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Memorandum

To: Anne Summers and Marcel Hermans – Port of Portland

From: Ben Hung and John Verduin, PE – Anchor Environmental, L.L.C.

CC: Krista Koehl – Port of Portland; Tom Schadt, Todd Thornburg, Rebecca Desrosiers, PE, and Elizabeth Appy – Anchor Environmental, L.L.C.

Date: June 9, 2006

Re: Proposed Sampling and Analysis Plan for Additional Column Settling Testing, Geotechnical Testing, and Sediment Quality Characterization
Port of Portland—Terminal 4 Early Action

This memorandum presents the proposed sampling and analysis plan (SAP) to conduct additional column settling and geotechnical testing on sediments collected in Slip 3, as well as additional sediment quality testing in the vicinity Berth 414. Anchor Environmental L.L.C. (Anchor) has reviewed the previously completed column settling test (CST) results and methodology as reported in the 2004 *Terminal 4 Early Action Characterization Report* and has recommended that additional CSTs be performed with material collected from representative areas within the proposed Slip 3 dredge prism. This recommendation was based in part on the fact that the source material used in the first analysis was a composite that included sediments outside of the proposed dredge prism, including portions of Wheeler Bay and Berth 414. Additional geotechnical analyses [including seepage-induced consolidation (SIC) tests] are also included in this SAP to assist with the settlement predictions in the confined disposal facility (CDF). Finally, additional sediment quality testing was requested by the USEPA and Oregon DEQ to further define the extent of contamination around two previous sampling locations where relatively high PAH concentrations were reported in the vicinity of Berth 414 in 1998. In addition, Anchor reviewed the available project data for purposes of the dredge and cap design and is recommending additional sampling in the vicinity of Berth 414, Slip 3, and Wheeler Bay. Four additional core locations in the vicinity of Berth 414 are recommended, and an additional eight core locations in Slip 3 are recommended to further define the depth of contamination. Surface samples from four locations in Wheeler Bay are also recommended to further refine the boundary between the capping and monitored natural recovery areas.

The field operations, equipment, sample handling and analysis will be performed using the previously approved procedures specified in the 2004 *Terminal 4 Early Action Engineering Evaluation/Cost Analysis Work Plan* (BBL 2004), Appendix A, Field Sampling Plan and Quality Assurance Project Plan. A reduced list of analytes targeting semivolatile organics and petroleum hydrocarbons will be performed on the samples collected for sediment quality testing. Otherwise, the only procedure proposed in this SAP that was not included in the already approved plan is the SIC testing. As such, protocols related to the SIC testing are in this memorandum.

Sampling for CST and SIC Analysis

Two composites will be prepared from sediment cores taken in Slip 3. The attached figure and table summarize the proposed core locations and compositing scheme. The cores were located based on existing sediment chemistry data to provide representative coverage of the depth and extent of the dredge prism in Slip 3, and are focused on areas with thicker accumulations of contaminated sediment, as well as finer grained sediment that is likely to settle more slowly in a CDF. Composite T4-COMP-01 is representative of the dredge prism at the head of Slip 3 and composite T4-COMP-02 is representative of the dredge prism in the central and outer portions of Slip 3. The river water to be used in the CST will be ambient water in the Willamette River and will be obtained during sediment sampling activities.

Sampling for Sediment Quality Characterization in Berth 414, Slip 3, and Wheeler Bay

Four sediment cores will be taken from Berth 414 and advanced to a target depth of 8 feet. The attached figure and table summarize the proposed core locations. The cores were located based on existing sediment chemistry data to reconfirm and further define the extent of contamination around two previous sampling locations (HC-S-38 and HC-S-39) where relatively high PAH concentrations were reported in 1998. Two of the new cores in Berth 414 will be co-located with the previous samples. Based on the reported results from all of the locations in Berth 414, some of the highest levels of contamination are found on the surface. Concentrations generally decrease rapidly with depth. Hence, the target depth of eight feet should be deep enough to determine the depth of contamination. The remaining two cores in Berth 414 will be taken down the slope towards the river channel to help further define the extent of the contamination in both the vertical and horizontal dimensions.

Eight sediment cores will be taken from Slip 3 and advanced to a target depth of 8 feet. The attached figure and table summarize the proposed core locations. The cores were located based on existing sediment chemistry data to further define the extent of contamination, primarily in areas where previous cores where not advanced deep enough to bound the depth of contamination.

Four surface sediment samples will be taken from Wheeler Bay. The attached figure and table summarize the proposed sampling locations. The samples were located to further refine the boundary between the capping and monitored natural recovery areas.

Field Operations and Equipment

Sediment cores will be collected using a vibracore with a 3-inch or 4-inch-diameter core barrel deployed from the sampling vessel. If a 4-inch-diameter core barrel is used, the number of CST/SIC cores will be reduced to 4 per composite. The attached table identifies which CST/SIC core locations will be omitted. Northwest Underwater Construction will provide the vessel, vessel operator, vibracore, and coring technician. The depth of recovery will be measured and recorded. If the depth of penetration is evident from a mudline trace on the core barrel, this depth will also be recorded. Sampling depths will be corrected for coring-induced compaction by multiplying the observed depth in the core by a compaction correction factor (= penetration depth/recovery depth). The surface samples will be collected with a Van Veen or Ponar type grab sampler or equivalent.

As samples are collected, logs and field notes of sediment sampling activities and observations will be maintained in a project notebook. Included in this documentation will be the following:

- Estimated elevation of each sediment sample (relative to the project datum)
- Positioning information, including coordinates and/or measurements
- Date and time of sampling
- Field descriptions of the sediment
- Log of sample IDs and compositing scheme
- Chronological occurrence of events during sampling operations
- Deviations, if any, from the specifications of this SAP

At least 41 gallons of river water will be collected from the water column in Slip 3. This volume will be sufficient to supply both CST analyses and SIC tests. The river water will be collected from the center of the mouth of Slip 3, a few feet below the surface of the water column, using a peristaltic or purge pump.

Sample Handling

The top six inches of the surface samples will be processed and containerized immediately after collection. The sediment cores and river water will be taken to a facility on shore for processing and preparation for shipping to the laboratory. Sediment cores will be kept vertical until such time as they are split and core logs are prepared. The specified intervals from each CST/SIC core (T4-CS-01 through T4-CS-10) will be combined per the attached Table 1 and transferred to clean 5-gallon HDPE buckets to create two composite samples. Sediment quality characterization cores will be sectioned into 1-foot intervals. Containerized sediment and river water will be transported to the laboratory under proper chain-of-custody procedures for further processing and testing after subsampling and compositing is completed. The shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container and consultant's office address) to enable positive identification.

Laboratory Analysis

Analytical Resources, Inc. (ARI) in Tukwila Washington will perform the CSTs and bulk sediment testing. The sediment composites will be homogenized manually or mechanically by ARI until both color and texture are uniform. The amount of sediment composited and homogenized is expected to exceed the amount needed for the CST tests. Excess sediment from both CST/SIC composites will be archived for future analysis if needed.

Column Settling Test. The CSTs will be completed in general accordance with the procedure developed by the U.S. Army Corps of Engineers Waterways Experiment Station (USACE 1987).

Bulk Sediment Geotechnical Testing. ARI will perform the following analysis on the two composite bulk sediment samples:

- Grain size (Modified ASTM Method; ASTM D 422)
- Specific gravity (total; ASTM D 854)

- Specific gravity (for particles greater than 0.074 mm; ASTM D 854)
- Specific gravity (for particles less than 0.074 mm; ASTM D 854)
- Moisture content (ASTM D2216)
- Atterberg limit determination (ASTM D4318-05)

Bulk Sediment Quality Testing. ARI will also perform the following analysis on the sediment samples from Berth 414:

- Semivolatile organics
- Total petroleum hydrocarbons
- Total organic carbon
- Grain size (sample volume permitting)

The specific analytes and methods used will be the same as specified in BBL 2004. Detection limits will meet or exceed those specified in BBL 2004. The top three intervals (top three feet) from each of the Berth 414 cores will be analyzed first. The two to six foot intervals from each of the Slip 3 cores will be analyzed first. The rest of the intervals from these cores will be archived for future analysis based on the initial results.

SIC Tests. The University of Colorado at Boulder Process Flow Laboratory will perform (SIC) testing. SIC testing is used in place of standard incremental load testing when the compressibility of extremely soft sediments is to be characterized. Up to two tests will be performed, one from each of the composite sampling locations. Prior to SIC testing, Atterberg limit determinations will be made by ARI. Based on the results of the Atterberg limit and grain size analysis either one or two SIC tests will be completed. SIC testing will be performed in general accordance with procedures outlined in Znidarcic et al. (1992). A summary of these procedures is provided as an attachment to this SAP.

Use of the Data

The CST results will be used to predict, on a batch basis, the gravity settling behavior of re-slurried sediment hydraulically discharged in the CDF, and the turbidity and total suspended solids (TSS) concentrations in the effluent. CST and related geotechnical results are direct inputs into SETTLE, a CDF design model.

The SIC will provide data necessary to develop sediment constitutive models of compressibility and permeability. These two relations will provide an analysis of the magnitude and rate of settlement that may be experienced during placement of dredged material in the CDF.

The sediment quality data from Berth 414, Slip 3, and Wheeler Bay will be used to inform the detailed design of the remedies in the respective areas of Terminal 4.

References

Blasland, Bouck, & Lee, Inc. (BBL). 2004. *Work Plan, Terminal 4 Early Action Engineering Evaluation/Cost Analysis.* Report prepared for Port of Portland, Portland, Oregon. February 23, 2004.

USACE. 1987. *Engineering and Design – Confined Disposal of Dredged Material.* Engineer Manual 1110-2-5027. US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. September 30, 1987.

Znidarcic, D., Abu-Hejleh, A. N., Fairbanks, T., and Roberson, A. 1992. *Seepage induced consolidation test, equipment description and user's manual.* Report prepared for FIPR. Department of Civil Engineering, University of Colorado, Boulder, Colorado.

Attachments

Table 1 – Proposed Sample Locations and Compositing Scheme
Figure 1 – Sample Location Plan
SIC Test Summary

Table 1 - Proposed Sample Locations and Compositing Scheme
Terminal 4 Early Action
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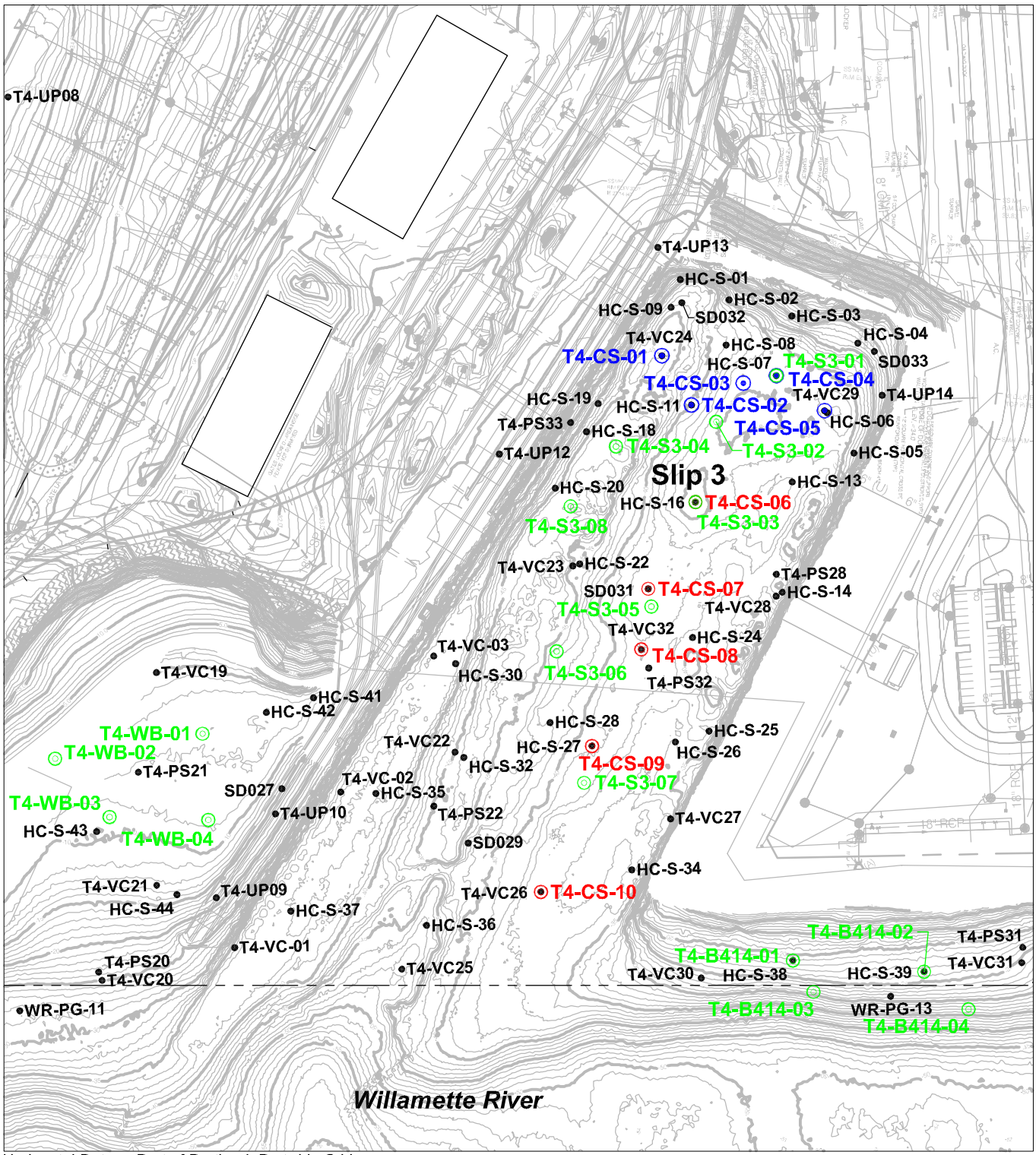
Historic Sample Location	New Core	X-coordinate	Y-Coordinate	PEC DOC	Peak PEC TPAH Enrichment Ratio	Average % Fines	New Core Target Depth	Composite
T4-VC 24	T4-CS-01	7,620,329	713,376	3.5	2.1	82	3.5 ft	T4-COMP-01
HC-S-11	T4-CS-02	7,620,284	713,312	>4.5	6.1	52	5.0 ft	
---	T4-CS-03[1]	7,620,326	713,267	---	---	---	5.0 ft	
HC-S-07	T4-CS-04	7,620,368	713,222	>4.5	4.4	52	5.0 ft	
T4-VC29	T4-CS-05	7,620,351	713,142	6.5	3.0	36	6.5 ft	
HC-S-16	T4-CS-06	7,620,165	713,252	>1	4.3	70	5.0 ft	T4-COMP-02
SD031	T4-CS-07	7,620,030	713,262	>4.5	4.9	66	5.0 ft	
T4-VC32	T4-CS-08	7,619,950	713,237	7.3	2.5	50	7.5 ft	
HC-S-27	T4-CS-09	7,619,802	713,244	>3.5	1.8	---	4.0 ft	
T4-VC26	T4-CS-10[1]	7,619,590	713,226	3.8	0.8	73	4.0 ft	
HC-S-38	T4-B414-01	7,619,646	712,872	>1	12.4	---	8.0 ft	NA
HC-S-39	T4-B414-02	7,619,706	712,702	>4	2.7	85.1	8.0 ft	NA
---	T4-B414-03	7,619,619	712,829	---	---	---	8.0 ft	NA
---	T4-B414-04	7,619,685	712,625	---	---	---	8.0 ft	NA
---	T4-S3-01	7,620,368	713,222	---	---	---	8.0 ft	NA
---	T4-S3-02	7,620,276	713,271	---	---	---	8.0 ft	NA
---	T4-S3-03	7,620,165	713,252	---	---	---	8.0 ft	NA
---	T4-S3-04	7,620,189	713,383	---	---	---	8.0 ft	NA
---	T4-S3-05	7,620,009	713,248	---	---	---	8.0 ft	NA
---	T4-S3-06	7,619,900	713,341	---	---	---	8.0 ft	NA
---	T4-S3-07	7,619,751	713,233	---	---	---	8.0 ft	NA
---	T4-S3-08	7,620,089	713,406	---	---	---	8.0 ft	NA
---	T4-WB-01	7,619,597	713,737	---	---	---	NA	NA
---	T4-WB-02	7,619,483	713,907	---	---	---	NA	NA
---	T4-WB-03	7,619,441	713,807	---	---	---	NA	NA
---	T4-WB-04	7,619,493	713,682	---	---	---	NA	NA

1. These cores will only be collected if a 3-inch core barrel is used.



Horizontal Datum: Port of Portland Portwide Grid
Vertical Datum: NGVD 29

T4-CS-01 Proposed Sample Location and Designation - T4-COMP-1

T4-CS-10 Proposed Sample Location and Designation - T4-COMP-2

T4-B414-01 Proposed Sample Location and Designation - Sediment Quality Characterization

T4-PS32 Existing Sample Location and Designation

0 200
Scale in Feet
Contour Interval 1 Foot

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Jun 09, 2006 3:07pm dholmer

ANCHOR ENVIRONMENTAL, L.L.C.

Figure 1
Sample Location Plan
Terminal 4 Early Action
Port of Portland

Seepage Induced Consolidation Test (SICT)

The seepage induced consolidation test is an experimental procedure used for determining the consolidation characteristics of soft soils and soil like materials (slurry mine waste, dredged spoils, sludge from waste water treatment plants etc.). The testing procedure consists of three steps.

In the first step the void ratio at the effective stress zero is determined by allowing a slurry column about 0.05 m high to consolidate under its own weight. The average void ratio of the settled slurry is considered the void ratio at the effective stress of zero, or the void ratio at which the soil is formed and the consolidation theory (as opposed to the sedimentation theory) applies.

In the second step, seepage at a constant flow rate is applied through the soil by means of a flow pump and the sample is allowed to consolidate completely, i.e. until the steady state is reached. The steady state is determined from the pressure difference across the sample that is continuously monitored during the test. At steady state, the pressure difference and the final height of the sample are recorded. It is recognized that during this phase of the test the void ratio within the sample is non-uniform and this is correctly accounted for in the test analysis.

In the third step the sample is consolidated under the maximum desired stress level and the hydraulic conductivity is measured with the flow pump using a low flow rate to maintain sample uniformity during the test. At the end of the test the sample is dried and the total volume of solids is determined.

The analysis of the test is performed using the software package SICTA (Seepage Induced Consolidation Test Analysis). The procedure is based on the inverse problem solution approach and the theory used is compatible with the finite strain nonlinear consolidation theory (i.e. no simplifying or restrictive assumptions are made in the analysis). The input data for the SICTA program are all obtained from the described test. The output gives five parameters A, B, Z, C and D that define the consolidation properties for the sample. The compressibility and hydraulic conductivity relations with the five parameters are defined as:

Compressibility $e = A\ (\sigma' + Z)^B$

Hydraulic Conductivity $k = C\ e^D$

The more detailed description of the testing equipment and testing and analysis procedures can be found in the following publications:

Abu-Hejleh, A N., and Znidarcic, D., 1992, User Manual for Computer Program SICTA, Prepared for Florida Institute of Phosphate Research, University of Colorado, Boulder, 122 pp.

Znidarcic, D., Abu-Hejleh, A N., Fairbanks, T. and Robertson A., 1992, Seepage-Induced Consolidation Test; Equipment Description and Users Manual, Prepared for Florida Institute of Phosphate Research, University of Colorado, Boulder, 52 pp.

Abu-Hejleh, A N. and Znidarcic, D., 1994, Estimation of the Consolidation Constitutive Relations, Computer Methods and Advances in Geomechanics, Siriwardane & Zaman (eds) Balkema, Rotterdam, pp. 499-504.

Abu-Hejleh, A.N. and Znidarcic, D., 1996, Consolidation Characteristics of Phosphatic Clays, Journal of Geotechnical Engineering, ASCE, New-York, Vol. 122, No. 4. pp. 295-301.