Upper Columbia River

FINAL
Soil Amendment Technology Evaluation Study
Phase III & IV Work Plan Addendum:
Depth-Discrete Sampling Plan

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TITLE AND APPROVAL SHEET

SOIL AMENDMENT TECHNOLOGY EVALUATION STUDY PHASE III & IV WORK PLAN ADDENDUM: DEPTH-DISCRETE SAMPLING PLAN

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ACRONYMS AND ABBREVIATIONS

ALS	ALS Environmental Kelso
EDTA	ethylenediaminetetraacetic acid
EPA	U.S. Environmental Protection Agency
IC	incremental composite
ICP-AES	inductively coupled plasma - atomic emission spectroscopy
OSU	The Ohio State University
SATES	Soil Amendment Technology Evaluation Study
SOP	standard operating procedure
TAI	Teck American Incorporated
TAL	target analyte list

UNITS OF MEASURE

bgs	below ground surface
ft	foot or feet
g	gram(s)
in.	inch(es)
µm	micrometer(s)

1 INTRODUCTION

The Soil Amendment Technology Evaluation Study (SATES) is a soil treatability study designed to identify and field test soil amendment technologies that could appropriately and cost-effectively reduce the long-term potential for human exposure to lead in shallow upland soils at the Upper Columbia River site[1] (USEPA 2016, Ramboll 2017a). The final Phase III & IV Work Plan: Test Plot Field-scale Implementation & Test Plot Monitoring (hereinafter the Phase III & IV Work Plan) (Ramboll 2020) describes the objectives, procedures, and requirements for SATES and the field-test phase of the study.

This work plan addendum describes the objective and procedures for the collection and analysis of depth-discrete soil samples as part of Phase IV; this will constitute the last step in the field-scale testing phase of this study. Phase III & Phase IV Work Plan elements applicable to soil sample collection, sample management, and documentation are identified herein and thereby incorporated by reference, with certain modifications or additional procedures relating to discrete sample collection and analyses described herein, as needed, to support this sampling effort. Additionally, all parts of the Phase III & Phase IV Work Plan that describe requirements and procedures pertaining to the management of investigation-derived wastes, quality assurance and quality control, data verification and validation, data management, and reporting apply to this work plan addendum and are not reproduced herein.

1.1 OBJECTIVE OF DEPTH-DISCRETE SAMPLING

The data from the depth-discrete samples will be used to evaluate whether the soil treatments applied to the test plots for field testing have affected metals concentrations in shallow (< 12 in.) subsurface soil relative to the control subplots and baseline conditions established for the test plots in Phase IA of the study (Ramboll 2019). To obtain data for this comparison, depth-discrete soil samples will be collected from each test plot at 2-in. intervals beginning at the soil surface (0 in.) to a total depth of 12 in.

[1] The Upper Columbia River site as defined within the June 2, 2006, Settlement Agreement is the areal extent of hazardous substances contamination within the United States in or adjacent to the Upper Columbia River, including the Franklin D. Roosevelt Lake, from the U.S.-Canada border to the Grand Coulee Dam, and those areas in proximity to the contamination that are suitable and necessary for implementation of response actions.

1.2 SCHEDULE

Phase IV incremental composite (IC) sampling began in May 2021 and ended in October 2022. The depth-discrete sampling will be conducted and completed in May 2023 (Ramboll 2020).

2 DEPTH-DISCRETE SOIL SAMPLE COLLECTION

This section presents the sampling and analysis plan for the depth-discrete soil sampling. Additionally, Appendices A through E of the Phase III & Phase IV Work Plan (Ramboll 2020) are applicable to the depth-discrete sampling effort and incorporated by reference into this work plan addendum. Of the standard operating procedures (SOPs) for field operations contained in Appendix B of the Phase III & Phase IV Work Plan (Ramboll 2020), the SOPs listed below (or parts thereof where noted) are also applicable:

- SOP-2 – Cultural Resources Coordination and Reporting
- SOP-4 – Field Documentation
- SOP-5 – Positioning Soil Sampling Locations (as appropriate for marking and recording locations of depth-discrete sampling points)
- SOP-7 – Sample Labeling (with modifications for depth discrete sampling, as presented in this work plan addendum)
- SOP-8 – Sample Custody
- SOP-9 – Sample Storage, Packaging, and Shipping
- SOP-10 – Decontamination of Soil Sampling Equipment
- SOP-11 – Electronic Data Deliverables Specifications

Additional requirements specific to this work plan addendum are provided in the following sections.

2.1 SAMPLE ANALYSES

The data requirements for the depth-discrete soil samples are listed in Table 2-1. These samples will be analyzed for the following parameters (see Table 2-2):

- Electrical conductivity (soil salinity) measured by electrode (field measurement)
- pH measured by electrode (field measurement)
- Temperature measured by electrode (field measurement)
- Extractable phosphorus by Mehlich III

  - Total target analyte list (TAL) metals[2] (except mercury) by EPA 3051A (sample preparation) and EPA 6010C
  - Soil moisture measured by direct measurement by EPA 160.3
- TAL metals analyses will be conducted on the < 2 mm soil fraction, consistent with the Phase IA baseline characterization analyses (Ramboll 2017a, 2017b, 2019).

2.2 DEPTH-DISCRETE SOIL SAMPLING PROCEDURE

Depth-discrete soil samples will be collected from each of the experimental test plots from the soil surface (0 in.) to 12 in. depth. Discrete samples will be collected at 2-in. depth intervals consistent with the discrete sample collection that was performed for the Phase IA baseline soil characterization (Ramboll 2017a, 2017b, 2019).

2.2.1 Sampling Locations

Depth-discrete soil samples will be collected from each subplot within test plots 258-3, 401-1, 401-2, and 441-1 (Maps 2-1 through 2-4). Each test plot is divided into four 50-ft by 50-ft subplots designated as subplots A, B, C, and D (Figure 2-1). Within each test plot, three subplots were treated with the soil amendments selected for field-scale testing and the fourth subplot was maintained as a control (untreated). As described in Section 2.2.2, samples will be collected from test pits that will be positioned at locations that have not been previously sampled and, within the same grid used for IC sampling. SOP-5 (Ramboll 2020) provides details on the sampling grids and the procedure for positioning IC sample locations within the subplots.

2.2.2 Methodology

The depth-discrete soil samples will be collected from three test pits in each subplot (a total of twelve pits per test plot) then composited at each depth interval, resulting in 1 sample per subplot at each of the 6 2-in.-thick depth intervals. The preferred test pit locations are shown in Figure 2-1, and coordinates for these locations are provided in Table 2-3. At each location, discrete (grab) soil samples will be collected at 2-in. depth intervals beginning at the soil surface (0 in.) and ending at a depth of 12 in. Thus, a total of 24 depth-discrete samples will be collected from each test plot (6 per subplot for a total of 24). Additionally, 2 replicate samples will be collected over all the

[2] TAL metals include Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, and Zinc.

subplots (12 additional samples) for a total of 108 samples (6 samples per subplot * 4 subplots * 4 plots + 6 samples per replicate * 2 replicates = 108 samples).

To supplement the SOPs applicable to this work plan addendum, the additional procedures for depth-discrete soil sample collection are provided below. The above-listed SOPs are referenced where applicable.

1. Locate each sample point and mark with a pin flag.
2. At each sampling point that has been marked, describe vegetation present and any anthropogenic features or evident disturbances in the vicinity of this location in the field notebook, and take digital photographs and record in the project photo log. A sample point may be shifted from the planned location by no more than 3 ft to avoid obstacles such as woody vegetation or rocks.
3. At each sampling point, clear vegetation and surface debris (e.g., woody debris, undecomposed leaves and pine needles, loose rocks) either by hand or by using a decontaminated sampling trowel to expose the mineral soil surface (0-in. depth). Place surficial materials on a plastic sheet or tarp and set aside until sampling has been completed.
4. After the sampling location has been cleared, excavate a test pit approximately 2 ft by 2 ft and approximately 12 to 14 in. in depth using decontaminated stainless steel hand tools (see SOP-10, full decontamination). Place the excavated soil on a clean plastic sheet or tarp and set aside, keeping separate from the surface materials cleared away in step 4. This soil will be used to backfill the pit after sampling has been completed.
   a. Prior to sampling, observe the test pit side walls, record a description of the soil in the field notebook (e.g., color, classification, root depth), and take a photo or photos of the test pit side walls and document record in the photo log.
   b. Collect 400 grams of soil sample material from the north test pit wall using a decontaminated stainless steel sampling scoop and/or disposable scoop at each target depth interval (0 to 2 in., 2 to 4 in., 4 to 6 in., 6 to 8 in., 8 to 10 in., and 10 to 12 in.). Samples should be collected in sequence along a plumb line (90 degrees from the surface) from top to bottom.
   c. Replicate samples will be collected from select discrete 2-in. sample intervals in close proximity to the primary sample location and depth (< 3 in. distance if possible). Two replicates will be collected for the study (10 percent frequency).
   d. Place the samples into a resealable bag for inspection by a cultural resource monitor.
   e. Allow the cultural resource monitor to inspect each sample, as set forth in SOP-2.

   i. If the sample passes the cultural resources review, continue sample collection following remaining steps and procedures outlined below.

   ii. If the sample does not pass the inspection, STOP SAMPLE COLLECTION. Notify the field supervisor for management-of-change procedures as described in SOP-2 and implement notifications required by the Cultural Resource Coordination Plan in Appendix A of the Phase III & Phase IV Work Plan (Ramboll 2020).

  f. After the samples pass cultural resource review, combine the three samples collected from each depth interval in a subplot into one resealable bag and homogenize by palpitating the bag. Remove roughly 100-gram sample for pH and electrical conductivity testing to be done by the field crew at the end of the day and place the remaining portion of the sample into a properly labeled laboratory-supplied sample container. (Procedures for field measurement of soil pH and conductivity are provided below, in Section 2.2.3.)

5. Complete field documentation for soil samples as outlined in SOP-4.
6. After all required samples have been collected, backfill the test pit with the excavated soil. Cover the area with the reserved duff and debris.
7. Discard disposable sample-dedicated equipment such as gloves, bags, etc.
8. Follow sample handling, packaging, and shipping procedures provided in SOP-8 (Sample Custody) and SOP-9 (Sample Storage, Packaging, and Shipping SOP).

2.2.3 Field Measurement of pH and Electrical Conductivity

The field crew will collect approximately 100 g of soil from each sample for soil pH and electrical conductivity measurements that will be done at the end of each field day (see step 4f above).

2.2.3.1 Field pH Measurement

Steps for instrument calibration, sample preparation, and collecting and recording the field measurements are outlined below.

1. At the beginning of each field day, the field supervisor or designee will calibrate the pH meter following the manufacturer’s instructions. Record the procedure, result, and time calibration was completed in the field logbook or on a field data sheet.
2. Remove a small amount of soil from the 100 g portion of sample reserved for field pH and conductivity measurements during sample collection, collecting three aliquots (approximately 20 g each) from different locations in the bag and placing approximately equal amounts into three clean glass or plastic containers designated for field pH testing, as specified for IC sampling.

3. Wet the soil with a small amount of laboratory-supplied deionized water and mix thoroughly to make a slurry. New, full containers of deionized water should be used to minimize the potential for acidification of the water upon exposure to atmospheric carbon dioxide. (pH probes cannot typically accurately measure the pH of deionized water because of the lack of dissolved ions, so testing the deionized water prior to sample preparation is not recommended.)

4. Set the pH probe in the soil slurry to measure the pH, following the instrument manufacturer's directions to obtain a pH reading for each of the three subsamples. Wetted soil from the pH tests should be discarded in the same container used to collect decontamination fluids as per SOP-10.

5. Record the pH measurements in the field logbook or on the field data sheet, along with the time measurements were taken and the depth-discrete sample ID. The three subsamples or aliquots will be recorded with the same sample ID as the sample and with the suffix -1, -2, or -3, as applicable to designate measurements for each of the subsamples.

2.2.3.2 Field Conductivity Measurement

- Obtain a Spectrum Technologies FieldScout Direct Soil EC Meter (Model 2265FS ID #9934) and ensure that it was factory calibrated.
- Collect three measurements from the homogenized composite sample from approximately at the 0-, 60-, and 120-degree positions of the sample.
- Record the measurements in the field logbook or on a field data sheet.

2.3 DEPTH-DISCRETE SAMPLE DESIGNATION AND LABELING

Sample labeling for the depth-discrete soil samples will follow the scheme described in SOP-7. To distinguish depth-discrete samples from IC samples collected in Phase IV, the depth-discrete samples will be labeled as follows:

- D for depth-discrete soil sample
- Test plot number
- Subplot letter (A, B, etc.)
- Six-digit date (MMDDYY)
- Top and bottom depth of interval where the sample was collected
- Three-letter code corresponding to the amendment applied to the sampled subplot:
  - CTL = control

- PHO = soluble phosphate
- CPS = compost-based potting soil
- PBI = soluble phosphate and biochar combination

For example, a sample collected on May 21, 2023 from test plot 258-3, subplot A with the soluble phosphate treatment (PHO), from a depth of 6 to 8 in. will be labeled by the identification number "D-258-3A-052123-6-8-PHO."

Field replicates will be labeled with the suffix "-R" added to the sample ID, for example, "D-258-3A-052123-6-8-PHO-**R**."

3 REFERENCES

Ramboll. 2017a. Final work plan for the Soil Amendment Technology Evaluation Study Phase I: test plot characterization and initial amendment alternatives evaluation. Prepared by Ramboll Environ, Seattle, Washington, for Teck American Incorporated. July.

Ramboll. 2017b. Addendum—Soil Amendment Technology Evaluation Study (SATES) final work plan for the Soil Amendment Technology Evaluation Study, Phase I: test plot characterization and initial amendment alternatives evaluation. Prepared by Ramboll Environ, Seattle, Washington, for Teck American Incorporated. September 29.

Ramboll. 2019. Final data summary report for the Soil Amendment Technology Evaluation Study phase IA: Test plot selection and characterization. Prepared for Teck American Incorporated by Ramboll US Consulting Inc, Seattle, WA. February

Ramboll. 2020. Final Soil Amendment Technology Evaluation Study Phase III and IV Work Plan: Test Plot Field-Scale Implementation and Test Plot Monitoring. Prepared by Ramboll, Seattle, Washington, for Teck American Incorporated. September.

USEPA. 2016. Letter from L. Buelow, EPA Project Coordinator, to K. McCaig, TAI Project Coordinator, dated June 21, 2016, regarding soil treatability testing to determine if soil amendment technologies can be developed as an alternative to soil removal and replacement. Letter included the UCR Soil Amendment Technologies Evaluation Study data quality objectives as an attachment.

MAPS

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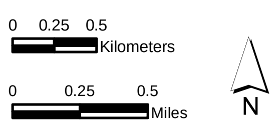

Map 2-1. **Location of DUs with SATES Test Plots**
Upper Columbia River SATES Program

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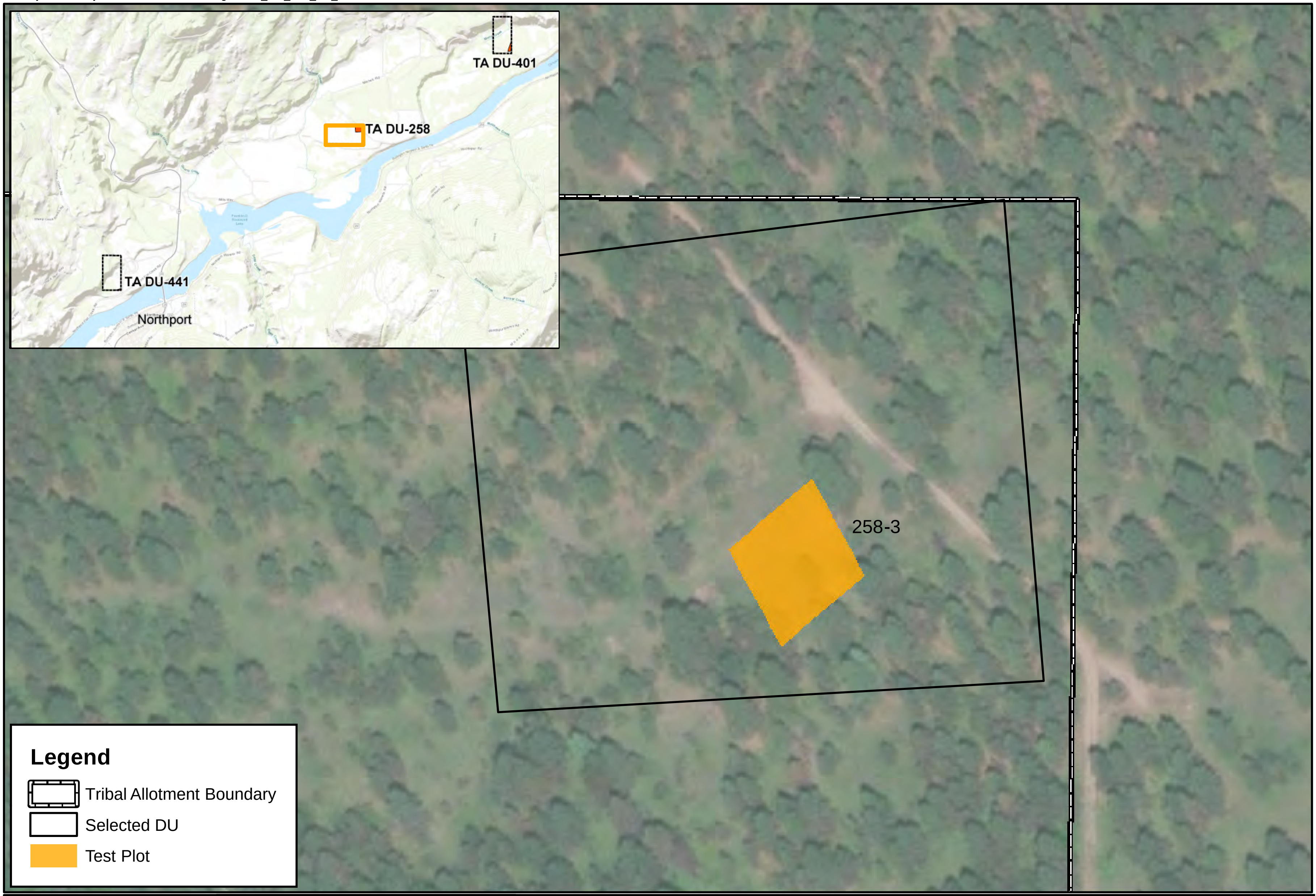

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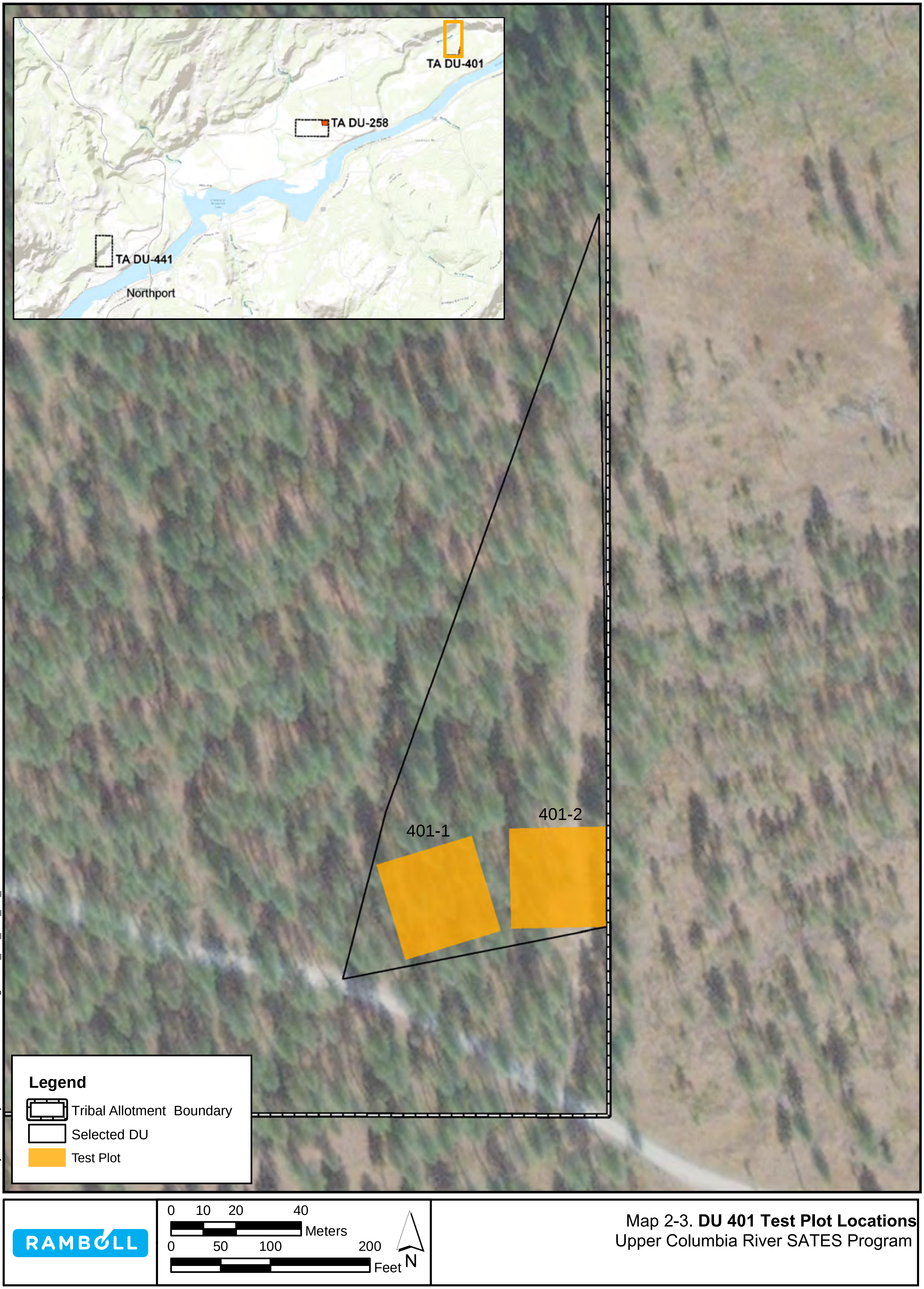
0 10 20 40 Meters
0 50 100 200 Feet
N

Map 2-2. **DU 258 Test Plot Location**
Upper Columbia River SATES Program



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Map 2-3. **DU 401 Test Plot Locations**
Upper Columbia River SATES Program

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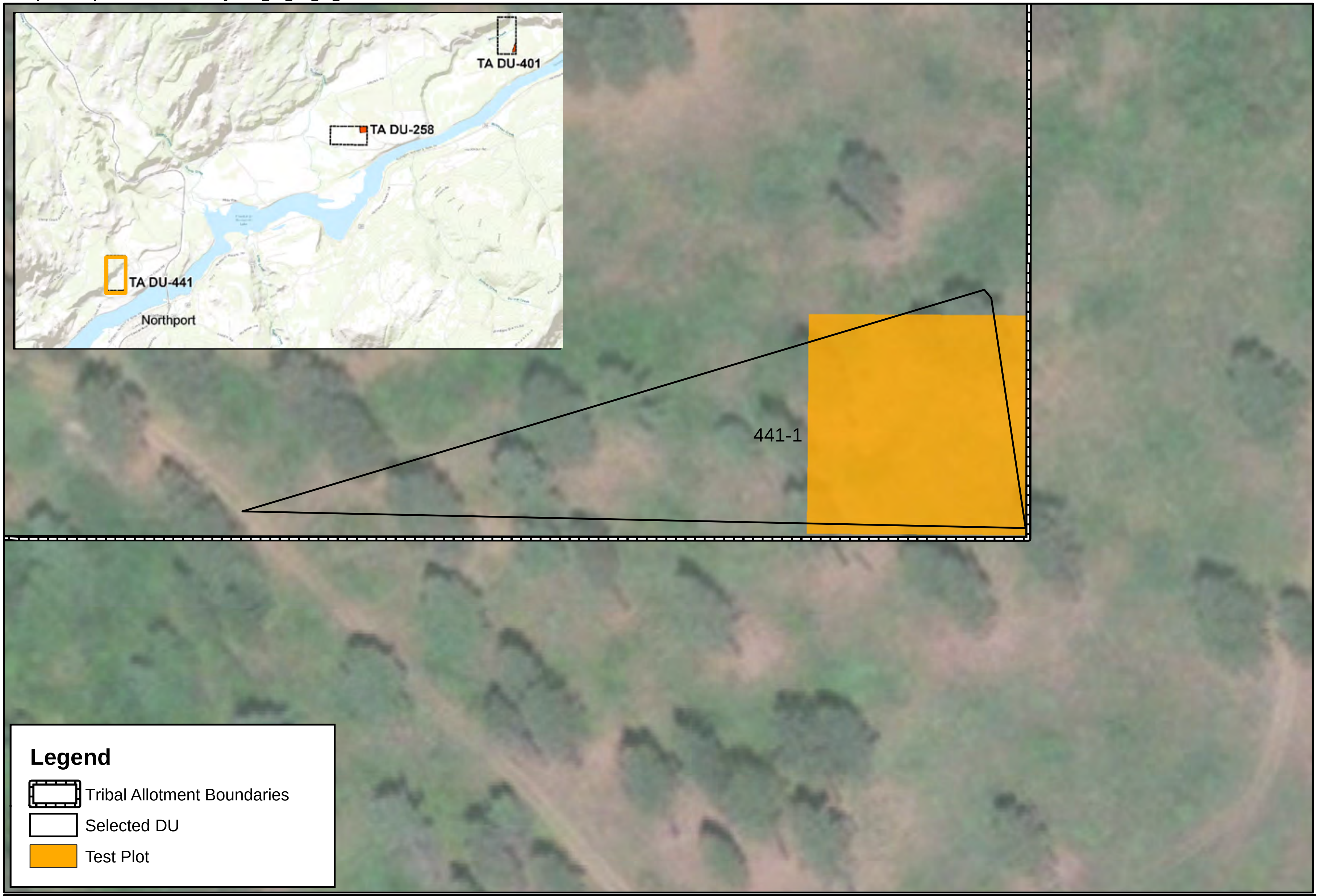
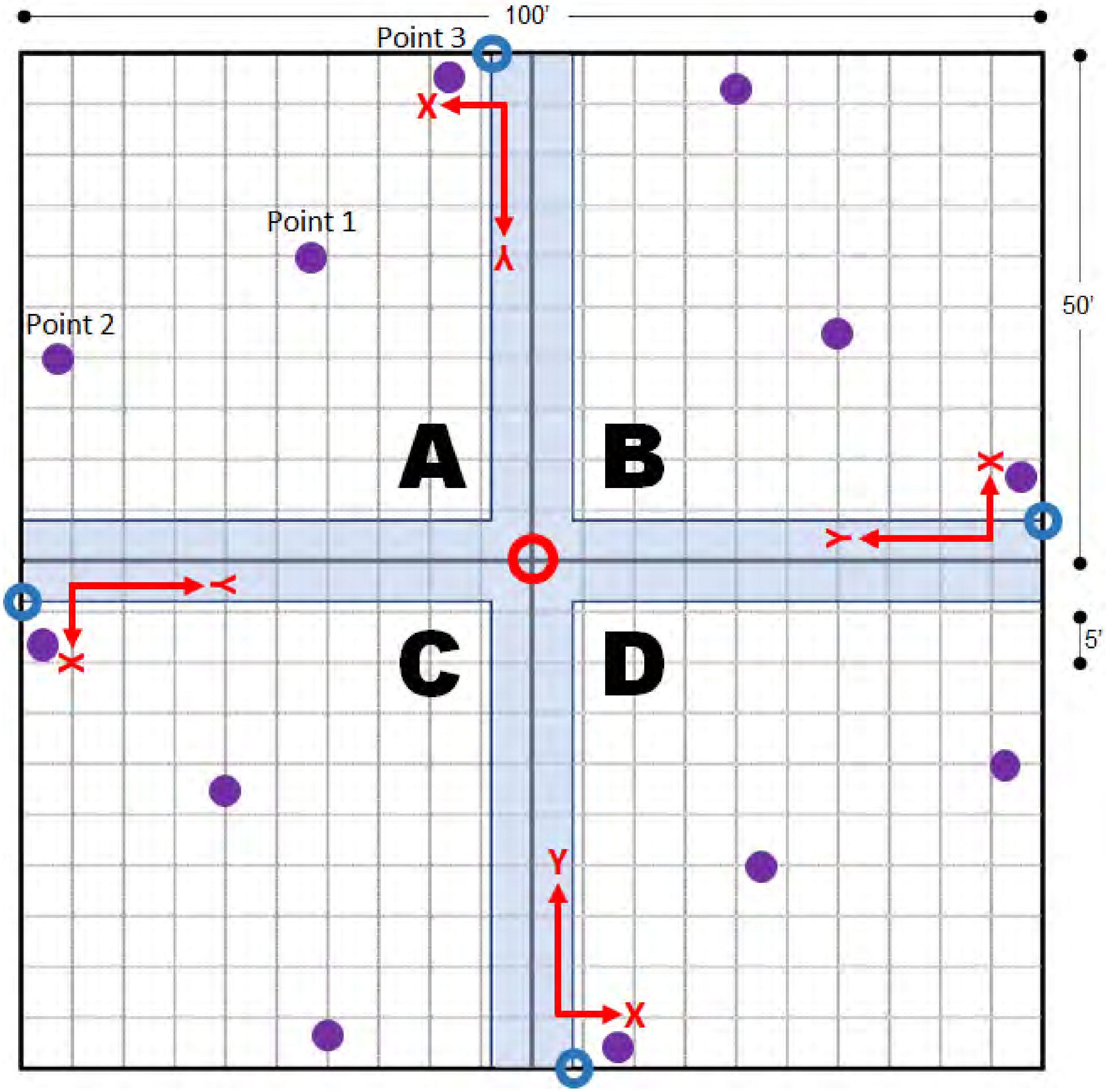


0 5 10 20 Meters
0 25 50 100 Feet
N

Map 2-4. **DU 441 Test Plot Location**
Upper Columbia River SATES Program

FIGURES



Note: The x and y axis orientation for each subplot rotates counterclockwise around the center of the test plot, starting with Subplot D, where the x axis is horizontal and the y axis is vertical. Moving counterclockwise, on the first rotation from Subplot D to Subplot B, the x and y axes rotate 90 degrees and so on for the second and third rotation around the center point.

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Legend
- Test plot center
- Depth-discrete sampling location
- Soil sampling starting node for each subplot (4,0)

Figure 2-1
Test Plot and Subplot Layout for Depth-Discrete Sampling
Upper Columbia River SATES Program

TABLES

Table 2-1. Data Requirements for Depth Discrete Sample Analysis

Analysis	Rationale	Laboratory
Electrical conductivity (salinity)	Evaluate for potential for amendment applications to affect plant growth	NA - field measured
pH	Affects bioavailability of metals and plant nutrients	NA - field measured
Temperature	Necessary for field electrical conductivity measurement	NA - field measured
Mehlich III extractable phosphorous	Evaluate treatment effect on available phosphorus	OSU
Total TAL metals (except mercury; <2mm soil fraction)	Evaluation of potential changes in soil chemistry following amendment application	ALS
Soil moisture	Affects chemical reactions in soil	ALS

Notes:
ALS - ALS Environmental Kelso
NA - not applicable
OSU - The Ohio State University
TAL - target analyte list

Table 2-2. Depth-Discrete Sample Analysis Plan

Analysis	Sample Preparation Method Reference	Sample Preparation Procedure	Sample Analysis Method Reference	Sample Analysis Procedure	Sample Sources	Sample Time Points	Soil Grain Size Fraction	Required Mass or Volume Per Sample	Total Number of Original Samples
Electrical conductivity (salinity)	NA	NA	SM 2510B	electrode	treated and control subplots	Final Phase IV monitoring event	bulk	5 g	108
Mehlich III extractable phosphorus	Mehlich 1984	acetic and nitric acid; ammonium fluoride and ammonium nitrate; EDTA	EPA 6010	ICP-AES	treated and control subplots	Final Phase IV monitoring event	<2 mm	1 g	108
Total TAL metals (except mercury)[1]	EPA 3051A	acid digestion	EPA 6010C	ICP-AES	treated and control subplots	Final Phase IV monitoring event	<2 mm	0.5 g	108
pH	NA	NA	Thomas 1996	electrode	treated and control subplots	Final Phase IV monitoring event	bulk	5 g	108
Soil moisture	EPA 160.3	evaporation of sample to dryness at 103-105°C	EPA 160.3	gravimetric	treated and control subplots	Final Phase IV monitoring event	<2 mm	0 g	108

Notes:

EDTA - ethylenediaminetetraacetic acid

ICP-AES - inductively coupled plasma - atomic emission spectroscopy

NA - not applicable

TAL - target analyte list

[1] TAL metals include Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, and Zinc.

Table 2-3. Depth-Discrete Sample Location Coordinates

Location	Coordinates		Plot and Subplot
Depth-Discrete Sampling Points for Each Subplot	X	Y	
Depth-Discrete Sampling Point 1	23	t	All
Depth-Discrete Sampling Point 2	46	30	All
Depth-Discrete Sampling Point 3	8	2	All
Depth-Discrete Sampling Points for Replicates	X	Y	
Depth-Discrete Sampling Replicate Point 1	23	20	258-3 D
Depth-Discrete Sampling Replicate Point 2	46	30	401-1 C