Cascadia Associates, LLC

Memorandum

To	Shawn Rapp, R.G. Oregon Department of Transportation	File no	0028-001-001-02
		cc	Bart Bretherton Oregon Department of Transportation
From	Kirsten White, P.E. Chris Breemer, R.G. Cascadia Associates, LLC		
Date	October 6, 2016		

Subject **Sampling and Analysis Plan – Statewide Highway Shoulder Soil Evaluation**

This Sampling and Analysis Plan (SAP) has been prepared by Cascadia Associates, LLC (Cascadia) as requested by the Oregon Department of Transportation (ODOT) and as detailed in Contract No. B33811. This SAP includes a summary of the state-wide highway shoulder soil[1] evaluation conducted to date, a statistical evaluation that was performed to develop the next phase of sampling, and the plan for collection and analysis of highway shoulder soil samples later in 2016. The proposed sampling and evaluation activities are being conducted to assist ODOT, in coordination with the Oregon Department of Environmental Quality (DEQ), to determine the likelihood that shoulder soil generated during roadway construction and improvement projects will meet DEQ clean fill criteria (DEQ, 2014) or other applicable criteria, and to develop a management plan for beneficial uses of soil that does not meet clean fill criteria. The results of this study may be used by ODOT as a basis for modifying ODOT *Directive GE 14-01(D) (e.g., limiting the need for soil sampling)* or for designing future studies to further reduce the scope of Directive GE 14-01(D).

BACKGROUND

Elevated concentrations of traffic-related hazardous constituents are widespread in shoulder soil in many parts of the world, including Oregon. In most cases, the impacted soil poses no threat to human health and the environment when it is in-place; that is, on the shoulders of highways. However, during highway construction projects it is often necessary to excavate and export soil. If exported soil is disposed of or re-used in sensitive locations (e.g., wetlands or residential areas), constituents in soil could pose a risk to human and ecological

1 The term "shoulder soil", as used herein, refers to soil in the ODOT right of way, outside of areas covered by pavement.

health. Therefore, a management plan for shoulder soil is necessary. Currently, shoulder soil in Oregon is managed under ODOT Directive GE 14-01(D). As detailed in the directive, soil excavated from the surface to 1.5 feet below the ground surface within the ODOT right-of-way must be characterized prior to export from the construction area. Soil that meets clean fill criteria can be managed unrestricted. Soil that does not meet clean fill criteria must be managed as solid waste. In practice, this often involves collection and laboratory analysis of soil samples. Excavated soil that does not meet clean fill criteria requires special management (e.g., reuse through a solid waste letter of authorization from DEQ). In practice, soil that does not meet clean fill criteria is often disposed of at licensed landfills, leading to increased construction costs, reduced landfill capacity, and reductions in project sustainability metrics. The analysis of soil samples and the disposal fees associated with maintaining compliance with ODOT Directive GE14-01(D) can be cumbersome and cost prohibitive to many roadway construction and improvement projects.

2015 SHOULDER SOIL DATA EVALUATION

In 2015, an initial phase of analysis was performed on shoulder soil in Oregon. During that phase of work, soil data from 64 ODOT roadway projects were evaluated to develop a general understanding of the types, magnitude, and extent of constituents in shoulder soil and to identify data gaps that could potentially be resolved through a supplemental sampling effort. Data gaps that were identified included the influence of sampling variables (e.g., depth of sample collected, physiographic province, distance from edge of pavement, and average annual daily traffic [AADT]) on the detected concentrations of constituents of interest (COIs). A shoulder soil sampling effort was conducted in May 2015 to expand the soil dataset and improve the understanding of the distribution of constituents in shoulder soil and to evaluate options for developing a management plan for shoulder soil. The general locations of the samples collected for the 64 ODOT projects and the 2015 sampling effort are shown on Figure 1.

During the 2015 evaluation of the ODOT soil dataset, data were classified based on the sampling variables, when available. As detailed in the *Oregon Department of Transportation State-Wide Highway Shoulder Soil Data Analysis* (Apex, 2015; the "Shoulder Soil Evaluation Report"), lead and benzo(a)pyrene were determined to be the two constituents that were both traffic related and regularly exceeded clean fill criteria). These constituents have been identified as traffic-related constituents in a number of other studies in the United States and other countries. Other constituents detected in shoulder soil were determined to be either: (1) not traffic related, or (2) possibly traffic related (e.g., selenium and nickel), but consistently below the clean fill criteria. Based on these findings, lead and benzo(a)pyrene were carried forward as constituents of concern (COC) for the 2016 shoulder soil evaluation.

The data and analysis presented in the *Shoulder Soil Evaluation Report* were useful for improving the understanding of the distribution of constituents in shoulder soil; however, the data were not sufficient to develop a predictive model of the distribution of constituents in soil that would provide a level of certainty necessary to modify ODOT Directive GE 14-01(D). Consequently, the *Shoulder Soil Evaluation Report* recommended the following next steps:

- Develop region-specific soil management criteria;
- Coordinate with DEQ on alternative(s) to the clean-fill criteria; and
- Develop a better understanding of the magnitude and extent of lead and benzo(a)pyrene in shoulder soil through the collection and analysis of soil samples in underrepresented areas of the state or with underrepresented characteristics (e.g., depth, distance from the pavement, etc.).

OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY COORDINATION

Representatives of ODOT, DEQ, and Cascadia met in April and May 2016 to discuss the results of previous ODOT shoulder soil studies, identify management options for shoulder soil that does not meet clean fill criteria, and to develop methods appropriate for characterizing shoulder soil. An outcome of those meetings was DEQ's May 4, 2016 memorandum - *Concepts for ODOT Road Shoulder Materials Management Project*. The DEQ memorandum included the following:

- Soil should be characterized using a stratified systematic random sampling program that considers covariates such as depth, distance from shoulder, and physiographic province.

- Pesticides, volatile organic compounds (VOCs), and polychlorinated biphenyls (PCBs) are not important constituents in shoulder soil. Polycyclic aromatic hydrocarbons (PAHs), particularly benzo(a)pyrene, are important constituents. While lead is likely the most important constituent in roadside soil, DEQ stated that analysis of the full EPA target analyte list (TAL) of metals would be useful for classification modeling, even though most of the TAL metals have not been identified as COI.

- Sample collection and analysis using incremental sampling methods (ISM) should be considered to reduce data variability and reduce non-detect analytical results.

- It may be possible to manage shoulder soil based on a predictive model, under which, shoulder soil could be classified into two or more management categories (e.g., solid waste or clean fill). The predictive model should find a balance between simple linear models (relatively inflexible) and complex high variance models (very flexible but not useful for generalizing future data). DEQ recommended use of a decision trees model, enhanced by random forest methodology. Among the software packages recommended by DEQ was R (R Core Team, 2015).

While not memorialized in the May 4, 2016 memorandum, another outcome of the meetings was the identification of several options for managing excavated shoulder soil that does not meet clean fill criteria. These options include mine reclamation fill, non-residential construction fill, and disposal as solid waste.

DEQ reviewed this SAP and provided comments on August 2, 2016. Through those comments and a follow-up meeting on August 8, 2016, the following changes were incorporated into the sampling program, as detailed further in the SAP, or will be incorporated into the data evaluation:

- Soil samples will be analyzed for the primary pollutant list of PAHs in addition to benzo(a)pyrene.
- ISM processing techniques (i.e., grinding and subsampling the grab sample volume) will be incorporated into the sampling program.
- DEQ recommended using mean chemical concentrations instead of the 90% UCL of the mean for development of the predictive model for shoulder soil. DEQ noted in their comments "*The 90% Upper Confidence Limit (UCL) is set as the exposure estimator for risk assessments under OAR-340-122-0084. This was done so as to minimize the possibility of the estimated sample mean underestimating the true mean. However, for this project, a risk assessment is not being performed, so requirements in OAR-340-122-0084 do not need to be met. Moreover, the OAR allows for another criterion, if acceptable to DEQ. For this sampling and analysis plan, DEQ recommends using the mean instead of the 90% UCL for shoulder soils that will be removed and mixed*."

STATISTICAL EVALUATION OF EXISTING DATASET

To develop the next phase of sampling, the ODOT shoulder soil dataset was evaluated with a classification tree random forest model, using the R programming language (R Core Team, 2015). The goal of this evaluation was to determine how the sampling variable (e.g., sampling depth) or combination of variables influence the dataset and which combination of these variables are most likely to result in lead and benzo(a)pyrene concentrations below the clean fill criteria. The next phase of sampling would then be structured to collect additional samples with these combination of variables, to hopefully confirm these trends with enough certainty that ODOT could use them as a predictor for lead and benzo(a) pyrene passing the clean fill criteria. If predictors with a sufficient level of certainty can be identified, future management of shoulder soil can be simplified.

To facilitate evaluation using the R software, four sampling variables (physiographic province, distance from the edge of pavement, depth below ground surface [bgs], and AADT) that have been shown to affect constituent concentrations in soil were categorized (e.g., depth intervals, distance intervals, etc.) and coded in the database accordingly. The data were coded as described in Attachment A.

Data that could not be classified by each of the four key variables (i.e., sampling details were missing or unknown) were excluded from the evaluation. Soil samples that have been analyzed for either benzo(a)pyrene or lead were included in independent evaluations for each constituent. If lead or benzo(a)pyrene was analyzed in the sample and was not detected, only the samples with laboratory reporting limits equal to or less than the clean fill criteria were included in the evaluation (480 samples for benzo(a)pyrene and 859 samples for lead).

The importance of each variable as a predictor of whether the sample concentration was at or below the physiographic province specific screening limit[2] (a "pass") or exceeded the limit (a "fail") was determined based on how effective the variable was at accurately predicting the pass and fail responses for the lead and benzo(a)pyrene data. Non-parametric random decision forest analyses (Hothorn et al., 2006; Strobl et al, 2007; and Strobl et al., 2008) were run on the lead and benzo(a)pyrene datasets separately, and the importance values were plotted for lead and benzo(a) pyrene. As shown on Figure A-1 in Attachment A, the soil lead data were influenced most significantly by physiographic province, followed by depth, distance from pavement, and average annual daily traffic (AADT), in decreasing order. The soil benzo(a)pyrene data were most significantly influenced by province, while the remaining variables (distance from pavement, AADT, and depth) were all comparably poor predictors.

Individual classification trees (Hothorn et al., 2006b) for lead and benzo(a)pyrene were generated (Figures A-2 and A-3 in Attachment A, respectively). Classification trees present the combinations of sampling variables that have the strongest correlation with a pass (i.e., sampling results less than the clean fill criteria) or fail (i.e., sampling results greater than the clean fill criteria) result in the analytical data. As shown on Figure A-2, samples collected in the Basin and Range, Blue Mountains, High Lava Plains, and Cascade Mountain physiographic provinces are very likely (80% likelihood) to pass the clean fill criteria for lead (based on a sample size of 166). Similarly, samples collected in the Coast Range, Deschutes-Columbia, Portland Basin, South Willamette physiographic provinces, at depths greater than 6 inches below the ground surface and more than 15 feet from the edge of pavement have a 90% chance of containing lead concentrations less than the clean fill criteria (based on a sample size of 42).

When interpreting these outcomes, it is important to note that are significant data gaps, and the data set did not have balanced representation of all levels across all predictor variables. For example, in some provinces, only samples within 0-15' of the pavement were represented in the database, so inference about the effect of distance from pavement cannot be made for all provinces due to this data gap. As a result, graphical and

2 The clean fill criteria for metals are based on the Oregon background metals concentrations in soil and vary by physiographic province (DEQ, 2013). Oregon physiographic provinces are shown on Figures 1 and 2.

tabular summaries were used to further describe the data patterns within and across the various levels of each variable. These were useful for identifying the candidate areas (province, distance and/or depth categories) that appeared to have the greatest chance of passing the clean fill criteria.

Box and whisker plots were generated showing the data patterns for the sampling depth and distance from pavement, for either physiographic province or AADT category (Figure A-4 and A-5, respectively). Because benzo(a)pyrene concentrations were most likely to be below clean fill criteria if lead concentrations were also below the criteria, more so than the other way around, lead data were the focus of this phase of the evaluation. These plots and associated data tables were used to identify the shoulder soil areas where it might be possible, within reasonable time and budget limitations, to collect the additional soil samples required to develop a predictive model demonstrating that lead and benzo(a)pyrene concentrations are consistently below the clean fill criteria.

Based on these evaluations, the following sample groups were found to have mean COC concentrations in soil that were well below the clean fill criteria.

- Basin and Range physiographic province, all depths, distances from pavement, all AADTs;
- Deschutes Columbia physiographic province, all depths, distance from pavement of greater than 15 feet, and all AADTs; and
- Blue Mountains physiographic province, all depths, distance from pavement of greater than 15 feet, and all AADTs.

The datasets used to draw the preliminary conclusions listed above are limited in size, and therefore, the level of certainty associated with these conclusions is insufficient for establishing robust predictive models that can be used as a soil management tool. Supplementing the existing dataset with data collected in the 2016 shoulder soil sampling effort will generate additional data to evaluate whether or not COC concentration trends persist at these low levels in a larger dataset with more evenly distributed sampling variables. The scope of the proposed sampling effort was designed under the assumption that any new data would show COC concentrations patterns (mean and variance) similar to those of previously collected data. There is no guarantee of this, of course, particularly since sampling is proposed within some areas not previously sampled. If the COC concentrations are higher than expected, this will provide evidence contrary to our operating assumption, indicating that soil COC concentrations within some subcategories may not be reliably predicted to be below the clean fill criteria. However, if the mean and variance in the future dataset are consistent with the values observed in the existing dataset, the mean is expected to be well below the clean fill criteria, thereby reinforcing the passing trend of the data. In addition, the balanced design will provide information about COC concentration trends across sampling depths and distances from pavement that may guide possible future sampling efforts.

A sample size of 25 (previously collected and proposed) is targeted for each of the data groups listed above to establish suitable confidence in the conclusions. The proposed sampling scope as it relates to these data trends is described later in this SAP.

ALTERNATIVE CRITERIA FOR MANAGEMENT OF SHOULDER SOIL

As noted previously, ODOT Directive GE 14-01(D) requires that soil that is generated in the interval between the surface and 1.5 feet bgs during roadway improvement or construction projects and scheduled for export from the ODOT right-of-way is assumed to be contaminated unless characterization indicates that the soil meets clean fill criteria. Soil that does not meet the clean fill criteria requires special management and/or disposal.

The clean fill criteria are conservative standards intended to be protective of human and ecological health under most potential exposure scenarios[3]. For example, the clean fill criteria for lead varies between 18 to 36 mg/kg based on physiographic province, whereas the DEQ Risk Based Concentrations (RBCs) for the residential and occupational lead direct contact exposure pathways are 400 mg/kg and 800 mg/kg, respectively. The clean fill criterion for benzo(a)pyrene is 0.015 mg/kg, which is equivalent to the DEQ RBC for residential exposure. By comparison, the RBCs for occupational and excavation worker exposure to benzo(a)pyrene are 0.29 mg/kg and 67 mg/kg, respectively. The minimum DEQ Level II Screening Level Value (an ecological screening value) for benzo(a)pyrene in soil is 125 mg/kg.

As shown by the comparisons presented above, soil with concentrations of lead and benzo(a)pyrene that exceed clean fill screening criteria may be suitable for a number of uses that do not require soil meeting clean fill criteria (e.g., non-residential uses). The Oregon Clean Fill Guidance (DEQ, 2014) notes, if statistical analyses of soil data do not show that “the material is substantially like clean fill” interested parties should “explore other disposal options such as site-specific or material-specific disposal determinations (solid waste letter authorization, permit exemption, mine reclamation material, restricted beneficial use as fill, or restricted uses such as use as fill at Cleanup sites with deed restrictions, etc.).”

3 The clean fill criteria are not applicable to aquatic or wetland exposure scenarios.

Due to the costs and limitations of managing shoulder soil based on a comparison to clean fill criteria alone, the following potential additional categories and associated criteria for classifying and managing shoulder soil have been identified:

- Non-Residential Fill: Consists of soil that exceeds clean fill criteria but contains constituent concentrations less than DEQ RBCs for the occupational exposure pathway. Does not exceed RBCs for leaching to groundwater.

- Mine Reclamation Fill: Consists of soil that exceeds residential and occupational RBCs, but contains constituent concentrations less than RBCs for the excavation worker exposure pathway. Does not exceed RBCs for leaching to groundwater.

A standing case-specific beneficial use determination (BUD) could be developed in coordination with DEQ. Following collection and analysis of the 2016 data, recommendations for categorization of data in exceedance of clean fill criteria, but lower than other potentially applicable criteria will be included in the results report.

2016 SHOULDER SOIL SAMPLING

The following sections describe the proposed scope for the 2016 shoulder soil sampling effort. As described previously, three groupings of sampling variables (physiographic province, depth, and distance from pavement) were determined to be indicative of shoulder soil that is likely to meet the clean fill criteria; however, additional data for each of these groupings is necessary to support the statistical evaluation and develop a robust statistical model. Based on the statistical characteristics (mean, variance, and distributional form) displayed by the previously collected data, a sample size of 25 samples is the targeted number to better characterize the concentration distributions and obtain confidence that the mean concentration is consistently below the clean fill criteria. Twenty-five samples are targeted for each variable combination to be evaluated within each grouping, including both previously collected data and data to be collected during the 2016 sampling program. Table 1 shows the number of samples that will be collected in each of the physiographic provinces and in each variable category.

Soil sampling using incremental sampling methodology (ISM) can be beneficial for reducing data variability and providing a relatively unbiased estimate of the soil sample concentration mean. ISM is not proposed for this phase of work; however, because the ODOT shoulder soil dataset is composed of data from discrete samples, and combining ISM data with discrete data is problematic for statistical analysis. However, as noted below, the samples will be ground by the laboratory prior to analysis, as performed during ISM sample processing. Grinding minimizes the effects of sample heterogeneity on analytical results. In the future, ODOT may further evaluate the application of ISM sampling and processing techniques for characterizing shoulder soil.

Table 1. Number of Soil Samples to be Collected during the 2016 Sampling Program

Physiographic Province	Number of Samples								
	0 to 15' from edge of pavement			15 to 30' from edge of pavement			>30' from edge of pavement		
	0-0.5' bgs	0.5-1' bgs	1-1.5' bgs	0-0.5' bgs	0.5-1' bgs	1-1.5' bgs	0-0.5' bgs	0.5-1' bgs	1-1.5' bgs
Basin and Range	15*	15*	15*	25	25	25	25	25	25
Blue Mountains	NA	NA	NA	18**	18**	18**	25	25	25
Deschutes - Columbia	NA	NA	NA	21	21	21	21	21	21

bgs = below ground surface

* The final dataset within this subgroup will contain between 23 and 31 samples. This plan provides a sufficient dataset to test for consistency of trends across distance and depth categories.

** The final dataset within this subgroup will contain between 23 and 27 samples. This plan provides a sufficient dataset necessary to test for consistency of trends across distance and depth categories.

As noted previously, the combinations of variables identified in Table 1 are the combinations that currently show likelihood of passing the clean fill criteria. To provide the most statistically robust dataset, samples will be collected from a range of geographic locations and AADT classifications within each physiographic province. The approximate sampling locations are shown on Figure 2. Precise sampling locations will be identified in the field. Locations targeted for sampling will be in areas with more than 30 feet of ODOT right-of-way beyond the edge of pavement, safe from traffic hazards, not exhibiting indications of contamination (e.g., staining), with no obvious signs of imported fill, and not adjacent to potential contaminant source areas (e.g., industrial facilities). Samples will not be collected from accumulations of traction gravel or cinders.

PRE-SAMPLING ACTIVITIES

Prior to collection of the soil samples, coordination with ODOT will occur in order to receive authorization to sample in the right-of-way. Following receipt of ODOT authorization, each of the proposed sampling locations will be marked and cleared for utilities by notifying the Oregon One-Call. Once the precise sampling locations have been marked, GPS coordinates will be recorded.

SOIL SAMPLING AND LABORATORY ANALYTICAL METHODS

At each boring location, an 18-inch deep boring will be advanced using a stainless steel hand auger and other hand tools, as necessary. Discrete soil samples will be collected from one or more of the following depth intervals, in accordance with Table 1: 0 to 6 inches, 6 to 12 inches, and 12 to 18 inches. Soil samples will be collected from one or more of the following distances from the edge of pavement: 0 to 15 feet, 15 to 30 feet, and greater than 30 feet. Soil samples will be placed in laboratory-supplied sample containers. Soil samples will be named according to the sample location (including depth and distance from pavement) and sample date, and labeled accordingly. Samples will be stored in a cooler on ice prior to transportation or shipment to the analytical laboratory.

Each of the soil samples will be submitted to the laboratory for the analysis of lead by EPA method 6020A and PAHs by EPA 8270D SIM. As noted previously, the sample volume from each location will be ground prior to analysis, consistent with ISM processing techniques. Laboratory method reporting limit goals will be equal to or less than clean fill criteria.

The health and safety plan (including traffic control requirements) and standard operating procedures for the 2016 highway shoulder soil sampling are included as Attachments B and C, respectively.

RESULTS REPORT

Following collection of the samples and receipt of the analytical data, the data will be evaluated using a classification tree random forest model and the results will be documented in a report. The report will include:

- Field methods;
- Tabulated analytical data;
- Field data, including boring logs;
- Laboratory data including a quality assurance/quality control review;
- Data analysis;
- Soil management recommendations;
- Data gaps; and
- Recommendations.

ATTACHMENTS

Figure 1	Shoulder Soil Sampling Locations - Existing Data
Figure 2	Proposed 2016 Shoulder Soil Sampling Locations
Attachment A	Shoulder Soil Statistical Evaluation Information
Attachment B	Health and Safety Plan
Attachment C	Standard Operating Procedures

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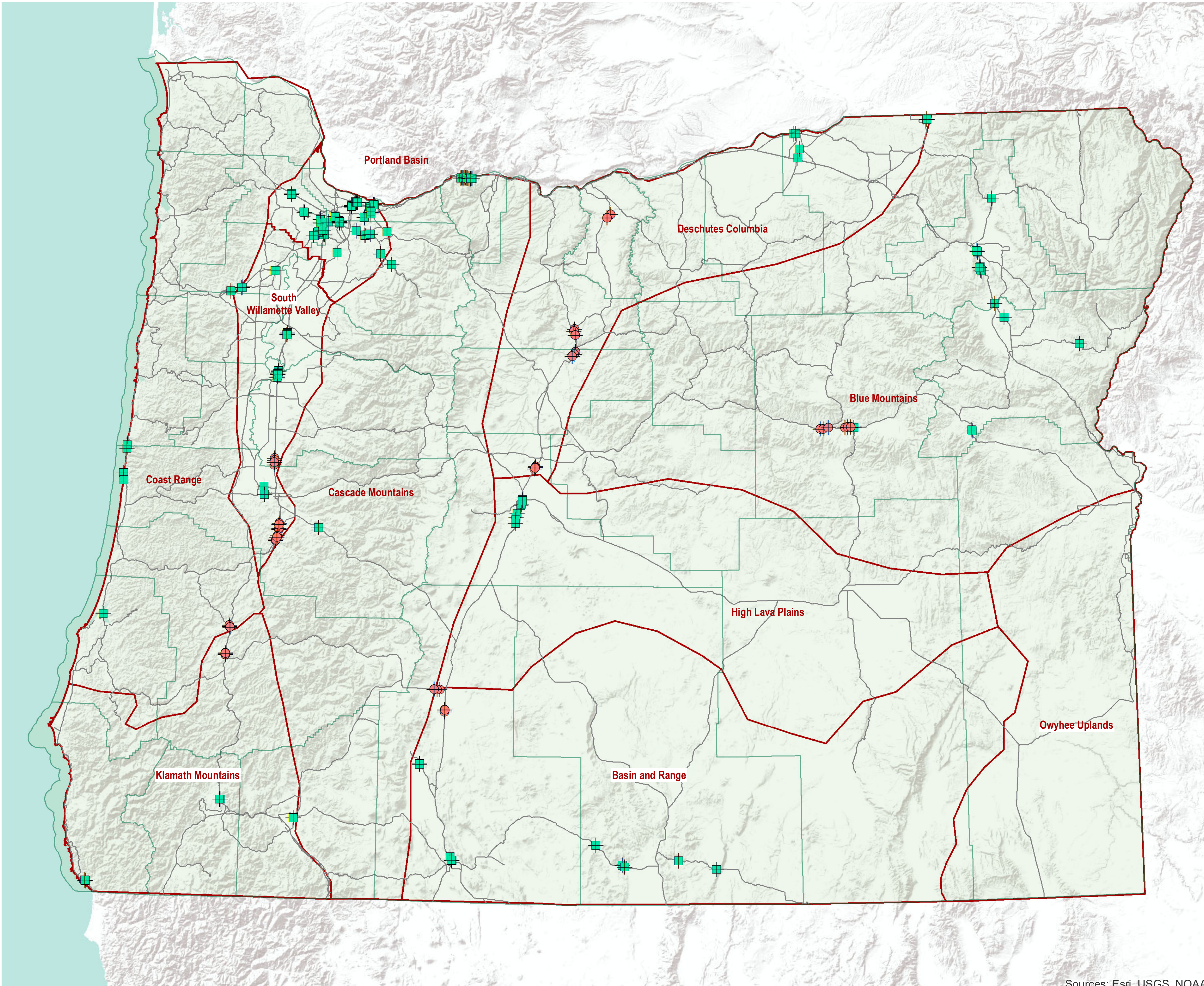
Strobl, C., Boulesteix, A., Kneib, T., Augustin, T., and Zeileis, A. (2008). Conditional Variable Importance for Random Forests. *BMC Bioinformatics*, 9(307). <http://www.biomedcentral.com/1471-2105/9/307.>



Shoulder Soil Sampling Locations - Existing Data

Oregon Statewide Shoulder Soil Sampling

Oregon Department of Transportation

Cascadia Associates, LLC

Project Number	0028-001-001-02	Figure
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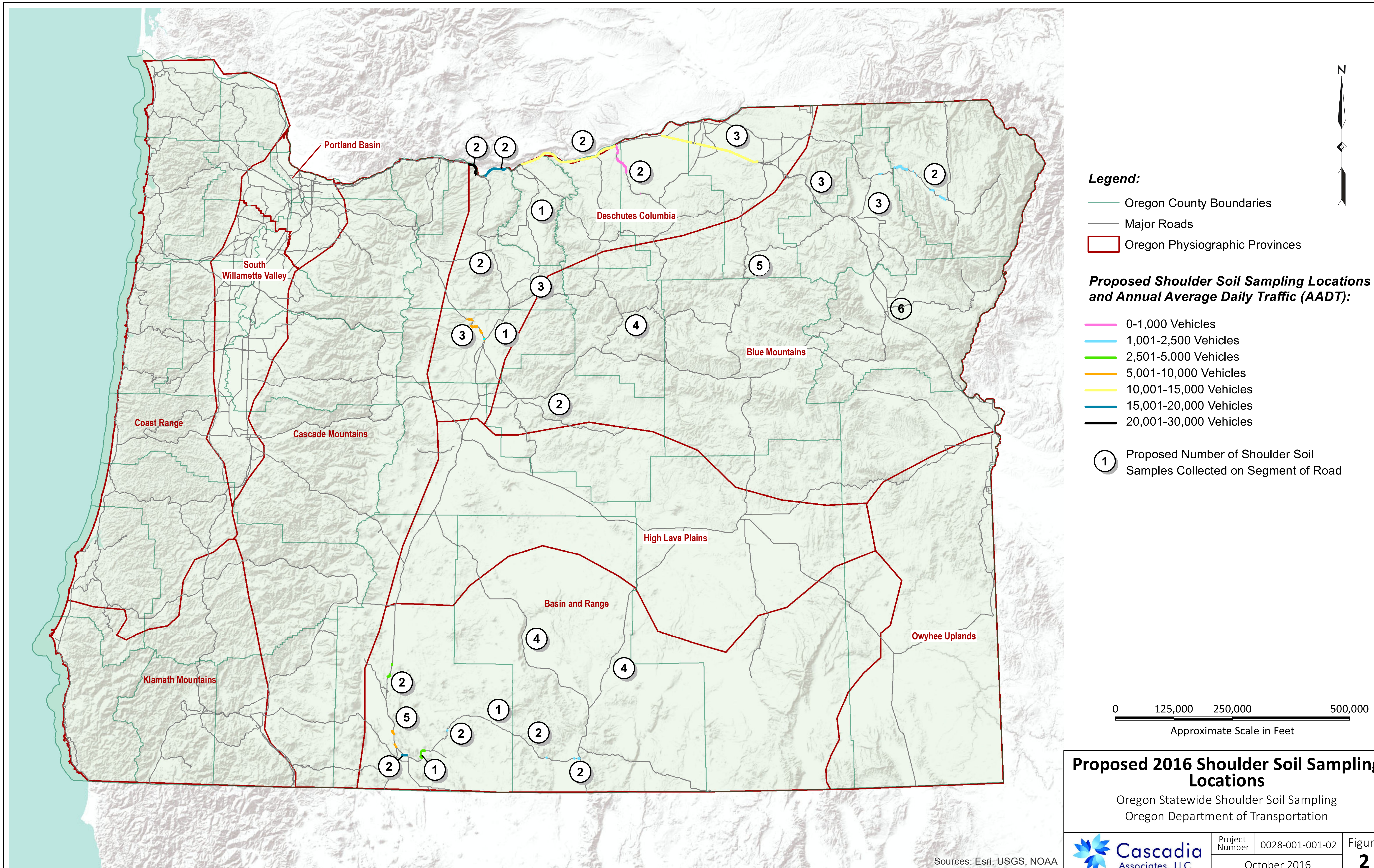

Proposed 2016 Shoulder Soil Sampling Locations

Oregon Statewide Shoulder Soil Sampling
Oregon Department of Transportation

Cascadia Associates, LLC | Project Number 0028-001-001-02 | October 2016 | Figure 2

Attachment A
Shoulder Soil Statistical Evaluation
Supporting Information

Attachment A: Shoulder Soil Statistical Evaluation Supporting Information

Sampling variables were coded in the database as detailed below.

- **Physiographic Province** for the sampling location was coded by name in the database. Province boundaries were assigned according to the designations found in *Development of Oregon Background Metals Concentrations in Soil, Technical Report* (DEQ, 2013).

- **Sample collection depths** were coded as shown below.

Database Interval ID	Top Depth (ft)	Bottom Depth (ft)	Retained in Data Evaluation?
1	0	0.5	Yes
2	0.5	1	Yes
3	0	1	No
4	1	<=2	Yes
5	2	>2	No
6	Other	Other	No
7	Interval is greater than one foot		No
8	Missing Depth Information		No

- **Distance from pavement** interval were coded in the database as follows, i.e., 1 = 0 to 15 feet from the edge of pavement; 2 = 15 to 30 feet from the edge of pavement; 3 = more than 30 feet from the edge of pavement; 4 = unknown. Data classified as category 4 were omitted from the data evaluation.

- **AADT** (average annual daily traffic) information was coded as shown below.

AADT	AADT.grp	Retained in Data Evaluation?
0 – 1,000	1	Yes
1,001-2,500	2	Yes
2,501-5,000	3	Yes
5,001 – 10,000	4	Yes
10,001 – 15,000	5	Yes
15,001 – 20,000	6	Yes
20,001 – 30,000	7	Yes
30,001 – 50,000	8	Yes
50,001 – 75,000	9	Yes
75,001 and up	10	Yes
(blank)	-99	No

Non-parametric random decision forests were run on the lead and benzo(a)pyrene datasets separately. Decision forests (e.g., Ho, 1995 and Breiman, 2001) are an ensemble learning method used for classification and regression. Decision forests use randomization and bootstrapping and a recursive partitioning framework to identify the best predictors of the categorical outcome (i.e., the sample passes or fails the screening criterion).

The decision forest algorithm (Hothorn et al., 2006; Strobl et al., 2007; and Strobl et al., 2008) was used to generate 10,000 trees (allowing up to three variables within each tree) for predicting pass or fail relative to the screening criterion. For each tree, two-thirds of the data were randomly selected for use as the training dataset to establish the decision rules for predicting the pass/fail response. The remaining one-third of the data was used as independent verification to measure the predictive accuracy of the tree fit during that iteration of the forest algorithm. This approach allowed computation of the relative "importance" of each variable, with a higher importance value indicative of a better predictor of pass/fail response, aggregated over all trees in the forest. The variable importance was measured by the decrease in prediction accuracy on the observations left out of the training dataset using the real data versus a random re-shuffling of the data. Thus, a small decrease in prediction accuracy indicated that the observed relationship was no better than a random permutation of the data, whereas a large decrease indicated that the variable was a good predictor.

The plots of the importance values (Figure A-1) indicate that physiographic province was the most important variable associated with lead concentrations that exceeded the screening level, followed by sample depth interval, distance from pavement interval, and AADT. For benzo(a)pyrene, physiographic province had the highest importance value, while the remaining variables (distance from pavement, AADT, and depth) were all comparably poor predictors.

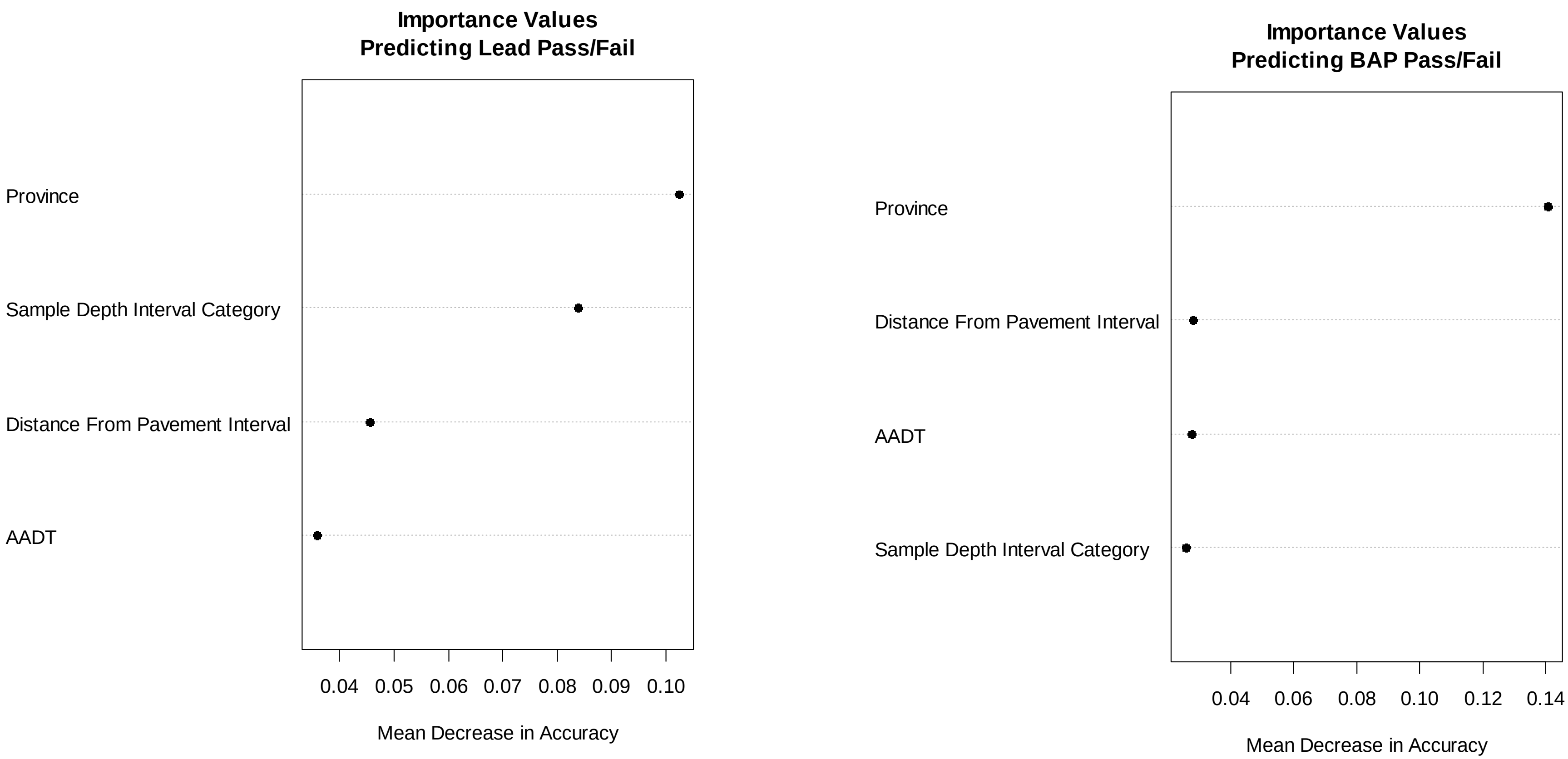

Figure A-1. Importance plots for Lead (left, total n = 859) and benzo(a)pyrene (right, total n = 480)).

The classification tree for lead is shown below and described further in the SAP text.

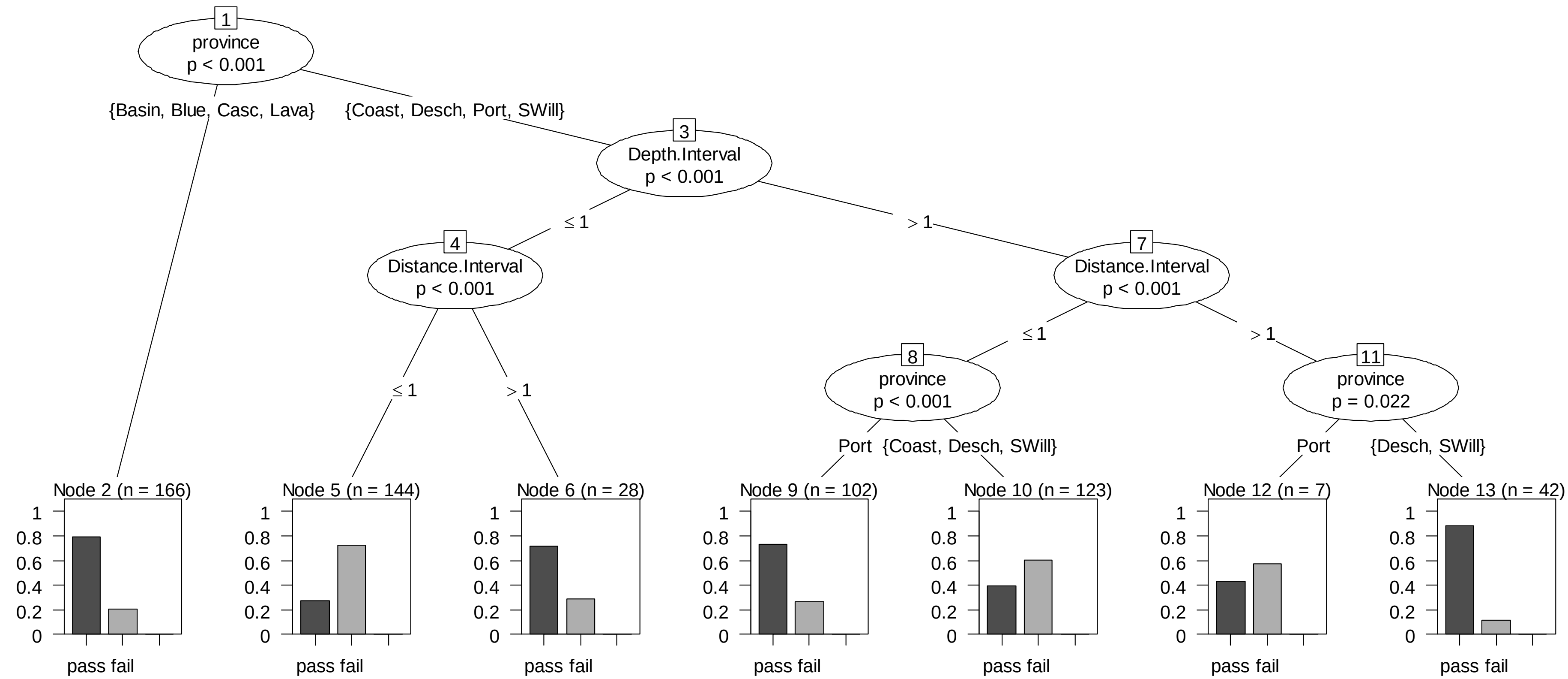

Figure A-2. Classification tree predicting lead pass/fail relative to the physiographic province-specific lead screening levels. Total sample size is 612 (uses only samples with known AADT classification, known distance from pavement, and sample depths in intervals 1 (surface 0-0.5'), 2 (near surface 0.5-1'), 4 (subsurface 1-2') or 6 (at depth >2')).

The classification tree for benzo(a)pyrene is shown below and described further in the SAP text.

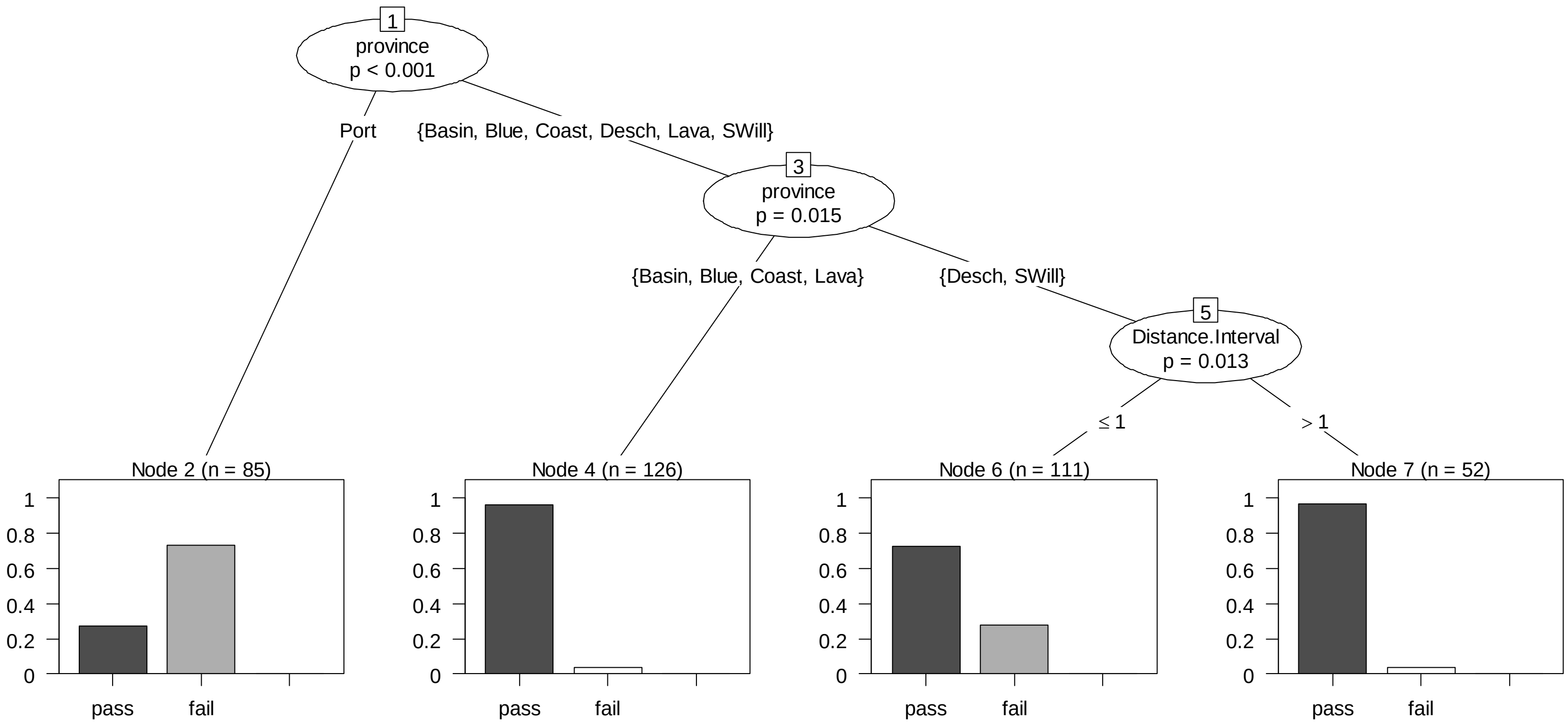

Figure A-3. Classification tree predicting benzo(a)pyrene pass/fail (or uncertain, where the detection limit exceeded the screening level) relative to the benzo(a)pyrene screening level of 0.015 ppm. Total sample size is 374 (uses only samples with detection limits at or below the screening limit, known AADT classification, known distance from pavement, and sample depths in intervals 1 (surface 0-0.5'), 2 (near surface 0.5-1'), 4 (subsurface 1-2') or 6 (at depth >2')).

The box and whisker plot showing lead concentrations by physiographic province is shown below and described in additional detail in the SAP.

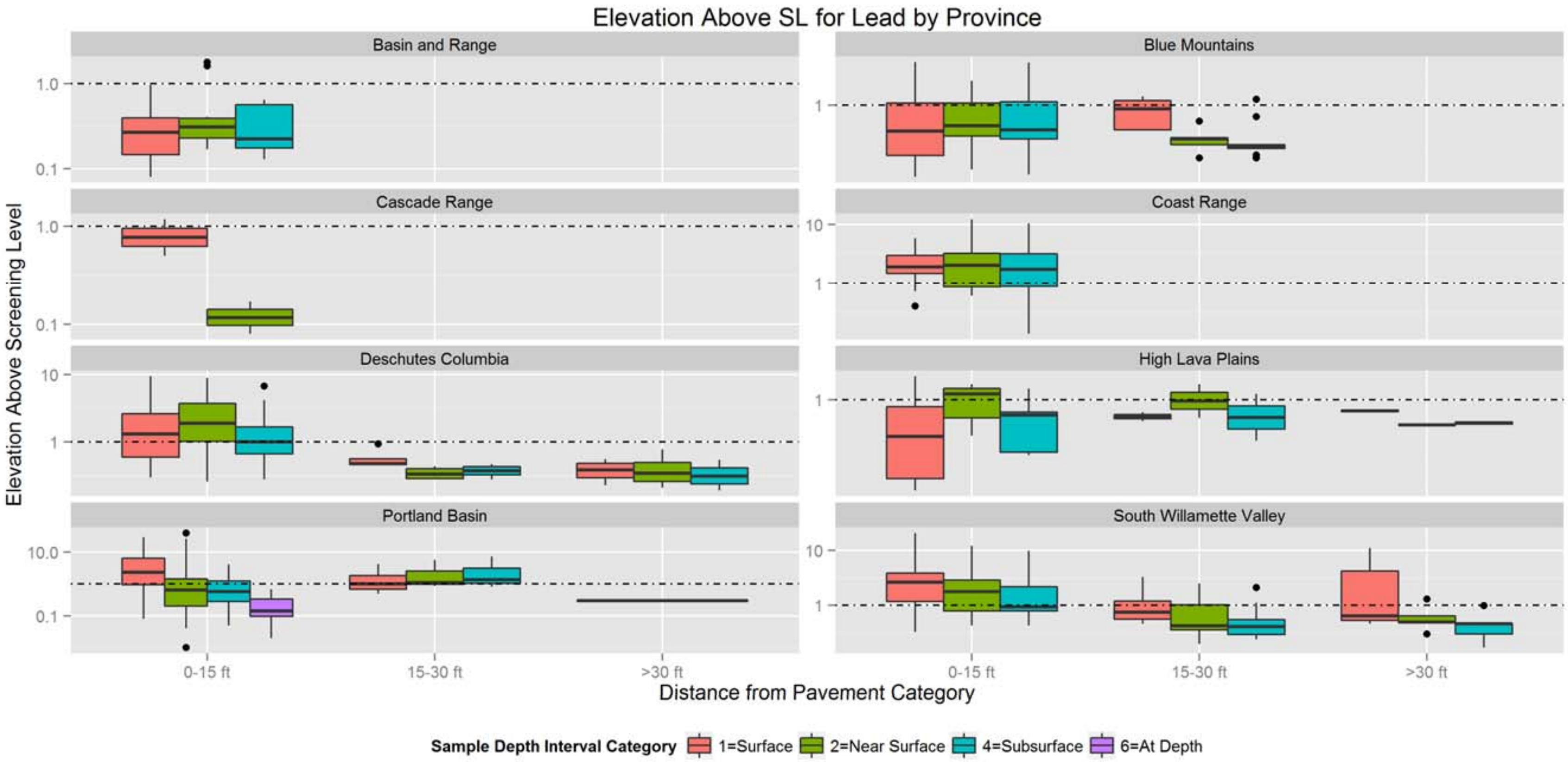

Figure A-4. Elevation above SL (EASL) for lead results shown on the y-axes (note the y-axis scales change between panels, and are log10 scaled): each panel represents the data for a different physiographic province, each color represents a different sample depth interval category, and each cluster on the x-axes represents a different distance from pavement category. The dashed line on each plot is at 1.0, i.e., values above this line exceeded the SL and failed the test for lead.

The box and whisker plot showing lead concentrations by AADT category is shown below and described in additional detail in the SAP.

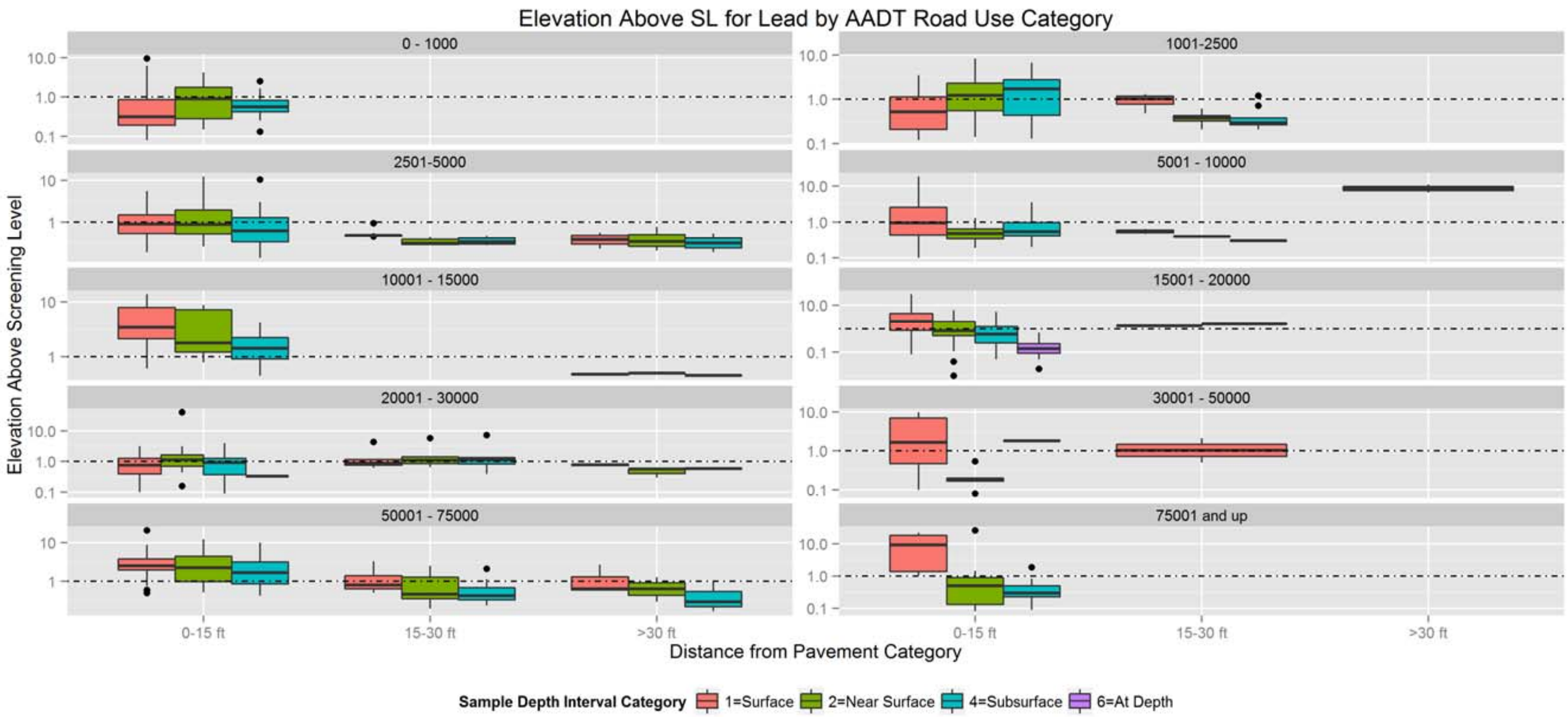

Figure A-5. Elevation above SL (EASL) for lead results shown on the y-axes (note the y-axis scales change between panels, and are log10 scaled): each panel represents the data for a different AADT road use category, each color represents a different sample depth interval category, and each cluster on the x-axes represents a different distance from pavement category. The dashed line on each plot is at 1.0, i.e., values above this line exceeded the SL and failed the test for lead.

Attachment B

Health and Safety Plan

Site-Specific Health and Safety Plan
ODOT Statewide Highway Shoulder Soil Evaluation

Prepared for:

Oregon Department of Transportation
Project Manager: Shawn Rapp, R.G.
999 NW Frontage Rd., Suite 250
Troutdale, OR 97060

Submitted by:

Cascadia Associates, LLC
6915 SW Macadam Ave.
Suite 255
Portland, Oregon 97219
(503) 906-6577

0028-001-001

July 2016

Site-Specific Health and Safety Plan
ODOT Statewide Highway Shoulder Soil Evaluation

This Site-Specific Health and Safety Plan (HASP) has been developed in accordance with OSHA 29 CFR 1910 and 1926 and has been streamlined to avoid duplication of existing Cascadia Associates, LLC (Cascadia) documents. The HASP must be updated annually and modified periodically when new tasks are introduced to the project. It is the principal's responsibility that the HASP is current and covers all work activities at the Site.

REVIEW AND APPROVALS

Prepared by:

________________________	July 5, 2016
Kirsten White	Date
Associate Engineer	

HASP EMERGENCY SUMMARY SHEET

RESPONDING EMERGENCY AGENCIES

Service	Telephone Number
Ambulance	911
Fire Department	911
Police Department	911

*A route to hospital map will also be available to the sampling staff and can be used if no cell phone service is available to call 911.

PROJECT EMERGENCY CALL LIST

Title	Name	Telephone Number
Project Manager	**Kirsten White**	(503) 906-6577 (Office) (971) 533-3159 (Mobile)
Client	**Shawn Rapp**	(503) 667-7442 (Office) (503) 551-7976 (Mobile)
In the event of an occupational accident or incident, please indicate to the medical facility that this is a Workers' Compensation case; that your employer is Cascadia; and that the insurance administrator is Berkley Custom Insurance Managers. Subcontractors will provide internal Workers' Compensation policy information; this should be provided to the Project Manager at the pre-work meeting.		

EMERGENCY TELEPHONE NUMBER LIST

Organization	Telephone Number
Oregon OSHA	1-800-321-OSHA for Emergencies (503) 229-5910
National Response Center	1-800-424-8802 or (202) 267-2675
EPA Environmental Response Team	(732) 321-6740

Nearest Phone: Carry cellular phone.

Nearest Water: Varies by sampling location; bring in potable water.

First Aid Kit: Located in Field Vehicle

POTENTIAL PHYSICAL HAZARDS:
Including but not limited to vehicle traffic, back injuries, biological agents, cold/heat stress, entanglement, electrocution, eye hazards, hand tool hazards, inclement weather, noise, slips, trips, and falls, and ultraviolet exposure.

High-visibility safety vests, safety glasses, and steel-toe boots shall be worn when conducting field work for this project. Personnel should use caution and maintain a heightened awareness of their surroundings, since field work will be conducted on highway shoulders.

POTENTIAL CHEMICAL HAZARDS:
Non-hazardous levels of petroleum hydrocarbons, metals

CHEMICAL MATERIALS HANDLED AT THE SITE:
Liquinox detergent

RECOMMENDED AIR MONITORING EQUIPMENT:
None

REQUIRED PERSONAL PROTECTIVE EQUIPMENT AND AIR MONITORING EQUIPMENT:
Level D and as specified in Activity Hazard Analysis (AHA) (see Appendix 1)

Task	Level of PPE Guideline*	Air Monitoring Requirement/Type
Field Activities		
Soil Sampling	Level D	No/NA

Note:
NA - not applicable

Table of Contents

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List of Appendices

1.0 INTRODUCTION

1.1 GENERAL INFORMATION

Client:
Oregon Department of Transportation
Shawn Rapp
(503) 667-7442

Site Health and Safety Officer:
Kirsten White
(971) 533-3159

1.2 PROJECT AREA AND SITE DESCRIPTION AND FEATURES

The project area includes highway shoulders across Oregon. Specific sampling location details vary.

1.3 SCOPE OF WORK

Shoulder soil samples will be collected from over 60 different locations across Oregon. The following activities will be completed:

- Collect surface soil samples using a hand auger or other hand tools
- Record sampling details such as soil type, distance from roadway, and depth below ground surface
- Decontaminate sampling equipment

1.4 SCHEDULED PROJECT AREA PERSONNEL AND CONTRACTORS

Name	Company	Project Title
Kirsten White	Cascadia	Project Manager
Onsite sampling staff - varies	Cascadia	Field Manager

1.5 PERSONNEL RESPONSIBILITIES

Project Manager or Field Manager (PM or FM):
The Project Manager (PM) or Field Manager (FM) is responsible for all field activities for enforcing safe work practices and for ensuring that daily tailgate meetings are conducted (either by the PM, FM, Site Health and Safety Coordinator or a rotation of field team members and subcontractor team members). The PM or FM serves as the Emergency Coordinator (EC) in emergency situations. The PM or FM is responsible for conducting accident and near-miss investigations and completing the First Aid Incident and/or Near Miss forms. The Supervisor of the person injured is responsible for completing the Supervisor's Report of Injury or Illness.

The PM or FM is the **primary** contact for health and safety during all field activities. The PM or FM has the authority to stop all work if conditions are judged to be hazardous to personnel or the public within the Project Area, and reports and investigates accidents and near misses. The PM, FM or designee must carefully document the implementation of this HASP by maintaining the project health and safety files. The PM or FM is responsible for the following activities:

- Establishes work zones, evacuation routes, and assembly areas.
- Makes the day-to-day decision to modify levels of protection provided in the HASP based on Project Area conditions or monitoring data.

Technical Staff:
All Cascadia and subcontracting personnel are responsible for compliance with all Safety and Health Regulations of the Occupational Safety and Health Act of 1970 (29 CFR. 1926 and 1910), including all amendments and modifications thereto (hereinafter "OSHA"). In the event there is a conflict between the safety and health provisions of federal, state/provincial or local regulations and Cascadia HASP or Subcontractor HASP, the more stringent applicable provision shall prevail.

All Cascadia personnel are responsible for taking all reasonable precautions to prevent injury to themselves and to their fellow employees and for being alert to potentially harmful situations. Technical staff members are expected to perform only those tasks that they believe can be done safely and to immediately report any accidents, near misses, and/or unsafe conditions to the PM or the FM.

1.6 REQUIRED SIGNAGE AND POSTINGS

As noted below in Section 2.2, signage or vehicle warning lights will be required to warn approaching motorists that work is being conducted on the highway shoulder.

Additionally, the following information will be kept at the Site by the FM.

- Health and Safety Plan
- Route to Hospital Map – to be developed for each sampling location or sampling region

2.0 HAZARD EVALUATION

Physical, chemical, and operational safety hazards anticipated during this project are evaluated and briefly described in this section. An activity hazard analysis of each work task and the appropriate protective measures are found in Appendix 1.

2.1 PHYSICAL AND OPERATING HAZARDS

Physical or operating hazards identified or reasonably anticipated to be associated with Project Area work tasks are listed below. These potential hazards are included in the activity hazard analysis for the field work, included in Appendix 1:

- Vehicle traffic
- Subsurface utilities
- Back injuries
- Biological agents - insects and plants
- Cold/heat stress

- Eye hazards
- Hand tool hazards
- Inclement weather, shut-down conditions
- Noise
- Slips, trips, and falls
- Ultraviolet exposure

2.2 VEHICLE TRAFFIC AND TRAFFIC CONTROL

Because the sampling activities will be conducted on the shoulder and not within the lanes of traffic, no active traffic control will be required. As needed, "shoulder work ahead" signage will be placed ahead of the work area to warn passing motorist that personnel are present on the highway shoulder. Alternatively, an activated flashing or revolving yellow light on the field vehicle may be used in lieu of signage.

Prior to selecting the precise sampling locations, potential traffic hazards for the sampling location will be evaluated. Locations that are not readily visible to traffic, do not offer an adequate area for parking a vehicle outside of the traffic lanes, or are located on curves or sections of highway with otherwise minimized stopping distances will not be targeted for sampling.

2.3 CHEMICAL EXPOSURE

The primary routes of entry for COPCs at the Site include inhalation of vapors and dusts, skin contact with contaminated materials, and ingestion of airborne dusts or materials from hand-to-mouth contact due to inadequate personal hygiene. To minimize these exposure pathways, all personal are required to wear protective equipment (PPE) as specified in Section 3.3.

The following COPCs under investigation may be present at non-hazardous low levels at the Project Area:

- Fuel related constituents (petroleum hydrocarbons, polycyclic aromatic hydrocarbons)
- Metals

See Appendix 2 for more detailed chemical information.

2.4 HAZARD COMMUNICATION

In addition to the COPCs, the following substances are anticipated to be brought onto the Project Area to supplement investigation activities:

- Liquinox detergent

These materials will be properly labeled with the identity of the chemical(s) contained therein. The MSDS for the material will be maintained onsite.

2.5 HAZARD ANALYSES

The hazard analysis for soil sampling is provided in Appendix 1.

3.0 PERSONNEL PROTECTION

The prescribed methods and procedures used to protect personnel from hazardous conditions posed by Project Area operations are grouped into three primary categories: Administrative Controls, Engineering Controls, and PPE.

3.1 ADMINISTRATIVE CONTROLS

3.1.1 Emergency Medical Treatment

Personnel who exhibit signs and symptoms of chemical or heat overexposure, or who have been injured on the job, will seek medical services as needed.

3.1.2 Training

Prior to initiation of site activities, the PM/FM will conduct a health and safety “kickoff” meeting. At this meeting, the site-specific HASP will be discussed, with special attention given to site’s chemical and physical hazards, PPE, and emergency procedures. Upon completion of this briefing, all Cascadia field personnel expected to be involved in this project will be required to read and sign the acceptance sheet of this HASP (Section 8).

Site visitors who do not attend this meeting will be required to undergo a specialized health and safety orientation, as documented in the field notebook.

As required by OSHA, “tailgate” safety meetings will be conducted each day by the PM/FM, or a rotation of Cascadia and subcontractor team members for **all** phases of work. Topics of discussion or review will include work tasks and designated PPE, emergency procedures, evacuation routes, instruction in use of safety equipment (as required), prior safety problems, recognition of signs and symptoms of overexposure, importance of proper decontamination, and personal hygiene. These meetings/reviews must be documented in the field notebook.

3.1.3 Safety Inspections

All project sites and equipment including but not limited by any type of field and construction work will be inspected DAILY by the responsible party. All deficiencies discovered will be reported to Cascadia immediately.

In accordance with 29 CFR 1910.157, all field personnel who are provided portable fire extinguishers for use should be familiar with general principles of use and the hazards of incipient (early stage) firefighting.

In accordance with 49 CFR 172, Department of Transportation (DOT) HM126F training is required for all employees who handle, transport, or prepare to transport hazardous materials.

3.1.4 Accident Prevention

The PM/FM as well as all Site employees will inspect the work Site and/or Project Area daily to identify and correct any unsafe conditions. Cascadia field personnel and site employees or subcontractors should inspect work area thoroughly before leaving the Site. Adherence to the safe work practices and procedures outlined in this HASP will assist with accident prevention.

3.1.5 Safe Work Practices

Personal Conduct:

- Unauthorized personnel are not allowed in site work areas
- Smoking, eating, drinking, chewing gum or tobacco, taking medication, and applying cosmetics will not be permitted within the sampling area.
- Personnel under the influence of alcohol or controlled substances are not allowed in the Project Area; those taking medications must notify the FM/PM.
- Project Area personnel will familiarize themselves with these practices and the emergency procedures during daily tailgate and pre-work safety meetings.
- Workers who are passengers or drivers of vehicles will wear their seat belts any time the vehicle is in motion.
- No cellular phone use while driving is permitted.

Personal Protection:

- Personnel will avoid skin contact with contaminated or potentially contaminated media. If such contact occurs, the affected areas should be washed thoroughly with soap and water.
- Discarded PPE will be placed into refuse bags and into dumpsters or garbage cans.
- Personnel should notify the FM/PM of any defective monitoring, emergency, or other protective/safety equipment.
- A supply of potable water, electrolyte replacement solutions, a shaded break area, and sufficient lighting are recommended.

Equipment and Activities:

- All unsafe conditions shall be corrected immediately. All unsafe conditions not in the scope of the project shall be reported to the PM/FM and the condition corrected.
- Do not fuel engines while vehicle is running.
- Install adequate Project Area roads, signs, lights, and devices.
- Store tools in clean, secure areas so they will not be damaged, lost, or stolen.
- When exiting a vehicle, shift into park, set the parking brake, and shut off the engine. Never leave a running vehicle unattended.

3.1.6 Logs, Reports, and Record Keeping

Submittal of Certifications:

All Cascadia employees' certificates are on file in the Cascadia Portland, Oregon office. Field projects will not be allowed to take place in the absence of adequate documentation.

Site Monitoring, Reports, and Records:

The health and safety field files maintained by the PM, or his/her designee, will be the primary form of record keeping and documentation of site health and safety activities. These documents will be completed in sufficient detail to document the work performed; any unusual or significant circumstances under which the work was performed; any unanticipated/unplanned action taken to mitigate or to otherwise cope with unexpected field conditions; and pertinent comments about site-specific conditions that could have a bearing on the work performed. Documentation is required for all phases of work.
The health and safety records will contain the following documents:

- Signed acceptance sheet of this HASP (signed by all routine Project Area personnel)

Daily tailgate meetings and additional health and safety meeting conducted at the Site for this project should be recorded in your field notebook.

3.2 ENGINEERING CONTROLS

3.2.1 Barriers and Signs

In accordance with the Manual on Uniform Traffic Control Devices, the field vehicle will be outfitted with a flashing yellow light or Shoulder Work ahead signage will be placed to warn passing motorists of the activity on the shoulder. Traffic cones will be used to demarcate the immediate sampling area, if necessary.

3.2.2 Noise Reduction

Site activities in proximity to welding, construction, and heavy equipment often expose workers to excessive noise. It is anticipated that situations may arise when noise levels may exceed the OSHA Action Level of 85 decibels (A-weighted scale) (dBA) in an 8-hour time-weighted average (TWA). If excessive noise levels occur, ear plugs will be used by sampling personnel.

3.3 PERSONAL PROTECTIVE EQUIPMENT

3.3.1 Levels of Protection

Initial level of protection for the Project Area is Level D. Protection may be upgraded or downgraded depending upon Project Area conditions, as determined by the FM or PM. The following outlines the **minimum** guidelines for Level D PPE.

Level D PPE:

- Work shirt and full-length pants or coveralls
- American National Standards Institute (ANSI) standard safety-toe work boots
- ANSI standard hard hat (when working around heavy equipment or overhead “bump” hazards)
- ANSI standard safety glasses
- High-visibility reflective vests are required
- EPA-approved hearing protectors (when working in high noise areas)

3.3.2 PPE Failure/Chemical Exposure

In the event of PPE failure, worker and/or buddy will cease work, perform personal decontamination procedures. Refer to the MSDS if emergency medical response is needed. If chemicals contact the eyes, irrigate for 15 minutes and consult a physician.

3.3.3 PPE Inspection, Storage, and Maintenance

Reusable PPE will be decontaminated, inspected, and maintained, as necessary, after each use. Personal equipment (e.g., steel-toe boots) shall be properly stored by the employee/subcontractor.

The FM will periodically inventory the disposable and reusable PPE at the Project Area and will replenish stocks in a timely manner.

4.0 PROJECT AREA CONTROL

4.1 PROJECT AREA SECURITY

Planned activities will occur in areas that are generally remote; therefore, few visitors/trespassers are expected. The FM will ask that any visitors remain outside of work areas. All equipment, tools, and property shall be secured at the end of each day.

4.2 VISITOR ACCESS

All Project Area visitors (except OSHA inspectors) must receive prior approval from the FM, PM, and Client, and may do so only for the purposes of **observing** site conditions or operations. All visitors, regardless of their rank or professional level, will not be allowed into controlled work areas unless training have been met and documented.

4.3 COMMUNICATIONS

Depending on site conditions, security, and/or work tasks, a "buddy system" may be enforced for select field activities. Each person will observe his/her buddy and will provide first aid or emergency assistance when warranted. A mobile phone will be carried by the FM while at the Project Area for emergency use.

5.0 DECONTAMINATION PROCEDURES

5.1 PERSONNEL DECONTAMINATION

Equipment	Decontamination Solution	Procedures	
		Intermediate	**Final**
Brushes Buckets Spray bottle Garbage bags Paper towels	Liquinox Distilled water	Replace gloves as needed Rinse boot if necessary	Dispose of gloves Rinse boot if needed
Note: Intermediate decontamination is for periodic exits from the sampling area for short breaks. Final decontamination is performed before lunch, when taking cool down breaks, and when exiting the Project Area.			

5.2 EQUIPMENT DECONTAMINATION

All equipment that will potentially contact samples will be decontaminated prior to, and following, the collection of each sample using a three-step process – rinse using tap water, Liquinox® soap wash, and rinse in distilled water.

5.3 DISPOSAL PROCEDURES

All discarded PPE and disposal supplies that accumulate from site activities will be placed in a plastic garbage bag and placed in a general refuse dumpster or trash can. Small quantities of equipment decontamination water with Liquonox will be generated during sampling activities.

6.0 SANITATION AND ILLUMINATION

6.1 SANITATION

Potable drinking water shall be supplied in tightly-closed containers and shall be clearly marked for its intended use. If vehicles are available for use by field crews, restrooms will be available within a reasonable distance from the site area.

6.2 ILLUMINATION

All site work will be conducted during daylight hours.

7.0 EMERGENCY ACTIONS

7.1 PREPLANNING AND GENERAL PROCEDURES

General Emergency Information:

Site personnel should be constantly alert to recognize potentially unsafe work practices, hazardous work environments, and conditions that are immediately dangerous to life or health (IDLH), and they should be routinely reminded of signs and symptoms of heat overexposure. Emergency response procedures should be reviewed daily, updated as necessary, and following incidents.

In the event of a large-scale emergency, the FM is expected to notify the PM; the PM notifies the Client, evacuates the area, and lets appropriately-trained emergency staff respond to the situation. The safety and well-being of Project Area personnel, visitors, and the adjacent community will be of utmost importance in determining the appropriate response to a given emergency.

Emergency Coordinator (EC):

The PM or FM will serve as the EC during an actual emergency response situation. The PM or FM will serve as the primary EC at all times; first aid and rescue duties are shared between the first aid/CPR trained team members. All foreseeable first aid and rescue equipment should be stored at the site in an accessible area. The EC will contact off-site emergency response agencies and will serve as the main spokesperson when the responders arrive at the site.

Project Area Maps:

A site area map that is used during daily tailgate meetings will be used to inform the staff of hazardous areas, zone boundaries, site terrain, evacuation routes, work crew locations, and any site changes. In the unlikely event that an emergency occurs, the problem areas will be pinpointed on the site map, and pertinent information, such as weather and wind direction, temperature, and forecast, will be added as obtained. This map will be provided to the responding agencies.

Safe Refuge Area:

To be determined; this will be discussed/reviewed in the tailgate meetings by the ECs daily, once at the site. In an emergency, the EC (PM or FM) will take a “head count” against the field notebook, notify the emergency crews (as applicable), and limit access into the emergency area to necessary rescue and response personnel in order to prevent additional injuries.

Emergency Equipment:
The following emergency equipment will be maintained in the field vehicle.

- First aid kit
- Spill equipment (e.g., absorbent pads)
- Fire extinguisher
- Cellular phone
- Route to hospital

7.2 SITE-SPECIFIC RESPONSE SCENARIOS

7.2.1 Natural Disasters

Earthquake:
Cease operations and turn off equipment. Seek protection under a table or stay in the open. Inspect area and equipment prior to starting work again.

7.2.2 Weather-Related Emergencies

All work will cease should any of the following weather conditions arise:

- Poor visibility
- Precipitation severe enough to impair safe movement/travel
- Lightning in the immediate area
- Excessive winds
- Flooding
- Other conditions as determined by the PM or FM

7.2.3 Fire or Explosion

Small-scale fires (less than one-half of the responder's height) should be extinguished with an accessible ABC fire extinguisher by any team member who is familiar with general principles of use and the hazards of incipient (early stage) firefighting. Trained emergency crews will be summoned to control any large-scale or potentially unmanageable incident.

7.3 NON-EMERGENCY INCIDENTS

<u>Before seeking medical attention other than the local first aid</u>

1. Report the situation to the PM (all incidents with the clear starting event should be reported within 1 hour of occurrence)

8.0 CASCADIA EMPLOYEE HEALTH AND SAFETY PLAN ACCEPTANCE

I have had access to the HASP and opportunity to ask questions about this HASP. I have received site-specific information and orientation regarding HazCom and the identified hazards anticipated at the Project Area. My signature certifies that I understand the procedures, equipment, and restrictions of this plan and agree to abide by them.

SIGNATURE	PRINTED NAME	COMPANY	DATE

9.0 NON-CASCADIA EMPLOYEE HEALTH AND SAFETY PLAN ACCEPTANCE

I have received site-specific information and orientation regarding HazCom and the identified hazards anticipated at the Project Area during a tailgate meeting by Cascadia field personnel and had opportunities to ask questions about health and safety for this project. My signature certifies that I understand the procedures, equipment, and restrictions of this plan and agree to abide by them.

SIGNATURE	PRINTED NAME	COMPANY	DATE

Appendix B-1
Activity Hazard Analysis for Soil Sampling

<table>
<tr><td>Project Name:
ODOT State-wide Shoulder Soil Sampling</td><td>AHA No.
001</td><td colspan="2">Date:
July 4, 2016</td></tr>
<tr><td>Location:
Oregon</td><td>Contractor:
Cascadia Associates, LLC</td><td>Work Operation:
Soil Sampling</td><td>On-Site Safety Officer:
Varies</td></tr>
<tr><td>Revised by:
Kirsten White</td><td>Date:
July 4, 2016</td><td>Reviewed by:</td><td>Revised:</td></tr>
<tr><td colspan="2">Required Personal Protective Equipment (PPE):
• Long pants, steel toed boots, safety glasses, reflective safety vest, nitrile gloves</td><td colspan="2">All field crew must review and become familiar with the Health and Safety Plan. Initial here to indicate that you have read the HASP and reviewed the AHA : ____________</td></tr>
<tr><td colspan="4">Training Requirements:
• All assigned employees are required to familiarize themselves with the contents of the project HASP and this AHA before starting a work activity and review this AHA during the daily safety meeting at each sampling locations. Field sampling teams should initial in the designated location in this form to acknowledge that they have reviewed the AHA during the daily safety meeting.</td></tr>
</table>

Appendix B-1
Activity Hazard Analysis for Soil Sampling

Work Activity	Potential Hazards	Preventive or Corrective Measures	Inspection Requirements
Outdoor, physical activity	Slips, trips, and falls	• Be aware of potentially slippery surfaces and tripping hazards. Wear footwear that has sufficient traction. • Maintain good housekeeping practices. Be aware of weather effects on the work area, including wet and/or frozen ground. • Jumping, running, and horseplay are prohibited. • Keep all areas clean and free of debris to prevent any trips and falls. • Notify the field team members of any unsafe conditions.	• Routinely inspect work area for unsafe conditions.
	Heat stress	• Adjust work schedules as necessary to avoid hottest part of the day. • Take rest breaks as warranted. • Provide shelter (air-conditioned, if possible) or shaded areas to protect personnel during rest periods. • Maintain body fluids at normal levels. • Train workers to recognize the symptoms of heat-related illness.	• Monitor workers' physical conditions. • Monitor outside temperature versus worker activity.
	Cold stress	• Provide shelter (enclosed, heated environment) to protect personnel during rest periods. • Educate workers to recognize the symptoms of frostbite and hypothermia. • Use appropriate cold-weather gear, up to and including Mustang-type bib coveralls or jacket/bib combinations. • Consider additional precautions if working near water in cold weather. • Have a dry change of clothing available. • Train workers to recognize the symptoms of cold-related illness.	• Monitor workers' physical conditions and PPE. • Monitor outside and water temperature versus worker activity and PPE.
	Rain	• Wear appropriate PPE (rain gear). • Be aware of slip hazards, puddles, and electrical hazards when working in wet conditions.	• PPE should be inspected daily prior to use. • Routinely inspect work area for deteriorating conditions.
	Sun exposure	• Have sunscreen available for ultraviolet protection. • Have abundant water available to prevent dehydration. • Consider wearing wide-brimmed headwear and light-colored, lightweight, sun-blocking clothing.	• Ensure that sunscreen and water are available.

Appendix B-1
Activity Hazard Analysis for Soil Sampling

Work Activity	Potential Hazards	Preventive or Corrective Measures	Inspection Requirements
Outdoor, physical activity (continued)	Lightning	• Stop work and shelter indoors or inside a vehicle if lightning occurs during sampling. Do not begin or continue work until lightning subsides for 30 minutes. • Disconnect and do not use or touch electronic equipment. • Notify the field implementation lead if lightning or thunder is observed.	• Obtain weather forecast and updates as needed. • Seek shelter indoors or in a vehicle for 30 minutes following lightning or thunder, per the HASP.
	High winds	• Wear goggles or safety glasses if dust/debris is visible.	• Ensure that goggles/safety glasses are available.
	Noise exposure	• Wear hearing protection in high noise environments or when working around heavy machinery/equipment (action level of 85 decibels averaged over an 8-hour day).	• Ensure that hearing protection is available.
	Sharps (e.g., needles, nails)	• Avoid walking or kneeling in areas with litter present because these materials may obscure the presence of sharps. • Use cut-resistant gloves when handling materials suspected of containing sharps. • Do not pick up or otherwise touch unidentified sharps. Leave them in place and notify the project on-site safety officer immediately.	• Inspect work area and avoid areas with litter and refuse
	Biological hazards (flora [e.g., poison oak] and fauna [e.g., ticks, bees, mosquitoes, and snakes])	• Be aware of likely biological hazards in the work area. • Wear appropriate clothing (i.e., hat, long-sleeve shirt, long pants, leather gloves, boots, and Tyvek coveralls, as appropriate), and apply insect repellant. • Wear hand and arm protection when clearing plants or debris from the work area.	• Ensure that insect repellent is available.
Working along Roadside Shoulder	Motor vehicle/pedestrian accident	• Park field vehicle completely outside of traffic lanes. • Monitor traffic during field activities. • Use cones and/or barricades to cordon off work area, if necessary. • Engage strobe or rotating yellow light on top of vehicle when parked alongside of road for sampling activities and/or place "shoulder work ahead" signs ahead of work area • Wear reflective vest	• Verify that traffic control devices are in place

Appendix B-1
Activity Hazard Analysis for Soil Sampling

Work Activity	Potential Hazards	Preventive or Corrective Measures	Inspection Requirements
Lifting, moving, and securing heavy objects including soil cores	Pinch points Back strain	• Lift heavy equipment greater than 50 pounds with a partner using the handles provided. • When lifting all heavy objects, use appropriate lifting technique to prevent back strain or injury.	• Evaluate weight and center of gravity of heavier items prior to lifting/moving. • Verify that heavy objects are secured prior to operation or transport
Collection of Soil Samples	Back strain Subsurface Utilities	• When lifting all heavy objects, use appropriate lifting technique to prevent back strain or injury. • Do not combine twisting and lifting motion when using the hand auger • Use a shovel to supplement use of the hand auger if needed • Subsurface utilities	• Notify Oregon One-Call of planned sampling activities • Use caution when hand augering
Sampling potentially contaminated media	Inhalation, ingestion, or skin/eye contact with contaminants including chemical hazards	• Wear appropriate PPE to prevent/reduce exposure. • Wash hands thoroughly after sampling prior to eating and drinking; do not eat or drink during sampling. • Use care when collecting samples to avoid unnecessary contact with media.	• Ensure that decontamination procedures are on hand and are reviewed. • Ensure that PPE and rinsing water are available. • PPE should be inspected daily prior to use.

Appendix B-2
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Acids										
Acetic Acid	10 ppm	None	Irritation, pulm func	10 ppm	15 ppm	50 ppm	10.66	4.0%/ (200°F): 19.9%	Inh Ing Con	Irrit eyes, nose, throat; eye, skin burns; derm; skin sens, dental erosion, black skin, hyperkeratosis, lac; phar edema, chronic bron
Chromic Acid	None	None	None	0.1 mg/m^3	None	15 mg/m^3	NA	NA/NA	Inh Ing Con	Irrit resp sys, nasal septum perf; liver, kidney damage; leucyt, leupen, monocy, esims; eye inj, conj, skin ulcer, sens derm; [carc]
Hydrogen Chloride (hydrochloric acid)	None	None	Irritation	5 ppm	5 ppm	50 ppm	12.74	NA/Na	Inh Ing Con	Irrit nose, throat, larynx; cough, chocking; derm
Nitric Acid	2 ppm	None	Irritation; dental erosion	2 ppm	4 ppm	25 ppm	11.95	NA/NA	Inh Ing Con	Irrit eyes, skin, muc memb; delayed pulm edema, pneuitis, bron; dental erosion
Phosgene	0.1 ppm	None	Irritation; pulmonary emphysema; pulmonary edema	0.1 ppm	0.2 ppm	2 ppm	11.55	NA/NA	Inh Icon (liq)	Irrit eyes; dry burning throat; vomit; cough, foamy sputum, dysp, chest pain, cyan; liq: frostbite
Sulfuric Acid	0.2 mg/m^3	Suspected human carc in strong inorganic acid mist	Pulm func	1 mg/m^3	3 mg/m^3	15 mg/m^3	None	NA/NA	Inh Ing Con	Irrit eye, skin, nose, throat; pulmonary edema, bron; emphy; conj; stomatis; dental erosion; trachbronc, eye, skin burns, derm
Alcohols										
Isobutyl alcohol, IBA, Isobutanol, Isopropylcarbinol, 2-Methyl-1-propanol	50 ppm	Skin	Irritation;	1,000 ppm	None	3,300 ppm	10.12	1.7/10.6	Inh Ing (soln) Con	Irritation eyes, skin, throat; headache, drowsiness; skin cracking; in animals: narcosis
Isooctyl alcohol	50 ppm	Skin	Irritation	None	Noned	None Listed	?	0.9/5.7	Inh Ing (soln) Con	Irrit eyes, skin, nose, throat; skin burns
tert-Butyl alcohol	100 ppm	None	Irritation; CNS	100 ppm	None	1,600 ppm	9.70	2.4/8.0	Inh Ing Con	Irrit eye, skin, nose, throat; drowsiness, narco.
Methanol	200 ppm	Skin	Neuropathy; vision; CNS	200 ppm	250 ppm	6,000 ppm	10.84	6.0%/36%	Inh Ing Con	Irrit eye, skin, upper resp sys; head drow; dizz, verti, li-head, nau, vomit; vis dist, optic nerve damage (blindness), derm

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Alkalies										
Ammonia	25 ppm	None	Eye damage	50 ppm	35 ppm	300 ppm	10.18	15%/28%	Inh Ing Con	Irrit eyes, nose, throat; dysp, bronspas, chest pain; pulm edema; pink frothy sputum; skin burns, vesic; liq: frostbite
Sodium Hydroxide	2 mg/m^3 (ceiling)	None	Irritation	See ceiling	2 mg/m^3	10 mg/m^3	NA	NA/NA	Inh Ing Con	Irrit eyes, skin, muc memb; pneuitis; eye, skin burns; tem. loss of hair
Cyanides										
Cyanide Salts (sodium, potassium, calcium)	None	Skin	Irrit; headache, nausea	5 mg/m^3	5 mg/m^3	25 mg/m^3	NA	NA/NA	Inh Abs Lng Con	Highly toxic at high conc. Corrosive, burns eyes, skin irrit. and upper resp. tract. Cyanide salts can produce highly toxic and flammable vapors of HCN with acid, acid fume, water, or steam
Hydrogen Cyanide	None	Skin	Irrit; headache, nausea	10 ppm	4.7 ppm	50 ppm	13.60	5.6%/40%	Inh Abs Lng Con	Asphy; weak, head, conf; nau, vomit; incr. rate and depth of respiration or respiration slow and gasping; thyroid, blood changes
Dioxin & Furans										
Dioxin (aka: 2,3,7,8-tetrachlorodibenzo-p-Dioxin, TCDD)	All routes of exposure shall be avoided	None	NA	All routes of exposure shall be avoided	ND	ND	ND	ND	Inh Abs Ing Con	Irrit eyes; allergic derm, chloracne; porphyria; GI dist; possible repro, terato effects; in animals: liver, kidney damage: hemorr; [carc]
Tetrachloro-dibenzofuran (TCDF)	None Established	None	NA	None established	ND	ND	ND	ND	Inh Abs Ing Con	Highly toxic, can injure skin and hair, cause dermatitis and anemia and damage the liver, teratogen

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Fuels										
Diesel Fuel	100 mg/m^3	Animal carcinogen Skin	Derm	None	None	None listed	None	1.1%5.9%	Inh Ing Con	Irrit eyes, nose, throat, dizz, drow, head, nav; dry cracked skin; chem pneu (aspir liq)
Methyl-tert Butyl Ether (MTBE)	50 mg/m^3	Animal carcinogen	Irritation; kidney	500 ppm	None	1,100 ppm	None	1.1%5.9%	Inh Ing Con	Nausea, vomiting, sedation; kidney damage; blood cell hemolysis, irrit. to noise, throat, skin, and cornea Respiration can cause lung pneumonitis
TPH (as gasoline)	300ppm	Animal carcinogen	Irritation; kidney; CNS; reproductive	None	500 ppm	None listed	None listed	1.4%/ 7.6%	Inh Abs Ing Con	Irrit eyes, skin, muc memb; derm; head, ftg, blurred vision, dizz, slurred speech, conf, convuls; chem pneu (aspir); possible liver, kidney damage [carc]
Tetraethyl lead	0.1 mg/m^3	Skin	CNS	0.075 mg/m^3	None	48 mg/m^3	11.10	1.8%/ND	Inh Abs Ing Con	Weak, lass, insom; facial pallor; pal eye, anor, low-wgt. malnut; constip, abdom pain, colic; anemia; gingival lead line; tremor; para wrist, ankles; encephalopathy; nephropathy; irrit eyes; hypertension
Kerosene	100 mg/ m^3	None	Irritation, CNS	None	None	ND	NA	0.7%/5%	Inh Ing Abs Con	Irritation eyes, skin, nose, throat; burning sensation in chest; headache, nausea, lassitude (weakness, exhaustion), restlessness, incoordination, confusion, drowsiness; vomiting, diarrhea; dermatitis; chemical pneumonitis (aspiration liquid)
Gases										
Carbon monoxide	25 ppm	None	Irritation, CNS	50 ppm	None	1,200 ppm	14.01	12.5/74	Inh Con	Head, tachypnea, nause, lassitude (weakness, exhaustion), dizz, conf, hallu; cyan; depressed S-T segment of electrocardiogram, angina, syncope

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Halogenated Aromatic Hydrocarbons										
Isopropylbenzene (cumene)	50 ppm	None	Irritation, CNS	50 ppm (skin)	None	900 ppm	8.75	0.9%/6.5%	Inh Abs Ing Con	Irrit eyes, skin, muc memb; derm, head, narco, coma
Halogenated Hydrocarbons										
Bromoform	0.5 ppm	Skin, animal carcinogen	Irritation, liver	0.5 ppm (skin)	None	850 ppm	10.48	NA/NA	Inh Abs Ing Con	Irrit eyes, skin, resp sys; CNS depres; liver, kidney damage
Chlorobenzene	10 ppm	Animal carcinogen	Liver	75 ppm	None	1,000 ppm	9.07	1.3%/9.6%	Inh Ing Con	Irrit eyes, skin, nose; drow, inco; CNS depres; in animals: liver, lung, kidney inj.
Chloroform	10 ppm	Animal carcinogen	Liver, reproductive, CNS	50 ppm	None	500 ppm	11.42	NA/NA	Inh Abs Ing Con	Irrit eyes, skin; dizz, mental dullness, nav, conf; head, ftg, anes; enlarged liver; [carc]
Ethylene dibromide (1,2- Dibromoethane; Ehtylene bromide; Glycol dibromide)	None	Animal carcinogen; skin	None Listed	20 ppm	30 ppm	100 ppm	9.45	NA/NA	Inh Abs Ing Con	Irrit eyes, respiratory sys; dermatitis with vesiculation; liver, heart, spleen, kidney damage; repro effects; [potential occupational carc]
1,2-Dichlorobenzene	25 ppm	None	Irritation; liver	50 ppm	50 ppm	200 ppm	9.06	2.2%/9.2%	Inh Abs Ing Con	Irritation eyes, nose; liver, kidney damage; skin blisters
1,4-Dichlorobenzene	10 ppm	Animal carcinogen	Irritation; Liver	75 ppm	None	150 ppm	8.98	?%/9.2%	Inh Ing Abs Con	Eye irritation, swelling periorbital (situated around the eye); profuse rhinitis; headache, anorexia, nausea, vomiting; weight loss, jaundice, cirrhosis; in animals: liver, kidney injury; [potential occupational carcinogen]

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
1,1-Dichloroehene	100 ppm	None	Skin, liver, kidneys, lungs, central nervous system	100 ppm	None	3,000 ppm	11.06	5.4%/11.4%	Inh Ing Con	Irritation skin; central nervous system depression; liver, kidney, lung damage
1,2-Dichloroethylene	200 ppm	None	Liver	200 ppm	None	1,000 ppm	9.65	5.6%/12.8%	Inh Ing Con	Irrit eyes, resp sys; CNS depres
Methylene Chloride (dichloromethane)	50 ppm	Animal carcinogen	CNS	25 ppm	125 ppm	2,300 ppm	11.32	13%/23%	Inh Abs Ing Con	Irrit eyes, skin; ftg, weak, som, li-head; numb tingle limbs; nau; [carc]
Vinyl Chloride	1 ppm	Human carcinogen	Liver	1 ppm	5 ppm	ND	9.99	3.6%/33.0%	Inh Con	Lassitude (weakness, exhaustion); abdominal pain, gastrointestinal bleeding; enlarged liver; pallor or cyanosis of extremities; liquid: frostbite; [potential occupational carcinogen]
Hydrocarbons, Aromatic										
Benzene	0.5 ppm	Skin, human carcinogen	Cancer	1 ppm	5 ppm	500 ppm	9.24	1.2%/7.78%	Inh Abs Ing Con	Irrit eyes, skin, nose, resp sys; gidd; head, nau, staggered gait; ftg, anor, las; derm; bone marrow depres; [carc]
Ethylbenzene	100 ppm	Animal carcinogen	Irritation; CNS	100 ppm	125 ppm	800 ppm	8.76	0.8%/6.7%	Inh Ing Con	Irrit eyes, skin, muc memb; head; derm; narco, coma
Styrene (monomer)	20 ppm	None	Neuro-toxicity, irritation, CNS	100 ppm	200 ppm	700 ppm	8.40	0.9%/6.8%	Inh Abs Ing Con	Irrit eyes, nose, resp sys; head, ftg, dizz, conf, mal, drow, weak, unsteady gait; narco; defatting derm; possible liver inj, repro effects
Toluene	50 ppm	Irritation; skin	CNS	200 ppm	300 ppm	500 ppm	8.82	1.1%/7.1%	Inh Abs Ing Con	Irrit eyes, nose; ftg, weak, conf, euph, dizz, head; dilated pupils, lac; ner, musc ftg, insom; pares; derm; liver, kidney damage.

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Trimethylbenzene (mixed isomers)	25 ppm	None	CNS; blood	None (25 ppm NIOSH)	None	None	8.27	0.9%/6.4%	Inh Inj Con	Irrit eyes, skin, nose, throat, resp sys; bron; hypochromic anemia, head, drow, ftg, dizz, nau, inco; vomit, conf; chemical pneu (aspir liq)
Xylene (o, m, p)	100 ppm	None	Irritation; CNS	100 ppm	150 ppm	900 ppm	8.56	1.1%/7.0%	Inh Abs Ing Con	Irrit eyes, skin, nose, throat; dizz, excitement, drow, inco, staggering gait; corn vacuolization; anor, nau, vomit; abdom pain; derm
Hydrocarbons, Polynuclear										
Naphthalene	10 ppm	Skin	Irritation; ocular; blood	10 ppm	15 ppm	250 ppm	8.12	0.9%/5.9%	Inh Abs Ing Con	Irrit eyes; head, conf, excitement, mal; nau, vomit, abdom pain; irrit bladder; profuse sweat; jaun; hema, hemog, renal shutdown; derm; optical neuritis, corn damage
PAHs (as coal tar pitch volatiles)	0.2 mg/m^3	Human carcinogen	Cancer	0.2 mg/m^3	None	80 mg/m^3	Not listed	Not listed	Inh Con	Derm, brom [carc]
Metals										
Antimony	0.5 mg/m^3	None	Skin; irritation	0.50 mg/m^3	None	50 mg/m^3	NA	NA/NA	Inh Ing Con	Irrit eyes, skin, nose, throat, mouth, cough; dizz, head; nau; vomit; diarr; stomach cramps; isom; anorex; unable to smell properly.
Arsenic (inorganic compounds)	0.01 mg/m^3	Human carcinogen	Cancer (lung, skin); lung	0.01 mg/m^3	0.002 mg/m^3 [15 min]	5 mg/m^3	NA	NA/NA	Inh Abs Ing Con	Ulceration of nasal septum, derm, GI disturbances, peri neur, resp irrit, hyperpig of skin, [carc]
Barium (as sulfate)	10 mg/m^3	None	Pneumon-iosis	5 mg/m^3 (respirable)	None	None determined	NA	NA/NA	Inh Con	Irrit eyes, nose, upper resp sys; benign pneumoniosis (baritosis)
Beryllium	0.002 mg/m^3	Human carcinogen	Cander (lung); berylliosis	0.002 mg/m^3	0.005 mg/m^3	4 mg/m^3	NA	NA/NA	Inh Con	Berylliosis (chronic exposure); anor, low-mgt, weak, chest pain, cough, clubbing of fingers, cyan, pulm insufficiency; irrit eyes; derm [carc]

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Cadmium Dust and compounds	0.002 mg/m^3 respirable	Suspected human carcinogen	Cancer; kidney; metal fume fever	0.005 mg/m^3 respirable	None	9 mg/m^3	NA	NA/NA	Inh Ing	Pulm edema, dysp, cough, chest tight, subs pain; head; chills. musc aches; nau, vomit, diarr; anor, emphy, prot, mild anemia; [carc]
Chromium Metal	0.5 mg/m^3	None	Irritation; dermatitis	1.0 mg/m^3	None	250 mg/m^3	NA	NA/NA	Inh Ing Con	Irrit eyes, skin; lung fib, sens derm
Chromium VI compounds (insoluble)	0.01 mg/m^3	Human carcinogen	Cancer, irritation	0.1 mg/m^3	0.1 mg/m^3	15 mg/m^3	NA	NA/NA	Inh Ing Con	Irrit resp sys, nasal septum perf; liver, kidney damage; leucyt, leupen, monocy, eosin; eye inj, conj; skin ulcer, sens derm [carc]
Copper (dusts and mists)	1 mg/m^3	None	Irritation; GI; metal fume fever	1 mg/m^3	None	100 mg/m^3	NA	NA/NA	Inh Ing Con	Irrit eyes, nose, pharynx; nasal ref; metallic taste; derm; in animals: lung. Liver kidney damage, anemia
Lead, elemental and inorganic compounds	0.05 mg/m^3	Animal carcinogen	CNS; GI; blood; kidney; reproductive	0.05 mg/m^3	None	100 mg/m^3	NA	NA/NA	Inh Ing Con	Weak, lass, insom; facial pallor; pal eye, anor, low-wgt. malnut; constip, abdom pain, colic; anemia; gingival lead line; tremor; para wrist, ankles; encephalopathy; nephropathy; irrit eyes; hypertension
Mercury (inorganic forms including metallic mercury)	0.025 mg/m^3	Skin	CNS; kidney; reproductive	0.1 mg/m^3	0.1 mg/m^3	10 mg/m^3	NA	NA/NA	Inh Abs Ing Con	Irrit eyes, skin; cough, chest pain, dysp, bron pneuitis; tremor, insom, irrity, indecision, head, ftg, weak, stomatitis, salv; GI dist, anor, low-wgt; prot
Nickel Metal inorganic compounds	1.5 mg/m^3 0.1 mg/m^3	None	Dermatitis; pneumocon; lung damage; lung and nasal cancer	1 mg/m^3	None	10 mg/m^3	NA	NA/NA	Inh Ing Con	Sens derm, allergic asthma, pneuitis; [carc]
Selenium	0.2 mg/m^3	None	Irritation	0.2 mg/m^3	None	1 mg/m^3	NA	NA/NA	Inh Ing Skin eye	Irrit eyes, skin, nose, throat; visual dist; head; chills, fev; dysp, bronch; metal taste, garlic breath, GI dist; derm, eye, skin burns.
Silver metal dust soluble compounds	0.1 mg/m^3 0.01 mg/m^3	None	Argyria	0.01 mg/m^3	None	10 mg/m^3	NA	NA	Inh Ing Con	gray eyes, nasal, septum, throat, skin; irrit, ulceration skin; GI dist

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Tin (organic)	0.1 mg/m^3	Skin	CNS, immun. toxicity; irritation	0.1 mg/m^3	0.2 mg/m^3	25 mg/m^3	Varies	NA/NA	Inh Abs Con Lng	Irrit eyes, skin; resp. sys; head, vertfi; psychoneurological dist; sore throat, cough; abdom pain, vomit; urine retention; paresis, focal anes; skin burns, puritus
Tin, metal and oxide	2 mg/m^3	None	Stannosis	2 mg/m^3	None	100 mg/m^3	NA	NA/NA	Inh Con	Irrit eyes, skin, resp sys; in animals: vomit, diarr, para w/musc twitch
Zinc oxide (as dust)	2 mg/m^3	Noner	Metal Fume Fever	5 mg/m^3 (respirable dust and fume) 15 mg/m^3 (total dust)	None	500 mg/m^3	NA	NA/NA	Inh	Metal fume fever: chills, musc ache, nau, fever, dry throat, cough, weak, lass; metallic taste; head; blurred vision; low back pain; vomit; ftg; mal; tight chest, dysp, rales, decr pulm func
Particulates										
Asbestos	0.1f/cc	Confirmed human carcinogen	Asbestosis; cancer	0.1f/cc	NA	N.D.	NA	NA/NA	Inh Lng Con	Asbestosis (chronic exposure); dysp, interstitial fib, restricted pulm function; finger clubbing, irrit eyes; [carc]
Silica, crystalline (quartz)	0.025 mg/m^3 (respirable)	Suspect human carcingoen	Silicosis; lung fibrosis; cancer	30 mg/m^3/ %SiO2+2 as total quartz	None	50 mg/m^3	NA	NA/NA	Inh Con	Cough, dysphea (breathing difficulty), wheezing; decreased pulmonary funct, progressive resp. symtoms (silicosis); irritation eyes [carc]
Pesticides (fungicides, insecticides, herbicides, rodenticides)										
Aldrin	0.25 mg/m^3	Skin	Liver	0.25 mg/m^3	None	25 mg/m^3	None	NA/NA	Inh Abs Ing Con	Head, dizz, nau, vomit, mal; myoclonic jerks of the limbs; clonic tonic convuls; coma, hema, azotemia; [carc]
2,4-D (dichlorophenoxy-acetic acid)	10 mg/m^3	None	Irritation	10 mg/m^3	None	100 mg/m^3	None	NA/NA	Inh Abs Ing Con	Weak, stupor, hyporeflexia, musc twitch; convuls, derm; in animals: liver, kidney inj

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Chlordane	0.5 mg/m^3	Skin	Seizures; liver	0.5 mg/m^3	None	100 mg/m^3	None	NA/NA	Inh Abs Ing Con	Blurred vision; conf, ataxia, delirium; cough; abdom pain, nau, vomit, diarr; irrity, tremor, convuls; anuria; in animals; lung, liver, kidney damage; [carc]
Chlorinated camphene/ Octachlorocamphene/ Polychlorocamphene/ Toxaphene	0.5 mg/m^3	Skin	Skin, CNS, liver	0.5 mg/m^3	1 mg/m^3	200 mg/m^3	None	NA/NA	Inh Abs Ing Con	Nausea, confusion, agitation, tremor, convulsions, unconsciousness; dry, red skin; [potential occupational carcinogen]
DDT	1 mg/m^3	Animal carcinogen	Seizures; liver	1 mg/m^3	None	500 mg/m^3	None	NA/NA	Inh Abs Ing Con	Irrit eyes, skin, pares tongue, lips, face; tremor; appre, dizz, conf, mal, head, ftg; convuls; paresis hands, vomit; [carc]
Dieldrin	0.25 mg/m^3	Skin	Liver; CNS	0.25 mg/m^3	None	50 mg/m^3	None	NA/NA	Inh Abs Ing Con	Head, dizz; nau, vomit, mal, sweat; myoclonic limb jerks; clonic, tonic convuls; coma; [carc]; in animals: liver; kidney damage
Diquat (respirable)	0.1 mg/m^3	Skin	Irrit; eye	None	None	ND	None	NA/NA	Inh Abs Ing Con	Irrit eyes, skin, muc memb, resp sys; rhin, epis; skin burns, nau, vomit; diarr, mal; kidney, liver inj; cough, chest pain, dysp, pulm edema; tremor; convuls; delayed healing of wounds
Endrin	0.1 mg/m^3	Skin	CNS; liver	0.1 mg/m^3	None	2 mg/m^3	None	NA/NA	Inh Abs Ing Con	Epilep convuls; stupor, dizz; abdom discomfort, nau, vomit; insom; aggressiveness, conf; drow, lass; anor; in animals: liver damage
Heptaclor	0.05 mg/m^3	Skin, animal carcinogen	CNS; liver; blood	0.5 mg/m^3	None	35 mg/m^3	None	NA/NA	Inh Abs Ing Con	In animals: tremor, convuls; liver damage
Lindane	0.5 mg/m^3	Skin, animal carcinogen	CNS	0.5 mg/m^3	None	50 mg/m^3	None	NA/NA	Inh Abs Ing Con	Irritation eyes, skin, nose, throat; headache; nausea; clonic convulsions; respiratory difficulty; cyanosis; aplastic anemia; muscle spasm; in animals: liver, kidney damage

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Malathion	1 mg/m^3	Skin	Cholinergic	15 mg/m^3	None	250 mg/m^3	None	NA/NA	Inh Abs Ing Con	Irrit eyes, skin; miosis, aching eyes, blurred vision, lac; salv; anor, nau, vomit, abdom cramps, diarr, dizz, conf, ataxia; rhin, head; chest
Paraquat (respirable)	0.1 mg/m^3	None	Lung, irritation	0.5 mg/m^3	None	1 mg/m^3	None	NA/NA	Inh Abs Ing Con	Irrit eyes, skin, nose, throat, resp syst; epis; derm; finger nail damage; irrit GI tract, heart, liver, kidney damage
Parathion	0.05 mg/m^3	Skin	Chloinergic	0.1 mg/m^3	None	10 mg/m^3	None	NA/NA	Inh Abs Ing Con	Irrit eyes, skin, resp sys; miosis; rhin; head; chest tight, wheez, lar spasm, salv, cyan; anor, nau, vomit, abdom cramps, diarr; sweat; musc fasc, lass, para; dizz, conf, ataxia; convuls, coma; low BP; card irreg
Strychnine	0.15 mg/m^3	None	CNS	0.15 mg/m^3	None	3 mg/m^3	None	NA/NA	Inh Abs Ing Con	Stiff neck, facial musc; restless, anxi, incr acuity of perception; incr reflex excitability; cyan; titanic convuls with opisthotonos
2, 4, 5T (2,4,5 trich-lorophenoxyacetic acid)	10 mg/m^3	None	PNS impair	10 mg/m^3	None	250 mg/m^3	None	NA/NA	Inh Ing Con	In animals: ataxia; skin irrit, acne-like rash, liver damage
Warfarin	0.1 mg/m^3	None	Blood; bleeding	0.1 mg/m^3	None	100 mg/m^3	None	NA/NA	Inh Abs Ing Con	Hema, backpain; hematoma arms, legs; epis, bleeding lips, muc memb hermorr, abdom pain, vomit, fecal blood; petechial rash; abnor hematologic indices
Phosphorus										
Yellow phosphorus, Elemental phosphorus, White phosphorus	0.1 mg/m^3	None	Eyes, skin, respiratory system, liver, kidneys, jaw, teeth, blood	0.1 mg/m^3	None	5 mg/m^3	None	NA/NA	Inh Abs Ing Con	Irritation eyes, respiratory tract; eye, skin burns; abdominal pain, nausea, jaundice; anemia; cachexia; dental pain, salivation, jaw pain, swelling

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Phenols										
Pentachlorophenol (PCP)	0.5 mg/m^3	Skin	Irritation, CNS, card	0.5 mg/m^3	None	2.5 mg/m^3	None	NA/NA	Inh Abs Ing Con	Irritate eyes, nose, throat; sneezing, cough; lassitude (weakness, exhaustion), anorexia, weight loss; sweating; headache, dizziness; nausea, vomiting; dyspnea (breathing difficulty), chest pain; high fever; dermatitis
Phenol	5 ppm	Skin	Irritation; CNS; lung	5 ppm (skin)	None	250 ppm	8.50	1.8%/8.6%	Inh Abs Ing Con	Irrit eyes, nose, throat; anor, low-wgt; weak, musc ache, pain; dark urine; cyan; liver, kidney damage; skin burns; derm; ochronosis; tremor, convuls, twitch
PCBs										
Polychlorinated Biphenyl (PCB) (42% chlorine)	1 mg/m^3	Skin	Irritation, chloroacne; liver	1 mg/m^3	None	5 mg/m^3	ND	NA/NA	Inh Abs Ing Con	Irritation eyes; chloracne; liver damage; reproductive effects; [potential occupational carcinogen]
Polychlorinated Biphenyl (PCB) (54% chlorine)	0.5 mg/m^3	Skin, animal carcinogen	Irritation, chloroacne; liver	0.5 mg/m^3	None	5 mg/m^3	ND	NA/NA	Inh Abs Ing Con	Irritation eyes, chloracne; liver damage; reproductive effects; [potential occupational carcinogen]
Semivolatile Organics										
Benzo(b)fluoranthene	None	Suspected human carcinogen	Cancer	None	None	None	NA	NA/NA		See coal tar pitch volatiles.
Benzo(a)anthracene	None	Suspected human carcinogen	Cancer	None	None	None	NA	NA/NA		See coal tar pitch volatiles.
Benzo(a)pyrene	None	Suspected human carcinogen	Cancer	None	None	None	NA	NA/NA		See coal tar pitch volatiles.
Chrysene	None	Confirmed animal carcinogen	Skin	None	None	None	NA	NA/NA		See coal tar pitch volatiles.
Coal tar pitch volatiles (as benzene solubles)	0.2 mg/m^3	Human carcinogen	Cancer	0.2 mg/m^3	None	80 mg/m^3	NA	NA/NA	Inh Con	Derm, bron, [carc]

Appendix B-2 (Continued)
Chemical Hazard Properties and Exposure Information

Chemical Name/Synonym	ACGIH® TLV® TWA	Notations	TLV® Basis	OSHA PEL	STEL (ST) or Ceiling	IDLH	IP (eV)	LEL/UEL	Route	Route/Systems** Symptoms
Solvents										
Acetone	500 ppm	None	Irritation, CNS	1,000 ppm	750 ppm	2,500 ppm	9.69	2.5%/12.8%	Inh Ing Con	Irrit eyes, nose throat; head, dizz, CNS depress; derm
Carbon tetrachloride	5 ppm	Skin, suspected human carcinogen	Liver, cancer	10 ppm	10 ppm	200 ppm	11.47	NA/NA	Inh Abs Lng	Irrit eyes, skin, CNS depres; nav, vomit, liver, kidney inj; drow, dizz, inco; [carc]
Chloroform (Methane trichloride and Trichloromethane)	10 ppm	N/A	Liver, kidney, heart, eyes, skin, central nervous system	50 ppm	None	Ca [500 ppm]	11.42	NA/NA	Inh Abs Ing Con	Irritation eyes, skin; dizziness, mental dullness, nausea, confusion; headache, lassitude (weakness, exhaustion); anesthesia; enlarged liver; [potential occupational carcinogen]
1,2-dichloroethane (ethylene dichloride) DCA	10 ppm	None	Liver, nausea	50 ppm	100 ppm	50 ppm	11.05	6.2%/16%	Inh Abs Ing Con	Irrit eyes, com opac; CNS depres; nau, vomit; derm; liver, kidney, CVS damage; (carc)
1,2-dichloroethylene (cis&trans DCE)	200 ppm	None	Liver	200 ppm	None	1,000 ppm	9.65	5.6%/12.8%	Inh Ing Con	Irrit eyes, resp sys; CNS depres
Ethyl Ether	400 ppm	None	Eyes, skin, respiratory system, central nervous system	400 ppm	None	1,900 ppm	9.53	1.9%/36%	Inh Abs Ing Con	Irritation eyes, skin, upper respiratory system; dizziness, drowsiness, headache, excited, narcosis; nausea, vomiting
1,4-dioxane	20 ppm	Skin	Liver	100 ppm (360 mg/m^3)	None	Ca [500 ppm]	9.13	2.0%/22%	Inh Abs Ing Con	Irritat eyes, skin, nose, throat; drowsiness, headache; nausea, vomiting; liver damage; kidney fail; [potential occupational carcinogen]
Fluorotrichloromethane/ Freon® 11/Monofluoro-trichloromethane/ Refrigerant 11/Trichloro-fluoromethane/ Trichloromono-fluoromethane	None	None	Cardiovascular system	1,000 ppm	1,000 ppm	2,000 ppm	11.77	NA/NA	Inh Abs Ing Con	Incoordination, tremor; dermatitis; cardiac arrhythmias, cardiac arrest; asphyxia; liquid: frostbite

ACGIH® = American Conference of Governmental Industrial Hygienists

ppm = Parts per million

NE = None established

IP = Ionization potential

TLV® = ACGIH® Threshold Limit Values

OSHA = Occupational Safety and Health Administration

mg/m^3 = Milligrams per cubic meter

TWA = Time weighted average

PEL = OSHA Permissible Exposure Limit

ND = None determined

IDLH = Immediately dangerous to life and health

STEL = Short-term exposure limit

NIOSH = National Institute of Occupational Safety and Health

LEL = Lower explosive limit

TPH = Total petroleum hydrocarbons

PAH = Polyaromatic hydrocarbon

NA = Not applicable

UEL = Upper explosive limit

Sources: The above information was derived from NIOSH Pocket Guide to Chemical Hazards, (September 2005). ACGIH® Threshold Limit Values (2006).

Cascadia
Associates, LLC

Attachment C
Standard Operating Procedures

1.0 SOIL SAMPLING PROCEDURES

The following standard operating procedures (SOPs) are used by Cascadia Associates, LLC (Cascadia).

1.1 HAND AUGER SOIL SAMPLING

Discrete soil samples will be collected using a stainless steel hand auger. The following general procedures will be used during soil sampling:

1. Prior to completion of the soil borings, the soil borings will be marked and the Oregon Utility Notification Center will be notified so the borings can be cleared of subsurface utilities.
2. The auger will be assembled and used to bore a hole to the desired sampling depth. Once the auger has been advanced to the desired depth, the auger will be withdrawn.
3. Soil will be logged as required for the project.
4. The desired sample volume will be collected. Sample volume may either be collected directly into the laboratory supplied sampling containers from the hand auger head or placed into a stainless steel bowl prior to placement into the sampling containers.
5. After collecting the sample and logging the soils, the process may be repeated until the desired total depth of the boring is reached.
6. The boring will be backfilled using soil cuttings.
7. All sampling equipment and other down-hole equipment is decontaminated between boring locations using a solution of water and non-phosphate detergent (e.g., Liquinox®). The sampling equipment is rinsed with distilled water following the wash.

2.0 FIELD DOCUMENTATION

The following is a description of the documentation completed during field sampling activities. All activities require entries in a field notebook, which are completed in waterproof pen or pencil. During drilling, boring logs are also completed.

2.1 SOIL DESCRIPTION

Cascadia uses the Unified Soil Classification System for soil description. Generally, soils can be classified using the following descriptors:

- Density (based on standard penetration test [SPT] blow counts or manual determination),
- Moisture content,
- Color (including mottling, stringers, color changes),
- Soil type classification,
- Soil modifier (e.g., sandy, with gravel),

- Other macroscopic characteristics such as sorting,
- Stratification,
- Percent varying grain sizes, and
- Sphericity and roundness of grains.

Each sample is described on a field boring log form. Sample recovery, sample times, and the results of vapor screening (if performed) are also recorded on the boring log form.

2.2 SOIL BORING LOGS

Soil boring logs are completed by the Cascadia staff. The information that is included on the boring logs is as follows:

- The boring number and/or monitoring well number;
- Drilling method, borehole diameter;
- Dates of start and completion of boring/well;
- Weather conditions;
- Drilling and sampling methods;
- Depths to water while drilling;
- Total depth of boring;
- Drilling characteristics (i.e., penetration rates, voids encountered, etc.);
- Drilling contractor and names of drillers and helpers;
- Cascadia field staff name(s);
- Soil lithologic description of collected samples and cuttings as described in Section 3.1;
- Field volatile readings obtained as described in Section 2.0;
- Well as-built information (construction details), if applicable; and
- Well start card number, if applicable.

2.3 FIELD NOTES

Field notes are prepared during all field activities. All pertinent information regarding the site and sampling procedures is documented. Notes typically include:

- Name, location and job number of site;
- Date of entries;
- The initials of the person recording the notes;
- The page number and total number of pages;
- Time of arrival and departure;
- Names of all persons on site and purpose of site visits, as applicable;
- Weather;
- Field observations;
- If field detection instruments are being used, calibration information and any malfunctions or inconsistent behavior of the instruments are recorded; and

- Specific information for the activities described below is included in the field notes.

2.4 SAMPLE COLLECTION DOCUMENTATION

Procedures used to collect each sample must be documented. The following items are recorded in the field log book:

- Sample identification number;
- Sample matrix;
- Sample location;
- Time of collection;
- Sample method (i.e., bailer material, type of pump, hand auger, etc.);
- Visual description
    - water: color, clarity, immiscible globules or sheen
    - soil: soil classification, texture, color, density;
- If applicable, groundwater collection purge data including volume purged, conductivity, pH, and temperature readings;
- Factors that may affect the quality of the sample (i.e., unavoidable aeration, sample collection in a high traffic area);
- Number and types of containers filled;
- PID readings (if applicable); and
- If decisions are being made in the field regarding where sample collection should take place, the justification for those decisions should be recorded (i.e., visual or olfactory observations, elevated PID readings, proximity to suspect materials were stored).

2.4.1 Blanks

Any blank samples collected are noted. The name of the samples, time and date of collection, and the type of blank (i.e., equipment blank, field blank, trip blank) are recorded.

2.4.2 Location Control

The exact location of sampling points is documented. One or more monuments are chosen to use as a stationary reference point from which sampling points can be measured. Measurements should be collected in a manner that, if needed, future field personnel will be able to determine the exact locations from which previous samples were collected when provided with the monument and measurement data. In some cases, location control is established using Global Positioning System (GPS) instruments and/or professional survey data.

3.0 POST-SAMPLING ACTIVITIES

Once the sample is collected into the appropriate container, the outside of the container should be wiped with a clean paper towel if needed to remove excess sampling material.

Sample containers will be packaged and stored in a manner that protects the sample from breakage and maintains the samples at the appropriate temperature (i.e., placed in a cooler on ice) for transport to the laboratory. Samples will be delivered to the laboratory for analysis with the recommended holding times.

Information such as sample number, location, collection time and sample description is recorded in the field logbook or forms as described in Section 2.3. Associated paperwork (e.g., chain of custody forms) are completed and stay with the sample(s), as described in Section 3.1.

3.1 CHAIN OF CUSTODY

The chain of custody (COC) form serves as a legal record of possession of the sample. When the COC is completed correctly, no lapses in sample accountability will be evident. The procedure to follow to maintain a complete record of sample possession is as follows:

- A COC listing every sample that has been collected during a sampling event is filled out upon completion of that event (examples of an event would be a drilling investigation, groundwater monitoring well sampling, collecting a remediation system effluent sample, etc.). The sample ID, date, time, preservative, number of containers and their volumes are listed for each sample. Requested laboratory analyses are indicated on the COC.
- The COC is signed, dated, and marked with the time when samples are turned over or shipped to the laboratory. The lab representative signs the COC and returns a copy to the sampler. The copy of the COC is maintained in the job file.