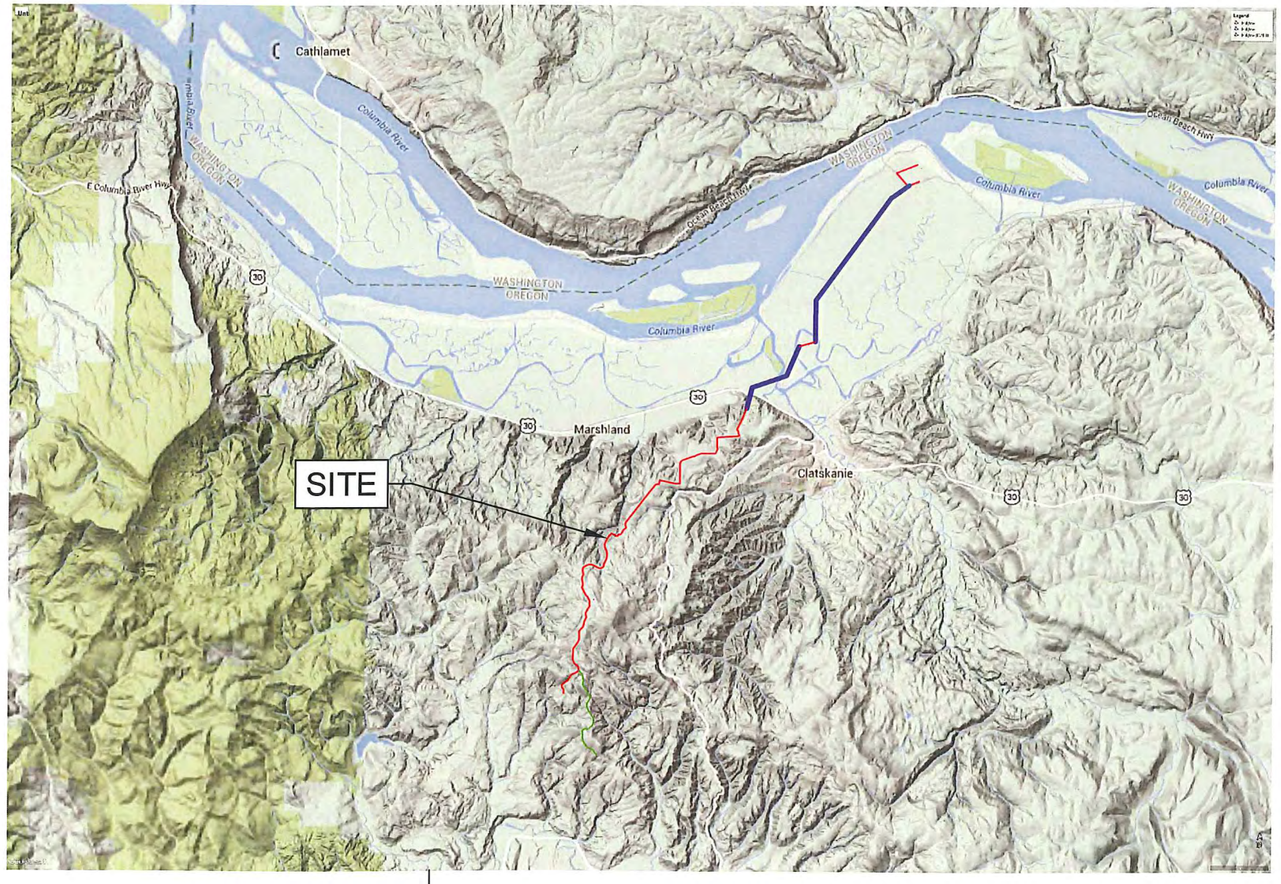
NORTH MIST PIPELINE EXPANSION PROJECT
EROSION AND SEDIMENT CONTROL PLAN



LEGEND

- HDD INSTALLATIONS (SUBSURFACE)
- OPEN TRENCH ALIGNMENT
- UTILITY CONDUIT ALIGNMENT

NW Natural

PREPARED FOR:

NW NATURAL GAS COMPANY
220 NW 2nd AVE., PORTLAND, OR 97209
PHONE: 503-226-4211
FAX: 503-273-4822

PREPARED BY:

GEOENGINEERS, INC.
15055 SW SEQUOIA PKWY., STE 140
PORTLAND, OR 97224
BRIAN C. RANNEY, CEG CESCL ID# 24107

April 3, 2015

CERTIFIED OREGON
BRIAN C. RANNEY
No. E1917
ENGINEERING GEOLOGIST
Exp. 11/30/2015

BCR : BTL

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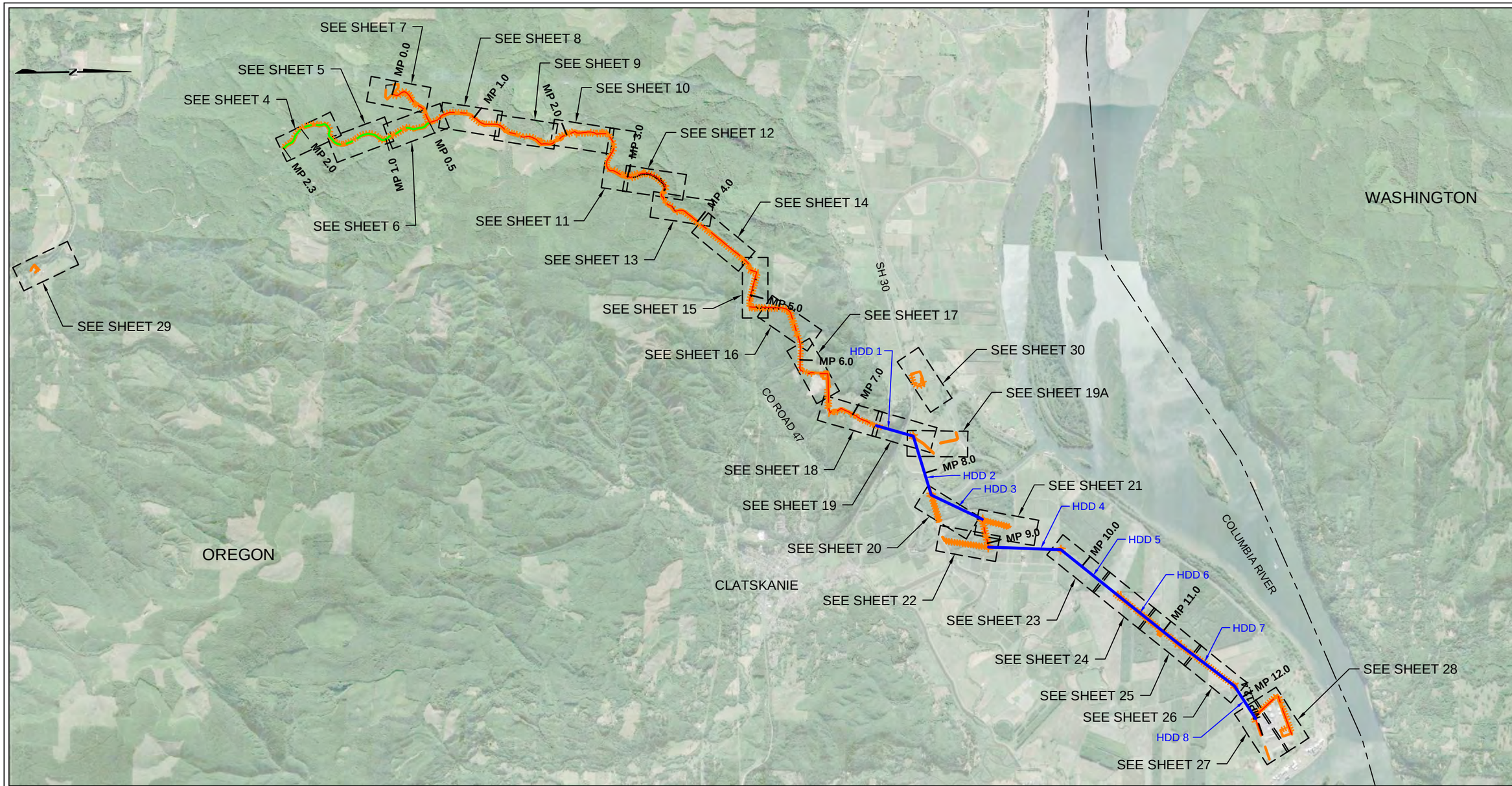

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PLAN

5000' 0 5000'

SCALE IN FEET

LEGEND

- HDD ALIGNMENT (SUBSURFACE)
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT ALIGNMENT
- LIMITS OF DISTURBANCE

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN SET KEY

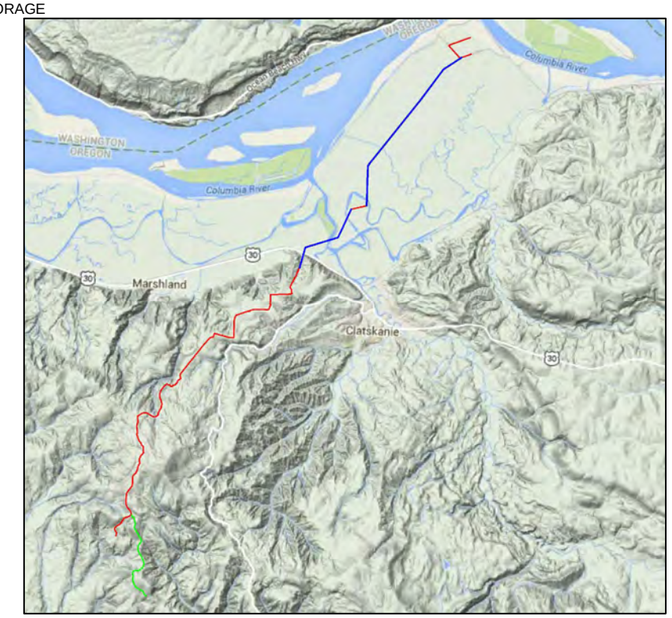
Drawing No.
KEY

Sheet

SHEET INDEX

EROSION AND SEDIMENT CONTROL PLAN

SHEET 1	COVER SHEET
SHEET 2	STANDARD ESCP SPEC
SHEET 3	STANDARD ESCP BMP
SHEET 4	ESCP - OPEN TRENCH
SHEET 5	ESCP - OPEN TRENCH
SHEET 6	ESCP - OPEN TRENCH
SHEET 7	ESCP - OPEN TRENCH
SHEET 8	ESCP - OPEN TRENCH
SHEET 9	ESCP - OPEN TRENCH
SHEET 10	ESCP - OPEN TRENCH
SHEET 11	ESCP - OPEN TRENCH
SHEET 12	ESCP - OPEN TRENCH
SHEET 13	ESCP - OPEN TRENCH
SHEET 14	ESCP - OPEN TRENCH
SHEET 15	ESCP - OPEN TRENCH
SHEET 16	ESCP - OPEN TRENCH
SHEET 17	ESCP - OPEN TRENCH
SHEET 18	ESCP - HDD 1 STRINGING AND FABRICATION AREA
SHEET 19	ESCP - HDD 1 SITE PLAN
SHEET 19A	ESCP - TEMPORARY ACCESS ROAD
SHEET 20	ESCP - HDD 3 SITE PLAN
SHEET 21	ESCP - HDD 3 STRINGING AND FABRICATION AREA
SHEET 22	ESCP - HDD 4 STRINGING AND FABRICATION AREA
SHEET 23	ESCP - HDD 5 SITE PLAN
SHEET 24	ESCP - HDD 5 STRINGING AND FABRICATION AREA
SHEET 25	ESCP - HDD 6 SITE PLAN
SHEET 26	ESCP - HDD 7 SITE PLAN
SHEET 27	ESCP - HDD 8 STRINGING AND FABRICATION AREA
SHEET 28	ESCP - OPEN TRENCH
SHEET 29	ESCP - PIPE STORAGE
SHEET 30	ESCP - PIPE STORAGE
SHEET 31	ESCP - DETAILS
SHEET 32	ESCP - DETAILS
SHEET 33	ESCP - DETAILS
SHEET 34	ESCP - DETAILS
SHEET 35	ESCP - DETAILS
SHEET 36	ESCP - DETAILS



VICINITY MAP
NOT TO SCALE

LEGEND

- HDD INSTALLATIONS (SUBSURFACE)
- OPEN TRENCH ALIGNMENT
- UTILITY CONDUIT ALIGNMENT

NARRATIVE DESCRIPTIONS

EXISTING SITE CONDITIONS

General

Existing topographic conditions along the proposed alignments can be separated into two distinct areas that are defined by Highway 30 near Clatskanie Oregon. South of Highway 30, topographic conditions consist of densely forested mountainous terrain, while north of Highway 30 topographic conditions consist of the relatively flat Columbia River Valley that is occupied by tree farms and other agricultural uses. The project will included installation of the 24-inch North Mist Pipeline, installation of an 8-inch utility conduit, and development of a compressor station and adjacent well pad. Topographic and vegetative conditions for each of these developments are described below.

In general, the proposed North Mist Pipeline route starts at the proposed compressor station at the south end of the project, traverses mountainous terrain northward to the Columbia River valley north of Highway 30, and then traverses the relatively flat Columbia River valley to an existing PGE power facility in Port Westward, Oregon. The proposed utility conduit route starts at the proposed compressor station and continues southward along mostly along existing gravel roads through rugged terrain to an existing utility junction box.

North Mist Pipeline

Beginning at the proposed compressor station, at an elevation of roughly 1,300 feet MSL, the proposed pipeline alignment climbs moderate to steep slopes cross country between MP 0 and MP 0.5 to an elevation of 1,580 feet MSL. Vegetation within this segment consists of a dense conifer forest. At MP 0.5 the alignment follows an existing gravel road and pipeline right-of-way (ROW) traversing moderately steep side-slopes to a maximum elevation of about 1,800 feet MSL at MP 1.65, where it then leaves the road, climbs a moderate forested slope to an elevation of about 1,840 feet MSL and then traverses a west facing forested slope to about MP 2.0. The alignment then descends moderately steep forested slopes to an existing road at MP 2.4. Between MP 2.4 and MP 2.8, the pipeline follows a gravel road traversing moderately steep side slopes, crossing a drainage, which is a tributary of Graham Creek. At this point, the alignment leaves the gravel road, but continues to traverse moderate steep forested side slopes just west of the gravel road to an elevation of about 1,440 feet MSL at about MP 3.0 The alignment then descends cross country between MP 3.0 and MP 3.4 along moderate forested slopes, predominately along the crest of a ridge to an elevation of about 1,060 feet MSL. From MP 3.4 to MP 7.0, the alignment generally follows an existing gravel road around the headwall of a tributary of Graham Creek, and then gradually descends gentle slopes along a broad ridge top, mostly following existing gravel and paved roadways, before descending the southern Columbia River Valley wall along Palm Hill Road to about MP 7.47, at an elevation of about 200 feet MSL. Between MP 7.47 and roughly MP 7.5, the pipeline alignment descends a cliff (by way of a HDD) adjacent to Highway 30. The proposed HDD exits on the relatively flat Columbia River valley at an elevation of about 0 feet MSL at about MP 7.5. Between MP 7.5 and the end of the pipeline at MP 12.2, the pipeline traverses cross-country across the relatively flat Columbia River valley, crossing the Clatskanie River and several sloughs within the valley to the existing PGE power generation facility near the southwest bank of the Columbia River. Land use and Vegetation within the Columbia River Valley segment consists of poplar tree farms, agricultural grass fields, blueberry farms and mint farms. Stream adjacent vegetation assocated with the Clatsakine River, Beaver Slough, Larson Slough and the many agricultrial drainage ditches generally consists of willows and blackberry. The pipeline within the Columbia River Valley segment will be installed almost entirely by HDDs, with short tie-inch trenches between each HDD as shown on the attached plans.

North Mist Pipeline Compressor Station

The proposed North Mist Pipeline Compressor station site is located on gentle slopes along a broad mid-slope bench with elevations ranging from approximately 1,285 feet above mean sea level (MSL) in the southwest corner of the site to approximately 1,320 feet above MSL on the eastern border of the site. Vegetation within the compressor station site generally consists of dense conifer forest.

Utility Conduit

The proposed utility conduit leaves the proposed compressor station site (approximate elevation 1,300 feet MSL) and is co-located with the proposed pipeline alignment to approximate MP 0.52. From MP 0.0 to MP 0.52, the utility conduit route climbs cross country through densely forested mountainous terrain to an existing gravel road at an elevation of approximately 1,500 feet MSL. The proposed utility conduit route then turns southwest and follows an existing road to about MP 0.75, where the route then follows a maintained power line corridor along a ridgeline to about MP 0.98. Vegetation within the power line corridor consists of forest shrubs (salal, fern, etc) and relatively short deciduous trees. at MP 0.98 the utility conduit route again meets up with an existing gravel road at an elevation of about 1,320 feet MSL. The proposed utility conduit route then traverses steep mountainous terrain as it follows a gravel road to the southern end of the proposed utility conduit route at an elevation of about 1,280 feet MSL. Between MP 1.0 and the southern terminus of the route at approximately MP 2.2, the gravel road and utility conduit route generally traverses steep, west to southwest facing slopes.

DEVELOPED CONDITIONS

North Mist Pipeline

Where the proposed North Mist pipeline traverses cross country across forested terrain south of Highway 30, the right-of-way (ROW) will be cleared of vegetation before construction. Topsoil will be segregated and stockpiled, and replaced after open trench installation. After open trench installation is completed, waterbars will be installed within the ROW to maintain long term erosion control, topsoil will be replaced to promote vegetation growth and the ROW will be mulched and seeded with native seed mixes that will establish short grasses within the ROW. Natural recruitment of native shrubs, deciduous trees and conifer trees will occur over time; however trees will be maintained within the ROW to allow survey crews to survey the pipeline alignment and perform leakage tests as required by federal mandates. Where the pipeline is located within existing gravel or paved roadways, the open trench will be backfilled with structural and road surfaces will be restored to their pre-construction conditions (gravel or pavement) after open trench installation of the pipeline. Structural fill and road surface restoration will be completed in accordance with state or county requirements, as appropriate.

North of Highway 30, the pipeline will almost entirely installed by means of 8 HDDs, with short tie-in trenches between each adjacent HDDs. Soils will be protected by the placement of timber mats within the HDD workspaces and access roads. Where excavations are planned for HDD entry and exit pits, topsoil will be removed from the excavation areas and stockpiled within the workspaces for reuse. After completion of each HDD and the associated tie in trenches, the trenches and HDD entry and exit pits will be backfilled with native soils to the pre-construction grades, topsoil will be replaced, and the disturbed areas will be mulched and seeded with native seed mixes to establish vegetation within the excavation areas. Where the excavations are located within agricultural fields, planting will be coordinated with the landowner to establish pre-construction agricultural vegetation within the disturbed areas.

North Mist Pipeline Compressor Station

Grading, foundation and structural plans have not yet been developed for the proposed compressor station site. Therefore, developed conditions are not yet known. It is anticipated that the compressor station site will be graded level using a combination of cutting and filling with native soils or imported fill. Concrete and gravel will then be placed for structures, roadways and permanent work areas. A site specific erosion control plan will be developed for the compressor station site upon completion of the civil engineering plans.

Utility Conduit

Where the proposed utility conduit traverses cross country across forested terrain, or within the power line ROW, the ROW will be cleared of vegetation before construction within excavation areas. Topsoil will be segregated and stockpiled, and replaced after open trench installation. After open trench installation is completed, waterbars will be installed within the ROW to maintain long term erosion control, topsoil will be replaced to promote vegetation growth and the ROW will be mulched and seeded with native seed mixes that will establish short grasses within the ROW. Natural recruitment of native shrubs, deciduous trees and conifer trees will occur over time; however trees will likely be maintained within the power line ROW by the power line operator. Where the utility conduit is located within existing gravel roadways, the open trench will be backfilled with native soils removed from the excavation and road surfaces will be restored to their pre-construction surface and topographic conditions.

NW Natural

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR | SCALE: AS NOTED
DRAWN: BTL | DATE: 04/03/15
CHECKED: TNH | FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
COVER SHEET

Drawing No.
SHEET 1
Sheet

BCR : BTL

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DEVELOPER

NW NATURAL GAS COMPANY
CONTACT: ANDREW BAUER
220 NW 2nd AVE., PORTLAND, OR 97209
PHONE: 503-226-4211
FAX: 503-273-4822

PLANNING / ENGINEERING / SURVEYING FIRM

GEOTECHNICAL ENGINEERING COMPANY
GEOENGINEERS, INC.
CONTACT: BRIAN C. RANNEY
15055 SW SEQUOIA PKWY STE. 140
PORTLAND, OREGON 97224
PHONE: 503-624-9274
FAX: 503-620-5940

PIPELINE ENGINEER:
AECOM
CONTACT:
2101 WEBSER STREET, SUITE 100
OAKLAND CALIFORNIA 94612-3060
PHONE: 510-622-6600
FAX: 510-834-5220

TOTAL SITE AREA = 6,201,952.75 SF = 142.38 ACRES

TOTAL DISTURBED AREA = 6,185,819.88 SF = 142.01 ACRES

RECEIVING WATER BODIES:

BEAVER CREEK
MC COON CREEK
GRAHAM CREEK
CLATSKANIE RIVER
BEAVER SLOUGH
LARSON SLOUGH

PERMITTEE'S PRIMARY SITE INSPECTOR: ANDREW BAUER
COMPANY/AGENCY: NW NATURAL
PHONE: 503-226-4211
FAX: 503-273-4822
E-MAIL: ANDREW.BAUER@NWNATURAL.COM
DESCRIPTION OF EXPERIENCE : ANDY IS CESCL-CERTIFIED AND HAS 11 YEARS OF EXPERIENCE AT GEOTECHNICAL CONSTRUCTION OBSERVATION.

Standard Erosion Control Notes

1. Hold a pre-construction meeting of project construction personnel that includes the inspector to discuss erosion and sediment control measures and construction limits. (Schedule A.8.c.i.(3))
2. All permit registrants must implement the ESCP. Failure to implement any of the control measures or practices described in the ESCP is a violation of the permit. (Schedule A 8.a)
3. Retain a copy of the ESCP and all revisions on site and make it available on request to DEQ, Agent, or the local municipality. During inactive periods of greater than seven (7) consecutive calendar days, retain the ESCP at the construction site or at another location. (Schedule B.2.a)
4. The ESCP measures shown on this plan are minimum requirements for anticipated site conditions. During the construction period, upgrade these measures as needed to comply with all applicable local, state, and federal erosion and sediment control regulations. (Schedule A.8.c.ii.(1)(c))
5. Submission of all ESCP revisions is not required. Submittal of the ESCP revisions is only under specific conditions. (Schedule A.12.c.iii)
6. Phase clearing and grading to the maximum extent practical to prevent exposed inactive areas from becoming a source of erosion. (Schedule A 8.c.ii.(1)(d))
7. Identify, mark, and protect (by fencing off or other means) critical riparian areas and vegetation including important trees and associated rooting zones, and vegetation areas to be preserved. Identify vegetative buffer zones between the site and sensitive areas (e.g., wetlands), and other areas to be preserved, especially in perimeter areas. (Schedule A.8.c.i.(1) & (2))
8. Preserve existing vegetation and re-vegetate open areas when practicable before and after grading or construction. (Schedule A.7.b.iii.(1))
9. Erosion and sediment control measures including perimeter sediment control must be in place before vegetation is disturbed and must remain in place and be maintained, repaired, and promptly implemented following procedures established for the duration of construction, including protection for active storm drain inlets and catch basins and appropriate non-stormwater pollution controls. (Schedule A.7.d.i and A.8.c)
10. Establish concrete truck and other concrete equipment washout areas before beginning concrete work.(Schedule A.8.c.i.(6))
11. Apply temporary and/or permanent soil stabilization measures immediately on all disturbed areas as grading progresses and for all roadways including gravel roadways. (Schedule A.8.c.ii.(2))
12. Establish material and waste storage areas, and other non-stormwater controls. (Schedule A.8.c.i.(7))
13. Prevent tracking of sediment onto public or private roads using BMPs such as: graveled (or paved) exits and parking areas, gravel all unpaved roads located onsite, or use an exit tire wash. These BMPs must be in place prior to land-disturbing activities. (Schedule A 7.d.ii.(1) and A.8.c.i(4))
14. When trucking saturated soils from the site, either use water-tight trucks or drain loads on site. (Schedule A.7.d.ii.(3))
15. Use BMPs to prevent or minimize stormwater exposure to pollutants from spills; vehicle and equipment fueling, maintenance, and storage; other cleaning and maintenance activities; and waste handling activities. These pollutants include fuel, hydraulic fluid, and other oils from vehicles and machinery, as well as debris, leftover paints, solvents, and glues from construction operations. (Schedule A.7.e.i.(2))
16. Water or use a soil-binding agent or other dust control technique as needed to avoid wind-blown soil. (Schedule A 7.b.iii)
17. The application rate of fertilizers used to reestablish vegetation must follow manufacturer's recommendations to minimize nutrient releases to surface waters. Exercise caution when using timerelease fertilizers within any waterway riparian zone. (Schedule A.9.b.iii)
18. If a stormwater treatment system (for example, electro-coagulation, flocculation, filtration, etc.) for sediment or other pollutant removal is employed, submit an operation and maintenance plan (including system schematic, location of system, location of inlet, location of discharge, discharge dispersion device design, and a sampling plan and frequency) before operating the treatment system. Obtain plan approval before operating the treatment system. Operate and maintain the treatment system according to manufacturer's specifications. (Schedule A.9.d)
19. Temporarily stabilize soils at the end of the shift before holidays and weekends, if needed. The registrant is responsible for ensuring that soils are stable during rain events at all times of the year. (Schedule A 7.b)
20. Construction activities must avoid or minimize excavation and creation of bare ground during wet weather. (Schedule A.7.a.i)
21. Sediment fence: remove trapped sediment before it reaches one third of the above ground fence height and before fence removal. (Schedule A.9.c.i)
22. Other sediment barriers (such as biobags): remove sediment before it reaches two inches depth above ground height. and before BMP removal. (Schedule A.9.c.ii)
23. Sediment basins and sediment traps: remove trapped sediments before design capacity has been reduced by fifty percent and at completion of project. (Schedule A.9.c.iii & iv)
24. Within 24 hours, significant sediment that has left the construction site, must be remediated. Investigate the cause of the sediment release and implement steps to prevent a recurrence of the discharge within the same 24 hours. Any in-stream clean up of sediment shall be performed according to the Oregon Division of State Lands required timeframe. (Schedule A.9.b.i)
25. The intentional washing of sediment into storm sewers or drainage ways must not occur. Vacuuming or dry sweeping and material pickup must be used to cleanup released sediments. (Schedule A.9.b.ii)
26. The entire site must be temporarily stabilized using vegetation or a heavy mulch layer, temporary seeding, or other method should all construction activities cease for 30 days or more. (Schedule A.7.f.i)
27. Provide temporary stabilization for that portion of the site where construction activities cease for 14 days or more with a covering of blown straw and a tackifier, loose straw, or an adequate covering of compost mulch until work resumes on that portion of the site. (Schedule A.7.f.ii)
28. The designated erosion and sediment control inspector must perform daily inspections of the BMPs and discharge outfalls when rainfall and runoff occur. Record the inspections and observations in a log that is on site. (Schedule B.1.b(1))
29. All ESCP controls and practices must be inspected visually once to ensure that BMPs are in working order prior to the site becoming inactive or in anticipation of site inaccessibility and must be inspected visually once every two (2) weeks during inactive periods greater than seven (7) consecutive calendar days. (Schedule B.1.b.(2) & (3))
30. If practical, inspections must occur daily at a relevant and accessible discharge point or downstream location during periods in which the site is inaccessible due to inclement weather. (Schedule B.1.b.(4))
31. Do not remove temporary sediment control practices until permanent vegetation or other cover of exposed areas is established. Identify the type of vegetative seed mix used. (Schedule A 7.b.iii)
32. Provide permanent erosion control measures on all exposed areas. Remove all temporary erosion control measures as exposed areas become stabilized, unless doing so conflicts with local requirements. Properly dispose of construction materials and waste, including sediment retained by temporary BMPs. (Schedule A.8.c.iii)
33. All cross country portions of the pipeline shall be regraded to the original pre-construction contours, or in accordance with the project grading plan.
34. All slopes disturbed by construction shall be tracked in accordance with the surface roughing detail on sheet 35 prior to placing seed and mulch.
35. Straw mulch shall consist of certified weed free and Columbia County approved mulch applied at a rate of 4,000 pounds per acre. Straw mulch shall be anchored to the slope by mechanical crimping, liquid tackifier, erosion control netting or other suitable means.
36. Liquid tackifiers, if used, shall be vegetable-based, organic products such as guar gum or plantigo. Liquid tackifiers will not be used within 100 feet of wetlands or water bodies.
37. Erosion control matting installed following seeding where mulch application and anchoring are not feasible. Typical erosion control matting applications may include slopes steeper than 50 percent and the banks of water bodies.
38. Erosion control matting shall be secured to the ground surface in such a manner that the fabric has contact with the seeded soil in all locations to prevent underwashing by water.

NW Natural

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
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F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
STANDARD ESCP SPECS

Drawing No.
SHEET 2
Sheet

BCR : BTL
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RATIONALE STATEMENT

A COMPREHENSIVE LIST OF AVAILABLE BEST MANAGEMENT PRACTICES (BMP) OPTIONS BASED ON DEQ'S GUIDANCE MANUAL HAS BEEN REVIEWED TO COMPLETE THIS EROSION AND SEDIMENT CONTROL PLAN. SOME OF THE ABOVE LISTED BMP'S WERE NOT CHOSEN BECAUSE THEY WERE DETERMINED TO NOT EFFECTIVELY MANAGE EROSION PREVENTION AND SEDIMENT CONTROL FOR THIS PROJECT BASED ON SPECIFIC SITE CONDITIONS, INCLUDING SOIL CONDITIONS TOPOGRAPHIC CONSTRAINTS, ACCESSIBILITY TO THE SITE, AND OTHER RELATED CONDITIONS, AS THE PROJECT PROGRESSES AND THERE IS A NEED TO REVISE THE ESC PLAN, AN ACTION PLAN WILL BE SUBMITTED.

SOIL ERODIBILITY STATEMENT

ON-SITE SOILS HAVE A MODERATE TO HIGH EROSION POTENTIAL. ALL FILL MATERIAL SHALL BE GENERATED ON-SITE FROM GRADING EXCAVATION AND UTILITY TRENCH SPOILS EXCEPT WHERE REQUIRED TO BE COMPACTED GRANULAR FILL WITHIN COLUMBIA COUNTY RIGHT-OF-WAY(ROW). FILL MATERIALS, PAVEMENT AND GRAVEL SURFACING WITHIN COLUMBIA COUNTY ROW SHALL CONFORM TO THE APPLICABLE COUNTY SPECIFICATIONS.

BMP MATRIX FOR CONSTRUCTION PHASES

Year:		2016						
BMPs	Month #:	1 [June]	2 [July]	3 [August]	4 [September]	5 [October]	6 [November]	7 [December]
Topsoil Segregation*		X	X	X	X	X	X	X
Sediment Fencing*		X	X	X				
Check Dams		X	X	X				
Waterbars**		X	X	X	X	X	X	X
Concrete washout		X	X	X	X			
Straw wattles**			X	X	X	X	X	X
Mulches (Straw mulch certified weed free, Columbia County approved)**			X	X	X	X	X	X
Maintain vegetative buffers		X	X	X	X	X	X	X
Erosion control fabric		X	X	X	X	X	X	X
Permanent seeding and planting**			X	X	X	X	X	X

Year:		2017										
BMPs	Month #:	1 [January]	2 [February]	3 [March]	4 [April]	5 [May]	6 [June]	7 [July]	8 [August]	9 [September]	10 [October]	11 [November]
Topsoil Segregation*		X	X	X	X	X	X	X	X	X		
Sediment Fencing*		X	X	X	X	X	X	X	X	X		
Check Dams		X	X	X	X	X	X	X	X			
Waterbars**		X	X	X	X	X	X	X	X	X	X	X
Concrete washout							X	X	X	X		
Straw wattles**		X	X	X	X	X	X	X	X	X		
Mulches (Straw mulch certified weed free, Columbia County approved)**		X	X	X	X	X	X	X	X	X	X	X
Maintain vegatative buffers		X	X	X	X	X	X	X	X	X		
Erosion control fabric		X	X	X	X	X	X	X	X	X		
Permanent seeding and planting**				X	X	X	X	X	X	X	X	X

** SIGNIFIES BMP THAT WILL BE INSTALLED PRIOR TO ANY GROUND DISTURBING ACTIVITY.

SITE SOIL CLASSIFICATION		
Map Key	Soil Unit Name	Percent Slopes
3E	Alstony gravelly loam	30 to 60 North
4E	Alstony gravelly loam	30 to 60 South
5D	Anunde silt loam	3 to 30
9F	Braun-Scaponia silt loams	60 to 90
12E	Caterl gravelly silt loam	30 to 60
15	Crims silt loam	protected
19E	Dowde silt loam	30 to 60 South
20	Eilertsen silt loam	
24	Hapludalfs-Udifluvents complex	
29	Locoda silt loam	protected
36D	Murnen silt loam	3 to 30
37	Natal silty clay loam	
49E	Scaponia-Braun silt loams	30 to 60 North
50E	Scaponia-Braun silt loams	30 to 60 South
56D	Tolke silt loam	5 to 30
58	Treharne silt loam	
61	Udipsamments	protected
64E	Wauld very gravelly loam	30 to 70
66	Wauna silt loam	protected
67	Wauna-Locoda silt loams	
68	Wauna-Locoda silt loams	protected
7D	Braun-Scaponia silt loams	5 to 30
W	Water	

Nature of Construction activity and estimated time table			
Activity	Estimated Start	Estimated end	Notes
Construction duration	1-Jun-16	30-Nov-17	Construction may consist of two stages to be completed in dry season
Mobilize onsite	1-Jun-16	1-Jul-16	
Install ESC Measures	1-Jun-16	30-Jul-16	To be amended for site conditions throughout construction duration, and to be installed throughout construction as needed
HDD Installations	1-Jul-16	30-Sep-17	
Open Trench Installation	1-Jul-16	30-Sep-17	
Install Dewatering pits	TBD	TBD	Contingent for HDDs if needed
Remove Dewatering pit equipment	TBD	TBD	Contingent if needed
Backfill HDD Entry and Exit pits	1-Aug-16	30-Oct-17	Pits to be backfilled after HDD is completed and adjacent HDD segments are tied-in.
Restore ground surface (HDDs)	1-Aug-17	15-Oct-17	Includes grading to match pre-construction grades, seeding and mulching
Restore ground surface (open trench)	1-Jul-17	30-Nov-17	Restoration to be completed concurrently with construction, includes grading to pre-construction conditions, seeding, mulching and waterbar construction
Prepare and Submit 1200-C Notice of Termination	N/A	31-Dec-17	

NW Natural

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
STANDARD ESCP BMP

Drawing No.
SHEET 3
Sheet

BCR : BTL

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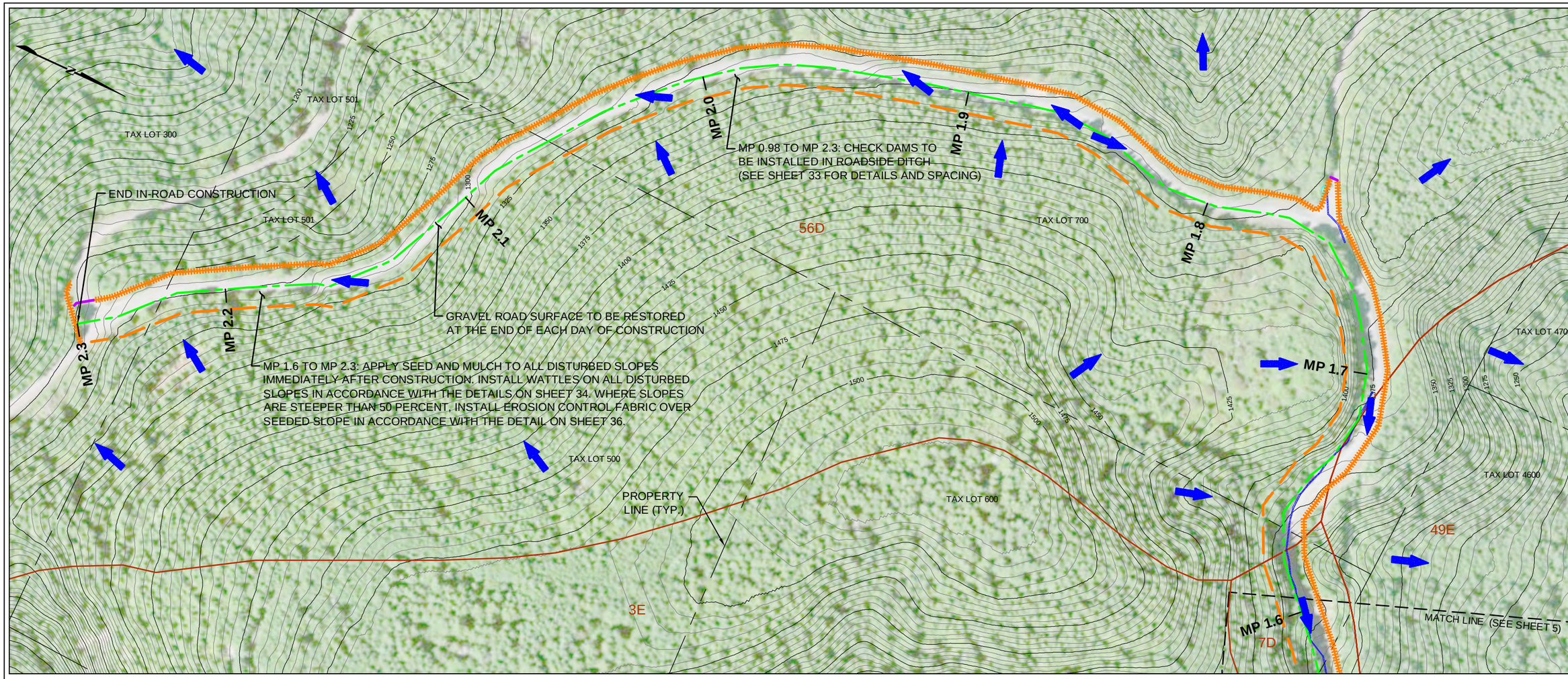

PLAN

200' 0 200'

SCALE IN FEET

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9. Aerial photos from ESRI ArcGIS Data Online.

LEGEND

- 56D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 4
Sheet

BCR : BTL

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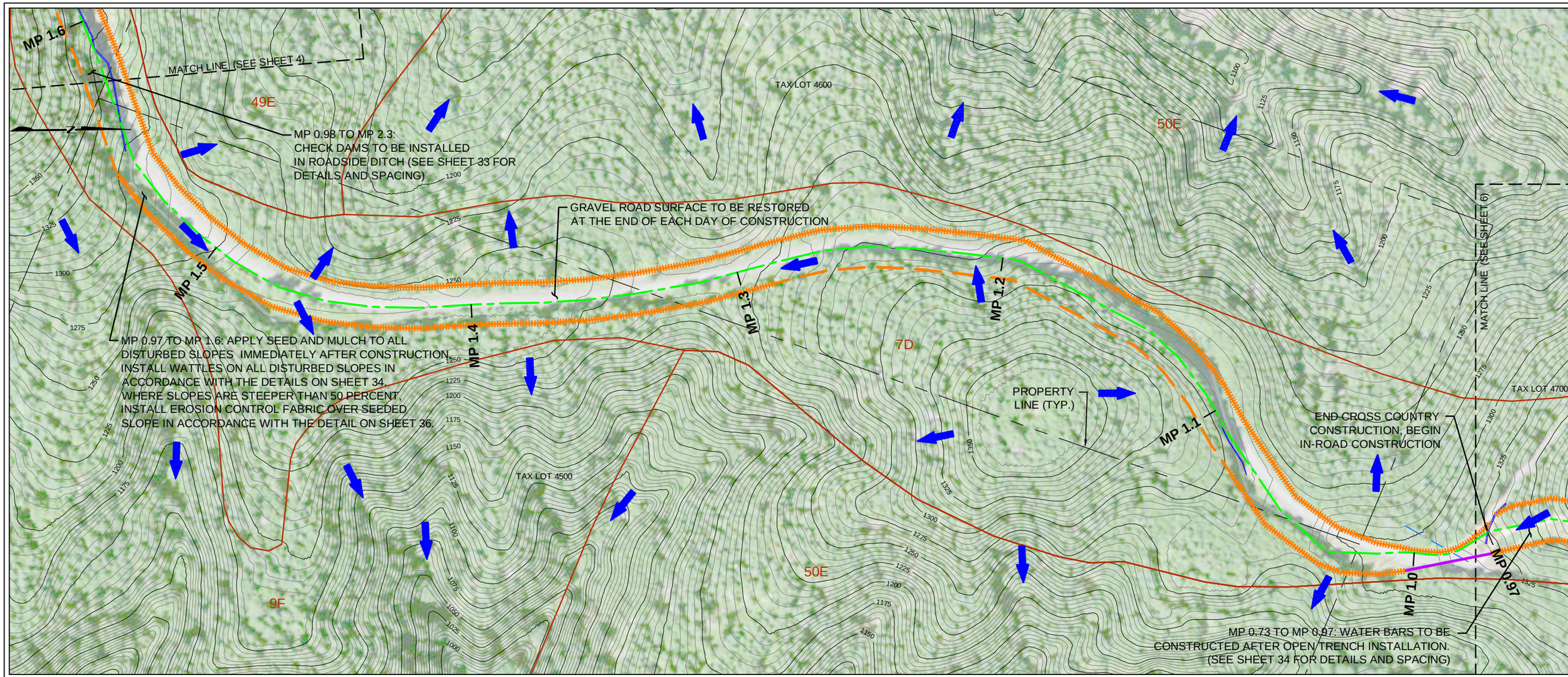

PLAN

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LEGEND

- 7D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
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SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 5

Sheet

BCR : BTL

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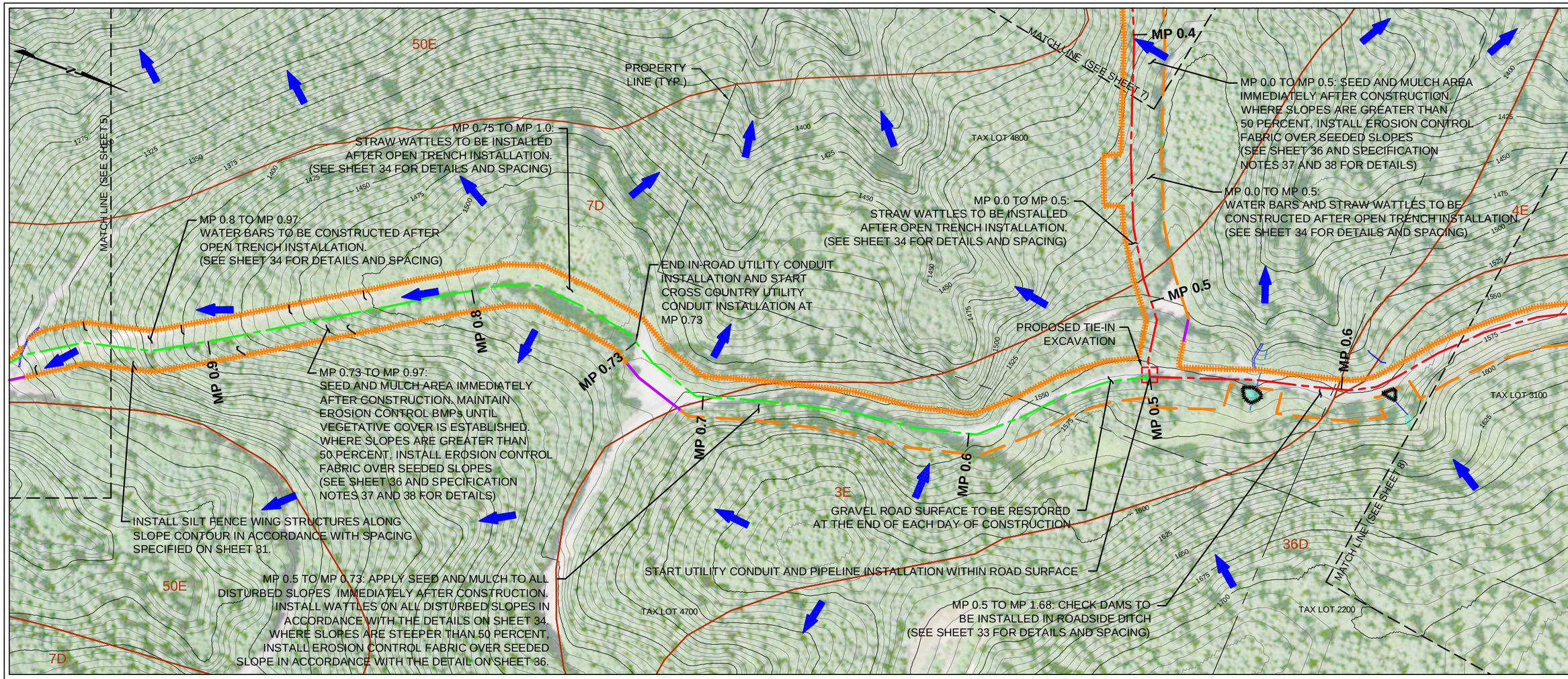

PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 7D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
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DATE: 04/03/15
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GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 6
Sheet

BCR : BTL

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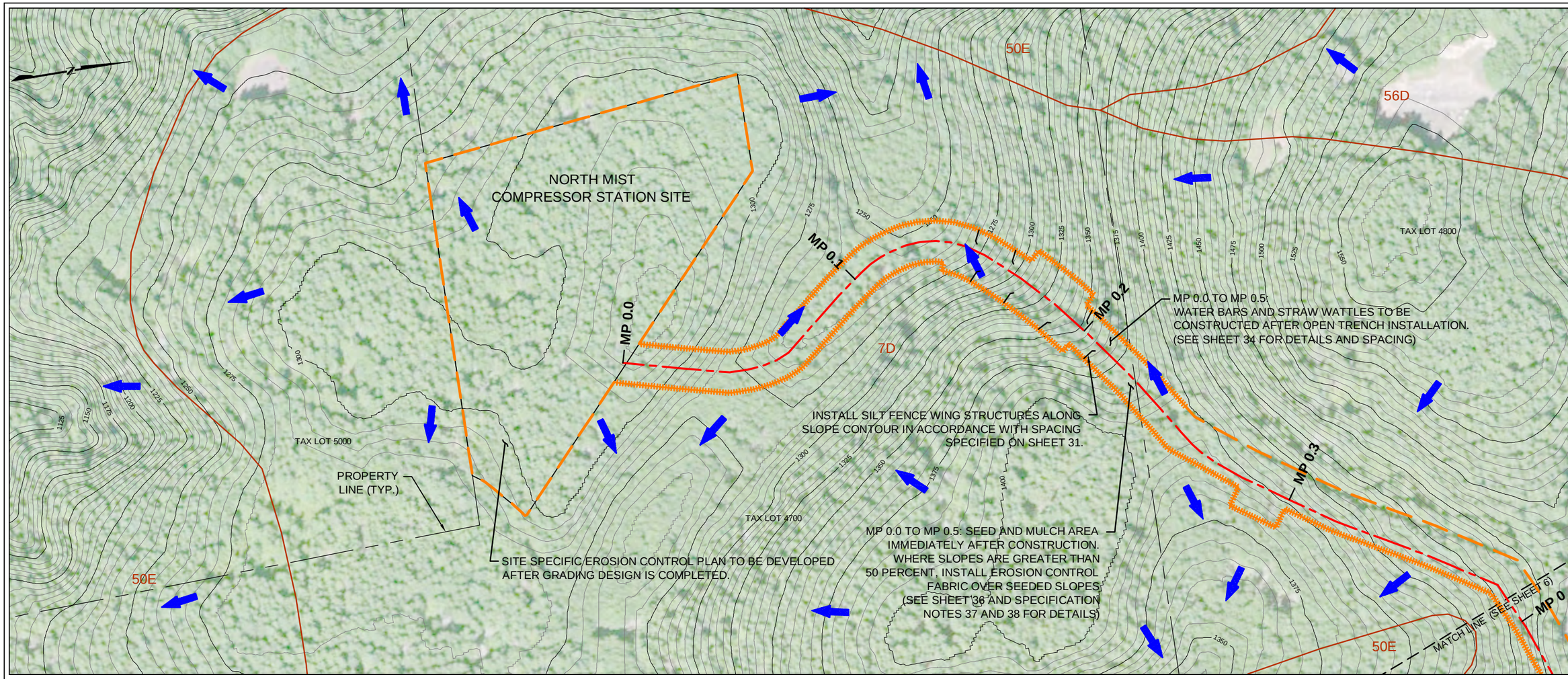

PLAN

200' 0 200'

SCALE IN FEET

LEGEND

- 7D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

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Revision	Description	Date	By	Chk	Rev

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DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
COMPRESSOR STATION AND OPEN TRENCH

Drawing No.
SHEET 7

Sheet

BCR : BTL

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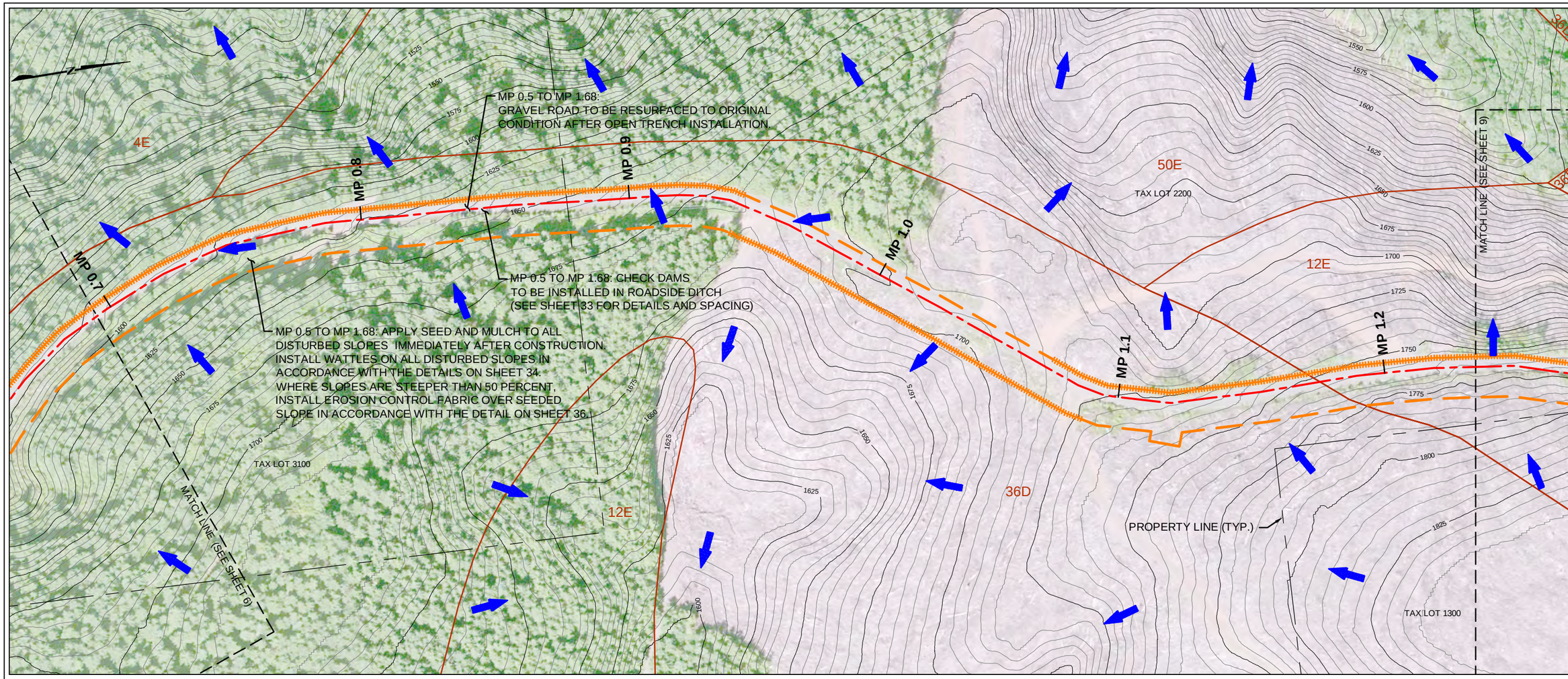

PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 36D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
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CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 8
Sheet

BCR : BTL

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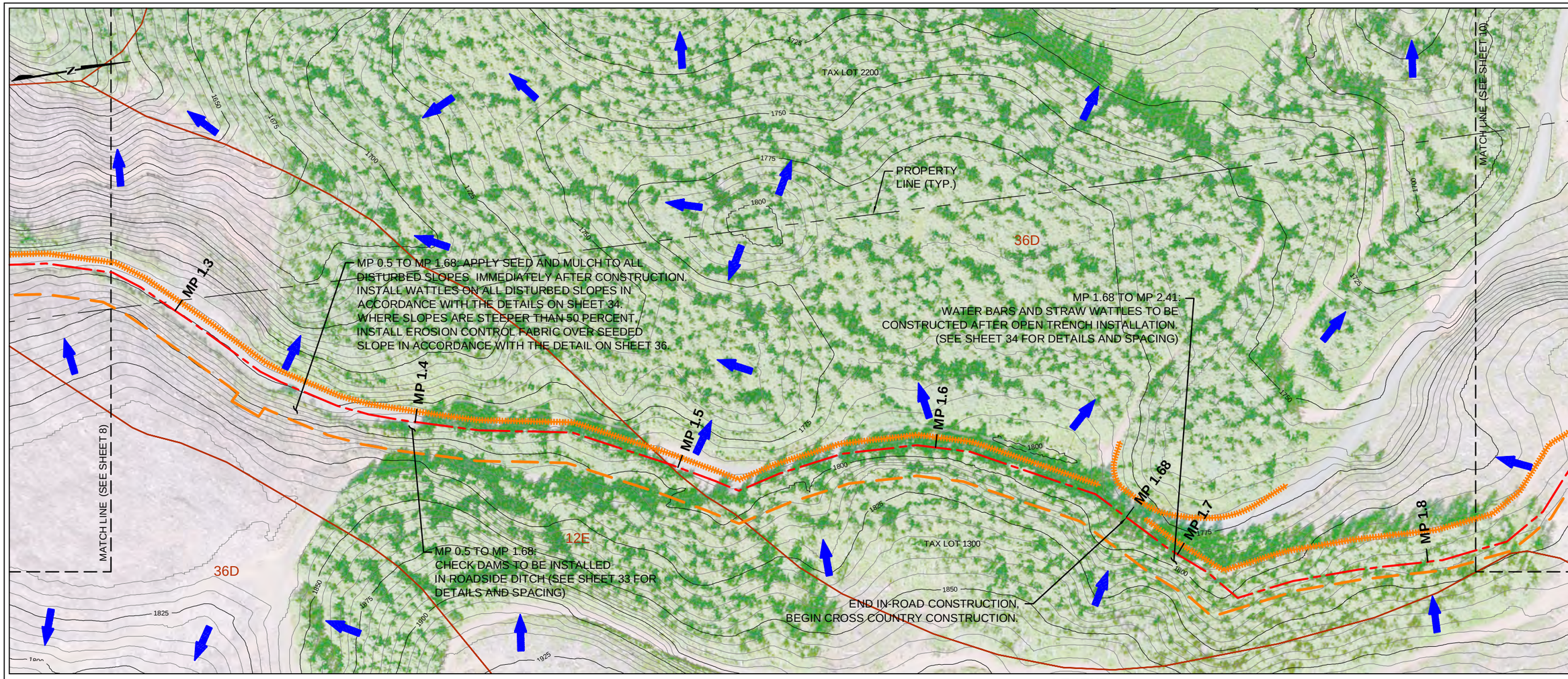

PLAN

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LEGEND

- 12E — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
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- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
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DATE: 04/03/15
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GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 9
Sheet

BCR : BTL

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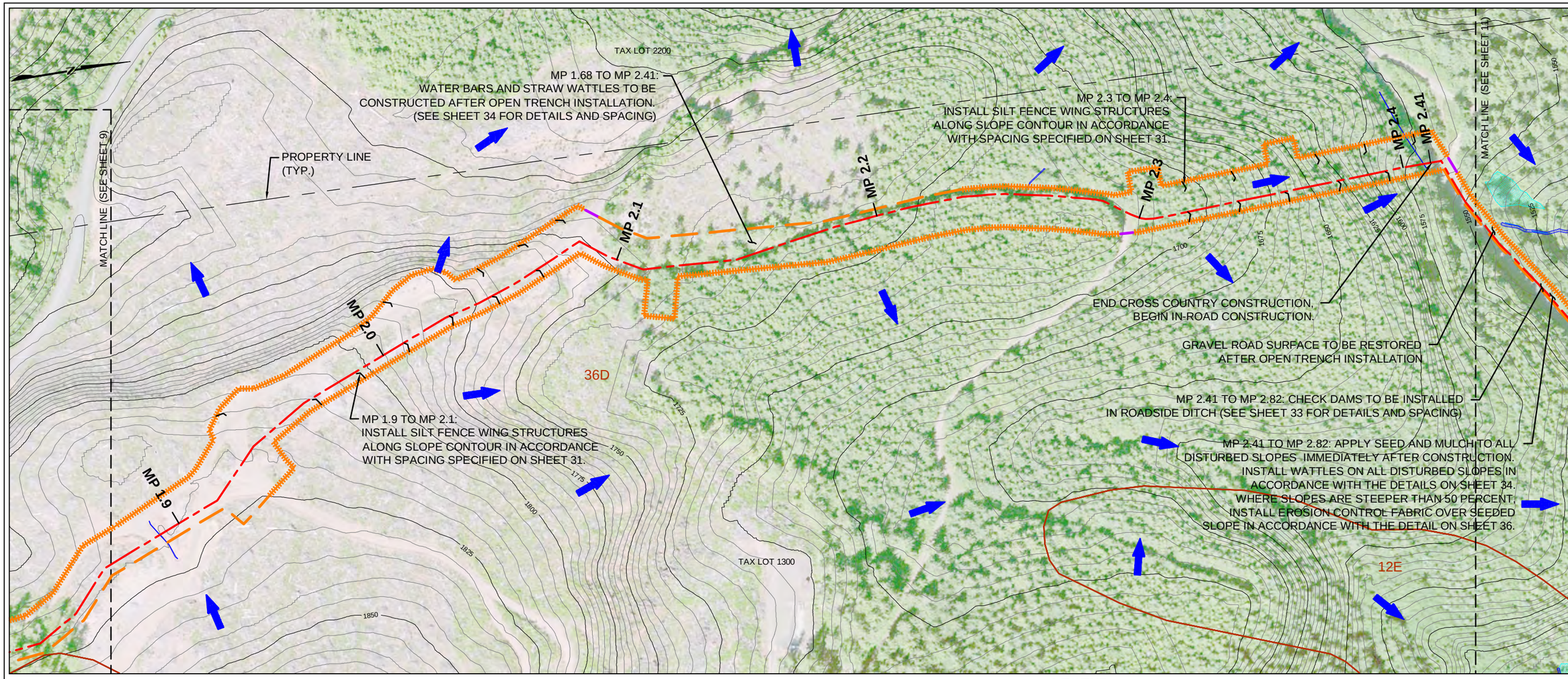

PLAN

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LEGEND

- 36D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
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- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
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- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

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CHECKED: TNH
SCALE: AS NOTED
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GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 10
Sheet

BCR : BTL
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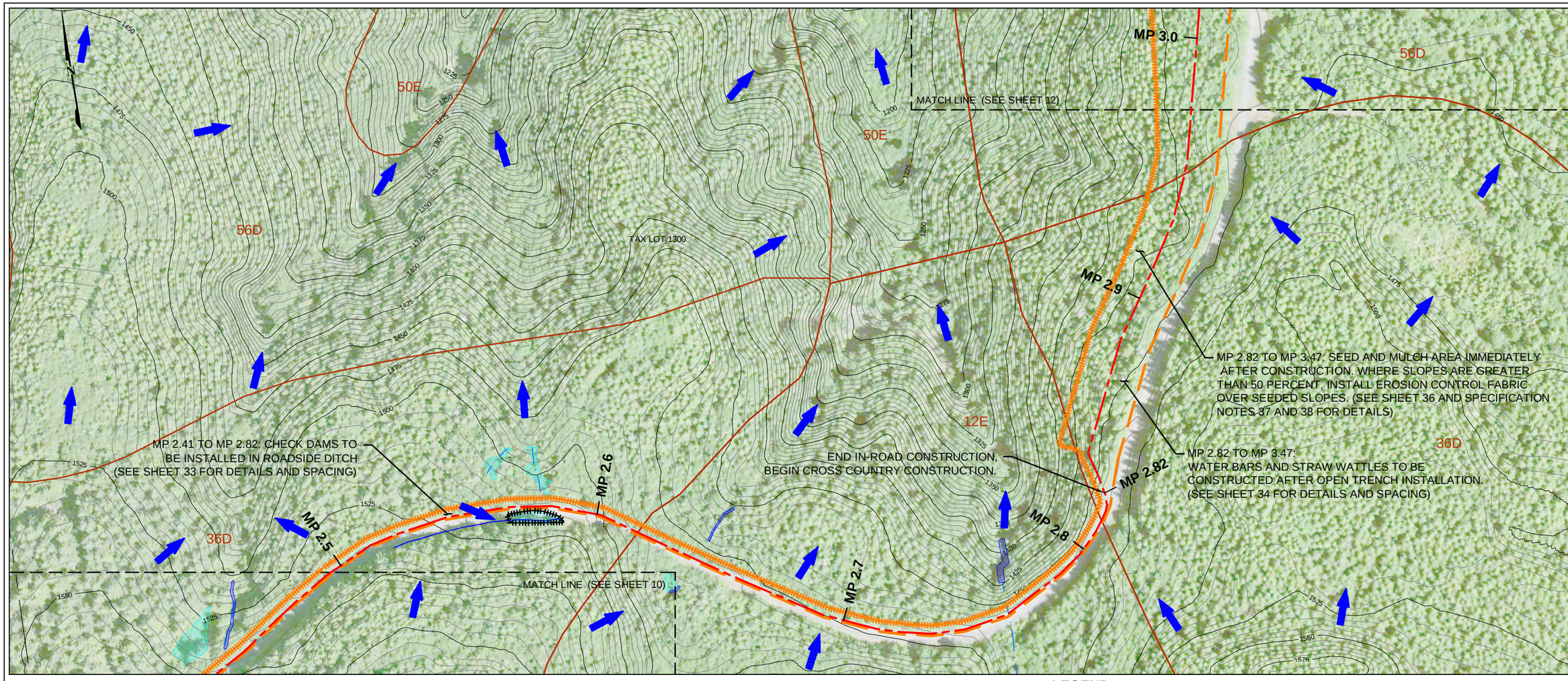

PLAN

200' 0 200'

SCALE IN FEET

LEGEND

- 12E — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
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- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
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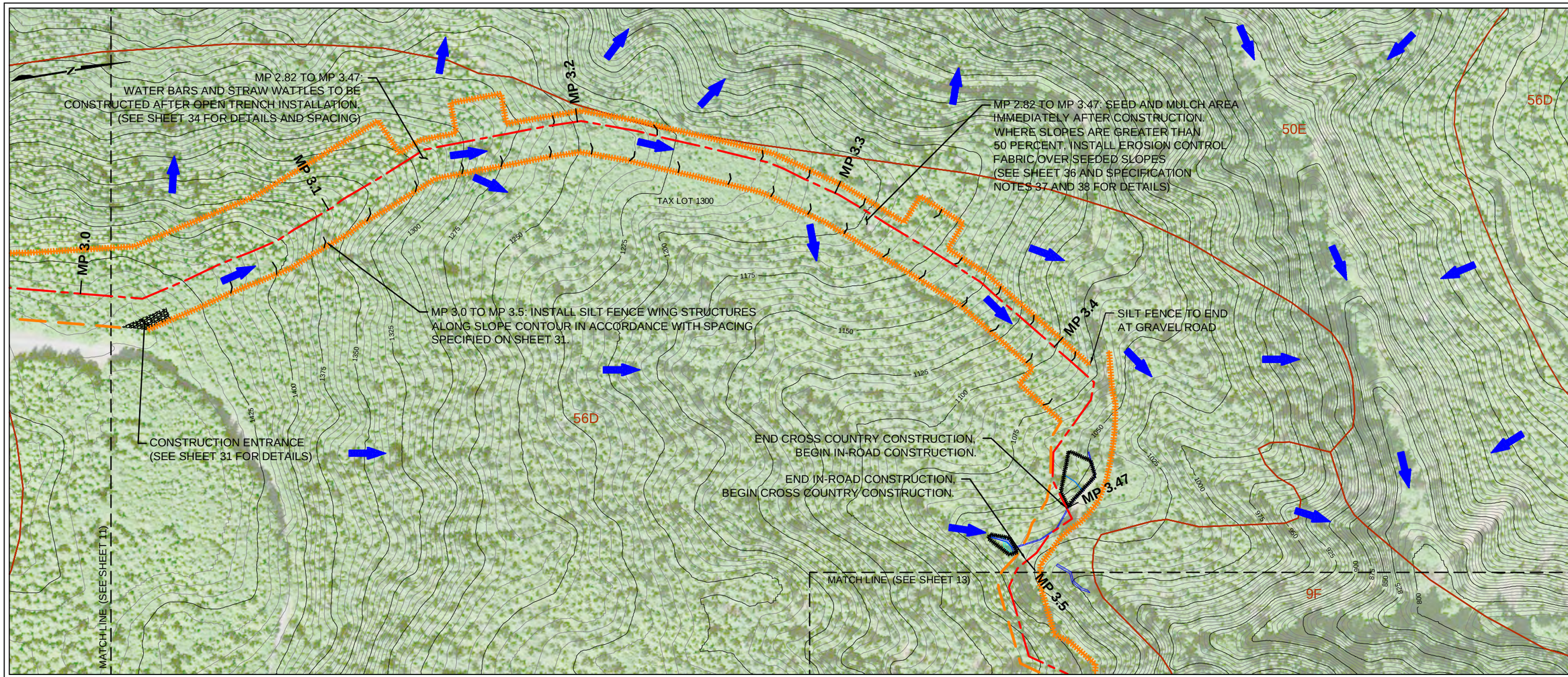
NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 11
Sheet

BCR : BTL
E:\ESCP\Sheet Files\ESCP SHT 8.dwg\TAB:SHEET 11 modified on Mar 30, 2015 - 12:37pm



PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 56D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
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Revision	Description	Date	By	Chk	Rev

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GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
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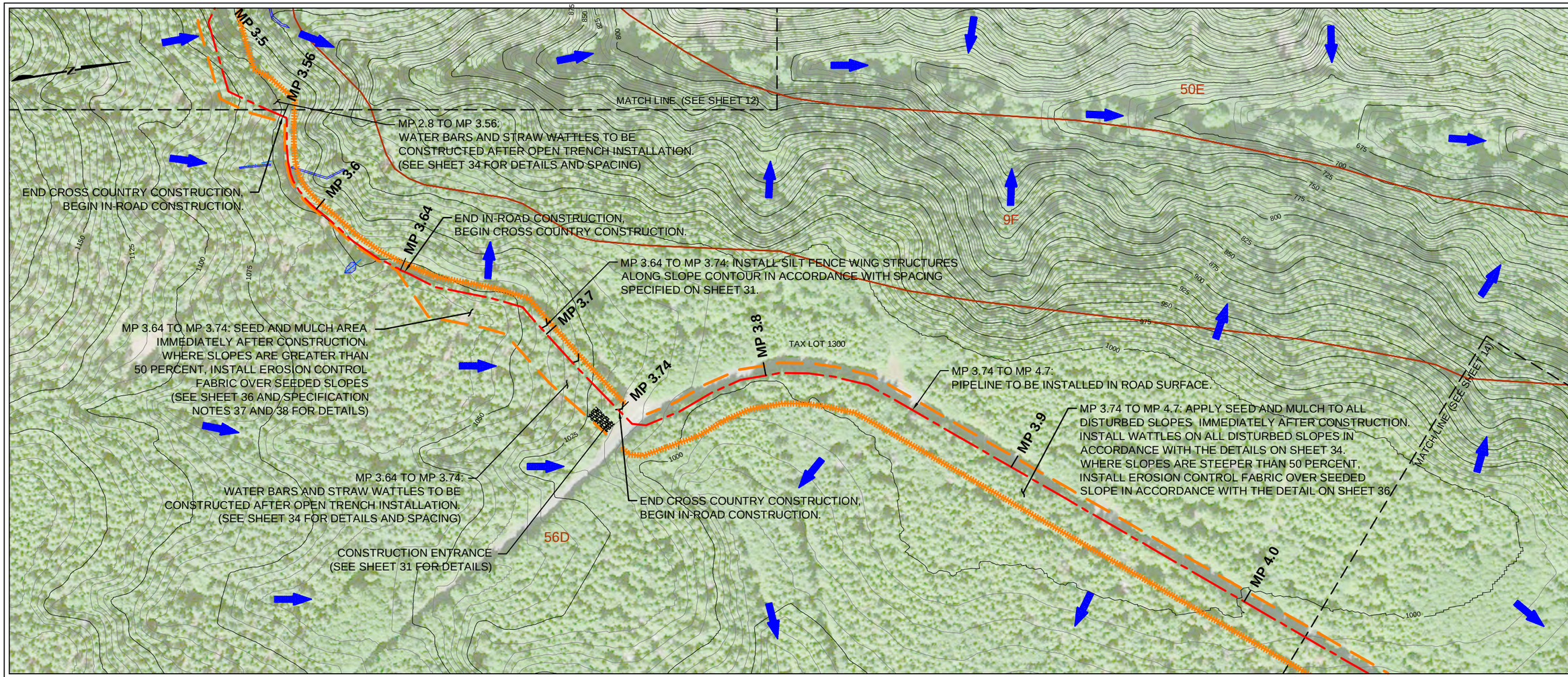
NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 12
Sheet

BCR : BTL

E:\ESCP\Sheet Files\ESCP SHT 12.dwg\TAB:SHEET 12 modified on Mar 30, 2015 - 3:04pm



PLAN

200' 0 200'

SCALE IN FEET

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9. Aerial photos from ESRI ArcGIS Data Online.

LEGEND

- 56D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

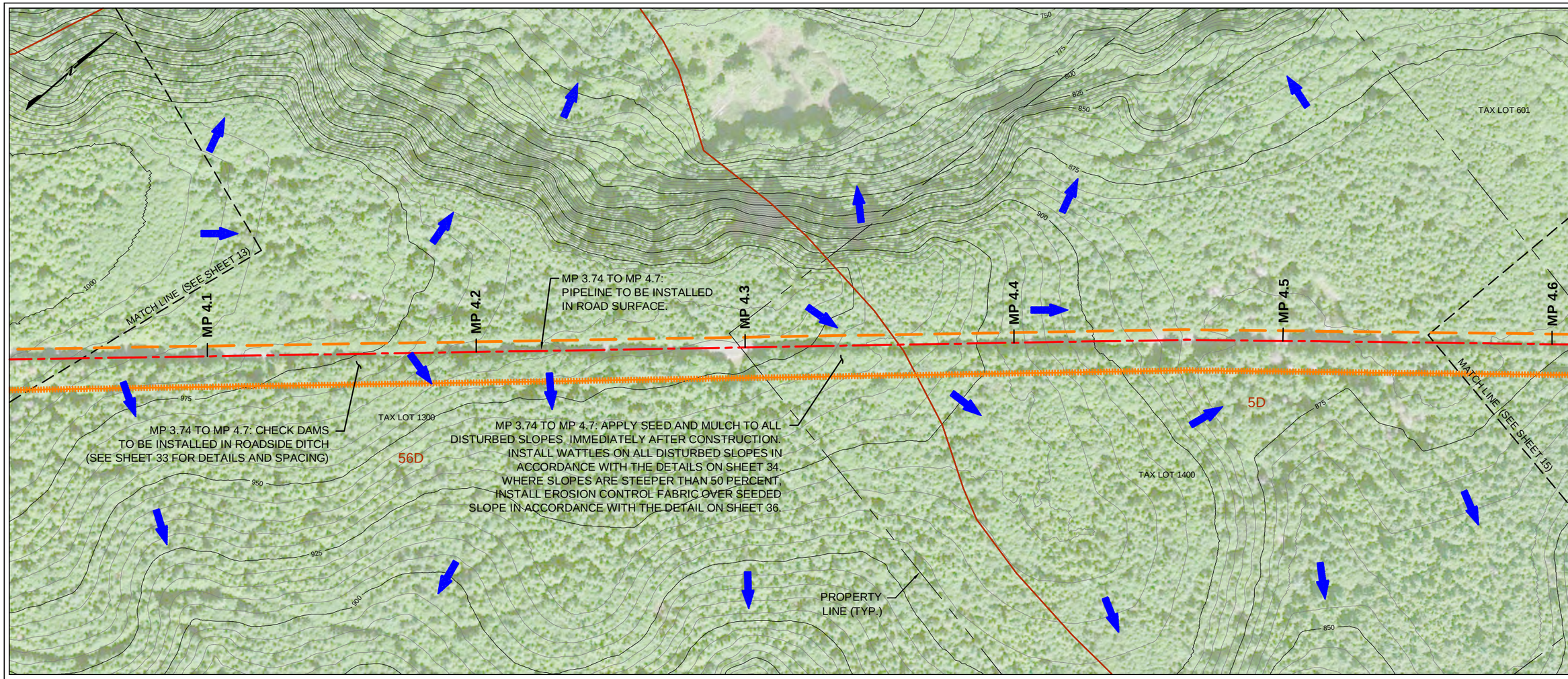
NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 13
Sheet

BCR : BTL

E:\ESCP\Sheet Files\ESCP SHT 12.dwg\TAB:SHEET 13 modified on Mar 31, 2015 - 6:46am



PLAN

200' 0 200'

SCALE IN FEET

LEGEND

- 56D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

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Revision	Description	Date	By	Chk	Rev

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DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 14
Sheet

BCR : BTL
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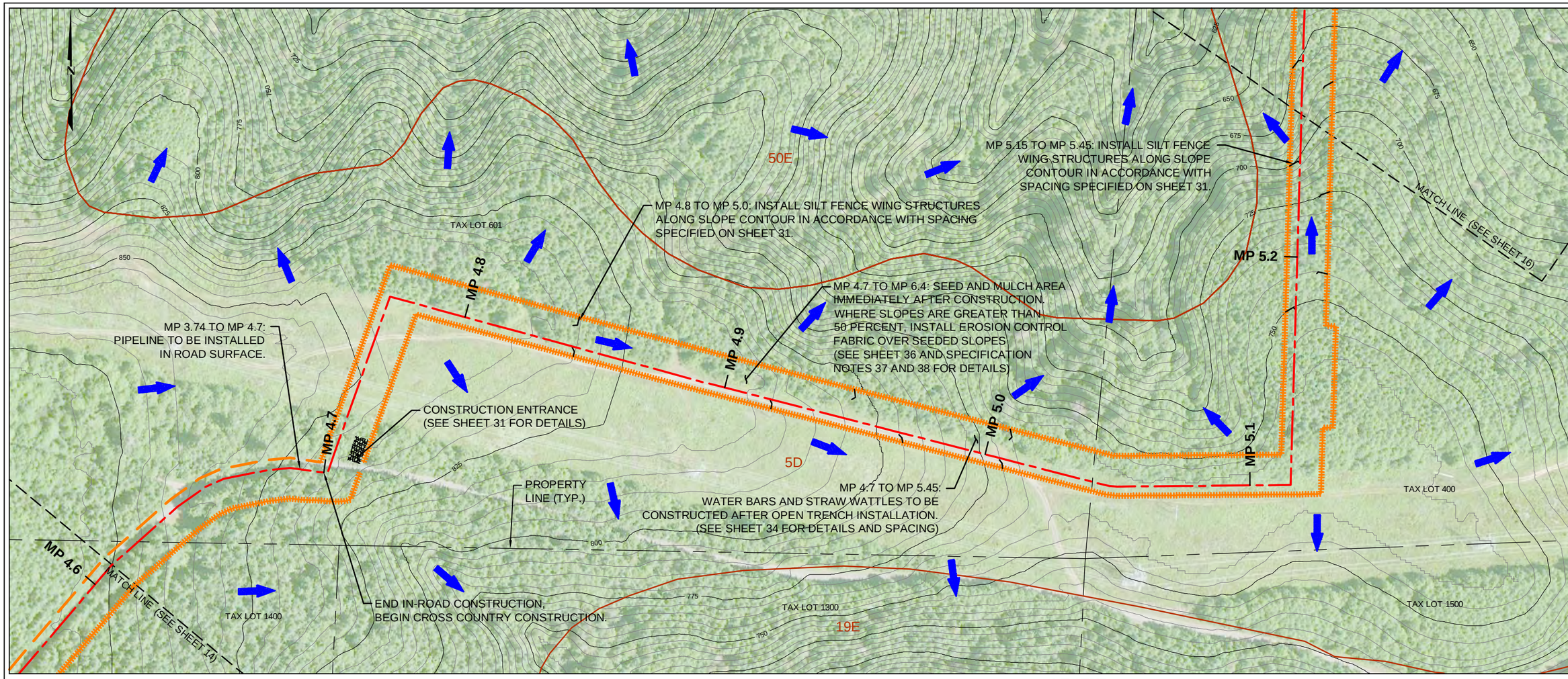

PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 50E — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 15
Sheet

BCR : BTL

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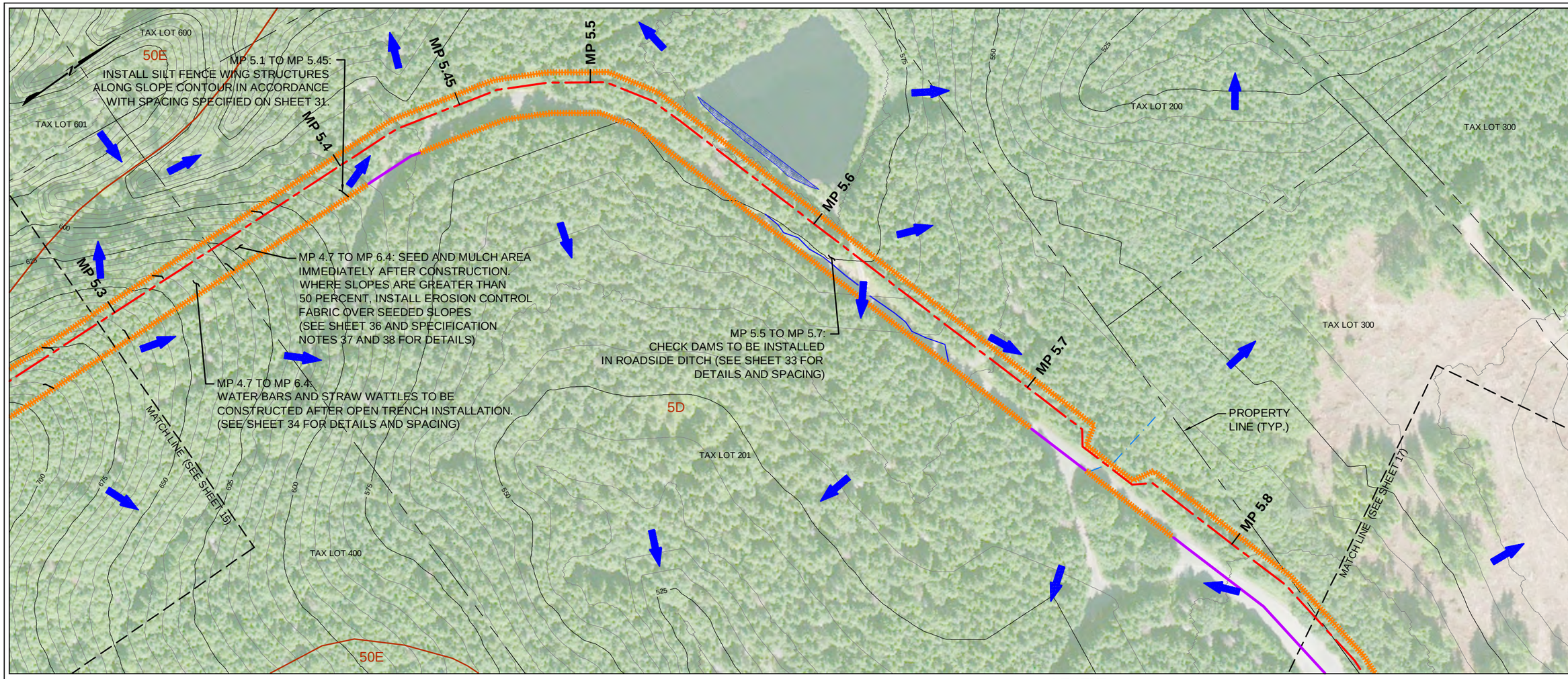

PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 5D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
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SCALE: AS NOTED
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GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
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NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 16
Sheet

BCR : BTL

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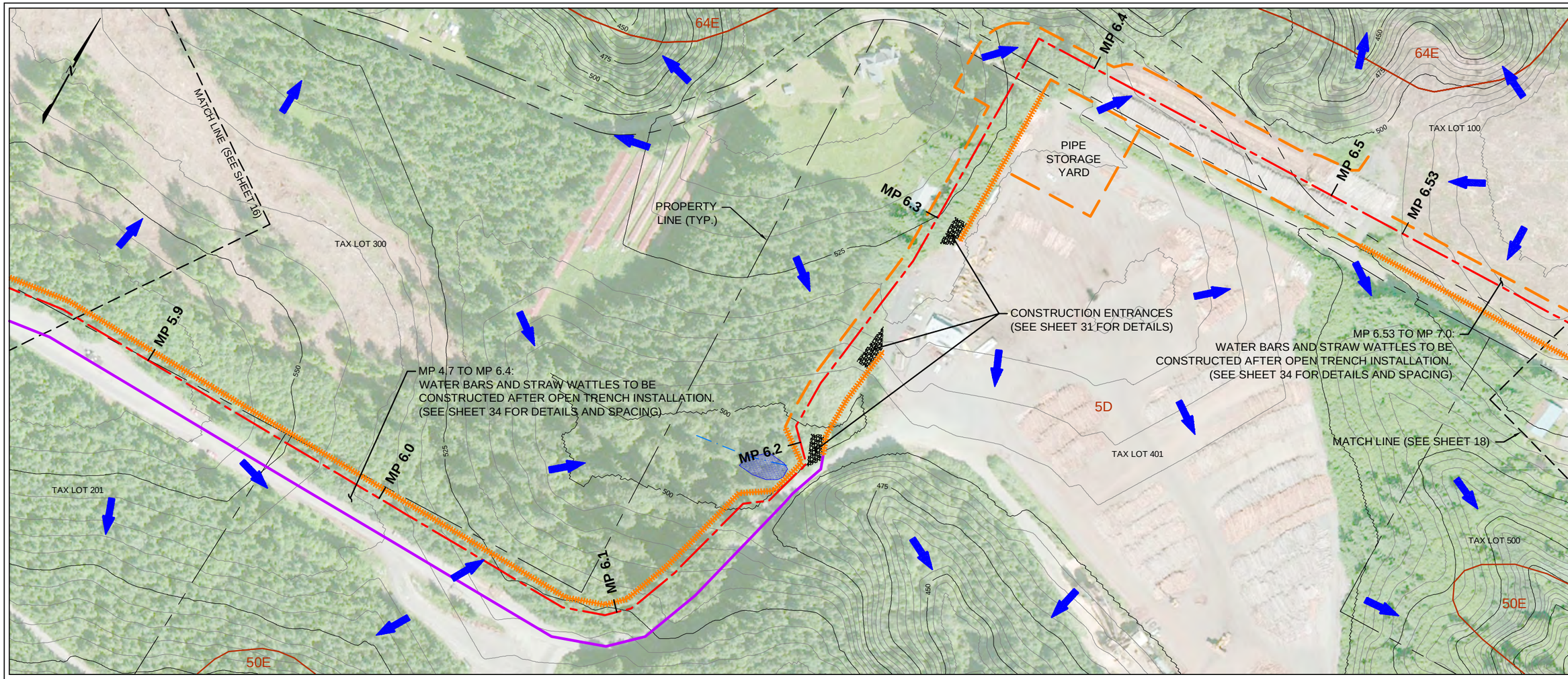

PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 5D — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
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SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 17
Sheet

BCR : BTL

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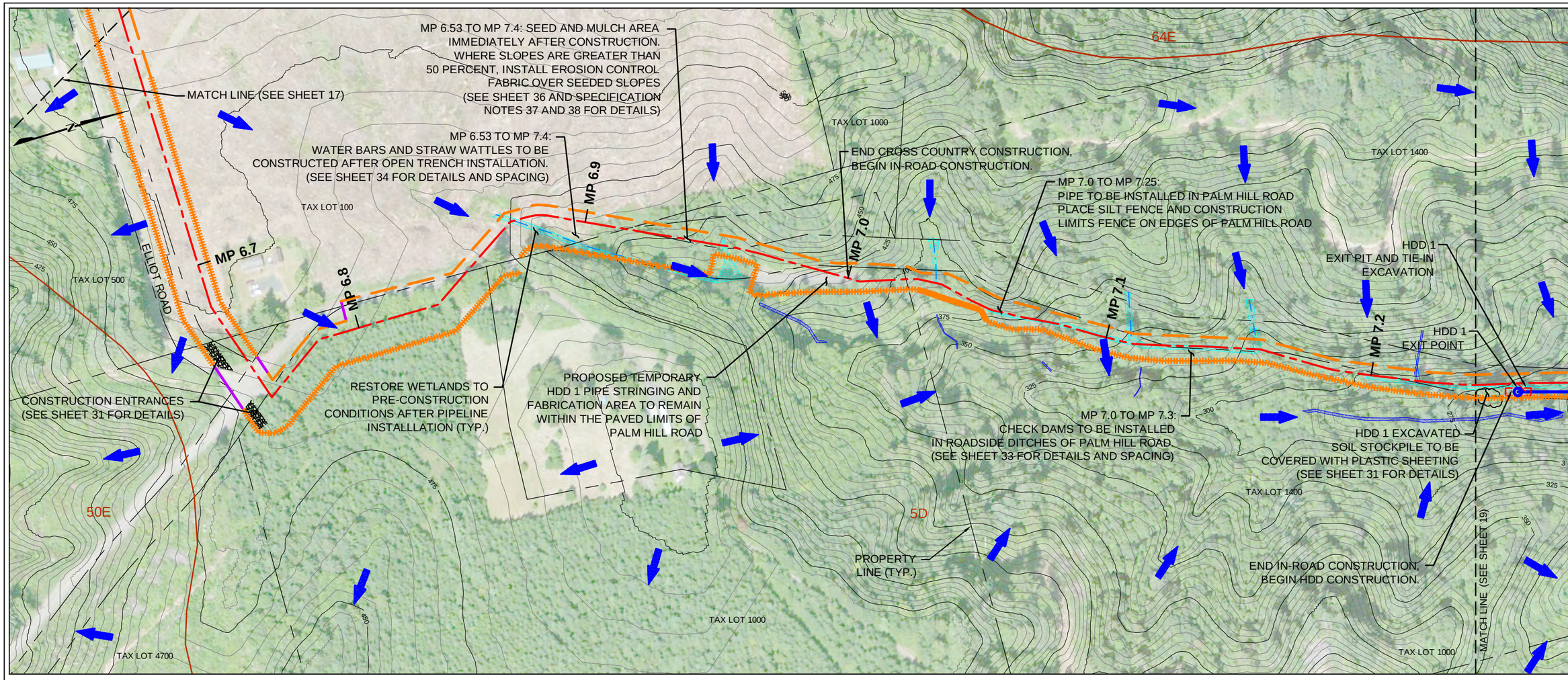

PLAN

200' 0 200'

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LEGEND

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- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
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Revision	Description	Date	By	Chk	Rev

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GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
HDD 1 STRINGING AND FABRICATION AREA

Drawing No.
SHEET 18

Sheet

BCR : BTL

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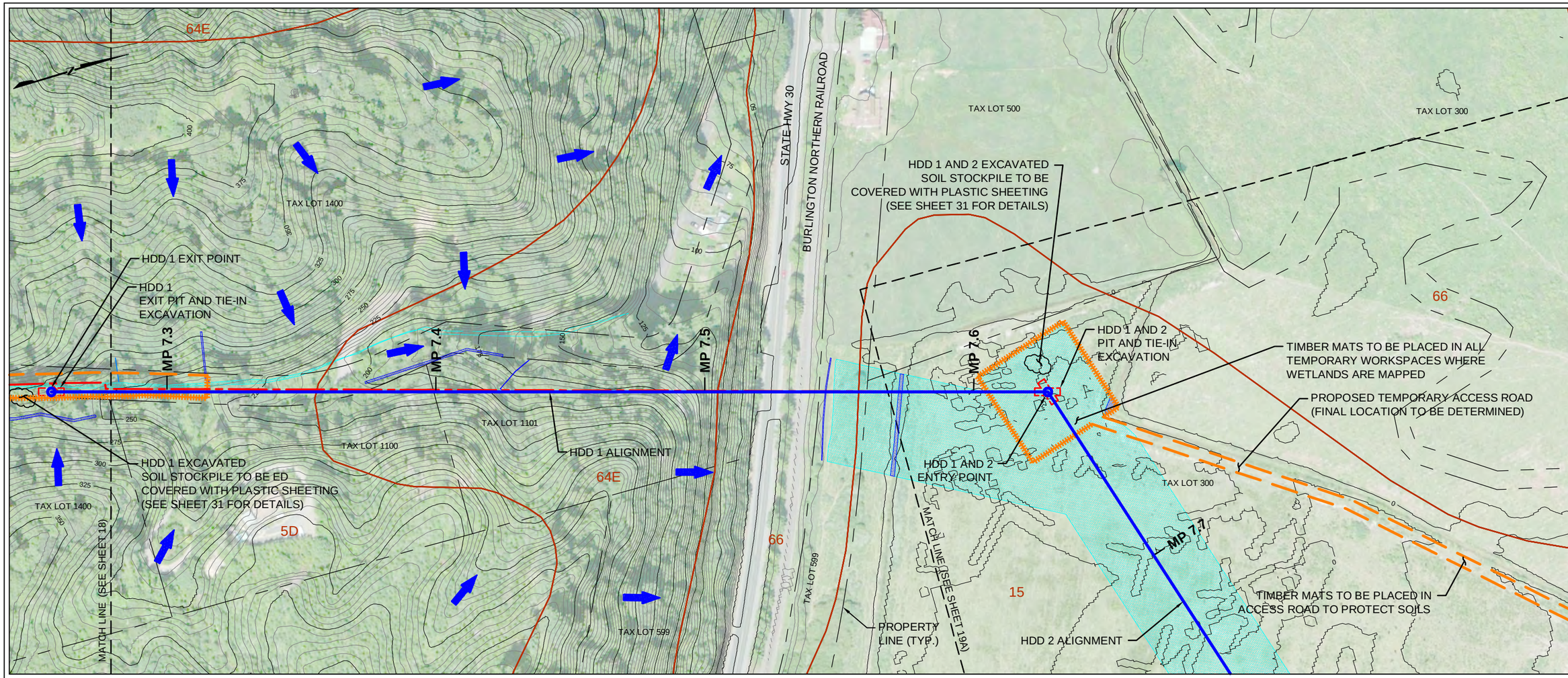

PLAN

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LEGEND

- 64E — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR SCALE: AS NOTED
DRAWN: BTL DATE: 04/03/15
CHECKED: TNH FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
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NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
HDD 1 SITE PLAN

Drawing No.
SHEET 19
Sheet

BCR : BTL

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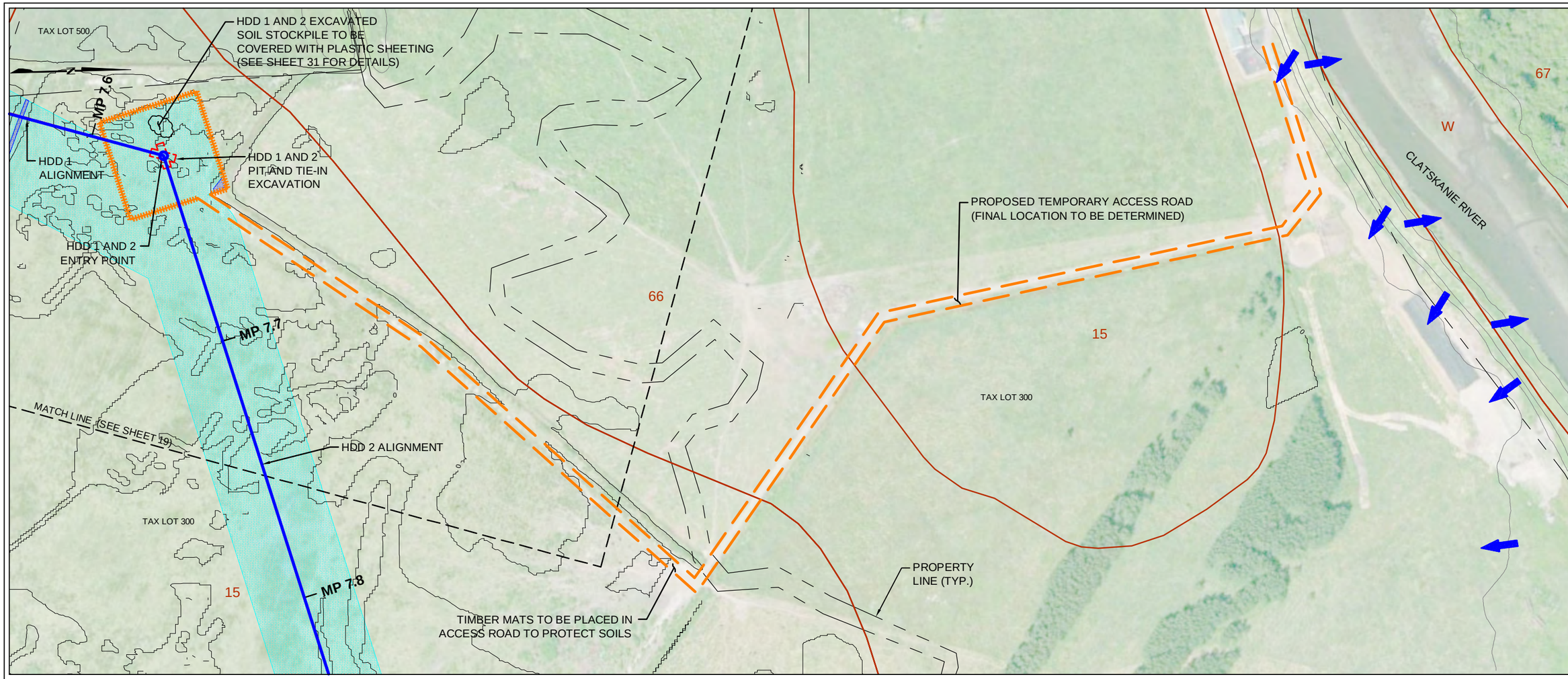

PLAN

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LEGEND

- 64E — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
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Revision	Description	Date	By	Chk	Rev

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DATE: 04/03/15
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GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
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NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
TEMPORARY ACCESS ROAD

Drawing No.
SHEET 19A
Sheet

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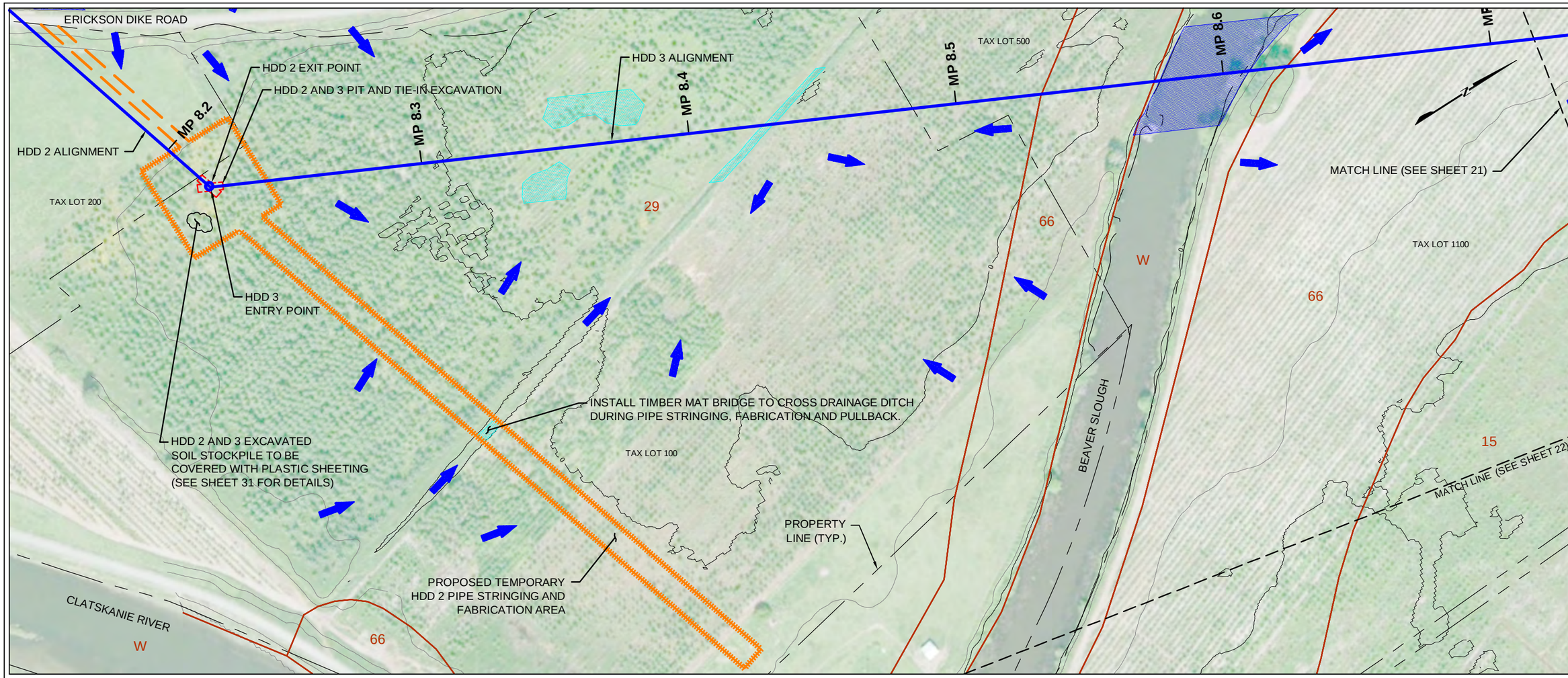

PLAN

200' 0 200'

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LEGEND

- 66 — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
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- LIMITS OF CONSTRUCTION
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- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

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SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
HDD 3 SITE PLAN

Drawing No.
SHEET 20

Sheet

BCR : BTL

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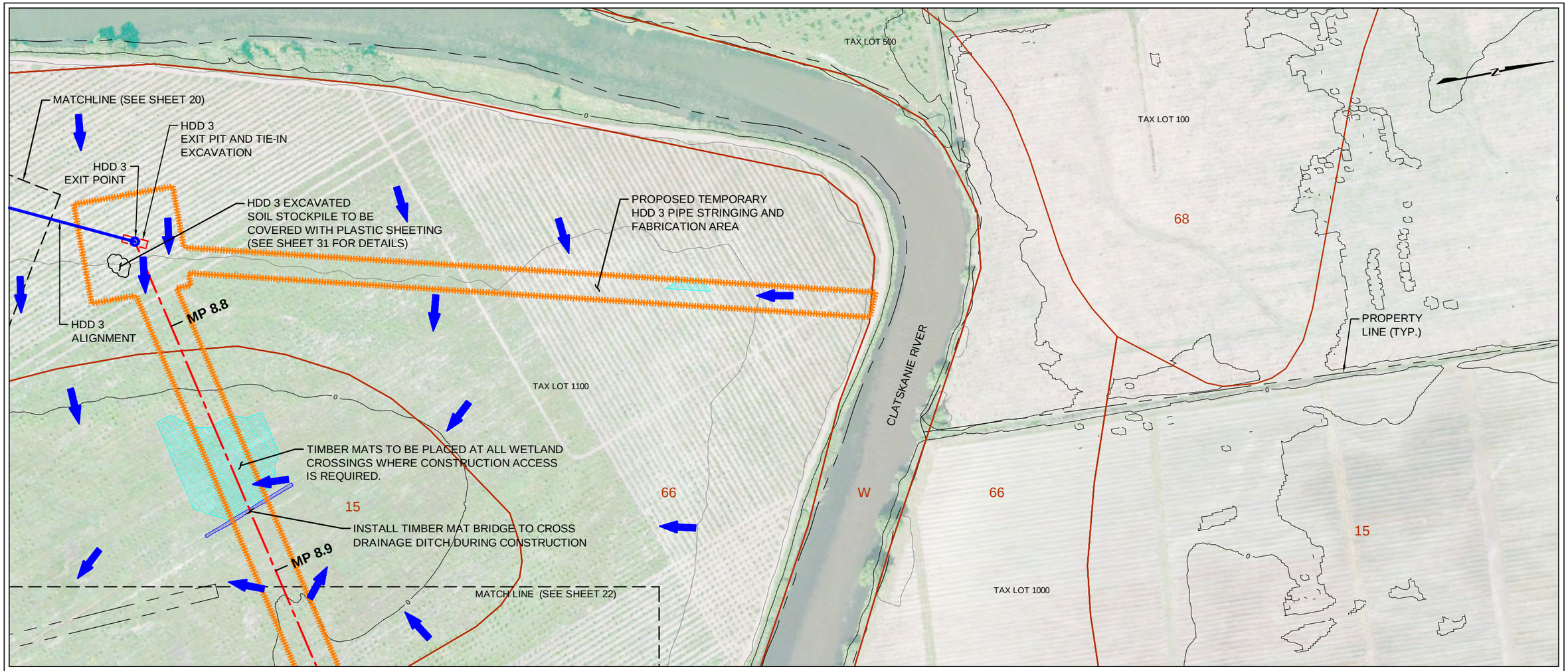

PLAN

200' 0 200'

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LEGEND

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- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
HDD 3 STRINGING AND FABRICATION AREA

Drawing No.
SHEET 21
Sheet

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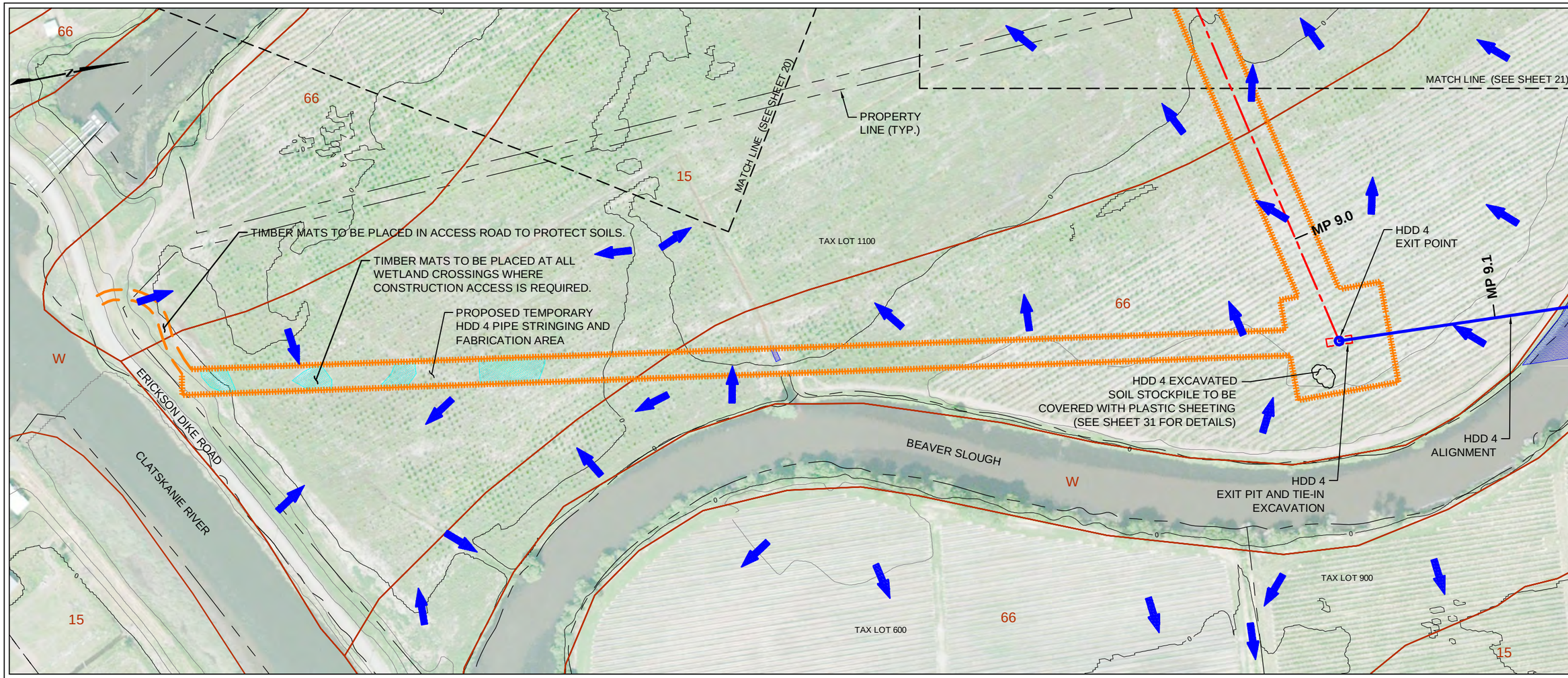
BCR : BTL



PLAN

200' 0 200'

SCALE IN FEET

General Notes:

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8. Topography based on LiDAR data provided by NW Natural. A site specific topographical survey has not been completed.
9. Aerial photos from ESRI ArcGIS Data Online.

LEGEND

- 66 — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
HDD 4 STRINGING AND FABRICATION AREA

Drawing No.
SHEET 22

Sheet

BCR : BTL

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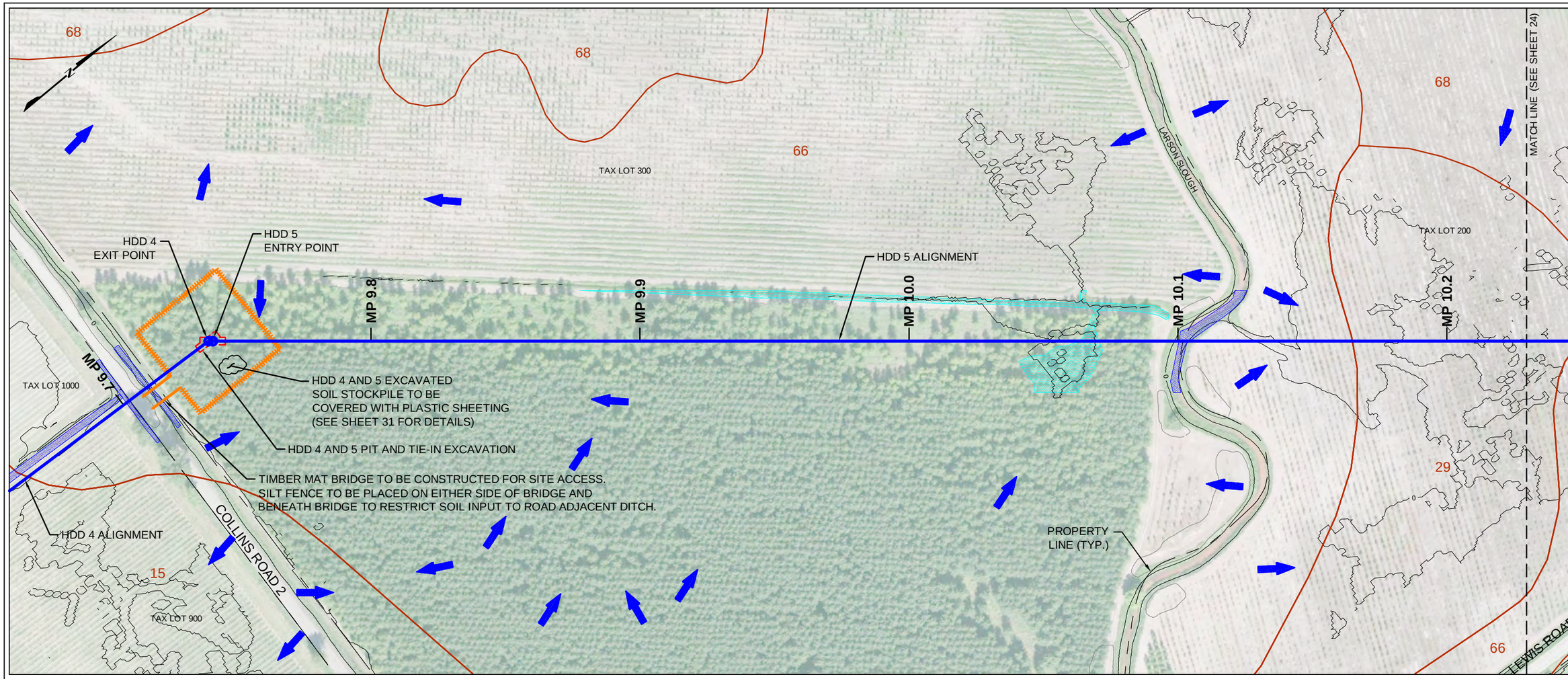

PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 66 — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
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SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
HDD 5 SITE PLAN

Drawing No.
SHEET 23
Sheet

BCR : BTL

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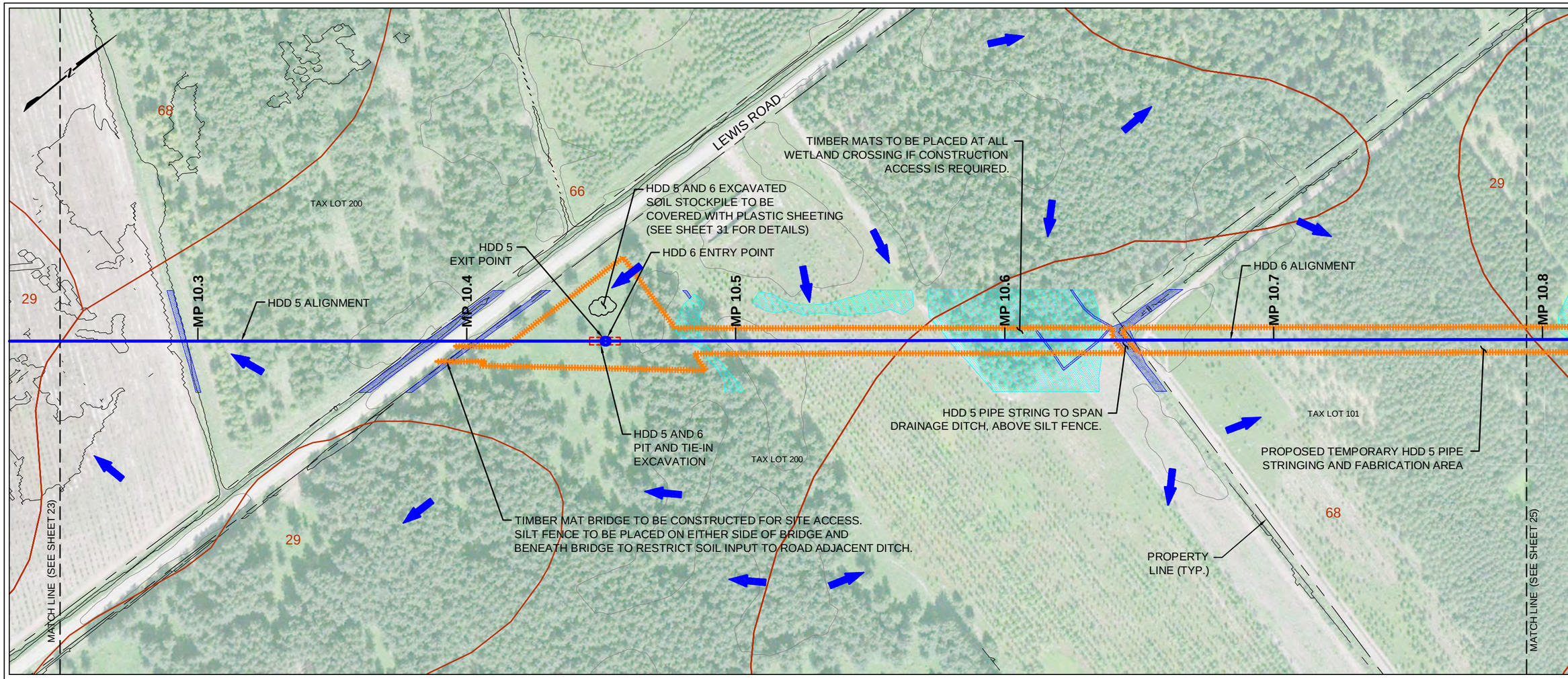

PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

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- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
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SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
HDD 5 STRINGING AND FABRICATION AREA

Drawing No.
SHEET 24

Sheet

BCR : BTL

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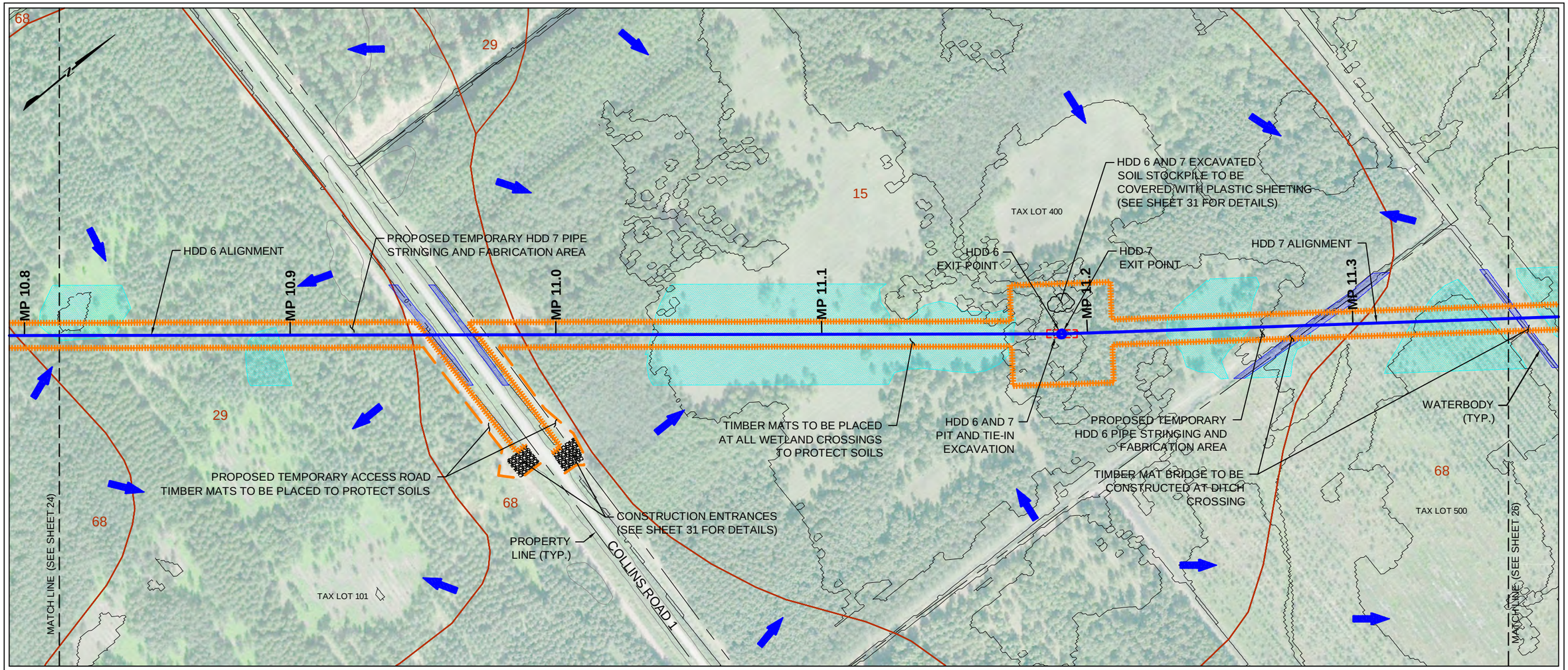

PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 15 — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
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SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
HDD 6 SITE PLAN

Drawing No.
SHEET 25
Sheet

BCR : BTL

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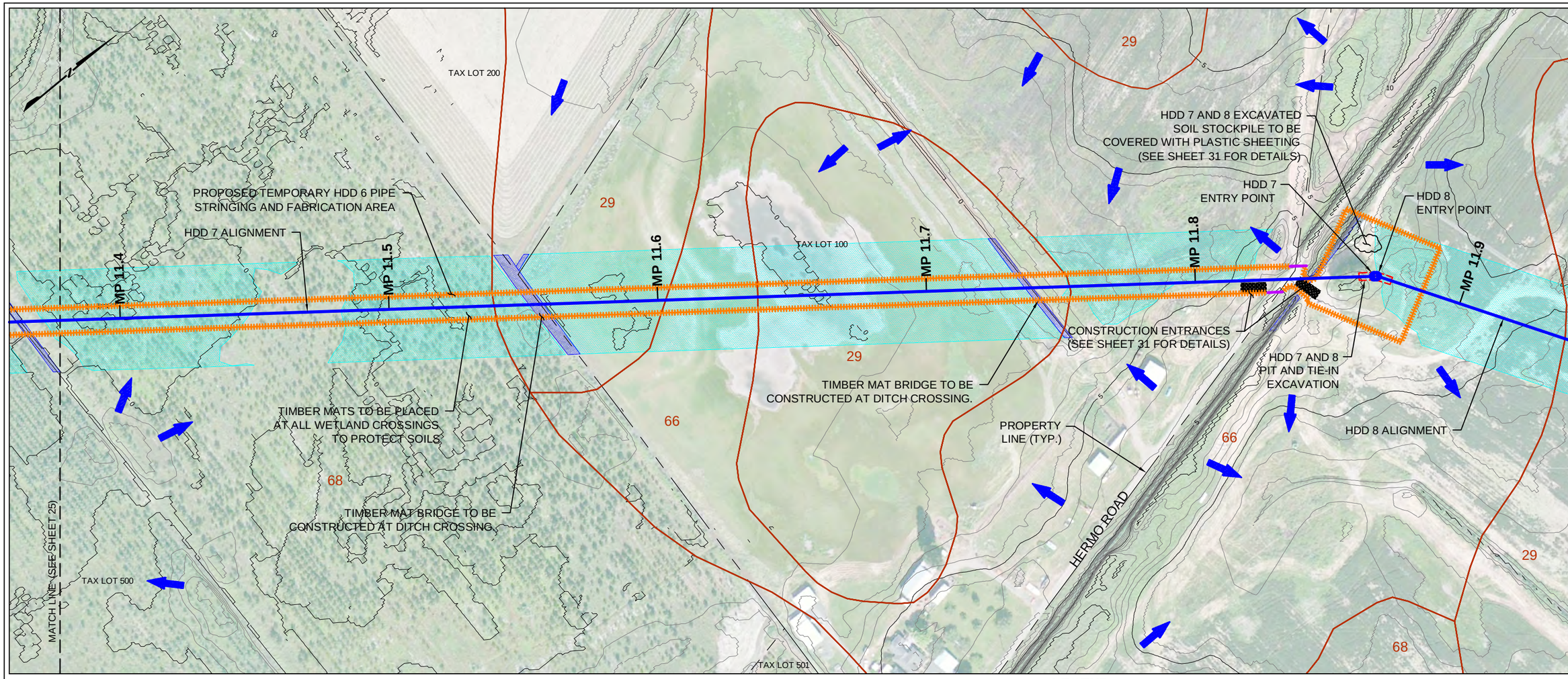

PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 66 — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
DRAWN: BTL
CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
HDD 7 SITE PLAN

Drawing No.
SHEET 26
Sheet

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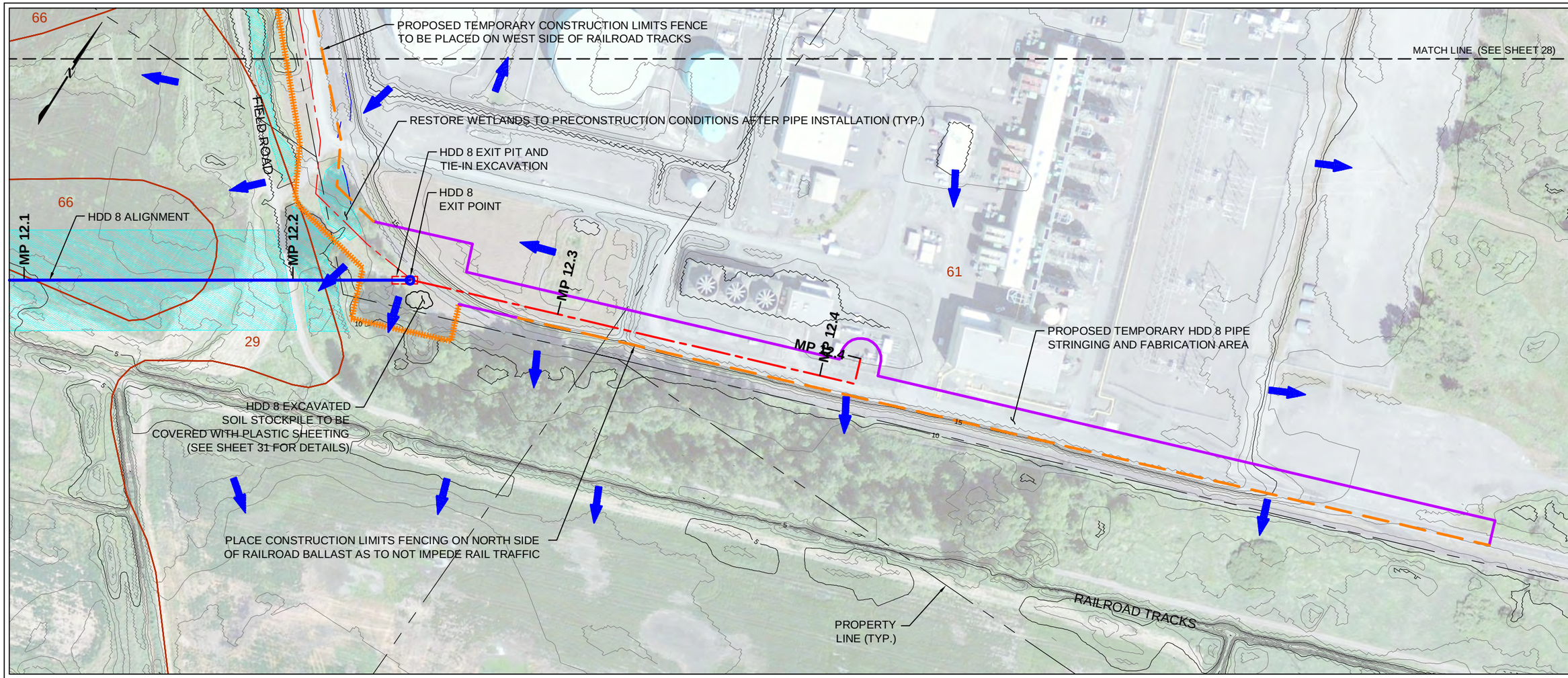
BCR : BTL



PLAN

200' 0 200'

SCALE IN FEET

LEGEND

- 61 — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

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FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
HDD 8 STRINGING AND FABRICATION AREA

Drawing No.
SHEET 27

Sheet

BCR : BTL

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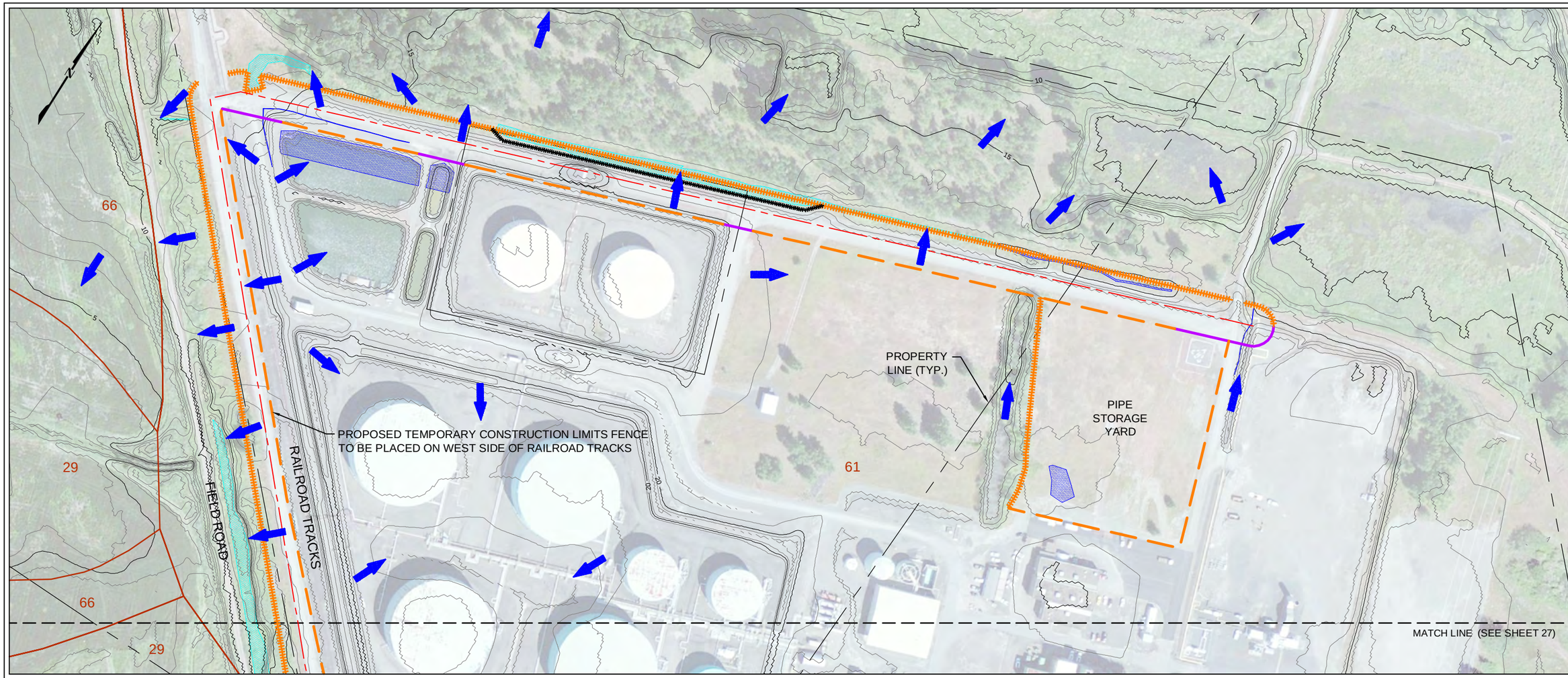

PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 61 — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
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CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

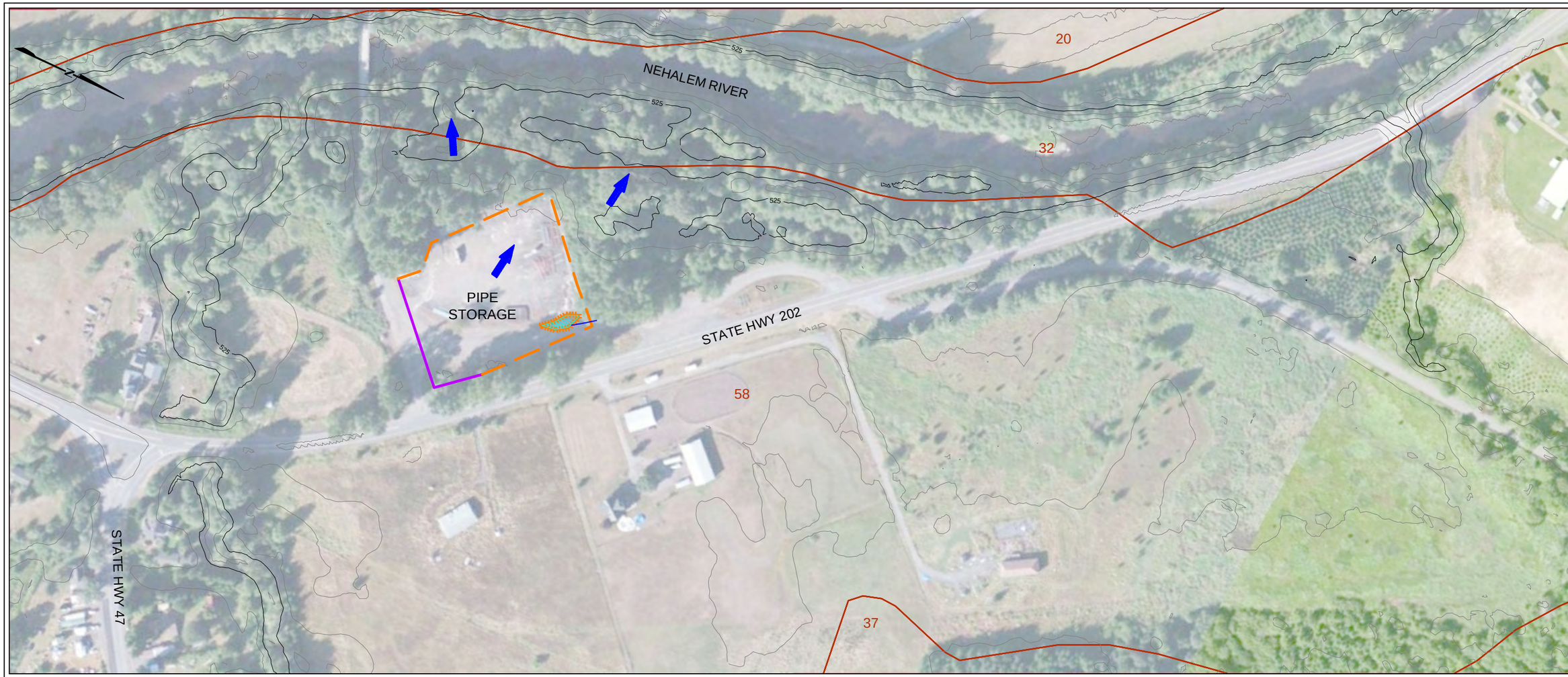
NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
OPEN TRENCH

Drawing No.
SHEET 28
Sheet

BCR : BTL

E:\ESCP\Sheet Files\ESCP SHT 26.dwg\TAB:SHEET 28 modified on Mar 30, 2015 - 3:37pm



PLAN

200' 0 200'

SCALE IN FEET

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LEGEND

- 58 — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
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Revision	Description	Date	By	Chk	Rev

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FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
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F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
PIPE STORAGE

Drawing No.
SHEET 29
Sheet

BCR : BTL
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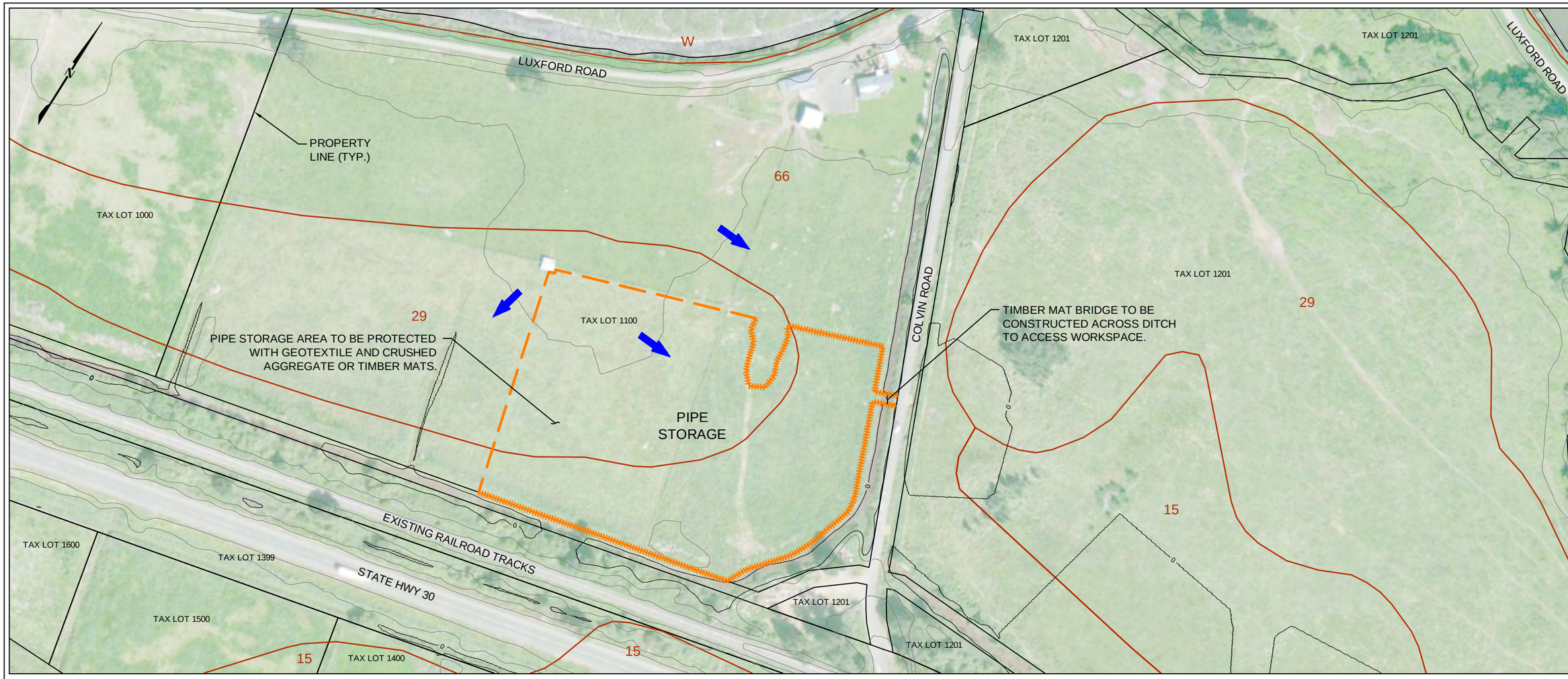

PLAN

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SCALE IN FEET

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LEGEND

- 29 — NRCS SOIL MAP UNIT BOUNDARY AND ID (SEE SHEET 3)
- HDD ALIGNMENT (SUBSURFACE)
- DRAINAGE DIRECTION
- PIPELINE TO BE INSTALLED IN OPEN TRENCH
- UTILITY CONDUIT TO BE INSTALLED IN OPEN TRENCH
- PLANNED EXCAVATION BOUNDARIES
- ORANGE SILT FENCE AND CONSTRUCTION LIMITS (SEE SHEET 31 FOR DETAILS)
- SILT FENCE (SEE SHEET 31 FOR DETAILS)
- LIMITS OF CONSTRUCTION
- ORANGE CONSTRUCTION LIMITS FENCE (SEE SHEET 33 FOR DETAILS)
- EXISTING WATERBODY
- EXISTING DRAINAGE
- EXISTING WETLANDS
- MAJOR CONTOUR - 25' INTERVAL
- MINOR CONTOUR - 5' INTERVAL

Revision	Description	Date	By	Chk	Rev

DESIGNED: BCR
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CHECKED: TNH
SCALE: AS NOTED
DATE: 04/03/15
FILE: 6024-157-03

GEOENGINEERS
15055 SW SEQUOIA PKWY
SUITE 140
PORTLAND, OREGON 97224
P: 503/624-9274
F: 503/620-5940

NORTHWEST NATURAL
NORTH MIST EXPANSION PROJECT
COLUMBIA COUNTY, OREGON

EROSION AND SEDIMENT CONTROL PLAN
PIPE STORAGE

Drawing No.
SHEET 30
Sheet

BCR : BTL

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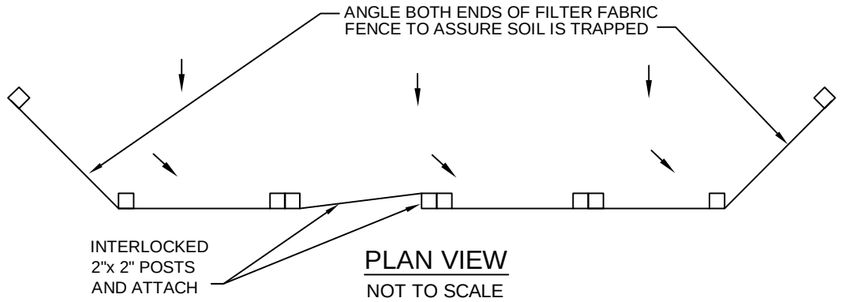
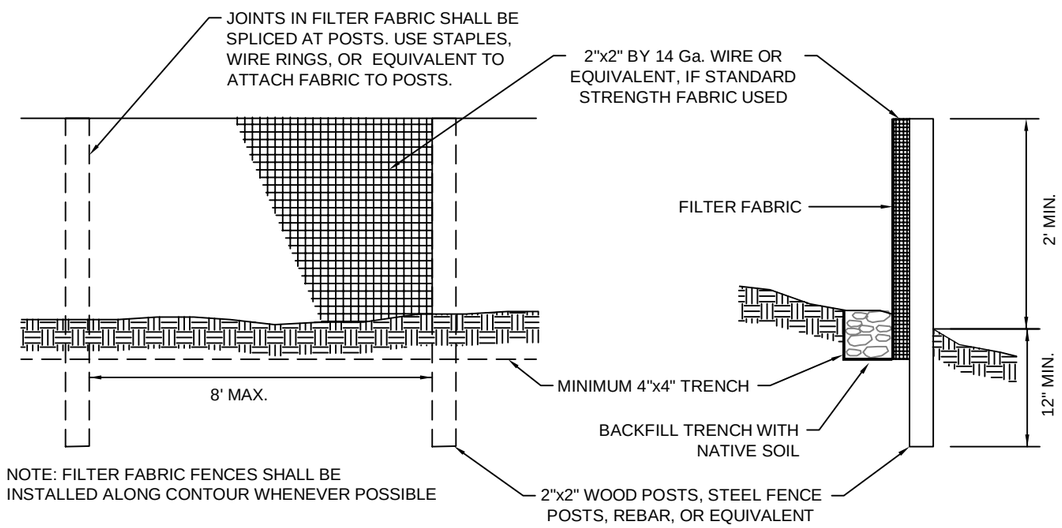


PLAN VIEW

NOT TO SCALE

NOTES:

1. BURY BOTTOM OF FILTER FABRIC 6" VERTICALLY BELOW FINISHED GRADE.
2. 2"x 2" FIR, PINE OR STEEL FENCE POSTS.
3. POSTS TO BE INSTALLED ON UPHILL SIDE OF SLOPE.
4. COMPACT BOTH SIDES OF FILTER FABRIC TRENCH.
5. PANELS MUST BE PLACED ACCORDING TO SPACING TABLE 1 & 2.



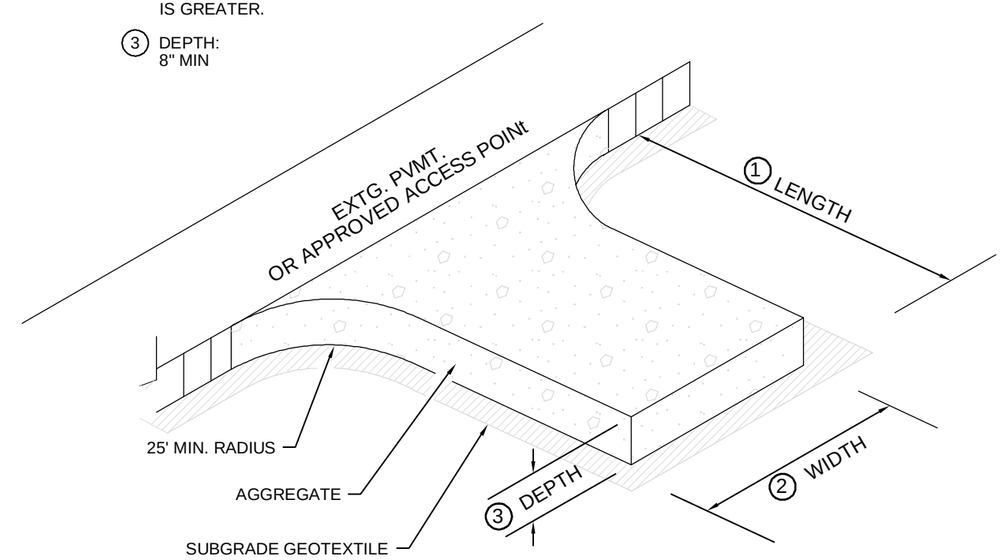
NOTE: FILTER FABRIC FENCES SHALL BE INSTALLED ALONG CONTOUR WHENEVER POSSIBLE

TEMPORARY ORANGE SEDIMENT/SILT FENCE DETAILS

NOT TO SCALE

NOTES:

1. LENGTH:
   50' MIN. - FOR LESS THAN 1 ACRE EXPOSED SOIL
   100' MIN. - FOR GREATER THAN 1 ACRE EXPOSED SOIL
2. WIDTH:
   20' - OR WIDTH OF EXTG. APPROACH, WHICHEVER IS GREATER.
3. DEPTH:
   8" MIN



CONSTRUCTION ENTRANCE DETAIL

NOT TO SCALE

TABLE 1
Barrier Spacing for General Application

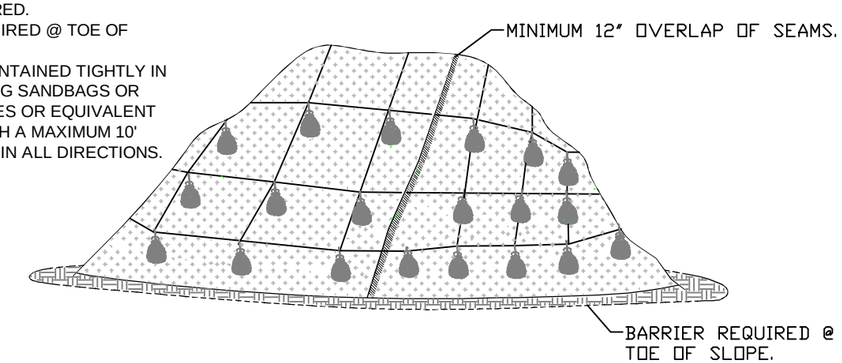
Install Parallel Along Contours as Follows		
% Slope	Slope	Maximum Spacing on Slope
10% Flatter	10H:1V or Flatter	300 feet
10 > %	<15 10H:1V > x < 7.5H:1V	150 feet
15 > %	<20 7.5H:1V > x < 5H:1V	100 feet
20 > %	<30 5H:1V > x < 3.5H:1V	50 feet
30 > %	<50 3.5H:1V > x < 2H:1V	25 feet

TABLE 2
Sediment Fence Fabric Specifications

Woven Polypropylene Sediment Fence Fabric		
Property	Test Procedure	Minimum Fabric Value
Grab Tensile Strength	ASTM D 4632	180 lbs. Grab
Elongation	ASTM D 4632	15%
Trapezoid Tear	ASTM D 4533	70 lbs. Mullen
Burst	ASTM D 3786	300 psi
Puncture	ASTM D 4833	80 lbs.
Permitivity	ASTM D 4491	.07 sec-1
Permeability	ASTM D 4491	.005 cm/sec.
A.O.S.	ASTM D 4751	50 U.S. Standard Sieve
UV Resistance (500 hours)	ASTM D 4355	90%

NOTES:

1. MINIMUM 12" OVERLAP OF ALL SEAMS REQUIRED.
2. BARRIER REQUIRED @ TOE OF STOCK PILE.
3. COVERING MAINTAINED TIGHTLY IN PLACE BY USING SANDBAGS OR TIRES ON ROPES OR EQUIVALENT WEITGHTS WITH A MAXIMUM 10' GRID SPACING IN ALL DIRECTIONS.



SOIL STOCKPILE PLASTIC SHEETING DETAIL

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EROSION AND SEDIMENT CONTROL PLAN DETAILS

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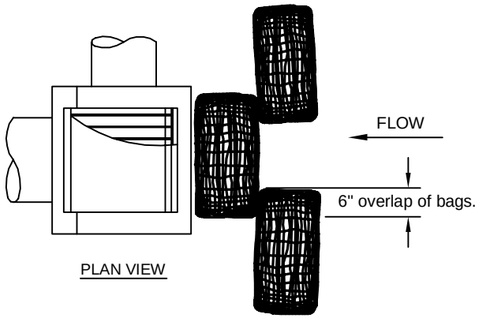
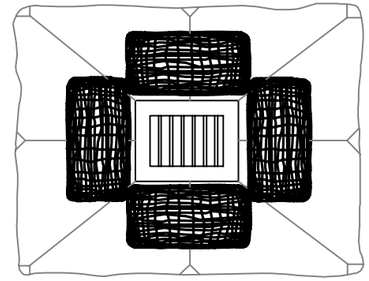
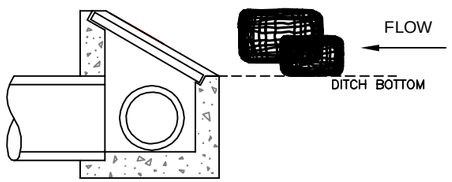


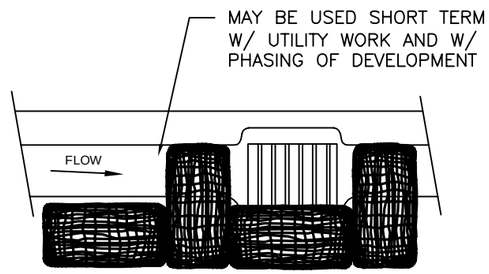
PLAN VIEW



AREA DRAIN



DITCH INLET



CATCH BASIN

NOTE: USE FILTER FABRIC INSERT SACKS ALONG WITH BIO-BAGS TO PROTECT INLEST.

NOTES

1. ADDITIONAL MEASURES MUST BE CONSIDERED DEPENDING ON SOIL TYPES.
2. BIOFILTER BAGS SHOULD BE STAKED WHERE APPLICABLE USING (2) 1"x2" WOODEN STAKES OR APPROVED EQUAL PER BAG.

INLET PROTECTION (TYPE 4) DETAIL

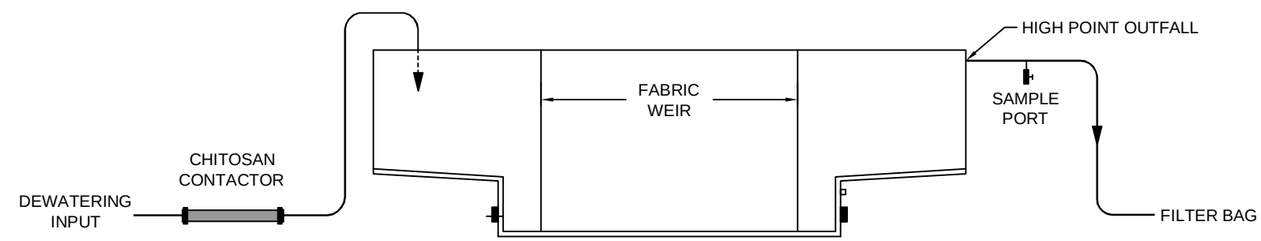
NOT TO SCALE

Filter Bags shall be used to collect silt and sediment from pumped water prior to discharge. Several types and sizes of filter bags are available. The contractor should choose the appropriately sized filter bag for the volume of water that will be pumped into the filter bag prior to discharge. Filter bags shall consists of a nonwoven polypropylene geotextile with the minimum requirements noted in the table below. Connection of the pump hose to the filter bag shall include a secure clamp, tie or taped connection that does not allow water to leak from the connection.

PROPERTY	TEST METHOD	ENGLISH	METRIC
Mullen Burst	ASTM D-3786	350 psi	2,413 kPa
Puncture Strength	ASTM D-4833	120 psi	534 N
Trapezoidal Tear	ASTM D-4533	85 lbs	378 N
Apparent Opening Size	ASTM D-4751	80 US Sieve	0.180 mm
Permittivity	ASTM D-4491	1.35 Sec-1	1.35 Sec-1
Water Flow Rate	ASTM D-4491	90 g/min/sf	3,657 l/min/sm

GEOTEXTILE FILTER BAG DETAIL

NOT TO SCALE



FILTER TANK	
Equipment:	Baker Style Open Top
Capacity:	500 BBL (21,000 gals)
Approx. Size:	35'L x 8'W x 12'H

NOTES:

1. A dewatering water filtration system such as the one shown above shall be used prior to discharging water that will flow to waters of the state such as rivers, streams or jurisdictional wetlands.
2. The dewatering cleaning system shown is conceptual. For more specifics details and products, contact BarkerCorp of Portland, Oregon.

DEWATERING DISCHARGE BAKER TANK DETAIL

NOT TO SCALE

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EROSION AND SEDIMENT CONTROL PLAN DETAILS

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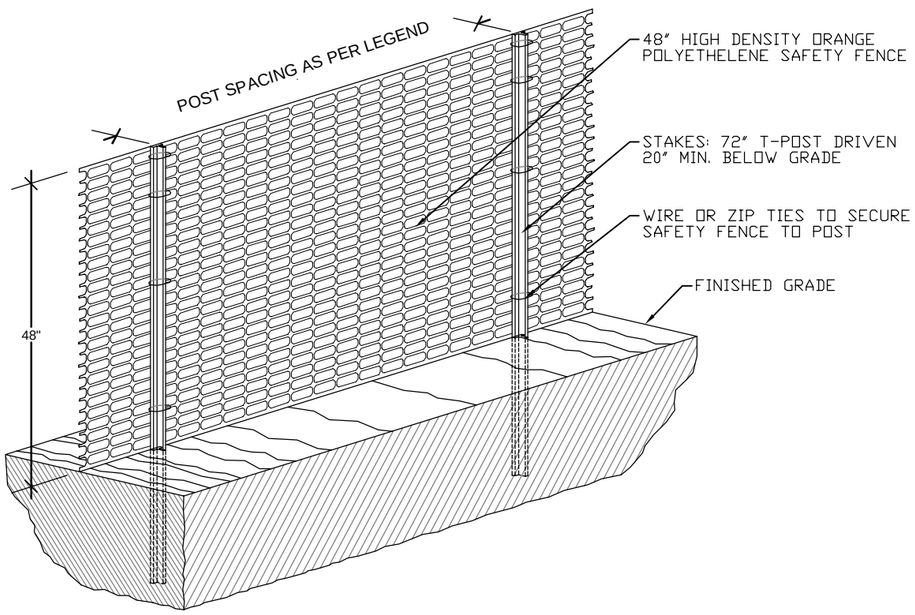
LEGEND

SAF12	48" ORANGE FENCE, 12 FEET O.C.
SAF11	48" ORANGE FENCE, 11 FEET O.C..
SAF10	48" ORANGE FENCE, 10 FEET O.C.
SAF9	48" ORANGE FENCE, 9 FEET O.C.
SAF8	48" ORANGE FENCE, 8 FEET O.C..
SAF7	48" ORANGE FENCE, 7 FEET O.C.
SAF6	48" ORANGE FENCE, 6 FEET O.C.

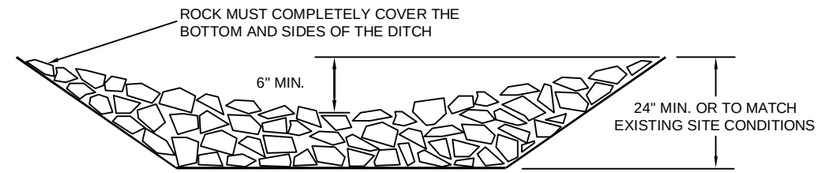


NOTES

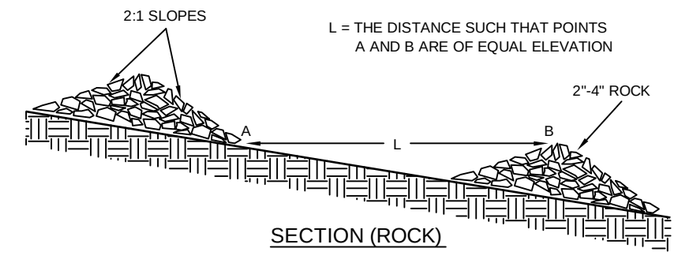
1. CONSTRUCTION SAFETY FENCE SHALL BE USED TO MARK THE LIMITS OF CONSTRUCTION AT EACH END OF THE HDD AND ALONG THE LEASE BOUNDARY EAST OF THE TRENCH. FENCE SHALL BE PUT UP BEFORE ANY GROUND DISTURBING ACTIVITY OCCURS.
2. CONSTRUCTION SAFETY FENCE SHALL BE SIGNED "CONSTRUCTION AREA LIMIT" EXCEPT ON SIDED FACING WETLAND AREAS. ON THOSE SIDES, THE SIGN SHALL SAY "PROTECTED RESOURCE - DO NOT ENTER".
3. FENCE SHALL BE REMOVED ONLY AFTER ALL GROUND DISTURBING ACTIVITY ON THE PROJECT (OR PROJECT AREA) CEASES AND THE SITE IS READY FOR PERMANENT REVEGETATION.
4. ON PAVED AREAS, PERIMETER OF WORK AREA CAN BE MARKED WITH FENCE SUPPORTED BY PYLONS, SAWHORSE BARRICADES, TRAFFIC CONES, OR EQUIVALENT.

CONSTRUCTION LIMITS FENCE (ORANGE) DETAIL

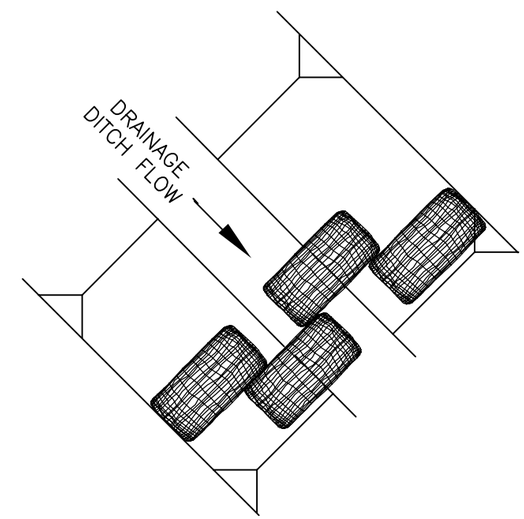
NOT TO SCALE



PROFILE (ROCK)



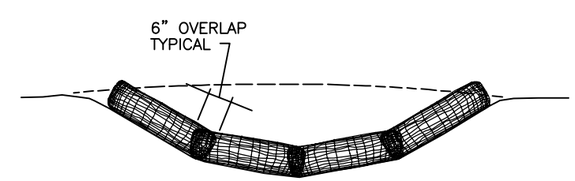
SECTION (ROCK)



PLAN VIEW (BIO BAG)

NOTES

1. STAKING OF BAGS REQUIRED USING (2) 1"X2" WOOD STAKES OR APPROVED EQUAL PER BAG.
2. SURFACE MUST BE SMOOTH BEFORE APPLICATION.



PROFILE (BIO BAG)

SLOPE	SPACING
1 to 10 percent	100 feet
5 to 10 percent	75 feet
10 to 25 percent	50 feet
25 to 50 percent	25 feet
>50 percent	10 feet

BIO BAG OR ROCK CHECK DAM INSTALLATION DETAIL

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EROSION AND SEDIMENT CONTROL PLAN DETAILS

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SHEET 33
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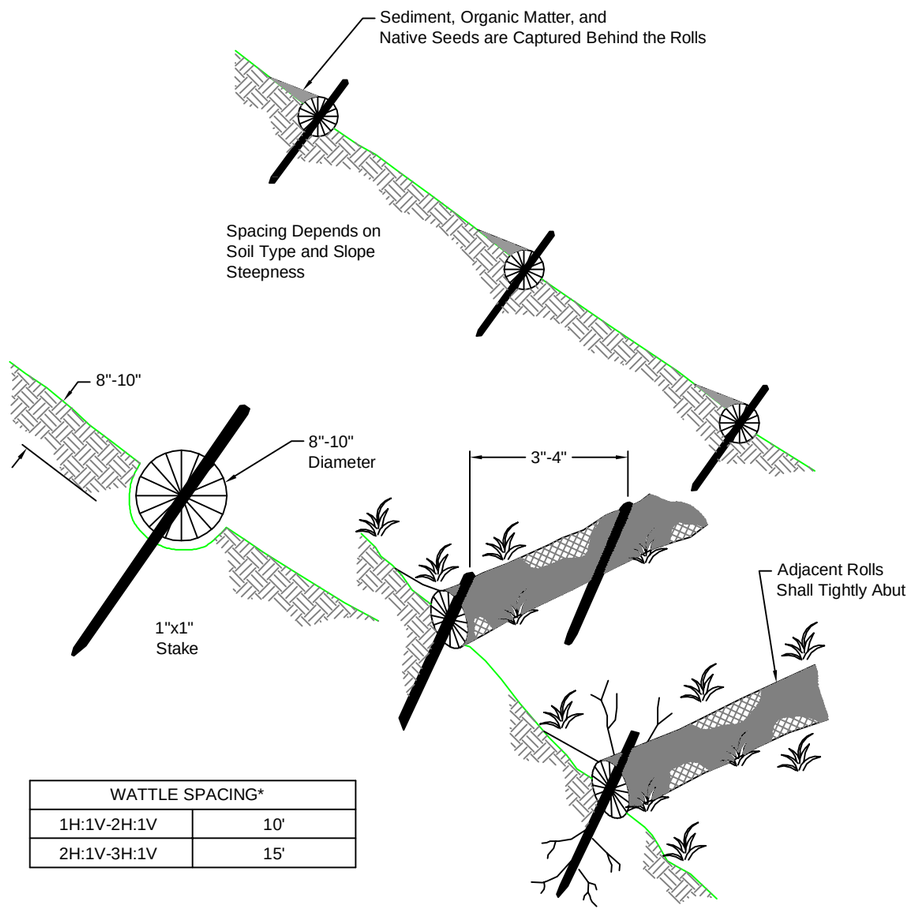


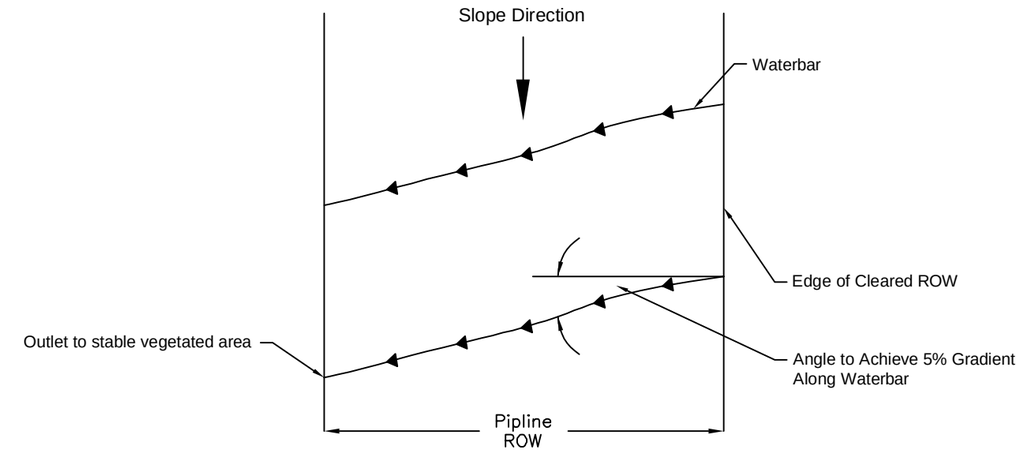
WATTLE SPACING*	
1H:1V-2H:1V	10'
2H:1V-3H:1V	15'

SPECIFICATIONS:

1. Place wattles on all poorly vegetated or disturbed slopes greater than 3H:1V within 100' of the OHWM.
2. Wattles shall be placed on contour, perpendicular to slope.
3. Wattles shall be placed into 3-5" deep trench to ensure that water does not seep beneath the wattles.
4. Drive anchor stakes through wattle, perpendicular to slope.
5. Anchor stakes shall consist of wooden 1"x1"x18" stakes.

STRAW WATTLE INSTALLATION DETAIL

NOT TO SCALE

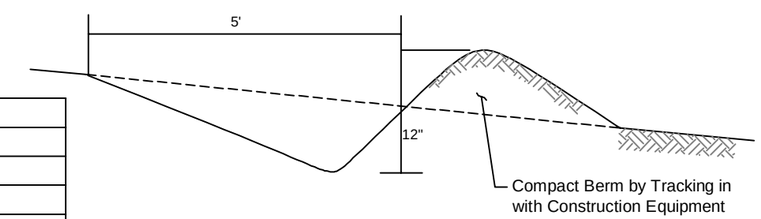


NOTE: Orientation of waterbar and direction of outlet to be determined in the field based on site specific conditions.

INVERSE WATERBAR ORIENTATION

NOT TO SCALE

WATERBAR SPACING	
SLOPE %	SPACING
< 5	125'
5 - 10	100'
10 - 20	75'
20 - 35	50'
> 35	25'



STANDARD /INVERSE WATERBAR DETAIL

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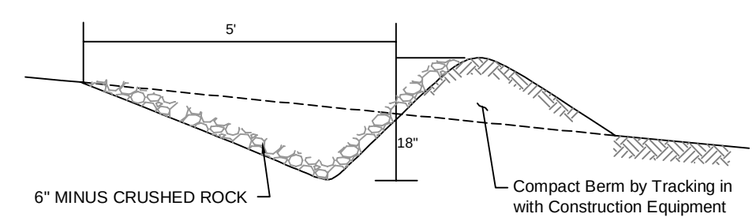

GRAVEL LINED WATERBAR DETAIL

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EROSION AND SEDIMENT CONTROL PLAN
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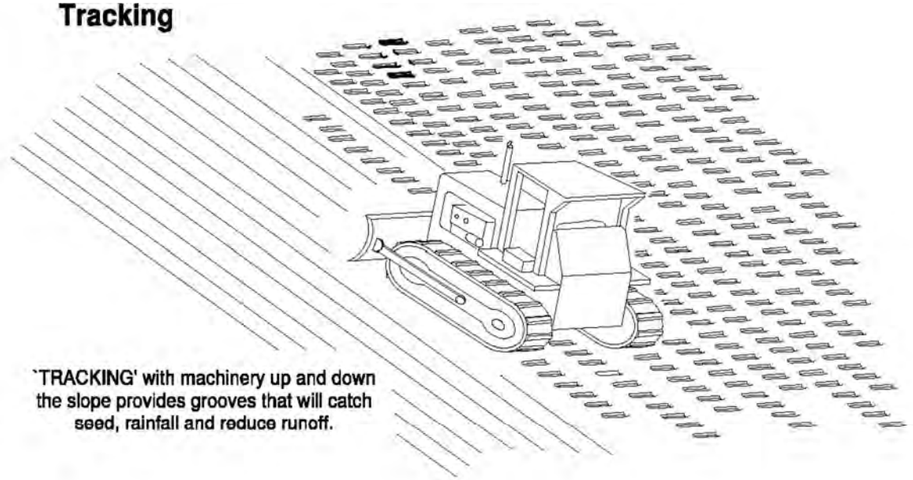
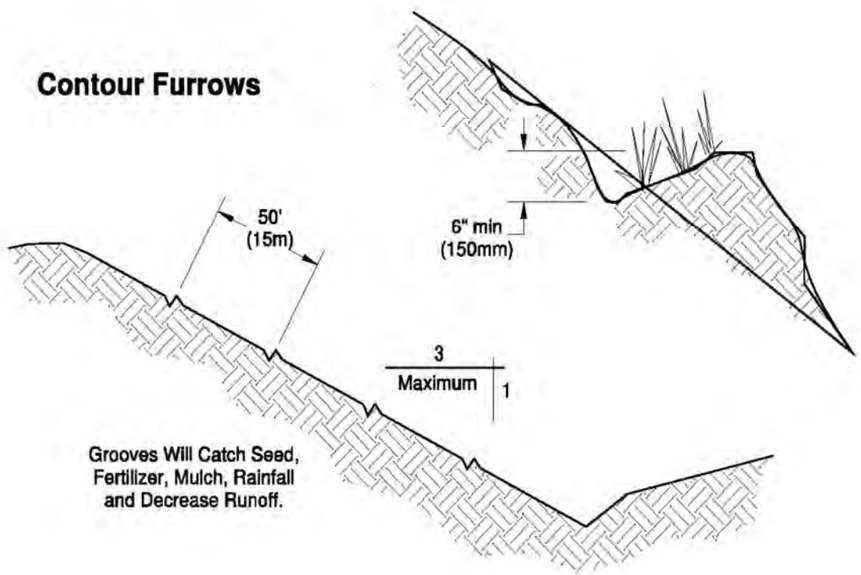
Tracking



Contour Furrows



SURFACE ROUGHING DETAIL

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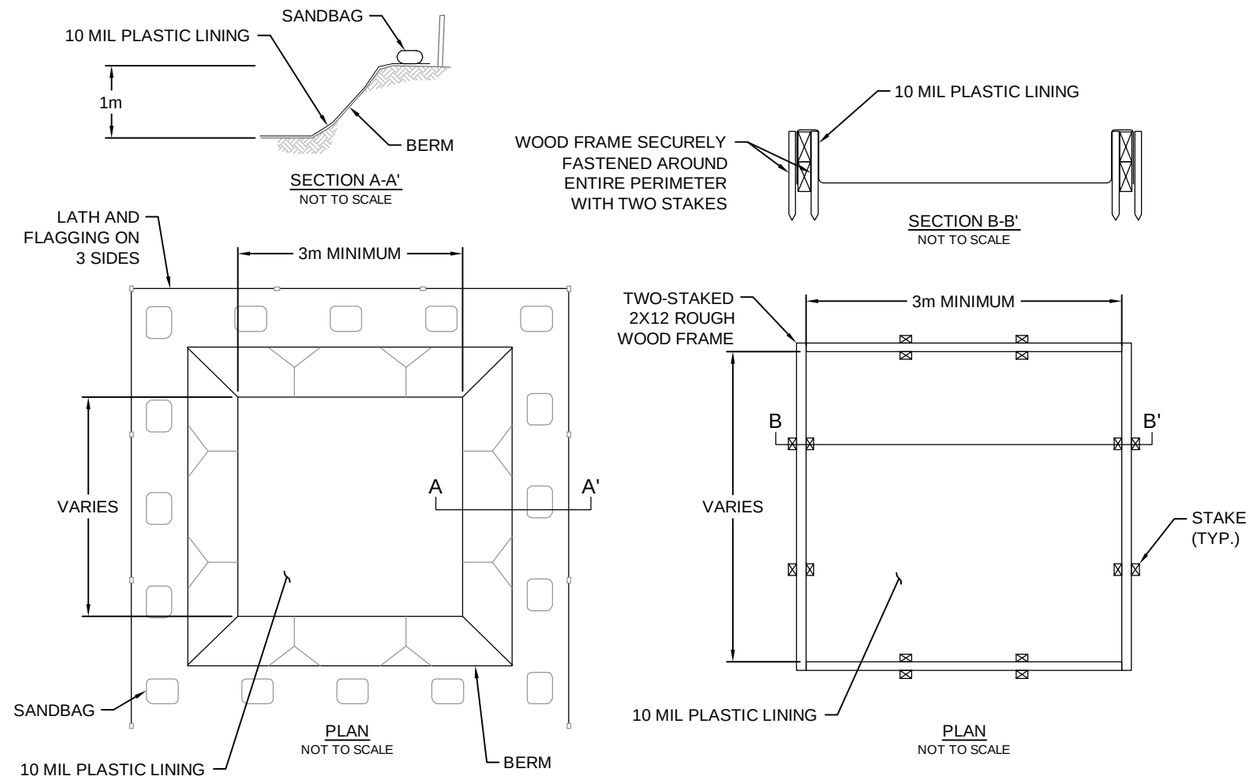

NOTES

1. ACTUAL LAYOUT DETERMINED IN THE FIELD.
2. THE CONCRETE WASHOUT SIGN SHALL BE INSTALLED WITHIN 10m OF THE TEMPORARY CONCRETE WASHOUT FACILITY.
3. A PRE-MANUFACTURED CONCRETE WASHOUT TUB OR BUCKET MAY BE USED IN LIEU OF THIS WASHOUT. USE PRE-MANUFACTURED CONCRETE WASHOUT IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS.

CONCERETE WASHOUT DETAIL

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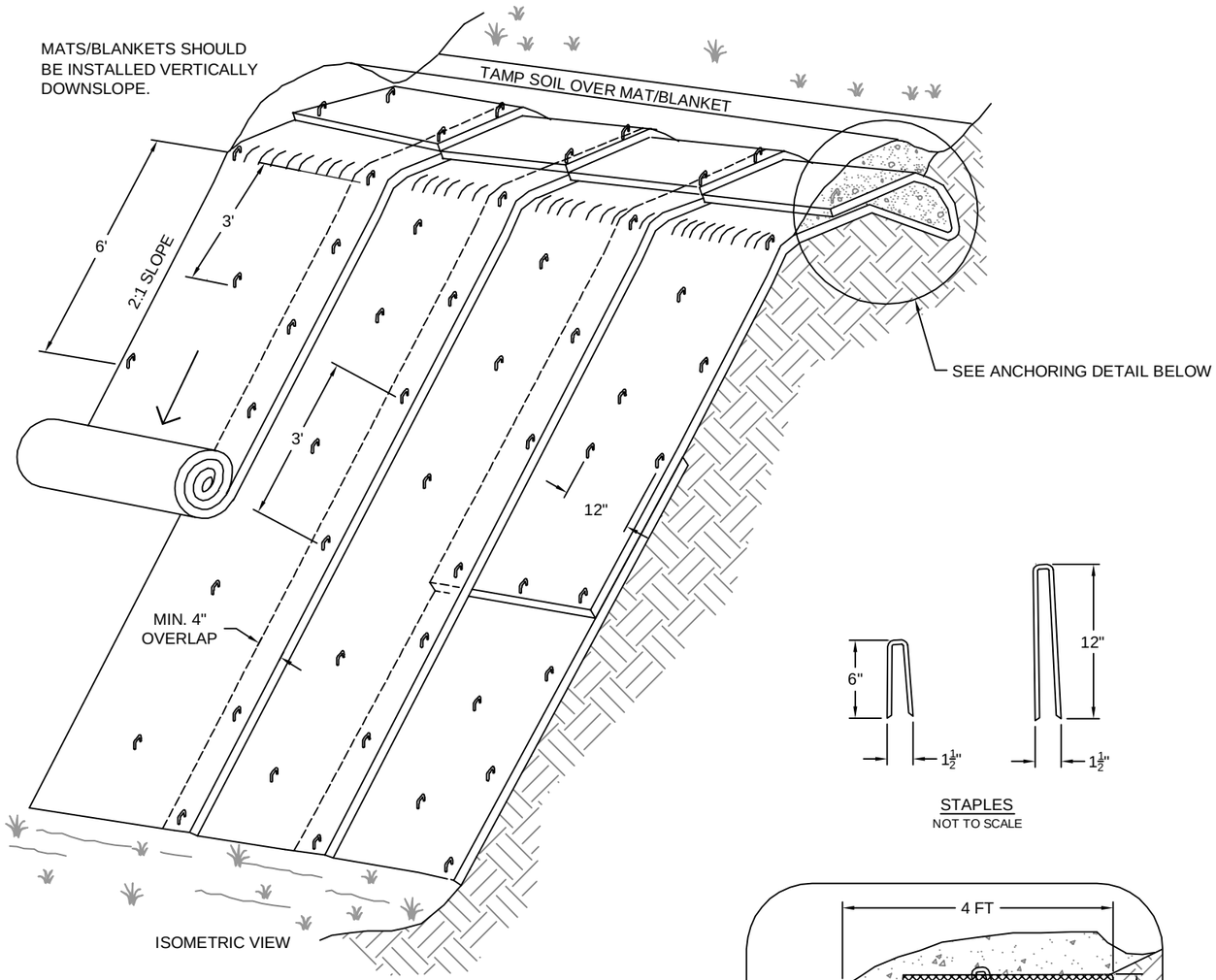

TYPICAL SLOPE SOIL STABLIZATION
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STAPLES
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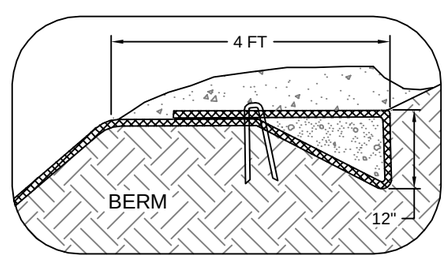

ANCHORING DETAIL
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TYPICAL EROSION BLANKETS

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