B&L Woodwaste Site
Pierce County, Washington

Engineering Design Report (EDR)

Appendix B
Geotechnical Investigation Report

FINAL

Technical Memorandum

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Re: **Geotechnical Investigation Report**

INTRODUCTION

This Geotechnical Investigation Report supports implementation of the final Cleanup Action Plan (CAP) for the barrier wall and groundwater interception trench for the B&L Woodwaste Landfill (Landfill) as shown on Figure B.1. The Washington State Department of Ecology (Ecology) issued the final CAP in 2008 and requires, among other cleanup actions, that a perimeter barrier wall be installed around the Landfill. The 2008 CAP specifies that this barrier wall should be tied into both the existing landfill cap and a low-permeability soil unit located below the Landfill. The purpose of the subsurface, low-permeability barrier wall is to hydraulically isolate and contain arsenic-contaminated groundwater beneath the Landfill to prevent migration of arsenic beyond the landfill perimeter.

The physical characteristics of the Landfill are described in the Groundwater Alternatives Evaluation (GAE; Floyd|Snider 2007). Previous subsurface investigations revealed the presence of four subsurface units: (1) a near surface silt or upper silt aquitard, (2) an upper sand aquifer, (3) a lower silt aquitard, and (4) a lower sand aquifer. Although present in most soil borings, the lower silt aquitard appeared to be absent in one boring near the southwest perimeter of the Landfill and in borings to the east of the Landfill

A geotechnical investigation was performed to collect site-specific information needed for design of the subsurface barrier wall. This investigation was completed in general accordance with the Geotechnical Investigation Work Plan (Work Plan) which was included as Appendix F to the Groundwater Remediation Work Plan (GRWP; Floyd|Snider/AMEC Geomatrix 2009). This report presents a summary of the geotechnical investigation and findings. Geotechnical results are presented in the context of the barrier wall design in Addendum 1 to this EDR.

PURPOSE

The purpose of the geotechnical investigation was to determine the depth to the lower silt aquitard, the continuity of the lower silt aquitard, and to assess the engineering characteristics of subsurface soils along the barrier wall alignment. Specifically, the objectives of this geotechnical investigation were as follows:

- Develop stratigraphic information concerning the depth and thickness of the upper sand aquifer and the presence and the depth to the lower silt aquitard;
- Obtain sufficient geotechnical data to complete the design of the subsurface barrier wall; and
- Collect soil and groundwater samples for compatibility testing for use in designing the barrier wall backfill.

SCOPE OF WORK

The following tasks were completed for this investigation:

- Drilled 15 soil borings using hollow-stem augers (HSA) along the proposed barrier wall alignment.
- Advanced nine push probes in the vicinity of the southwest gap in the lower silt aquitard. Push probes were not included in the Work Plan, but were considered necessary to properly characterize the aquitard based on the discontinuities identified in HSA borings.
- Conducted cone penetrometer testing (CPT) at 46 locations along the anticipated subsurface barrier wall alignment and in the areas where gaps in the lower silt aquitard were identified.
- Collected soil samples that were submitted to a geotechnical laboratory for testing of physical characteristics and for compatibility testing.
- Conducted compatibility testing to confirm that the proposed barrier wall construction materials are compatible with the contaminated groundwater, using groundwater from a monitoring well completed in the Upper Sand Aquifer beneath the Landfill and potable water from the local water supply.

FIELD INVESTIGATION

Project staff from Floyd|Snider and AMEC Geomatrix, Inc. (AMEC) conducted the field investigation between August 11 and September 30, 2008 to support implementation of the final 2008 CAP. A representative of the project team was present during all field investigations. After completion of each exploration point, the exploration location was backfilled with bentonite slurry in accordance with the State of Washington water well regulations. The field investigation was performed in general accordance with the Work Plan; the scope of work was modified from the Work Plan scope in consultation with Ecology to investigate the extent of the gaps that were identified in the Lower Silt Aquitard.

FIELD ACTIVITIES

Fifteen soil borings (H-1 through H-15) were drilled around the perimeter of the Landfill on the existing Landfill access road from August 11 to 15, 2008. These boring locations are shown on Figure B.2. The soil borings were completed by Cascade Drilling, Inc. using hollow-stem augers. The soil borings were logged and samples classified based on visual method using the

Unified Soil Classification System (USCS) as described in ASTM Standard D 2487-00. The soil classifications on the boring logs were subsequently adjusted to reflect the laboratory test results. The boring logs are included as Attachment B.1.

Standard penetration tests (SPT) were conducted during the drilling and blow counts were recorded on the logs. The soil borings were advanced to a maximum depth of 41 feet (ft) below ground surface (bgs) through the lower silt aquitard layer where this unit was present. At Boring H-10 location, a gravel and cobble layer was encountered near the ground surface, resulting in refusal. This boring was offset 5 ft and re-drilled, and was completed to the planned depth.

The HSA investigation revealed an absence or substantial reduction of thickness of the lower silt aquitard in the southwest portion of the alignment, between Borings H-3 and H-15, and on the east side between Borings H-9 to H-10.

Following HSA borings, nine push probes (A-1 through A-9) were advanced in the southwest corner of the Landfill from August 22 to 29, 2008 in an attempt to define the extent of the aquitard gap in this area (Figure B.2) based on HSA borings. Push probe logs are included in Attachment B.1.

As described in the Work Plan, in order to assess the continuity of the lower silt aquitard between the HSA borings, 46 cone penetration tests (CPTs) were performed from September 22 to 30, 2008 by In Situ Engineering of Snohomish, Washington. Only 30 CPTs were proposed in the Work Plan; however, additional CPTs were required to delineate the gaps in the lower silt aquitard. To compare results with the HSA method, CPTs C-7 and C-12 were positioned adjacent to Borings H-14 and H-6, respectively. The CPT readouts were compared to the logging results for the HSA borings.

CPTs C-1 through C-4, C-29, and C-30 were not performed as had been proposed in the Work Plan, since the HSA borings indicated a gap in the aquitard beneath the southwest corner of the Landfill, where the CPTs were located. Instead, six CPTs (C-31 through C-35) were completed on the upslope of the Landfill in an effort to identify the extent of the aquitard gap toward the center of the Landfill. Similarly, 10 CPTs (C-40, C-41, and C-45 through C-52) were completed upslope of the eastern aquitard gap to delineate the extent of the aquitard gap on the east side of the Landfill. C-26 was attempted at two locations, but due to refusal it was abandoned. The exploration points were surveyed for location and elevation by Barghausen Consulting Engineers, Inc. A summary of the exploration points, coordinates, and ground surface elevations is presented in Table B.1.

Soil samples were collected from SPT samplers during HSA soil borings for geotechnical testing as described in the Work Plan. Fifteen representative discrete samples were collected for moisture content and grain size for each soil type identified. Six representative discrete samples of cohesive soils were collected for Atterberg limit testing. Four undisturbed samples were collected using large-diameter drive samplers (Shelby tubes) from the Upper Sand Aquifer, fine-grained zones within the Upper Sand Aquifer, and the underlying Lower Silt Aquitard for permeability and triaxial strength testing. Undisturbed samples were also submitted for Atterberg limit testing.

In addition, four 5-gallon (80-lb) composite soil samples were collected from the 15 HSA soil borings to provide materials for compatibility testing. Each composite sample was collected from SPT samples from four to five HSA borings above the Lower Silt Aquitard. The Lower Silt Aquitard material was excluded from the composite samples.

Groundwater samples for compatibility testing were collected from Monitoring Well PD-107 (refer to Figure B.2) in accordance with the procedures described in the Sampling Analysis Plan/Quality Assurance Project Plan (SAP/QAPP; Appendix B to the GRWP) and Work Plan. A potable water sample for compatibility testing was collected from the City of Milton Public Works Department at Kent Street.

INVESTIGATION-DERIVED WASTE

The field sampling equipment and exploration equipment were decontaminated between samples and exploration locations in accordance with the protocols in the Work Plan and SAP/QAPP. Soil cuttings from HSA borings were characterized using composite samples from containerized wastes (WP 4-8 from Borings H-4 through H-8, WP 12-3 from Borings H-12 through H-3, and WP 9-11 from Borings H-9 through H-11) submitted to Fremont Analytical Inc. in Seattle, Washington. Soil cuttings from push probes advanced through the Landfill wastes were containerized and characterized in conjunction with HSA borings advanced through the Landfill (PD-107, PD-108, and PD-109) as part of other predesign studies (refer to Appendix C). Decontamination rinsate was characterized by samples (Decon 1 through Decon 4) submitted to Fremont Analytical.. The investigation-derived waste generated was disposed off-site along with other waste from the predesign investigations as dangerous (hazardous) and non-regulated waste, as applicable based on the waste characterization results. The waste characterization analytical laboratory results and waste manifests are included as Attachment B.2.

LABORATORY TESTING

Soil samples collected by split spoon and Shelby tube samplers were submitted for geotechnical testing to Soil Technology, Inc. on Bainbridge Island, Washington. Selected soil samples were tested for grain size, moisture content, Atterberg limits, strength, and permeability, as described in the Work Plan.

Compatibility testing consisted of testing five soil samples for hydraulic conductivity using potable water and groundwater. Four composite soil samples collected for compatibility testing were consolidated from the four composite samples by the test laboratory prior to preparation of compatibility test samples. The laboratory test report and sample chain of custodies are included in Attachment B.3. Two composite soil samples were mixed with different concentrations of bentonite, another two composite soil samples were mixed with different concentrations of bentonite and cement. A fifth sample was composed of cement mixed with bentonite. The mix ratios and hydraulic conductivity test results are summarized in Table B.2.

Impacted groundwater sampled from beneath the Landfill for compatibility testing was submitted for chemical analysis to Fremont Analytical.. Groundwater was analyzed for metals including arsenic, iron, calcium, magnesium, and sodium, and other water quality indicators including total alkalinity, chloride, dissolved organic carbon, and sulfide. Analytical results are summarized in Table B.3. The laboratory test report and sample chain-of-custody forms are included in Attachment B.3.

INVESTIGATION FINDINGS

The soil borings encountered a 3- to 3.5-ft thick layer of fill at the ground surface, which is the existing perimeter road berm. The Upper Silt Aquitard was encountered in most borings at depths ranging from approximately 3- to 11-ft below ground surface. A distinct shallow silt layer was absent at H-3, H-12, and H-14. Where present, the Lower Silt Aquitard was generally encountered at depths ranging from approximately 14-to 30-ft below grade. In the two areas along the barrier wall alignment, the southwest corner and an area on the eastern side of Landfill (refer to Figure B.2) low-permeability deposits were either not encountered or present only as thin seams or lenses. At most locations, transitions between silt and sand layers were very gradual. Otherwise, these layers were interbedded. The Lower Silt Aquitard was typically identified as olive grey silt or clayey silt, and was in places interbedded with peat. The Lower Silt Aquitard ranged in thickness from approximately 3.5- to 10.5-feet thick.

Delineation of the horizontal extent of the eastern aquitard gap toward the center of the Landfill was attempted, but was not determined. After two transects of CPTs, further delineation toward the center of the Landfill was deemed impractical due to the increasing and substantial thickness of wood waste. The horizontal extent of the southwest aquitard gap into the Landfill is shown on Figure B.2.

The laboratory test results confirmed the presence of silts in the Upper and Lower Silt Aquitards. The results indicated mostly non-plastic or low plasticity silt. However, at four locations the Lower Silt Aquitard was classified as high plasticity, organic silt with an average strength of approximately 1,500 pounds per square foot (psf). Hydraulic conductivity of the lower silt aquitard was tested in the laboratory on the high and low plasticity samples (H-4 at 26-ft bgs and H-11 at 24.7-ft bgs, respectively), to assess the range of hydraulic conductivity values for the Lower Silt Aquitard. The measured hydraulic conductivity ranged between 7×10^{-8} to 4×10^{-6} centimeters per second (cm/s).

Based on these findings, the barrier wall should extend to at least the midsection of the Lower Silt Aquitard, where a distinct silt layer is generally present. In the two aquitard gap areas, where a distinct silt layer is absent but thin silt lenses were typically encountered, the wall should continue below the depth of silt lenses. The recommended depth of the bottom of the barrier wall at each HSA boring location is presented in Table B.1.

The compatibility testing results indicate that Site groundwater composition has no significant effect on the barrier wall mix. The hydraulic conductivity tests indicated only minor differences between groundwater and potable water, which are believed to be in the range of accuracy of the test method. The hydraulic conductivity of the Site soil with addition of only 3 percent bentonite was found to be 5×10^{-8} cm/s. This mix ratio will meet the intent of the design and will be used for this project.

REFERENCES

Floyd|Snider. 2007. *B&L Landfill Groundwater Alternatives Evaluation.* Prepared for Murray Pacific Corporation, Tacoma, Washington. January.

Floyd|Snider/AMEC 2009. *Groundwater Remediation Work Plan.* Prepared for B&L Custodial Trust, Olympia, Washington. January.

Encl.: Table B.1–List of Exploration Locations
Table B.2–Backfill Mix Design
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Figure B.1–Site Vicinity Map
Figure B.2–Geotechnical Exploration Locations
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Copies:

Tables

Table B.1
List of Exploration Locations[1]

ID	Installation Date	Total Depth (ft. bgs)	Northing[2]	Easting[2]	Ground Surface Elevations (ft. NAVD 88)[3]	Depth to Bottom of Barrier Wall (ft. bgs)[4]
Hollow-stem Auger Borings						
H-1	8/12/2008	36.00	1185860.52	701618.68	20.15	31.00
H-2	8/12/2008	36.00	1185731.80	701721.70	19.49	28.00
H-3	8/12/2008	41.00	1185730.96	701907.42	19.39	35.00
H-4	8/13/2008	41.00	1185731.33	702092.07	18.80	26.00
H-5	8/13/2008	43.00	1185900.34	702214.87	19.20	26.00
H-6	8/13/2008	41.00	1186115.05	702324.37	19.24	26.00
H-7	8/14/2008	41.00	1186232.63	702371.60	19.12	24.00
H-8	8/14/2008	35.00	1186381.07	702329.80	18.95	22.00
H-9	8/14/2008	31.00	1186479.75	702171.01	19.29	27.00
H-10	8/15/2008	31.00	1186571.87	702003.16	19.85	27.00
H-11	8/15/2008	37.00	1186603.45	701839.72	19.93	24.00
H-12	8/11/2008	31.00	1186530.15	701685.61	20.43	23.00
H-13	8/11/2008	31.00	1186395.32	701617.75	20.56	27.00
H-14	8/11/2008	33.00	1186193.91	701613.66	20.80	25.00
H-15	8/15/2008	35.00	1186016.29	701616.94	20.44	27.00
Push Probes						
A-1	8/25/2008	40.00	1185794.60	701850.21	25.70	NA
A-2	8/25/2008	44.00	1185795.45	701779.16	25.79	NA
A-3	8/25/2008	44.00	1185905.00	701787.01	36.01	NA
A-4	8/25/2008	36.00	1185907.06	701714.87	29.35	NA
A-5	8/22/2008	32.00	1185953.23	701659.63	23.11	NA
A-6	8/22/2008	32.00	1186079.77	701614.84	20.54	NA
A-7	8/27/2008	28.00	1185985.27	701672.86	25.00	NA
A-8	8/29/2008	42.00	1185883.05	701846.85	36.02	NA
A-9	8/29/2008	40.00	1185890.57	701679.12	24.81	NA
CPTs						
C-1[5]	--	--	1185796.19	701623.92	20.04	NA
C-2[5]	--	--	1185737.55	701671.45	19.73	NA
C-3[5]	--	--	1185731.99	701781.95	19.49	NA
C-4[5]	--	--	1185730.30	701844.23	19.46	NA
C-5	9/24/2008	36.78	1185730.78	701968.27	19.24	NA
C-6	9/24/2008	29.53	1185730.95	702030.03	18.96	NA
C-7	9/23/2008	36.42	1185752.33	702147.33	19.64	NA
C-8	9/23/2008	33.96	1185828.26	702182.15	19.15	NA
C-9	9/23/2008	33.63	1185921.58	702226.32	19.18	NA
C-10	9/23/2008	32.64	1185971.56	702251.62	19.29	NA
C-11	9/23/2008	31.99	1186030.26	702281.81	19.07	NA
C-12	9/22/2008	34.94	1186120.56	702325.63	19.26	NA
C-13	9/22/2008	28.38	1186281.47	702380.72	19.04	NA
C-14	9/22/2008	26.57	1186339.53	702365.44	19.03	NA
C-15	9/22/2008	31.00	1186416.38	702275.23	19.14	NA
C-16	9/22/2008	22.31	1186448.49	702224.18	19.30	NA
C-17	9/23/2008	39.86	1186509.73	702116.67	19.45	NA
C-18	9/25/2008	32.97	1186537.20	702070.85	19.89	NA
C-19	9/25/2008	35.93	1186593.13	701957.46	19.91	NA

ID	Installation Date	Total Depth (ft. bgs)	Northing[2]	Easting[2]	Ground Surface Elevations (ft. NAVD 88)[3]	Depth to Bottom of Barrier Wall (ft. bgs)[4]
C-20	9/25/2008	35.93	1186607.24	701899.55	20.00	NA
C-21	9/25/2008	32.32	1186583.29	701782.92	19.99	NA
C-22	9/25/2008	26.41	1186558.76	701738.58	19.85	NA
C-23	9/25/2008	32.81	1186491.82	701649.00	20.50	NA
C-24	9/25/2008	38.88	1186446.57	701622.55	20.54	NA
C-25	9/24/2008	23.29	1186345.46	701617.64	20.66	NA
C-26[6]	--	--	1186268.14	701615.45	20.71	NA
C-27	9/22/2008	29.04	1186186.88	701615.24	20.80	NA
C-28	9/24/2008	31.33	1186045.05	701615.62	20.41	NA
C-29[5]	--	--	1185962.04	701616.74	20.34	NA
C-30[5]	--	--	1185910.21	701618.07	20.27	NA
C-31	9/23/2008	39.70	1185866.54	701724.42	29.06	NA
C-32	9/23/2008	40.03	1185844.06	701787.12	31.08	NA
C-33	9/23/2008	42.98	1185840.14	701831.99	31.25	NA
C-34	9/23/2008	46.42	1185835.50	701877.82	30.83	NA
C-35	9/25/2008	42.65	1185789.68	701885.54	25.12	NA
C-36	9/24/2008	42.98	1185731.52	701870.74	19.31	NA
C-37	9/29/2008	26.57	1186550.53	702041.26	20.06	NA
C-38	9/29/2008	29.86	1186521.96	702095.70	19.65	NA
C-39	9/29/2008	33.30	1186495.34	702142.48	19.34	NA
C-40	9/29/2008	32.64	1186490.18	702067.68	23.20	NA
C-41	9/29/2008	33.30	1186472.63	702095.85	23.24	NA
C-42	9/30/2008	32.64	1186309.35	701617.28	20.82	NA
C-43	9/30/2008	33.30	1186227.29	701615.77	20.76	NA
C-44	9/30/2008	29.86	1186119.53	701614.53	20.64	NA
C-45	9/29/2008	26.57	1186508.08	702036.99	23.08	NA
C-46	9/29/2008	30.18	1186451.03	702135.13	22.87	NA
C-47	9/29/2008	32.97	1186526.40	701995.91	23.66	NA
C-48	9/30/2008	38.22	1186481.66	701981.36	30.41	NA
C-49	9/30/2008	28.87	1186466.44	702014.68	30.24	NA
C-50	9/30/2008	40.52	1186447.26	702050.54	30.15	NA
C-51	9/30/2008	46.59	1186430.23	702083.32	29.87	NA
C-52	9/30/2008	27.89	1186410.59	702118.76	29.38	NA

Notes:

1 Exploration locations and elevations were surveyed by Barghausen Consulting Engineering, Inc. in November 2008.

2 Northings and Eastings in Washington State Plane coordinate system, NAD 83 South (ft).

3 Ground surface elevations in NAVD 88.

4 Barrier wall depth based on hollow-stem auger results.

5 CPTs were not advanced because soil borings did not encounter the lower silt aquitard.

6 CPT advanced twice but ultimately encountered refusal. A third boring at this location was not attempted.

Abbreviations:

bgs Below ground surface
CPT Cone penetrometer test
ft Feet
NA Not applicable

Table B.2
Backfill Mix Design

Mix Ratio	Hydraulic Conductivity (cm/s)	
	With Potable Water	With Groundwater
Soil with 3% bentonite	5×10^{-8}	5×10^{-8}
Soil with 7% bentonite	$<1 \times 10^{-8}$	$<1 \times 10^{-8}$
Soil with 3% bentonite and 7% cement	6×10^{-7}	3×10^{-7}
Soil with 6% bentonite and 7% cement	3×10^{-7}	1×10^{-7}
Cement with 5% bentonite	4×10^{-6}	9×10^{-7}

Table B.3
Groundwater Analytical Results for PD-107

Parameter	Analysis Method	PD-107-W-30' [1]	Units
Alkalinity	SM 2320B	648	mg/L
pH	SM 4500H	6.3	pH
Nitrate	SM 4500N03E	10.2	mg NO_3-N/L
Dissolved Organic Carbon (DOC)[2]	SM 5310B	29.6	mg/L
Arsenic	SW 6020	2.7	mg/L
Calcium		107	mg/L
Iron		38	mg/L
Magnesium		75	mg/L
Sodium		29	mg/L
Chloride	SW 300.0	68	mg/L

Notes:

1 Groundwater sample collected on 8/29/2008 at 11:00:00 AM.

2 Analyzed for total organic carbon following field-filtration at 0.45 µm.