COVER SYSTEM INSPECTION AND MAINTENANCE PLAN

Crownhill Elementary School Site

Prepared for: Bremerton School District

Project No. 100094 • December 17, 2015

Aspect
CONSULTING

earth + water

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Aspect Consulting, LLC

DAVID A. HEFFNER
30862

David A Heffner

12-17-15

Dave Heffner, PE
Associate Remediation Engineer
dheffner@aspectconsulting.com

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1 Introduction

1.1 General

The Bremerton School District (BSD) Crownhill Elementary School Site (Site; see Figure 1) includes the Crownhill Elementary School (School) property located at 1500 Rocky Point Road NW and the south-adjacent property occupied by the Bremerton United Methodist Church (Church). Portions of these two properties were used for sand and gravel mining up to the 1930s, and the mined area was later backfilled with municipal and industrial wastes. Based on the results of extensive soil explorations, and following the completion of two interim cleanup actions, all landfilled materials and near-surface impacted soils are covered with a minimum 1-foot thickness of “clean” soil or a “hard” surface such as pavement. As specified in the Site’s *Cleanup Action Plan* (CAP; Ecology, 2014), these cover features must be periodically inspected and maintained over the long term to prevent direct contact exposure to underlying contaminants. To address soil vapor intrusion (VI) concerns associated with volatile contaminants, the CAP also requires that: 1) the HVAC system in the main school building be run continuously during the school day; and 2) soil vapor sampling be conducted periodically to reconfirm protectiveness. Cover system inspection and maintenance requirements, as well as activities addressing the VI exposure pathway, are specified in this Cover System Inspection and Maintenance (I&M) Plan.

BSD is responsible for implementing the I&M Plan in accordance with Agreed Order (AO) No. DE11107 between the Washington Department of Ecology (Ecology) and BSD. Points of contact (POCs) for this program are provided in Table 1.

1.2 Project Background

The areas of the Site used for sand and gravel mining were backfilled in the 1930s and 1940s. The original school building was constructed in 1956, and partially burned down in 1993. Several environmental investigations were conducted during the period between that fire and construction of the new school building, completed in 1996. Additional investigations were conducted beginning in 2009, culminating in the preparation of a Remedial Investigation (RI) report (Aspect, 2014a). Subsurface conditions, described in detail in the RI, are summarized in Appendix A. Figure 2 shows the interpreted boundaries of two areas of landfill accumulation, designated the “north” and “south” landfill areas.

Site cleanup alternatives were developed and comparatively evaluated with respect to criteria specified in the Washington Model Toxics Control Act (MTCA; Chapter 173-340 WAC) in the Feasibility Study (FS) (Aspect, 2014b). Based on the FS evaluation, a cleanup action was selected for implementation. Refer to the CAP for a full description of the selected cleanup action.

1.2.1 Environmental Covenants

Under the provisions of the CAP, environmental covenants on the School and Church properties were recorded with Kitsap County to prohibit or restrict Site activities in and around the two landfill areas that could interfere with the integrity of the existing cover features or continued protection of human health. Figure 2 shows the specific areas, labeled “North Environmental Covenant Area” and “South Environmental Covenant Area,” within which the prohibitions/restrictions apply, as defined in the two environmental covenants. The provisions of the environmental covenants work in tandem with this I&M Plan to ensure long-term protection against direct contact exposure to landfilled materials and impacted soils.

The environmental covenants recognize that invasive work in soil will occasionally need to be performed in the cover system areas, and stipulate conditions for such work. Appendix A is included in this I&M Plan to provide workers and supervisors with a brief summary of subsurface conditions and the requirements specified in the environmental covenants for performing invasive work in the Environmental Covenant Areas.

1.2.2 Soil Vapor Sampling during the RI

Two rounds of sub-slab vapor sampling were completed during the RI (in August and November 2010) to evaluate whether air in the school was unacceptably impacted by VI. Semi-permanent sampling ports were installed in the floor slab at six locations inside the main school building, and vapor samples collected from these ports were submitted for laboratory analysis of 16 potential contaminants of concern (PCOCs), including 15 volatile organic compounds (VOCs) plus hydrogen sulfide (a common landfill gas). Sampling was conducted in accordance with Aspect’s site-specific Soil Vapor Intrusion Assessment Work Plan dated July 21, 2010, which is provided as Appendix B.

The November sampling event was conducted with the building’s HVAC system running continuously, whereas it was not running during the August sampling event. HVAC system operation appears to provide some positive pressurization in the building (relative to outdoor air), and this decreases VI potential. The VI assessment report for the November sampling event (Aspect, 2010) recommended that the standard practice of running the HVAC system throughout the school day be continued. As long as this is done, indoor air PCOC concentrations due to VI are expected to remain below levels of concern.

1.3 Site Cover Features

Four general types of cover features are present within the Environmental Covenant Areas shown on Figure 2:

- The **main school building** and the **portable classroom building** provide a cover for underlying soils. Soils directly beneath the buildings were not investigated during the RI, and it is not known whether a “clean” soil layer of some thickness is present. As required by the environmental covenant on the School property, Ecology will be contacted prior to building demolition or other activity that may disturb and/or expose soil beneath the buildings. As long as the buildings remain, there are no I&M requirements associated with these areas.
- The **paved parking area along Bertha Avenue NW**, which extends roughly 180 feet south from Point S5 on Figure 2. This area is distinct from other areas outside the main school building footprint in that underlying soil contamination

may be present within one foot of ground surface.[1] Therefore, the pavement alone constitutes the cover feature in this area.

- The three **interim action areas**, which are indicated by black hatching on Figure 2. Soil exceedances in these areas were covered (in 2012/2013) by a geotextile fabric underlying a “clean” soil and sod barrier layer at least one foot thick.[2] (The geotextile fabric does not reduce water infiltration, but provides a “marker” between clean and contaminated soils, and reduces the potential for exposure to underlying contaminated soils.)
- The cover system in **all other areas** consists of a minimum 1-foot thickness of “clean” soil. A portion of these areas are also covered by a hard surface such as pavement. However, I&M requirements in these areas apply only to the cover soil layer. That is, the pavement or other hard surface can be removed without compromising the cover system, as long as the minimum 1-foot thickness of “clean” soil is maintained.

2 Inspection and Maintenance

2.1 Inspections

BSD is responsible for conducting periodic site inspections to ensure the following:

- the cover features described in Section 1.3 continue to provide effective protection against direct contact exposure to underlying landfill materials and contaminated soils;
- the flush-mounted monuments of the groundwater monitoring wells (MW-1 through MW-16) and extraction well EW-17 are accessible and in good condition; and
- the HVAC system is operated continuously during the school day.

Inspections will be routinely performed on a semiannual basis, in the second and fourth quarters of the calendar year. In addition, a potential cover system breach or other potential deficiency reported to BSD by School/Church staff or others will trigger an immediate inspection. Inspections will be performed by the BSD POC or his/her designee. BSD will notify the Church POC prior to conducting an inspection on Church property.

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[1] As shown on Figure A-1 in Appendix A, a soil sample collected from the 0- to 3-foot depth interval at exploration NG-M4 exceeded the cleanup level for lead. The figure also shows an arsenic exceedance at exploration SG-J10 (same depth interval) in the south landfill area. However, as documented in the RI, resampling at that location confirmed that the exceedance occurred below 1-foot depth.

[2] It should be noted that much higher contaminant concentrations were detected directly beneath the geotextile in the spring 2012 interim action area compared to the other two areas. Refer to the RI for soil sampling results.

Inspections will be documented on an Inspection Record (Form 1), which provides a checklist of items to be addressed. If a condition of potential concern is observed (e.g., a breach in the cover system), the inspector will immediately take steps to limit access to the area of concern and initiate corrective measures. Deficiencies will be noted on Form 1 along with action items to address the deficiencies.

2.2 Maintenance

BSD is responsible for providing any maintenance that is required to ensure that the cover system remains functional and the monitoring well monuments are accessible and in good condition. Maintenance will be performed on an as-needed basis, when a deficiency is determined to exist. Maintenance to site cover features shall restore the feature(s) to the minimum thicknesses and material types specified in Section 1.3. In general, maintenance should be performed within 30 days of discovery or as soon as practicable to preclude further system deterioration.

Maintenance activities will be documented on a Cover System Maintenance Record (Form 2). Documentation should include a detailed description of the problem (in Section 1 of the form) and of the maintenance performed (in Section 2 of the form). The location of the work should be marked on the Site Plan (Figure 2), and color photographs should be taken both before and after maintenance is performed. The Maintenance Records, marked-up site plans, and photographs will be used to track repairs, and will be incorporated into the annual report (see Section 4) for documentation purposes and to facilitate follow-up inspections. The individual who identifies a maintenance item will complete Section 1 of the Maintenance Record. The individual responsible for coordinating and approving maintenance will complete Section 2 of the form when the repair has been completed. The forms will be sequentially numbered for each calendar year (e.g., 2015-01, 2015-02, etc.).

3 Soil Vapor Sampling

The CAP specifies that “the HVAC system in the main school building will be run continuously during the school day, and sub-slab vapor and/or indoor air sampling will be conducted periodically to reconfirm that vapor intrusion is not a concern.” Sampling of sub-slab vapor will be conducted under this I&M Plan, consistent with the first two vapor-phase sampling events in 2010. Sub-slab vapor sampling has potential advantages over indoor air sampling, including the following:

- It is less likely to result in “false positives.” That is, potential contaminant sources located inside the building (cleaning products, new carpets, etc.) are less likely to impact sub-slab vapor than indoor air.
- Since Ecology’s draft guidance allows application of a soil vapor attenuation factor to conservatively estimate indoor air concentrations, required analytical method reporting limits are more readily achieved.

- Sub-slab vapor concentrations are less likely to be influenced by weather conditions and changes in barometric pressure, so that reasonable “worst-case” sampling conditions are more readily captured.

On the other hand, sampling indoor air provides a direct indication of building occupant exposure levels, whereas sub-slab vapor sampling does not. As described in Ecology’s draft guidance document (Ecology, 2009), if sub-slab sampling indicates a potential VI concern, then follow-up indoor air sampling may be warranted.

Sub-slab vapor sampling will be conducted at 5-year intervals. The first post-RI sampling event was conducted in November 2015[3], 5 years after the most recent RI sampling event (described in Section 1.2.2). The November 2015 sampling event was conducted in general conformance with the requirements of the 2010 work plan (Appendix B), with the following updates:

- Table 2 of the 2010 work plan was updated with MTCA Method B air cleanup levels, sub-slab screening levels, and laboratory reporting limits current as of November 2015; and
- Appendix B of the 2010 work plan was updated to reflect Aspect’s latest standard operating procedure (SOP) for sampling permanent sub-slab soil vapor monitoring points.

The updated Table 2 and SOP used in the November 2015 sampling event are provided as Appendix C to this I&M Plan.

The next sub-slab vapor sampling event is scheduled for November 2020. The November 2015 sampling and analytical protocols will be followed unless modifications are approved by Ecology in advance of the sampling event. Sampling results will be compared (accounting for attenuation across the floor slab) to MTCA Method B air cleanup levels current at the time of sampling.

4 Reporting Requirements

Results of the cover system I&M and soil vapor sampling activities specified in this work plan will be reported to Ecology as follows:

- **Informal Reporting** – All inspection deficiencies will be informally reported to Ecology’s project manager (e.g., via e-mail), along with a description of the planned maintenance/corrective action, within 1 week of documentation (on Form 1) by the BSD inspector. Subsequent documentation of maintenance performed will also be informally reported within 1 week of completion. In addition, Ecology’s project manager will also be notified in advance of any invasive work to be performed within the Environmental Covenant Areas, in

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[3] The November 2015 sub-slab vapor sampling event will be documented in the 2015 Annual Report (refer to Section 4).

accordance with the requirements of the environmental covenants (see Appendix A).

- **Annual Reports –** BSD will prepare more formal reports documenting inspection, maintenance, and soil vapor sampling results on an annual basis. Annual reports will be comprehensive in nature, addressing all remedy implementation activities associated with the Site. (For example, results of activities conducted under the *Groundwater/LNAPL Monitoring and Contingency Plan* [Aspect, 2015a] and the *LNAPL Removal Work Plan* [Aspect, 2015b] will be documented in the same report.) Each report will cover activities completed on a calendar-year basis, and will be submitted to Ecology by January 31 of the following year.

- **Five-Year Review –** Ecology and BSD will meet at least every 5 years after initiation of the cleanup remedy to discuss the Site and the need, if any, for further remedial action. As specified in Section VIII.R of the AO, BSD will submit a summary report to Ecology at least 90 days prior to each 5-year review. The report will document whether human health and the environment are being protected based on the factors set forth in WAC 173-340-420(4).

References

Aspect Consulting, LLC (Aspect), 2010, Soil Vapor Intrusion Assessment November 2010 Sub-Slab Sampling, Crownhill Elementary School, Prepared for Bremerton School District, dated December 22, 2010.

Aspect, 2014a, Remedial Investigation, Crownhill Elementary School, Prepared for Bremerton School District, dated November 2014.

Aspect, 2014b, Feasibility Study, Crownhill Elementary School, Prepared for Bremerton School District, dated November 24, 2014.

Aspect, 2015a, Groundwater/LNAPL Monitoring and Contingency Plan, Crownhill Elementary School Site, Prepared for Bremerton School District, dated November 19, 2015.

Aspect, 2015b, LNAPL Removal Work Plan, Crownhill Elementary School Site, Prepared for Bremerton School District, dated November 19, 2015.

Washington State Department of Ecology (Ecology), 2009, Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action, Washington State Department of Ecology, Toxics Cleanup Program, Review DRAFT, October 2009.

Ecology, 2014, Cleanup Action Plan, Bremerton School District, Crownhill Elementary School Site, Washington State Department of Ecology, dated December 10, 2014.

Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Bremerton School District for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

TABLES

Table 1 – Points of Contact

Cover System Inspection & Maintenance Plan
Crownhill Elementary, Bremerton, Washington

CONTACT	TELEPHONE/E-MAIL
Ecology - Toxics Cleanup Program Jerome Cruz Project Manager	Office: (425) 649-7094 jcru461@ecy.wa.gov
Bremerton School District (BSD) Ron Carpenter Facilities Supervisor	Office: (360) 473-0502 Cell: (360) 536-6187 ron.carpenter@bremertonschools.org
Bremerton United Methodist Church Lee Crawford Church Administrator	Office: (360) 479-0129
Aspect Consulting, LLC (BSD environmental consultant) Dave Heffner Remediation Engineer	Office: (206) 838-5831 Cell: (206) 949-1564 dheffner@aspectconsulting.com

FORMS

Project Name: **Crownhill Elementary School**
Project No.:_________________

Date:_______________________
Inspector's Name:_______________________
Inspector's Signature:_______________________

Weather Conditions:______________________________
Inspector's Title/Affiliation:____

FORM 1 - INSPECTION RECORD

INSPECTION ITEM	**YES**	**NO**	**COMMENTS/NOTES**
1. North Environmental Covenant Area			
a. Building or pavement modifications since last inspection?			
b. Pavement deterioration/damage along Bertha Ave NW?[1]			
c. Evidence of soil disturbance?			
d. Geotextile fabric visible in interim action area?			
2. South Environmental Covenant Area			
a. Building or pavement modifications since last inspection?			
b. Evidence of soil disturbance?			
c. Geotextile fabric visible in interim action areas?			
3. Other Inspection Items			
a. Are all wells (MW-1 through EW-17) accessible?			
b. Evidence of well monument damage/tampering?			
c. HVAC system operates continuously during school day?[2]			

Deficient Action Items & Other Comments:

Notes

Revision: December 2015

1. Item 1b refers to the paved parking area described in Section 1.3.
2. The inspector should describe under COMMENTS/NOTES how the determination is made regarding HVAC system operation.

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Revision: December 2015

Project Name: **Crownhill Elementary School**

Project No.:_________________

FORM 2 - COVER SYSTEM MAINTENANCE RECORD

Record No.:_______________

SECTION 1

Problem Description:

Date Deficiency Observed:___________________

Deficiency Reported By:___________________

SECTION 2

Maintenance Performed:

Firm Performing Maintenance:____

Maintenance Start Date:____________

Maintenance Completion Date:____________

Approved By

Printed Name:___________________________

Signature:___________________________

Title/Affiliation:___________________________

Date:____________

FIGURES

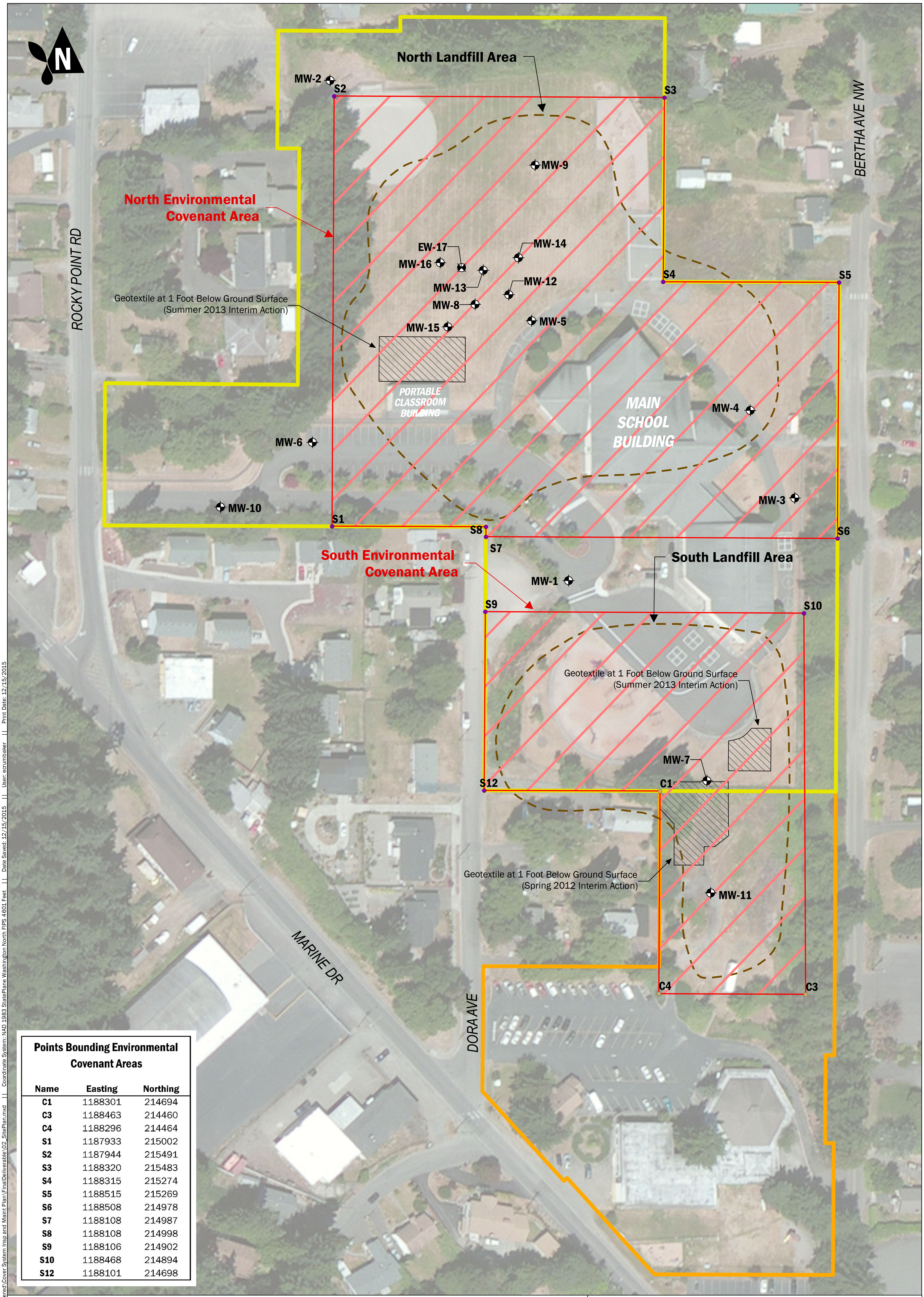
Vicinity Map

Cover System Inspection and Maintenance Plan
Crownhill Elementary, Bremerton, Washington

Aspect CONSULTING	DEC-2015	BY: PPW	FIGURE NO.
	PROJECT NO. 100094	REV BY: SCC / EAC	1

GIS Path: T:\projects_8\CrownhillElementary\Delivered\Cover System Insp and Maint Plan\Final\Deliverable\01_VicinityMap.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 12/15/2015 || User: ecrumbaker || Print Date: 12/15/2015

Basemap Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.



Points Bounding Environmental Covenant Areas

Name	Easting	Northing
C1	1188301	214694
C3	1188463	214460
C4	1188296	214464
S1	1187933	215002
S2	1187944	215491
S3	1188320	215483
S4	1188315	215274
S5	1188515	215269
S6	1188508	214978
S7	1188108	214987
S8	1188108	214998
S9	1188106	214902
S10	1188468	214894
S12	1188101	214698

⊕ Monitoring Well

⊗ Extraction Well

▨ Area of Environmental Covenant Soil and Structure Prohibitions

⬚ Interpreted Extent of Landfill Activity

🟨 Bremerton School District Property Boundary

🟧 Bremerton United Methodist Church Property Boundary

Site Plan

Cover System Inspection and Maintenance Plan
Crownhill Elementary, Bremerton, Washington

Aspect CONSULTING

DEC-2015

PROJECT NO.
100094

BY:
PPW

REV BY:
SCC / EAC

FIGURE NO.
2

GIS Path: T:\projects_8\CrownHillElementary\Delivered\Cover System Insp and Maint Plan\FinalDeliverable\02_SitePlan.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 12/15/2015 || User: ecrumbaker || Print Date: 12/15/2015

APPENDIX A

Subsurface Conditions and Requirements for Performing Invasive Work in Soil

Subsurface Conditions and Requirements for Performing Invasive Work in Soil

Portions of the Crownhill Elementary School (School) and Bremerton United Methodist Church (Church) properties were used for sand and gravel mining up to the 1930s, and the mined area was backfilled with municipal and industrial wastes. Based on the results of extensive soil sampling, and following interim actions completed during the Remedial Investigation (RI), all landfilled materials and near-surface impacted soils are covered with a minimum 1-foot thickness of clean soil or a “hard” surface such as pavement. Environmental covenants on the School and Church properties prohibit or restrict Site activities that would interfere with the integrity of the cover system or continued protection of human health.

It is recognized that invasive work in soil will occasionally need to be performed in the cover system areas. The primary purpose of this appendix is to provide workers and supervisors with a brief summary of subsurface conditions and requirements for performing such work.

Summary of Subsurface Conditions

Based on the RI results, soil contamination correlates closely with the occurrence of landfilled materials. Using multiple lines of evidence (e.g., historical photographs, site assessment activity, construction observations), two generalized areas of landfill accumulation (designated the ‘north’ and ‘south’ landfill areas) were identified in the RI. The interpreted boundaries of these areas are shown on Figure A-1. While typically limited to depths of less than 15 feet below ground surface (bgs), landfilled materials were found as deep as 40 feet bgs at some locations.

Soil quality data generated during the RI are summarized in Table A-1. Constituents of concern (COCs) in site soil include total petroleum hydrocarbon (TPH) in the diesel and motor oil ranges, six metals, trichloroethene (TCE), and carcinogenic polycyclic aromatic hydrocarbons (cPAHs). A grid-based sampling approach was implemented to delineate areas of soil contamination to a depth of 15 feet bgs. Sampling locations are shown on Figure A-1. Depth-discrete detections of arsenic, lead, and TPH are summarized on Figures 16 through 19 of the RI report (Aspect, 2014a).

COC concentrations exceeding soil cleanup levels were identified within 1 foot of ground surface in a portion of the south landfill area, and an interim action was successfully implemented at that location in spring 2012. That interim action consisted of removing impacted soil to a 1-foot depth, installing a geotextile fabric, and constructing a clean soil and sod cover layer at least 1 foot thick. A second interim action was subsequently conducted at two locations on the School property where lead cleanup level exceedances were identified in the 1- to 3-foot depth range. In summer 2013 those areas were covered with a geotextile fabric, and an additional 1-foot thickness of fill soil was imported and hydroseeded to supplement the pre-existing clean soil cover layer.

The spring 2012 and summer 2013 interim action areas are shown on Figure A-1 along with two other RI sampling locations where soil cleanup level exceedances were detected above 3-foot depth. The lead exceedance at exploration NG-M4 is currently covered by pavement. Follow-up sampling at exploration SG-J10 (located on Church property) indicated that the marginal arsenic exceedance at that location is covered by a minimum 1-foot thickness of "clean" soil.

Vadose zone soils (i.e., soils above the water table) beneath a deep portion of the north landfill area are impacted by petroleum hydrocarbons, and separate-phase petroleum-based product (referred to as light non-aqueous-phase liquid, or LNAPL) is floating on the water table at 120 to 130 feet bgs. Although a wide range of petroleum hydrocarbon liquids were likely disposed of at the site, many decades of weathering have left behind a high-viscosity mixture of relatively low-solubility compounds. LNAPL in vadose zone soils, which comprises the majority of petroleum hydrocarbon mass at the site, is likely trapped in the soil pore spaces (i.e., no longer moving downward).

Localized "plumes" of dissolved TPH, arsenic, and TCE are also present in groundwater beneath the School property, which flows in a southwesterly direction. For additional information on the water table LNAPL and dissolved contaminant plumes, refer to the *Groundwater/LNAPL Monitoring and Contingency Plan* (Aspect, 2015a) and to the annual reports discussed in this Cover System I&M Plan.

Requirements for Performing Invasive Work in Soil

Examples of invasive work in soil include: drilling; digging; piercing the cover system with a sampling device, post, stake, or similar device; grading; excavation; installation of underground utilities; removal of the cover system; or application of loads in excess of the cover system load-bearing capacity. The following requirements are applicable to all invasive work to be performed within the Environmental Covenant Areas defined on Figure 2 of this Cover System I&M Plan:

- **For invasive work not to exceed 1-foot depth:**
  1. provide notice to Ecology's project manager in advance via e-mail or letter;
  2. ensure that such work is supervised by BSD's Facilities Supervisor; and
  3. notify workers of subsurface conditions (summarized above).
- **For invasive work exceeding 1-foot depth:**
  1. provide notice to and receive approval from Ecology's project manager prior to performing the work;
  2. use personnel with hazardous waste health and safety training (per 29 CFR 1910.120);
  3. notify such personnel of subsurface conditions (summarized above); and
  4. contractors performing the work must develop, implement, maintain, and enforce their own site-specific health and safety plan (HASP).

Invasive work in soil must not result in a reduction in the thickness of the “clean” cover soil layer.

Additional Considerations for Excavation of Potentially Contaminated Materials

For invasive work in which potentially contaminated materials will be exposed/excavated, Ecology will likely require a project-specific work plan (separate from the contractor’s HASP) describing the procedures and protocols to be followed in performing the work. Specific items that may need to be addressed in the work plan include the following:

- **Erosion, Sedimentation, and Dust Control.** When potentially contaminated materials are exposed/excavated, temporary erosion and sedimentation control (TESC) practices compliant with applicable state and local laws, regulations, ordinances, and permits must be followed. In addition, construction best management practices (BMPs) must be implemented to minimize generation of dust in accordance with applicable state and local laws, regulations, ordinances, and permits.

- **Materials Handling On Site.** Potentially contaminated materials that are excavated and temporarily managed on site must be stockpiled or placed into appropriate covered containers (e.g., drums). Access to stockpiles/containers must be restricted. Stockpiles must be constructed and maintained to prevent erosion, contact with stormwater runoff, dust generation, and worker contact. Each stockpile must be underlain by a low-permeability liner and covered with a liner when not in use.

- **Testing and Final Disposition of Excavated Materials.** Samples will be collected from stockpiles/containers of potentially contaminated materials for chemical testing. For off-site disposal, the disposal facility will have specific waste profiling requirements that must be satisfied before transport and disposal is allowed. Transport and off-site disposal of all waste materials must be conducted in accordance with Chapter 173-303 WAC and other applicable federal, state, and local laws, regulations, ordinances, and permits. The property owner will be the generator for all waste materials generated on their property. Depending on project-specific circumstances and subject to Ecology approval, backfilling/reuse of excavated materials may also be pursued, in which case chemical testing to support on-site backfilling/reuse will be proposed in the work plan.

Numerous borings were advanced in and around the Environmental Covenant Areas over the course of the RI. Boring logs and landfill area cross sections included in the RI report (Aspect, 2014a) may provide useful information on subsurface conditions in the specific area of planned work. Reviewing the RI information during the project planning phase is recommended to help minimize the likelihood of encountering unanticipated conditions during performance of the work.

Table A-1 - Soil Quality Data Summary

Project No. 100094, Crownhill Elementary, Bremerton, Washington

Constituent of Concern[(2)]	Number of Sample Locations	Number of Samples	Number of Detected Results	Maximum Detected Value (mg/kg)	Soil Cleanup Level[(2)] (mg/kg)	Exceedances of Soil Cleanup Level: Number of Samples	Exceedances of Soil Cleanup Level: % of Samples
Total Petroleum Hydrocarbon (TPH)							
Diesel Range	210	597	53	27,000	2,000	16	3
Motor Oil Range	210	597	80	72,000	2,000	19	3
Metals							
Antimony	40	54	25	544	5.4	24	44
Arsenic	237	611	500	63	20	39	6
Chromium III	5	17	17	1,710	1,000	5	29
Copper	40	54	37	6,820	260	17	31
Lead	236	608	580	26,300	250	73	12
Zinc	5	17	17	14,600	6,000	4	24
Volatile Organic Compounds (VOCs)							
Trichloroethene (TCE)	9	29	1	0.1	0.03	1	3
Polycyclic Aromatic Hydrocarbons (PAHs)							
cPAHs TEF[(3)]	13	33	9	26	0.14	1	3

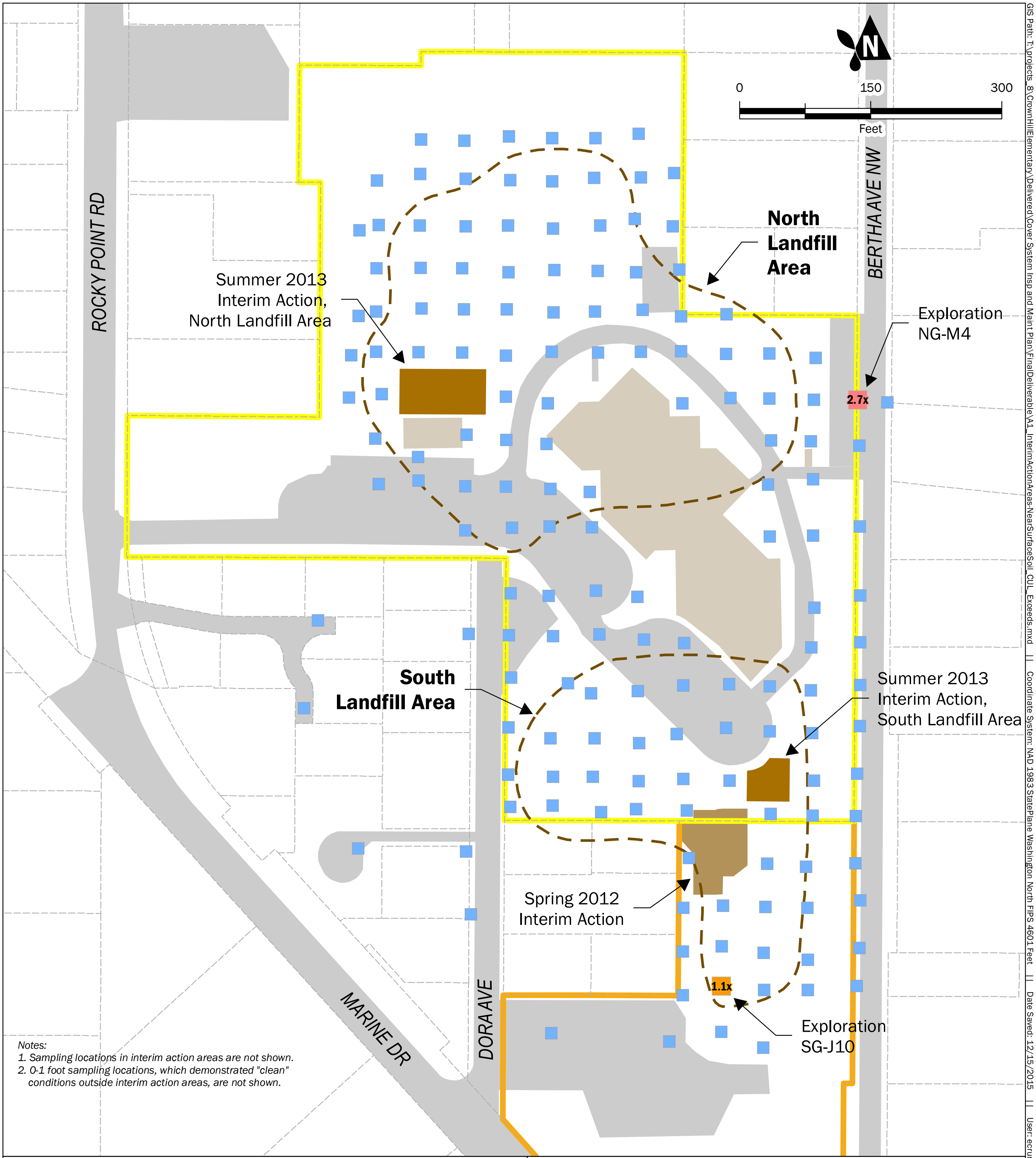
cPAH	carcinogenic PAH	mg/kg	milligrams per kilogram	TEF	toxicity equivalency factor

Notes

1) The soil quality data summarized in this table are documented in the Remedial Investigation report (Aspect, 2014a). Samples from soils removed as part of the Spring 2012 Interim Action are not counted in the number of detects, maximums, and exceedances.

2) Determination of site-specific constituents of concern and soil cleanup levels is documented in the Cleanup Action Plan (Ecology, 2014).

3) The cPAHs TEF is calculated from the concentrations of seven carcinogenic PAHs, using the method described in WAC 173-340-708.



Notes:
1. Sampling locations in interim action areas are not shown.
2. 0-1 foot sampling locations, which demonstrated "clean" conditions outside interim action areas, are not shown.

Soil Sampling Locations (0-3 foot depth interval)

Cleanup level exceedance factor

- 🟥 2.7x *Lead cleanup level exceedances*
- 🟧 1.1x *Arsenic cleanup level exceedances*
- 🟦 *No cleanup level exceedances*

- Interpreted Extent of Landfill Activity
- Parcel Lines
- Bremerton School District Property Boundary
- Bremerton United Methodist Church Property Boundary
- School Building Footprint
- Pavement

Interim Action Areas and Near-Surface Soil Cleanup Level Exceedances

Cover System Inspection and Maintenance Plan
Crownhill Elementary, Bremerton, Washington

Aspect CONSULTING	DEC-2015	BY: DAH / PPW	FIGURE NO.
	PROJECT NO. 100094	REV BY: SCC / EAC	**A-1**

GIS Path: T:\projects_8\CrownHillElementary\Delivered\Cover System Insp and Maint Plan\FinalDeliverable\A1_InterimActionAreas-NearSurfaceSoil_CUL_Exceeds.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 12/15/2015 || User: ecrumbaker || Print Date: 12/15/2015

APPENDIX B

Soil Vapor Intrusion Assessment Work Plan, July 2010

SOIL VAPOR INTRUSION ASSESSMENT WORK PLAN

Crownhill Elementary School
Bremerton, Washington

Prepared for: Bremerton School District

Project No. 100067-001-01 • July 21, 2010 •

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SOIL VAPOR INTRUSION ASSESSMENT WORK PLAN

Crownhill Elementary School
Bremerton, Washington

Prepared for: Bremerton School District

Project No. 100067-001-01 • July 21, 2010

Aspect Consulting, LLC

DAVID A. HEFFNER
30862
07-21-10

Hydrogeologist
385
Douglas L. Hillman

David A. Heffner, PE
Associate Engineer
dheffner@aspectconsulting.com

Doug Hillman, LHG
Principal Hydrogeologist
dhillman@aspectconsulting.com

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1 Introduction and Background

This document presents a work plan for assessing soil vapor intrusion (VI) into the Crownhill Elementary School building located at 1500 Rocky Point Road in Bremerton, Washington (Figure 1). The 10.4-acre school property, which was acquired by the Bremerton School District in 1954, was historically used as a landfill. The original Crownhill Elementary School building was constructed on the property in 1958. That building was partially destroyed by fire in 1993, and remaining portions of the building were demolished that same year. Uncontrolled fill and soils containing petroleum hydrocarbons and possibly other regulated compounds were encountered during construction of the new (existing) two-story slab-on-grade school building in the mid-1990s. As a result, the School District, in consultation with Ecology, modified the grading design to include clean imported cover soils to reduce the potential for direct contact exposure to the fill materials and impacted soils.

Several investigations of soil vapor and indoor air quality have been conducted, including the following:

- A soil vapor survey was conducted in September 1994, after the old school building was demolished but before the new building was constructed. Results are documented in AGRA, 1994. Low concentrations of petroleum hydrocarbons and chlorinated volatile organic compounds (VOCs) were detected in several near-surface soil vapor samples. Detected concentrations were below levels of concern with respect to construction workers.
- Indoor air sampling was conducted in August 1996, after construction was completed and the new building was ventilated for 30 days (prior to occupancy by students). Results are documented in Clayton, 1996. Indoor air samples collected on charcoal sorbent tubes contained detectable concentrations of several petroleum hydrocarbon constituents/fractions, acetone, d-Limonene (an orange peel extract used in cleaning products), and total VOCs. Total VOC concentrations were judged to be low compared to “past data from other newly constructed schools.”
- Air quality monitoring was conducted inside the school building in December 2009 by Terracon Consultants, Inc. Due to significant quality assurance/quality control (QA/QC) concerns, however, sampling results were not considered representative of actual conditions, and were not documented in a formal report.

The School District is in the process of entering into an Agreed Order with the Washington State Department of Ecology (Ecology) for further investigation of site conditions. The purpose of the sub-slab soil vapor sampling proposed in this work plan is to further evaluate whether the potential exists for indoor air to be unacceptably impacted by VI. A draft work plan (Aspect Consulting, 2010) was submitted to Ecology for review, and Ecology’s comments have been incorporated into this revised work plan.

If sampling results indicate the potential for unacceptable impacts, the School District will consult with Ecology regarding the need to either further assess indoor air impacts or implement an interim measure to mitigate the VI pathway.

2 Potential Contaminants of Concern

Vapor-phase contaminants associated with landfills typically include VOCs, methane, and hydrogen sulfide. These are the contaminants that were evaluated in the 1994 soil vapor survey. Excerpts of the AGRA, 1994 report addressing the soil vapor survey are provided in Appendix A. In this section, results of that survey are used to develop a list of potential contaminants of concern (PCOCs) for the current investigation.

Table 1 summarizes the screening process used. It lists the 11 VOCs that were detected in at least 1 of the 7 soil vapor samples collected in the 1994 survey. For each of these VOCs, the maximum detected concentration and the corresponding sample ID are also provided in the table. Figure 4 in Appendix A shows the sampling locations with respect to the new school building.

Methane and hydrogen sulfide are commonly generated at former landfill sites as by-products of the anaerobic biodegradation of landfilled materials. For this reason they are included in the screening evaluation, although they were not detected in any of the 1994 soil vapor samples.

The Table 1 compounds were screened by comparing the highest soil vapor concentrations detected in the 1994 survey to the corresponding Washington State Model Toxics Control Act (MTCA) Method B air cleanup levels. These air cleanup levels are applicable to a residential exposure scenario, and standard formula values for both carcinogens and non-carcinogens are provided in the table. For each compound, the ratio of the maximum detection to the most stringent Method B air cleanup level was calculated (second-to-last column in Table 1). Compounds detected at concentrations greater than 10 percent of the cleanup level (i.e., ratios greater than 0.1) were then identified as PCOCs for the current investigation.

Ecology guidance (Ecology, 2009) allows a soil vapor attenuation factor of 0.1 to be applied across a floor slab to conservatively estimate indoor air concentrations based on shallow soil vapor sampling results. Therefore, this screening process identifies as a PCOC any compound that was detected in the 1994 survey at greater than 1 percent of the concentration likely to cause a cleanup level exceedence in indoor air.

As noted above, methane and hydrogen sulfide were not detected in any of the 1994 soil vapor samples. Since methane is non-toxic, it is not an inhalation concern. However, its presence in landfill environments is often a flammability concern. The lower explosive limit (LEL) for methane in air is 5 percent by volume, or 50,000,000 parts per billion by volume (ppbv). Since it was not detected in any of the 1994 samples at a detection limit of 14,000 ppbv, methane is not considered a flammability concern at this site and is not a PCOC for the current investigation.

As shown in Table 1, the detection limit for hydrogen sulfide in the 1994 survey was too high to allow for effective PCOC screening using the process described above. Since it could not be screened out, hydrogen sulfide is included as a PCOC.

In the course of addressing Ecology's comments on the draft work plan, it was agreed to include naphthalene and 6 additional chlorinated solvents on the list of PCOCs. The full list of PCOCs for the current investigation is provided in Table 2.

3 Sampling Methodology

Sampling will be conducted in general conformance with the Standard Operating Procedure (SOP) for Sub-Slab Soil Vapor Sampling provided in Appendix B. Semi-permanent sampling points will be installed so that repeated sampling can be conducted, as necessary, to evaluate seasonal variations.

The decision to collect sub-slab soil vapor samples rather than indoor air samples at this stage of VI assessment is consistent with the tiered remedial investigation approach described in Chapter 3 of the Ecology guidance document (Ecology, 2009). Sub-slab sampling has potential advantages over indoor air sampling, including the following:

- It is less likely to result in "false positives." That is, potential contaminant sources located inside the building (cleaning products, new carpets, etc.) are less likely to impact sub-slab vapor than indoor air.
- Since Ecology guidance allows application of a soil vapor attenuation factor to conservatively estimate indoor air concentrations, required analytical method reporting limits are more readily achieved (see Section 4 discussion).
- Sub-slab vapor concentrations are less likely to be influenced by weather conditions and changes in barometric pressure, so that reasonable "worst-case" sampling conditions are more readily captured.

On the other hand, sampling indoor air provides a direct indication of building occupant exposure levels, whereas sub-slab vapor sampling does not. As described in the Ecology guidance document, if sub-slab sampling indicates a potential VI concern, then follow-up indoor air sampling may be warranted.

Additional details on sampling methodology and logistics are as follows:

- Sub-slab soil vapor samples will be collected at the 6 proposed locations shown on Figure 2 (SSV-1 through SSV-6). Since the 1994 soil vapor survey results do not indicate that one portion of the school building is more likely to be impacted than another, the proposed sampling locations are spaced to provide coverage over the entire building footprint. The sampling locations will be away from external walls and doors.

- Samples for VOC analysis will be collected in 6-liter Summa canisters, and samples for hydrogen sulfide analysis in 1-liter Tedlar® bags. Analytical methods are specified in Section 4.
- One sampling location (SSV-1) will be "leak tested" using helium to ensure that sampling apparatus leakage is not excessive. (See Section 4 and the Appendix B SOP for additional discussion.)
- Flow controllers will be used with the evacuated Summa canisters in order to collect 1-hour time-integrated samples, and a peristaltic pump will be used to collect the Tedlar® bag samples. (Note: Indoor air samples are typically collected over 8-hour or 24-hour sampling periods to accurately monitor exposures of individuals occupying the space. Conditions in the sub-slab vapor space are expected to have considerably less variability over the course of a day, so a shorter sampling period can be used to monitor those conditions.) All samples will be collected at a sampling rate of less than 0.1 liter per minute. This low flow rate ensures that the sampling-induced pressure difference across the floor slab will not be excessive.
- The Summa canisters and Tedlar® bags will be packed in their original shipping containers and shipped by FedEx overnight service to Air Toxics, Limited, in Folsom, California, for analysis.
- The holding time for hydrogen sulfide analysis is only 24 hours. The FedEx shipping center in Silverdale (10854 Myhre Place NW, 360-698-7099) has a "last call" for express delivery of 4:15 pm on weekdays. In addition, Air Toxics is not open on Saturdays. Therefore, in order to meet the hydrogen sulfide holding time, the sampling event will be scheduled for early afternoon on a Monday through Thursday, such that the sample containers can be packaged and delivered to the Silverdale shipping center before 4:15 pm.

4 Laboratory Analysis and Evaluation of Results

Canister samples will be analyzed for the following PCOCs using modified EPA Method TO-15-LL (Sp):

Freon 12
vinyl chloride
1,1-dichloroethene
trans-1,2-dichloroethene
1,1-dichloroethane
cis-1,2-dichloroethene
chloroform
benzene
1,2-dichloroethane
trichloroethene
tetrachloroethene
ethylbenzene
xylenes (total)
1,2,4-trimethylbenzene
naphthalene

Tedlar® bag samples will be analyzed for hydrogen sulfide by ASTM Method D-5504 (Sh). Reporting limits (RLs) are provided in Table 2.

The sub-slab soil gas sample results will be evaluated against the screening levels shown in Table 2. For each PCOC, the screening level is 10 times the most stringent corresponding MTCA Method B air cleanup level. Thus, these screening levels conservatively account for soil vapor attenuation across the floor slab in accordance with the Tier I methodology specified in Ecology's *Guidance for Evaluating Soil Vapor Intrusion in Washington State*.

As shown in Table 2, the analytical method specified for the canister samples is expected to yield compound-specific reporting limits that are lower than the corresponding screening levels. The analytical method specified for the Tedlar® bag samples is expected to yield a hydrogen sulfide reporting limit of approximately 5.7 µg/m^3. Although that is slightly higher than the corresponding screening level (4.6 µg/m^3), it is a substantial improvement over the reporting limit of 71 µg/m^3 achieved in the 1994 soil vapor survey (see Table 1), and is the lowest available reporting limit for hydrogen sulfide cited by Air Toxics.

The Tedlar® bag sample collected at the leak test location (SSV-1) will also be analyzed by the laboratory for helium using modified ASTM Method D-1946. If the sample contains greater than 10 percent by volume of helium, sample dilution due to leakage may be too great to be reliably corrected for, and the integrity of the vapor port seals will need to be considered. In this case, Ecology will be consulted regarding path forward.

Regardless of the outcome of the above evaluation, a VI assessment report that documents sampling results and recommends next steps will be prepared and submitted to Ecology. The report will also include the following:

- Information on soil characteristics directly beneath the floor slab, obtained from the building's geotechnical report and from observations made during installation of the sub-slab soil vapor sampling points.
- Information on utility corridors/trenches and a discussion of implications with respect to preferential vapor pathways.
- Information on building pressurization characteristics (e.g., Is the building positively pressurized when the heating system is operating?), and a discussion of implications with respect to capture of "worst-case" vapor intrusion conditions.

5 Data Quality Indicators

Data quality indicators (DQIs), including precision, accuracy, representativeness, comparability, and completeness (PARCC parameters), and data reporting limits are dictated by the data quality objectives, project requirements, and intended uses of the data. For this project, a primary criterion of the analytical data is to be of sufficient technical quality to determine whether PCOC concentrations in the sub-slab soil vapor samples exceed the corresponding screening levels.

An assessment of data quality is based upon quantitative (precision, accuracy, and completeness) and qualitative (representativeness and comparability) indicators. Definitions of these parameters and the applicable QC procedures are presented below.

5.1 Precision and Accuracy

Precision measures the reproducibility of measurements, while accuracy measures correctness and includes components of random error (variability due to imprecision) and systemic error. Analytical precision is the agreement among multiple analyses of the same sample, which is quantitatively expressed as the relative percent difference (RPD) between duplicate sample results. Analytical accuracy is measured by comparing the percent recovery of analytes spiked (as compared to the expected value) to pre-established acceptance criteria.

Elements of quality control employed by Air Toxics to ensure analytical precision and accuracy (as well as other DQIs) are discussed in their Quality Manual, excerpts of which are included in Appendix C.

Field duplicate samples represent total precision, the reproducibility associated with the entire sampling and analysis process for a given sampling event. However, the actual variability in vapor concentrations between sampling events is expected to be greater than any variability in measured concentrations that would be quantified through the analysis of field duplicate samples. For this reason, we do not propose to collect field duplicates for this project.

5.2 Representativeness

Representativeness measures how closely the measured results reflect the actual concentration or distribution of the chemical compounds in the matrix sampled. The goal of sampling is to determine “worst-case” PCOC concentrations in soil vapor beneath the school’s floor slab. The following steps will be taken to increase the likelihood that sampling results are representative:

- Six sub-slab vapor samples will be collected simultaneously from different building locations, and the highest PCOC detections will be used to access exceedence of the screening levels;
- Sampling equipment will be “certified clean” by the analytical laboratory;
- Time-integrated samples will be collected over a 1-hour sampling period; and
- Leak testing will be conducted at one sampling location to ensure that sample train leakage is not resulting in an unacceptable amount of indoor air entering the sampling containers.

5.3 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. The use of standard techniques for sample collection and a certified analytical laboratory for laboratory analyses should make data collected comparable between air sampling events.

5.4 Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid measurements. Results will be considered valid if all the precision, accuracy, and representativeness objectives are met and if reporting limits are sufficient for the intended uses of the data. PCOC concentrations in the soil vapor samples are considered critical and thus have a 100 percent target completeness goal.

If overall completeness is less than 100 percent, the reason for the lack of completeness will be assessed. Further sample collection may be necessary, and will be completed under advisement from Ecology.

6 Schedule

Target dates and timeframes for sampling and reporting include the following:

- Sub-slab soil vapor sampling will be conducted after Ecology approves this work plan (anticipated in August 2010, prior to commencement of the 2010-2011 school year).
- Air Toxics should provide sampling results within 15 business days of sample receipt (anticipated in September 2010).
- A report that documents sampling results and recommends next steps will be submitted to Ecology within 30 days of receiving sampling results (anticipated in October 2010).

7 References

AGRA Earth & Environmental, Inc., 1994, Phase I Construction, Environmental Sampling and Analysis Report, Crownhill Elementary School, Bremerton School District, November 14, 1994.

Aspect Consulting, LLC, 2010, Soil Vapor Intrusion Assessment Work Plan, Crownhill Elementary School, Bremerton, Washington (DRAFT), July 14, 2010.

Clayton Environmental Consultants, 1996, Limited Indoor Air Quality Evaluation for Heery International, Inc., at the Bremerton School District, Bremerton, Washington, September 9, 1996.

Ecology, 2009, Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action, Washington State Department of Ecology, Toxics Cleanup Program, Review DRAFT, October 2009.

Terracon Consultants, Inc., 2010, DRAFT Remedial Investigation, Agency Review Draft, Crownhill Elementary School, 1500 Rocky Point Road, Bremerton, Kitsap County, Washington, May 4, 2010.

8 Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Bremerton School District for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

Table 1 - Screening for Potential Compounds of Concern

Crownhill Elementary School, Bremerton, Washington

Analyte(1)	Maximum Detection in 1994 Soil Vapor Survey(1)			MTCA Method B Air Cleanup Level, Standard Formula Value in µg/m^3		Ratio of Maximum Detection to Most Stringent MTCA Method B Air Cleanup Level(3)	Potential Compound of Concern?(3)
		Concentration					
	Sample ID(2)	ppbv	µg/m^3	Carcinogen	Non-Carcinogen		
Freon 12 (dichlorodifluoromethane)	SVP-1	1.9	9.6	NR	80	0.12	Yes
Freon 11 (fluorotrichloromethane)	SVP-1	1.2	6.9	NR	320	0.02	No
Chloroform	SVP-6	12	60	0.11	NR	550	Yes
Benzene	SVP-7	2.8	9.1	0.32	140	28	Yes
Trichloroethene	SVP-6	13	71	0.1	16	710	Yes
Toluene	SVP-3	2.2	8.4	NR	2,200	0.004	No
Tetrachloroethene	SVP-6	2.2	15	0.42	16	36	Yes
Ethylbenzene	SVP-5	12	53	NR	460	0.12	Yes
Xylenes (total)	SVP-5	56	250	NR	46	5.4	Yes
1,2,4-trimethylbenzene	SVP-1	1.1	5.5	NR	2.7	2.0	Yes
1,2,4-trichlorobenzene	SVP-2	1.0	7.5	NR	94	0.08	No
Methane(4)	(all)	<14,000	<9,400	non-toxic		NA	No
Hydrogen Sulfide(4)	(all)	<50	<71	NR	0.46	<150	Yes

ppbv	parts per billion by volume
MTCA	Model Toxics Control Act
NA	not applicable
NR	not researched
µg/m^3	micrograms per cubic meter

Notes:

1) Except for methane and hydrogen sulfide (two common landfill gases), the compounds listed in this table were detected in at least one of the soil vapor samples collected during the 1994 survey (see Appendix A).
2) Refer to Appendix A for sampling locations.
3) For the purpose of this screening evaluation, analytes with ratios greater than 0.1 are identified as potential compounds of concern (PCOCs). Refer to discussion in Section 2.
4) Methane and hydrogen sulfide are commonly generated as by-products of the anaerobic biodegradation of landfilled materials. For this reason they are included in the screening evaluation, although they were not detected in any soil vapor survey sample. Refer to screening discussion in Section 2.

Table 2 - Screening Levels and Reporting Limits for Potential Compounds of Concern

Crownhill Elementary School, Bremerton, Washington

*** NOTE: THIS TABLE WAS UPDATED FOR THE NOVEMBER 2015 SAMPLING EVENT; REFER TO APPENDIX C OF THE COVER SYSTEM INSPECTION AND MAINTENANCE PLAN ***

Potential Compound of Concern (PCOC)	Screening Level (2)	Reporting Limit cited by Air Toxics, Ltd.(3)	Reporting Limit (Approx.) after Accounting for Canister Pressurization (4)
Freon 12	800	0.50	0.80
Vinyl chloride(5)	2.8	0.26	0.42
1,1-Dichloroethene(5)	910	0.40	0.64
trans-1,2-Dichloroethene(5)	320	0.40	0.64
1,1-Dichloroethane(5)	3,200	0.41	0.66
cis-1,2-Dichloroethene(5)	160	0.40	0.64
Chloroform	1.1	0.50	0.79
Benzene	3.2	0.33	0.52
1,2-Dichloroethane(5)	22	0.41	0.66
Trichloroethene	1.0	0.55	0.87
Tetrachloroethene	4.2	0.69	1.1
Ethylbenzene	4,600	0.44	0.71
Xylenes (total)	460	0.88	1.4
1,2,4-Trimethylbenzene	27	0.5	0.8
Naphthalene(5)	14	2.7	4.3
Hydrogen sulfide	4.6	5.7	5.7

Notes:

1) All concentrations are in units of micrograms per cubic meter (ug/m^3).

2) Values in this column were obtained by multiplying the most stringent MTCA Method B air cleanup level by 10, to conservatively account for soil vapor attenuation across the floor slab in accordance with Ecology's *Guidance for Evaluating Soil Vapor Instrusion in Washington State.*

3) Reporting limits cited by Air Toxics, Ltd., for analysis by ASTM D-5504 (Sh) for hydrogen sulfide and by modified TO-15 LL (Sp) for all other compounds. These limits do not take into account sample dilution due to canister pressurization. Per Air Toxics, the dilution factor from pressurization will typically raise reporting limits by a factor of 1.5 to 1.7 when using a 6-liter canister.

4) Except for hydrogen sulfide, values in this column were obtained by simply multiplying the previous column values by 1.6 (the average of 1.5 and 1.7; see Note 3). Hydrogen sulfide is a Tedlar bag sample, which has no pressurization dilution factor.

5) Compound was added to the list of PCOCs per Ecology's comments on the draft Work Plan (see Appendix D).

Project Location Map

Soil Vapor Intrusion Assessment Work Plan

Crownhill Elementary School
Bremerton, Washington

Aspect CONSULTING

DATE: July 2010	PROJECT NO. 100067
DESIGNED BY: DH	
DRAWN BY: SCC	FIGURE NO. 1
REVISED BY: -	

Q:\Crown Hill Elementary\100067 Crown Hill Elementary School\2010-06 Vapor Sampling\100067-01.dwg 8.5x11 Landscape

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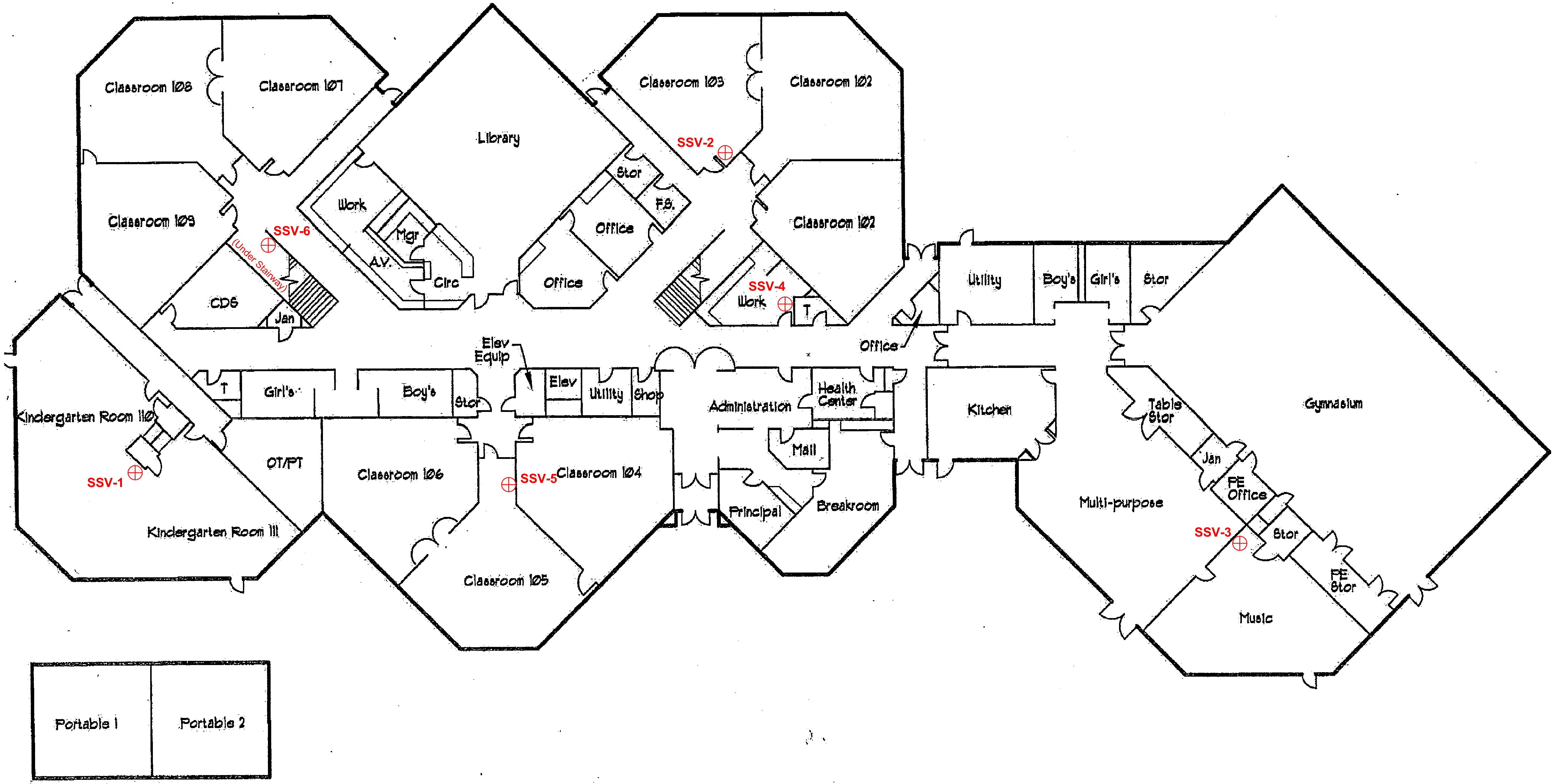


⊕ Sub-Slab Vapor Sampling Location

0 25 50
Approximate Scale in Feet

Aspect CONSULTING

Sub-Slab Vapor Sampling Locations
Soil Vapor Intrusion Assessment Report
Crownhill Elementary School
Bremerton, Washington

DATE: November 2015	PROJECT NO. 100067
DESIGNED BY: DH	
DRAWN BY: SCC	FIGURE NO. 2
REVISED BY: EJM/ELG	

Q:\Crown Hill Elementary School\100067 Crown Hill Elementary School\2010-06 Vapor Sampling\100067-02_ELG.dwg 11x17 Landscape

Nov 12, 2015 9:04am egeissinger

APPENDIX A

1994 Soil Vapor Survey Report Excerpt

Appendix A – 1994 Soil Vapor Survey Report Excerpt

Reference:
AGRA, *Phase I Construction, Environmental Sampling and Analysis Report*, dated November 1994.

7.0 SOIL GAS SURVEY

AGRA performed a soil gas survey at the subject site on 1 September 1994. The purpose of the soil gas survey was to assess the presence of hydrogen sulfide, methane and volatile organic compounds in the soil gases at selected areas of the subject site. The areas sampled consisted of the current location of the temporary classrooms, and the proposed locations for the north play field, northeast playground toy area, and school building.

Seven sample locations were selected for this investigation ("SVP-#" on Figure 4). Two samples (SVP-1 and SVP-3) were collected from within the footprint of the proposed school building; one sample (SVP-2) was collected from the area of the proposed playground toy area; two samples (SVP-4 and SVP-5) were collected from the area of the proposed north playfield; and two samples (SVP-6 and SVP-7) were collected from the vicinity of the mobile classroom located on the site at the time of this investigation. Approximate sample locations are presented on Figure 4.

Soil gas samples were collected at the locations noted above by advancing a hand auger to the maximum depth practicable at the sample location. A soil gas sampling probe consisting of one-half inch steel pipe fitted with a disposable gas collection tip and Teflon tubing was driven one to two feet into the soil from the bottom of the hand augered hole. Sample depths ranged from one and one-half feet below the existing grade to five feet below the existing grade.

After advancement and setting of the soil probe, the probe was withdrawn slightly to expose a screened section in the tip of the probe, through which soil gases could be extracted. The Teflon tubing was purged of ambient air using a hand operated vacuum pump. After purging, one sample of the soil gas was collected in each location using a vacuum canister. A second sample was collected using a tedlar bag and a hand operated vacuum pump. The samples were submitted under chain-of-custody procedures to Air Toxics Limited, of Folsum, California for the following analyses:

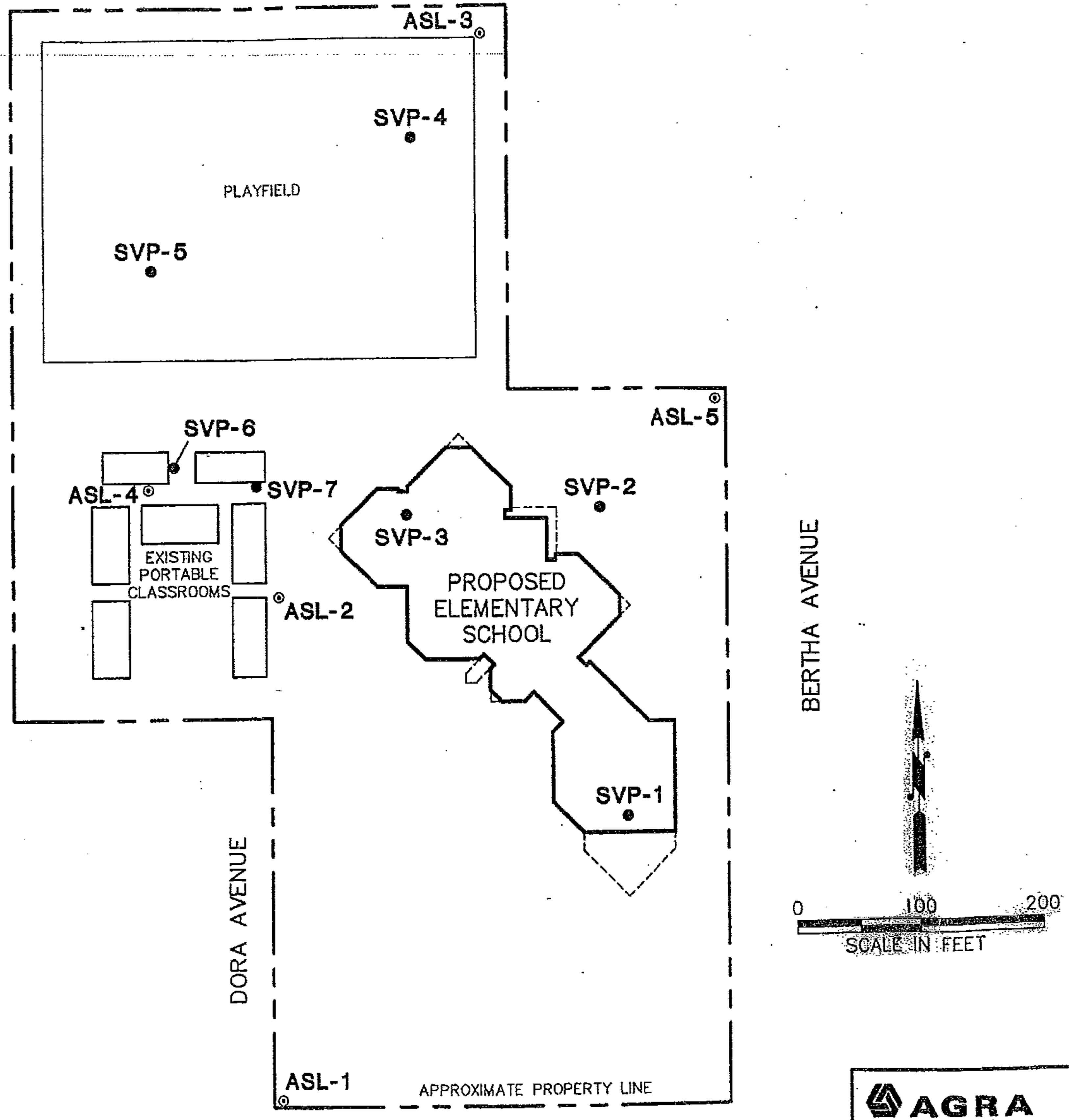
- Hydrogen Sulfide by EPA method 15;
- Atmospheric Gases (Methane only) by ASTM D-3416; and
- Volatile Organics by EPA method TO-14.

Hydrogen Sulfide and Methane were not detected in any of the samples at concentrations exceeding the detection limits of the test methods used. Selected volatile organics were present in all of the samples. Sampling information and the results of the analyses performed are summarized in Table 4. Copies of the analytical reports and chain-of-custody records are attached. Surrogate recoveries were measured and a laboratory blank analyzed as part of the quality assurance for the volatile organics analyses. Surrogate recoveries were within the method limits. None of the analytes were present in the laboratory blank at concentrations exceeding the method detection limit.

The concentrations of volatile organics detected in the soil gas samples were compared to the Permissible Exposure Limits (PEL) as listed in Part H of the Washington State "General Occupational Health Standards" (WAC 296-62-075). The PELs are for use with adult workers in industrial settings. The PELs refer to airborne concentrations of substances without regard to the use of respiratory protection and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse affect. The PELs for Freon 11 and 1,2,4-Trichlorobenzene are ceiling limits as shown in Table 4.

Ceiling limits have been determined for substances which cause predominately acute health effects and whose permissible limit is based on this response. Ceiling limits may not be exceeded during any part of the work day (WAC 296-62-07503 (1) and (2). Safety professional also commonly use one-tenth of the PEL for comparison purposes in non-industrial settings, which AGRA considers a more appropriate comparison for this site. The concentrations of volatile organics detected in the samples collected for this investigation were orders of magnitude below the applicable PEL or Ceiling limits. The concentrations were also orders of magnitude below the one-tenth guidance for non-occupational settings. It is of importance to note that the samples were collected under "worst case" conditions for assessment of non-occupational exposures. The typical concentration of the volatile organics at the surface would be expected to be less due to dilution in an open area as opposed to the closed area sampled. It is our opinion that their is no reasonable risk of exposure or adverse health effects for site occupants.

In addition to comparing the concentrations of volatile organics to the PELs, the equivalent exposure was calculated using the method presented in WAC 296-62-07507. This calculation is based upon the assumption that the measured volatile organics have similar health effects. The equivalent exposure is calculated by dividing the concentration for each compound by the exposure limit for that compound. The results are added together to derive the equivalent exposure which must be less than 1.0 to be within acceptable limits. To calculate the equivalent exposure for this investigation, the greatest concentration of each analyte detected was utilized. This produced a conservative equivalent exposure value since not all of the volatile organic compounds detected were present in each sample. When calculated in the manner described above, the equivalent exposure equaled 0.01, well below the limit of 1.0.



LEGEND

SVP-7 ●	SOIL VAPOR PROBE SAMPLE NUMBER AND LOCATION
ASL-5 ◎	AMBIENT AIR SAMPLING NUMBER AND LOCATION

Table 4

Analyte	Sample Number (with depth in feet)						
	SVP-1 (3)	SVP-2 (1 1/2)	SVP-3 (4)	SVP-4 (5)	SVP-5 (4)	SVP-6 (4)	SVP-7 (3)
Freon 12 (dichlorodifluoromethane)	1.9	<0.7	<0.85	<0.7	<0.8	1.1	0.92
Freon 11 (fluorotrichloromethane)	1.2	<0.7	<0.85	<0.7	<0.8	<0.95	<0.8
Chloroform	<0.7	<0.7	<0.85	<0.7	<0.8	12	0.91
Benzene	0.97	2.6	1.2	1.9	1.2	1.3	2.8
Trichloroethene	<0.7	0.9	<0.85	<0.7	<0.8	13	4.6
Toluene	1.5	1.4	2.2	2.1	1.8	1.1	<0.8
Tetrachloroethene	<0.7	0.78	<0.85	<0.7	<0.8	2.2	<0.8
Ethylbenzene	2.6	1.6	<0.85	9.4	12	<0.95	<0.8
m,p-Xylenes	4	2.3	<0.85	28	37	1	<0.8
o-Xylenes	1.8	1.6	<0.85	11	19	1.6	0.83
1,2,4-trimethylbenzene	1.1	0.71	<0.85	<0.7	<0.8	<0.95	<0.8
1,2,4-trichlorobenzene	<0.7	1	<0.85	<0.7	<0.8	<0.95	<0.8
Methane	<14,000	<14,000	<14,000	<14,000	<14,000	<14,000	<14,000
Hydrogen Sulfide	<50	<50	<50	<50	<50	<50	<50

Concentrations reported in parts per billion by volume (ppbv).

AGRA
Earth & Environmental
11335 N.E. 122nd Way, Suite 100
Kirkland, WA, U.S.A. 98034-6918

W.O. 11-08362-10
DESIGN RPC
DRAWN MJF
DATE SEP 1994
SCALE 1"=100'

CROWNHILL ELEMENTARY SCHOOL
BREMERTON, WASHINGTON

Figure 4

AIR MONITORING AND
SOIL GAS SURVEY LOCATIONS

AGRA EARTH & ENVIRONMENTAL, INC. DRAWING NO. \11\08362-10\SITE.DWG

APPENDIX B

SOP for Soil Vapor Sampling

NOTE: THIS SOP WAS UPDATED FOR THE NOVEMBER 2015 SAMPLING EVENT; REFER TO APPENDIX C OF THE COVER SYSTEM INSPECTION AND MAINTENANCE PLAN

APPENDIX C

Quality Manual Excerpts
Air Toxics, Limited

Appendix C
Quality Manual (Excerpts)
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APPENDICES

REFERENCES

4.0 QUALITY OBJECTIVES

The primary objective of the QA Program is to ensure that the laboratory is producing data that meet the laboratory's standard acceptance criteria for each method. Acceptance criteria from project-specific QAPPs are also used when required.

The laboratory's standard acceptance criteria and the sources of those criteria are specified throughout Section 6.0 of this Quality Manual. Definitions of parameters used to assess the quality of the data are defined below.

4.1 PRECISION, ACCURACY, REPRESENTATIVENESS, COMPLETENESS, AND COMPARABILITY

4.1.1 Precision

Precision measures the reproducibility of measurements. Analytical precision is the agreement among duplicate (two) or replicate (more than two) analyses of the same sample. The acceptance for precision is determined using the relative percent difference (RPD) between the duplicate sample results. The %RSD (relative standard deviation) is used to document precision of linearity for the initial calibrations. The formula for the RPD and RSD calculations are provided in Exhibit 4.1.

Field duplicate samples represent *total* precision, the reproducibility associated with the entire sampling, and analysis process. However, the identification of field duplicate samples are typically not known to the laboratory, and therefore not specifically evaluated by the laboratory's QA department.

4.1.2 Accuracy

Accuracy measures correctness and includes components of random error (variability due to imprecision) and systemic error. Analytical accuracy is measured by comparing the percent recovery of analytes spiked (as compared to the expected value) to pre-established accuracy limits (i.e., acceptance criteria). Any type of spiked sample measures accuracy. The formula for calculation of accuracy is included in Exhibit 4.1 as percent recovery (%R) from pure and sample matrices.

4.1.3 Representativeness

Representativeness is achieved through use of the standard analytical procedures described in this Quality Manual.

4.1.4 Completeness

Completeness is the percentage of data, which meets the established acceptance criteria referenced in Section 6.0. ATL's goal is to achieve at least 95% completeness for both normal turn-around-time (TAT) and rush TAT data. Meeting the method specification outlined in each SOP prior to analyzing project samples is our means of achieving this goal.

4.1.5 Comparability

Comparability is the confidence with which one data set may be compared to another. The objective for this QA/QC program is to produce data with the greatest possible degree of comparability. Comparability is achieved by using standard analytical methods, reporting data in standard units, and using standard and comprehensive reporting formats.

4.2 LIMIT OF DETECTION, LIMIT OF QUANTITATION, AND INSTRUMENT CALIBRATION REQUIREMENTS

4.2.1 Limit of Detection

The Limit of Detection - LOD (or Method Detection Limit) is a statistically determined value (by Method Detection Limit per 40CFR

Part 136 Appendix B). The LOD must be less than the Limit of Quantitation (LOQ). If the true concentration is below this value, the analyte may not be detected. Each LOD study is repeated at least once per twelve-month period, when a new instrument is installed, when there is a major change in the analytical configuration such as column, detector, sample concentrator, sample loop size, etc. or when there is a major change in the extraction method such as solvent, extraction apparatus, clean-up procedure, etc.

All analytical constituents noted by methods in Section 6.0 are to be reported with a valid and current LOD, but in the case of special request compounds LODs are performed only when a client specifies it to be a project requirement. Special request compounds are reviewed by the Department Managers to determine the cost to the laboratory for additional LOD analyses. The additional value added is then factored into the bid that is submitted to the prospective client.

For Navy and DoD projects, the reporting limit for each compound must be 3 times the LOD value. Upon evaluation of the LOD if a compound does not meet this requirement, the results between the LOD and 3 times the LOD will be flagged as estimated values, even if the result is greater than the reporting limit.

4.2.2 Limit of Quantitation

ATL reports down to the Limit of Quantitation - LOQ (or Reporting Limit) which is the lowest concentration contained in a linear calibration.

The LOQ represents a uniform value that can be accurately detected for any particular analyte on each instrument thereby providing consistency for samples analyzed on different instruments. The Reporting Limit is verified by the statistical and analytical LOD studies.

The acceptance criterion for the LOD study is a value of less than the LOQ. Corrective action including raising the LOQ may be performed if the statistically and analytically determined LOD does not meet the stated criterion.

4.2.3 Instrument Calibration

Analytical instruments are calibrated in accordance with the referenced analytical methods and internal SOPs. The acceptance criteria are summarized in Section 6.0. All specific target analytes are included in the initial and continuing calibrations.

If multi-point calibrations do not meet acceptance criteria stated in the relevant SOPs, an option to narrow the range of the curve either by eliminating the low point or the high point of the curve may be considered providing all project criteria are still met. Otherwise, the entire calibration curve is repeated. Reanalysis of any level of the multi-point calibration in order to meet QC acceptance criteria is not allowed unless there is evidence of an anomaly such as instrument malfunction or an improper load volume. Documentation of the anomaly must accompany the raw data for the Initial Calibration. Elimination of any of the inner levels of the multi-point calibration in order to meet QC acceptance criteria is not allowed.

Records of instrument calibration and records that unambiguously trace the preparation of standards and their use in instrument calibration are maintained for 5 years. Calibration standards are traceable to standard materials.

A second source (or different lot) standard that contains all target compounds, as noted in the Section 6.0 tables, is analyzed after each initial calibration curve to verify that the standards are correct and the calibration is accurate. The acceptance criteria for the independent source recoveries are presented in Section 6.0.

In the case of special request compounds, a second source analysis is performed only when a client specifies it to be a project requirement. Special request compounds are reviewed by the Department Managers to determine the cost to the laboratory for additional second source analyses. The additional value added is then factored into the bid that is submitted to the prospective client.

Analyte concentrations are determined primarily using the average RF from the initial multi-point calibration.

4.2.4 Retention Time Windows

The techniques used to establish retention time windows for GC and HPLC analyses vary by method, based on the class of compounds targeted, as well as the instrument specifications (e.g., column type, etc.). Protocol for establishing retention time windows can be found in the method-specific SOPs.

4.3 ELEMENTS OF QUALITY CONTROL

The various types of QC samples are described below. The method specific laboratory QC sample frequency and acceptance criteria may be found in Section 6.0.

4.3.1 Analytical Batch Definition

For non-extractable methods, samples analyzed during a single 24-hour period along with associated matrix specific laboratory QC samples make up an analytical batch. At a minimum, any analytical batch will include a Laboratory Blank, CCV, LCS and an end check for non-GC/MS methods. Reporting of the batch QC samples varies according to project requirements. The number of field samples included in any one analytical batch is limited to 20.

In the case of samples that require extraction prior to analysis, the sample preparation process defines the batch. At a minimum, the sample preparation batch will include a Laboratory Blank and a Laboratory Control Sample (LCS). The maximum number of samples included within one preparation batch may not exceed 20 in one given day.

4.3.2 Continuing Calibration Verification (CCV)

A Continuing Calibration Verification (CCV) containing all analytes of concern is performed at the start of each day and, if required, at the start of every 12 or 24 hour clock for GC/MS analyses. GC and HPLC sample analyses are generally bracketed by opening and end check CCVs (TO-4A and TO-10A methods excluded). Mid-batch CCVs are also analyzed as per individual SOP.

The concentration of the CCV is usually near the mid-level of the calibration. The CCV is analyzed at other concentrations within the working range at least once a quarter, or more frequently if specified in an SOP. If the CCV fails to meet the performance criteria then the test is repeated with the same standard (or optionally with a different preparation of the same calibration mix). If the second analysis fails criteria, maintenance should be performed and the test repeated a third time. If the system still fails the calibration verification, a new multi-point calibration curve is performed.

4.3.3 Laboratory Control Spike (LCS)

Each analytical or extraction batch contains at least one mid-level spike using a second source (or different lot) standard containing all the target analytes or the target analytes required by the method. In the case of non-extracted batches, the LCS is generally analyzed daily prior to sample analysis, but may also serve as an End Check standard. If the stated criteria are not met, the system is checked and the standard reanalyzed. In the event that the criteria cannot be met, the instrument is recalibrated. In the case of extracted LCS, out-of-control recoveries result in data flags since samples cannot be re-extracted.

4.3.4 Internal Standard (IS)

For all GC/MS methods an IS blend is introduced into each standard and blank to monitor the stability of the analytical system. The internal standard acceptance criteria vary by method, but for all applicable analyses at ATL, if the internal standards for the blank do not pass the acceptance criteria, the system is inspected and the blank reanalyzed. Analyses are discontinued until the blank meets the internal standard criteria.

4.3.5 Surrogates

For GC/MS methods and some GC methods, the recovery of the surrogate standard is used to monitor for unusual matrix effects, gross sample processing errors, and to provide a measure of recovery for every sample matrix. The surrogate recovery acceptance criteria vary by method, but for all applicable analyses at ATL, if the surrogate recoveries for the Laboratory Blank do not pass the acceptance criteria, the system is inspected and the blank is reanalyzed. Analyses are discontinued until the blank meets the surrogate recovery criteria.

In some extractable methods, surrogates are added prior to extraction to monitor the efficiency of the extraction process. If the surrogate recoveries are outside acceptance limits, reanalysis occurs. Re-extraction of samples is not possible.

If the surrogate recoveries for a sample are outside the limits, the sample is reanalyzed unless obvious matrix interference is documented. If the surrogate recoveries are within limits in the reanalysis, the second analysis will be reported. If the surrogate recoveries are out of limits a second time, the initial analysis is reported with a narrative indicating that the acceptance criteria for surrogate recoveries are exceeded. Upon request, the data from the matrix effect confirmation analysis is provided to the client.

4.3.6 Laboratory Blank

A Laboratory Blank is analyzed after any applicable standards and prior to the analysis of project samples. A blank is also analyzed in the event saturation-level concentrations are incurred to demonstrate that contamination does not exist. For methods that involve an extraction, a Laboratory Blank is prepared with each set of no more than 20 samples per method per matrix.

The acceptance criterion for the Laboratory Blank is a result less than the Limit of Quantitation (Reporting Limit). The Laboratory Blank is analyzed immediately after the LCS (non-extractable analysis) or the CCV (extractable analysis) to ensure that both the instrument and extraction process are free from contamination. When samples that are extracted together are analyzed on different analytical clocks, a solvent (instrument) blank is analyzed to demonstrate that the instrument is free from contamination.

For work that falls under the scope of the DoD, the acceptance criteria for the Method Blank is as follows:
No analytes detected at ≥ ½ the RL. For common laboratory contaminants, no analytes detected ≥ the RL. If an analyte in the laboratory blank fails these criteria the associated samples must be reprocessed in another analytical batch unless the analyte resulted in a non-detect. In no sample volume remains for re-analysis, the results will be reported with the appropriate data qualifying code (B flag).

4.3.7 Laboratory Duplicate

Project samples are analyzed in duplicate on a minimum of 10% of the samples received. For some projects the required frequency is one duplicate analysis per analytical batch. The acceptance criteria for analytical reproducibility generally apply to analytes present at ≥ 5 times the Reporting Limit. If the noted criterion is exceeded, the sample is re-analyzed a third time. If acceptable reproducibility is still not obtained, the cause is investigated and the system is brought back to working order. If no problem is found on the system, the data is narrated to note the non-conforming event.

4.3.8 Matrix Spike

Matrix spiking permanently alters the native concentrations of whole air samples. Therefore, matrix spiking is performed only on samples, such as condensates, submitted as part of a sampling train or on extractable samples provided they are submitted in duplicate for matrix spike and in triplicate for the matrix spike duplicate. When applicable, matrix and matrix duplicate spiking is performed using a subset of target analytes. Recoveries and demonstrated reproducibility values, which do not meet the acceptance criteria, are flagged and explained in the laboratory narrative.

4.3.9 Field QC Samples

Field blanks, field spikes, and field duplicates are generally treated as normal project samples by the laboratory. The exceptions include methods in which the laboratory at the direction of the client specifically prepares the sample media. To assure consistency it is recommended that certified summa canisters connected to a sampling tee be used for the collection of field duplicate samples.

4.4 QUALITY CONTROL PROCEDURES

4.4.1 Holding Times

All sample preparation and analysis are to be completed within the method-required holding times. The analytical holding time for a non-extractable method begins the day of sample collection. For extractable methods, the holding time is calculated from the day of sample collection for the extraction process and from the day the extraction process begins for the analytical process.

If holding times are exceeded, a CAR form (Section 3.3.2) is generated, the client is notified, and situation is narrated on the final report.

4.4.2 Confirmation

GC and HPLC methods do generally not perform quantitative confirmation for air sample analysis. The exception is for analysis of pesticides by SW-846 methodology, in which case, second column confirmation is completed within the method-required holding times.

4.4.3 Standard Materials

All purchased supplies, reagents, solvents and standards are verified as acceptable and meeting criteria for analysis prior to use. All neat and liquid standards used are traceable to the National Institute of Standards and Technology (NIST) and NIST traceable weights are used to verify balance calibration. Documentation from the manufacturers is maintained to verify each standard. Gaseous standards (which are by nature unable to be quantified on a balance) are verified by accuracy documentation supplied by the manufacturer.

A second source (or different lot) standard is used to confirm the accuracy of primary source calibration standards. Ideally the second source is obtained from a vendor other than that of the primary standard. In the case

6.8 TO-14A/TO-15 VOLATILE ORGANIC COMPOUNDS BY SIM

This method involves Selective Ion Monitoring (SIM) GC/MS analysis of whole air samples collected in evacuated stainless steel canisters. Samples are analyzed for volatile organic compounds using EPA Method TO-14A/TO-15 protocols. An aliquot of the sample is withdrawn from the canister through a mass flow controller and concentrated using a cryogenic trap. The focused air sample is then flash heated through a hydrophobic drying system that removes water from the sample stream. The sample is then focused onto a cryogenic cooled column prior to analysis by GC/MS in the (SIM) mode.

Some MSD's can be set to acquire both SIM and full scan data simultaneously. This generates two separate data files in the analytical software. One file contains full scan data following the operating procedures outlined in this SOP and the other contains SIM data following the procedures in SOP #38. This allows a lower reporting limit for the selected SIM compounds. The results for each sample in a report will be from two separate data files originating from the same analytical run. The two data files have the same base file name and are differentiated with a "sim" extension on the SIM data file.

Certain compounds are not included in ATL's standard target analyte list. These compounds are communicated at the time of client proposal request. Unless otherwise directed, ATL reports these non-standard compounds with partial validation. Validation includes a 3-point calibration with the lowest concentration defining the reporting limit, no second source verification is analyzed, and no method detection limit study is performed unless previous arrangements have been made. In addition, stability of the non-standard compound during sample storage is not validated. Full validation may be available upon request.

Air Toxics Ltd. performs a modified version of this method. The target analyte list and Limit of Quantitation reflect relevant risk driving compounds and are available upon request. The method modifications, QC criteria, and QC summary may be found in the following tables.

Table 6.8.1 Summary of Method Modifications

Requirement	TO-14A	TO-15	Air Toxics Ltd. Modifications
Sampling/concentrator system	Nafion Drier.	Multi-sorbent concentrator.	Multi-sorbent concentrator
Blank acceptance criteria	< 0.2 ppbv.	< RL.	< RL.
Blank and standards	Zero air.	Zero air.	Nitrogen.
BFB absolute abundance criteria	Within 10% of that from previous day.	Not mandated.	CCV internal standard area counts are compared to ICAL, corrective action for > 40% D.
ICAL %RSD acceptance criteria	< 30% RSD.	≤ 30%, with two compounds allowed to ≤ 40%.	Project specific; default criteria is ≤30% RSD with 10% of compounds allowed out to ≤ 40% RSD.

Requirement	**TO-14A**	**TO-15**	**Air Toxics Ltd. Modifications**
Daily CCV	≤30% D.	≤30% D.	Project specific; default criteria is 70-130%. Compounds exceeding this criterion and associated data will be flagged and narrated. If more than 10% of compounds from the standard list recover outside of 70-130%, corrective action will be taken. Unless prior client approval; under no circumstances will samples be analyzed if any compound exceeds 60-140%.
Method Detection Limit	Not Specified.	Follow 40CFR Pt.136 App. B.	The MDL met all relevant requirements in Method TO-15 (statistical MDL less than the LOQ). The concentration of the spiked replicate may have exceeded 10X the calculated MDL in some cases.

Table 6.8.2 Internal Standards

Analyte	**Accuracy (% R)**
Bromochloromethane	60 - 140
1,4-Difluorobenzene	60 - 140
Chlorobenzene-d_5	60 - 140

Table 6.8.3 Surrogates

Analyte	**Accuracy (% R)**
1,2-Dichloroethane-d_4	70 – 130
Toluene-d_8	70 – 130
4-Bromofluorobenzene	70 – 130

Table 6.8.4 Summary of Calibration and QC Procedures for Methods TO-14A/TO-15 by SIM

QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**
Tuning Criteria	Every 24 hours, or every 12 hours if project requires.	SW – 846 tune criteria.	Correct problem then repeat tune.
5-6-Point Calibration	Prior to sample analysis	≤ 30% for standard compounds with 10% of the compound list allowed out to ≤ 40% RSD.	Correct problem then repeat Initial Calibration Curve.

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
Laboratory Control Standard (LCS)	After each initial calibration curve, and daily prior to sample analysis.	Recoveries for 90% of "Standard" compounds must be ±30%; for 80% of "Non-standard" compounds, recoveries must be ±40%. No recovery may be <50%. * If specified by the client in-house generated control limits may be used.	Check the system and re-analyze the standard. Re-prepare the standard if necessary. Re-calibrate the instrument if the criteria cannot be met.
Continuing Calibration Verification (CCV)	At the start of each day and, if required by a specific project, every 12 hours.	70-130%. Compounds exceeding this criterion and associated data will be flagged and narrated with the exception of high bias associated with non-detects. If more than 10% of compounds from the standard list recover outside of 70-130%, corrective action will be taken. Unless prior client approval; under no circumstances will samples be analyzed if any compound exceeds 60-140%.	Perform maintenance and repeat test. If the system still fails the CCV, perform a new calibration curve.
Laboratory Blank	After the LCS.	Results less than the laboratory reporting limit.	Inspect the system and re-analyze the blank.
Internal Standard (IS)	As each standard, blank, and sample is being loaded.	Retention time (RT) for blanks and samples must be within ±0.33 min of the RT in the CCV and within ±40% of the area counts of the daily CCV internal standards.	**For blanks:** inspect the system and re-analyze the blank. **For samples:** re-analyze the sample. If the ISs are within limits in the re-analysis, report the second analysis. If ISs are out-of-limits a second time, dilute the sample until ISs are within acceptance limits and narrate.
Surrogates	As each standard, blank, and sample is being loaded.	70 - 130%. * If specified by the client in-house generated control limits may be used.	**For blanks:** inspect the system and re-analyze the blank. **For samples:** re-analyze the sample unless obvious matrix interference is documented. If the %R is within limits in the re-analysis, report the second analysis. If %R is out-of-limits a second time, report data from first analysis and narrate.

QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**
Laboratory Duplicates	10% of the samples.	RPD ≤ 25% for detections >5 X's the RL.	Re-analyze the sample a third time. If the limit is exceeded again, investigate the cause and bring the system back to working order. If no problem is found with the system, narrate the data.

APPENDIX C

November 2015 Updates to Soil Vapor Intrusion Assessment Work Plan

Updated Table 2 - Cleanup Levels, Screening Levels, and Reporting Limits for PCOCs

2015 Sub-Slab Vapor Sampling, Crownhill Elementary School, Bremerton, Washington

Potential Compound of Concern (PCOC)	MTCA Method B Air Cleanup Level[(2)]		Sub-Slab Screening Level[(3)]	TO-15 Method Reporting Limit (Approx.)
	Non-Carcinogen	Carcinogen		
Freon 12	45.7	--	1,520	0.99
Vinyl chloride	45.7	0.28	9.33	0.51
1,1-Dichloroethene	91.4	--	3,050	0.79
trans-1,2-Dichloroethene(4)	--	--	--	0.79
1,1-Dichloroethane	--	1.56	52	0.79
cis-1,2-Dichloroethene(4)	--	--	--	0.79
Chloroform	44.8	0.109	3.63	0.98
Benzene	13.7	0.321	10.7	0.64
1,2-Dichloroethane	3.2	0.0962	3.21	0.81
Trichloroethene	0.914	0.37	12.3	1.1
Tetrachloroethene	18.3	9.62	321	1.4
Ethylbenzene	457	--	15,200	0.87
Xylenes (total)	45.7	--	1,520	1.7
1,2,4-Trimethylbenzene	3.2	--	107	0.98
Naphthalene	1.37	0.0735	2.45	1.0
Hydrogen sulfide	0.914	--	30.5	7.0

Notes:

1) All concentrations are in units of micrograms per cubic meter (ug/m^3).

2) MTCA Method B air cleanup levels were obtained from the CLARC Master Table on 11/3/15.

3) Sub-slab screening levels were obtained by dividing the most stringent MTCA Method B air cleanup level by 0.03, to conservatively account for soil vapor attenuation across the floor slab in accordance with Ecology guidance.

4) Chemical has been removed from Ecology's vapor intrusion (VI) list because toxicity values are no longer available in CLARC.

SOP for Installing and Sampling Permanent Sub-Slab Soil Vapor Monitoring Points (November 2015 Revision)

1 Sub-Slab Soil Vapor Point Installation and Sampling Procedures

The purpose of this SOP is to provide field personnel with an outline of the specific information needed to collect and document representative sub-slab soil vapor samples. The recommended sub-slab soil vapor sampling technique, as presented in this SOP, is based on the assumption that soil vapor samples should be representative of chemicals that may volatilize from the uppermost aquifer into the vadose zone.

1.1 Equipment and Materials

Temporary Installation

The following equipment and materials are required for temporary Vapor Pin™ installation:

- Rotary hammer drill.
- 5/8-inch diameter drill bit.
- 1½-inch diameter drill bit.
- ¾-inch diameter bottle brush.
- Wet/dry vacuum.
- Extension cord.
- Generator (if no power is available on site).
- Assembled Vapor Pin™.
- Vapor Pin™ installation/extraction tool.
- Dead blow hammer.
- VOC-free hole patch material (hydraulic cement) and putty knife, for hole repair after sampling.
- Appropriate personal protective equipment (PPE).

Permanent Installation

The following equipment and materials are necessary for permanent AMS vapor point installation:

- Rotary hammer drill with a 1-inch and a 2-inch carbide tipped bit.
- Extension cord and generator (if no power outlets are available).
- 3-inch (length) stainless steel (SS) screen assembly with locking cap (AMS GVP probe assembly or equivalent).
- Hose barb, stainless steel (1/4-inch).
- Teflon® tape.

- 100% Beeswax, to seal vapor port borehole annulus.
- Quick Set Concrete Patch, to seal vapor port borehole annulus.

Sample Collection

The following equipment and materials are necessary to properly conduct sub-slab soil vapor sampling (see Figure 1):

- Air pump and appropriate connection tubing, tee fittings, valves, and flow metering device for purging and sampling vapor ports.
- Sufficient number of Summa canisters with appropriate flow controllers and/or 1-liter Tedlar® bags to collect soil vapor samples.
- Equipment required for collection of samples using Summa canisters, including appropriate wrenches and pressure gauges.
- An accurate and reliable watch that has been properly set.
- A calculator.
- Field notebook, applicable sampling analysis plan, and Chain of Custody.
- Health-and-safety equipment and supplies (e.g., personal protective equipment [PPE]) as described in the relevant site health-and-safety plan (HSP).
- Shipping package for the Summa canisters or 1-liter Tedlar® bags.

When leak testing is required, additional equipment and materials include:

- Syringe or vacuum pump for shut-in testing.
- Leak test shroud of sufficient size to cover soil gas vapor probe or vapor pin.
- 1-liter Tedlar® bags to collect purged vapors and test for tracer gas.
- A soft gasket to seal the leak test shroud to the floor.
- Tracer gas (helium).
- Flow regulator with 1/8-inch barbed outlet and tubing to connect the helium gas cylinder to the shroud.
- MGD-2002 helium meter or equivalent.

1.2 Sub-Slab Soil Vapor Point Installation

Temporary Installation

Use the following steps to install Vapor Pins™:

- Prior to beginning, clear sampling locations for utilities, verify access agreements are in place, and obtain required permits, as appropriate.
- Set up wet/dry vacuum to collect drill cuttings.
- Drill a 5/8-inch diameter hole through the slab and approximately 1-inch into the underlying soil (if present).
- Remove the drill bit, brush the hole with the bottle brush, and remove loose cuttings with the vacuum.
- Place the lower end of the Vapor Pin™ assembly into the drilled hole. Unscrew the threaded coupling from the handle of installation/extraction tool, place the small hole located in the handle of the installation/extraction tool over the Vapor Pin™ to protect the barb fitting/cap, and tap the Vapor Pin™ into place using a dead blow hammer. Make sure the installation/extraction tool is aligned parallel to the Vapor Pin™ to avoid damaging the barb fitting.

Permanent Installation

Prior to sampling, it is recommended that the sub-slab vapor point be installed at least one day in advance to allow the seal to set up properly. However, the use of quick-setting concrete will allow for same day sampling if desired.

- Prior to beginning, clear sampling locations for utilities, verify access agreements are in place, and obtain required permits, as appropriate.
- Drill a 2-inch borehole to a depth of approximately 3 inches.
- Drill a 1-inch borehole through the center of the 2-inch borehole through the floor slab of the building foundation to a depth of approximately 12 inches below the surface.
- Construct the vapor point as shown in Figure 1 and insert such that the top of the assembly is set approximately 1/8-inch below the top of the slab.
- Seal the vapor port by melting the beeswax with a small butane torch. Pour the beeswax from the rubber plug up to the bottom ½-inch of the 2-inch borehole.
- Allow beeswax to solidify and harden.
- Mix Quick Set concrete patch and apply from top of beeswax seal to within ¼-inch of the top of the slab.

1.3 Sampling Procedure

Sample Train Assembly

Assemble sampling train. The sampling train will be set up so that the Summa canister is in-line between the vapor port and the air pump, with a valve between the canister and the pump (see Figure 1):

- Verify the Summa canister number engraved on the canister matches the number listed on the certified clean tag to insure proper decontamination of the canister was completed. Fill out the sample tag.
- Verify the canister valve is closed tightly and remove the threaded cap at the inlet of the canister.
- Attach the flow controller to the inlet of the canister; the flow controller will have a built in pressure gauge.
- Connect the tubing from vapor port to inlet of a ¼-inch tee fitting.
- Connect the Summa canister/flow controller to one outlet of the tee fitting.
- Connect air pump to the other outlet of the tee fitting, insert a ¼-inch shutoff valve between the tee fitting and the air pump.

Leak Testing

Where leak testing is required, shut-in testing of the sample train will be conducted to test the sample train (excluding the vapor point) for leaks. A shroud containing tracer gas will be used to test the vapor point. The shroud consists of a plastic PVC cap or equivalent. Three holes will be drilled near the top of the shroud; one for connection of the helium gas cylinder, one for connection of the helium gas meter, and one for connection of the sample train located outside the shroud (see Figure 1).

- Before purging or sampling begins, assemble the sample train and vapor shroud. Crimp or plug the silicon tubing connection at the vapor point.
- Attach either a syringe or vacuum pump to the downstream end of the purge point valve. Draw a vacuum of at least 15 inches of mercury and shut the valve.
- The sample train should hold vacuum for 5 minutes. If the gauge vacuum decreases during this time period, check/tighten all connections and retest.
- After successful shut-in test, remove the crimp or plug and attach to the vapor point. The tubing from the tee connection above the canister will pass through the wall of the shroud to connect with the air pump outside.
- Connect the helium cylinder to the leak test shroud using tubing from the flow regulator on the cylinder, through a hole in the top of the shroud. Be sure to keep the cylinder in an upright position at all times.
- Connect the helium meter to the leak test shroud.
- Use the flow regulator to slowly release helium into the leak test shroud until a concentration of 30%-50% helium is contained within the shroud. The helium

concentration will be measured using the helium meter. Maintain helium concentrations throughout the purging and sampling period by continuously bleeding cylinder gas into the shroud as needed.

Sample Collection

Prior to collecting the canister sample, the vapor port will be purged as described below. If leak testing is performed with helium, purged vapor contained in the Tedlar® bags will be field screened using the helium meter to ensure that the concentration of helium inside the bags is less than 5 percent of the shroud concentration. If leakage is detected, the vapor port seal will be enhanced and connections will be inspected and tightened. This process will be repeated until no significant leakage has been demonstrated.

- Purge the vapor port and sampling train at approximately 100 ml/min using the air pump to ensure the sample is representative of subsurface conditions. Capture purged vapor in 1-liter Tedlar® bags at the outlet of the air pump and release the vapor outdoors. Three-to-five tubing volumes should be removed. Use the following equation to calculate volume to be purged:

  $$\mathbf{V = \pi \ x \ r^2 \ x \ l}$$

  Where:

  V = Volume of tubing

  r = the inner radius of the tubing being used [inches]

  l = the length of the tubing being used [inches]

  $\pi = 3.14$

  (Convert to ml using 1-inch^3 = 16.387 ml to determine how long to purge port)

- If leak testing is performed with helium, purged vapor contained in the Tedlar® bags will be field screened using the helium meter after purging to ensure that the concentration of helium inside the bags is less than 5 percent of the shroud concentration.
- If the sampling and analysis plan calls for Tedlar® bag samples to be collected for analysis, these samples will be collected at the outlet of the air pump following purging of the vapor port (prior to collection of the Summa canister sample).
- Begin sample collection by closing the ¼-inch shutoff valve between the Summa canister and the air pump and opening the valve on the Summa canister. Immediately record the pressure on the gauge as the “initial pressure” on the tag attached to the canister.
- After sampling begins and the apparatus is verified to be operating correctly, leave the canister to fill.
- Record all sample information in the field book and/or applicable field forms including the following:
  - Canister number and sample identification,

  - Sample start date and times,
  - Location of sample (distance from walls shown on building floor plan),
  - Initial and final pressure of canister, and
  - Notes regarding leak test, if applicable.
- Return to check canisters periodically (depending on length of sample period), to ensure proper operation. It is necessary to check the canister prior to completion because the accuracy of the flow regulators can vary, causing the canisters to fill faster than expected. The final pressure at the end of sampling should be approximately -5 to -6 inches mercury (Hg). If the canister has already reached this point, sampling is complete, the canister valve should be closed, and the pressure recorded as the "final pressure" on the sample tag, the field book, and applicable field forms. Sample collection will be considered complete, regardless of final pressure, after the stated sample period has elapsed.
- Record the exact pressure of the canister and time at the end of sampling on the sample tag for that canister, in the field book, and on the applicable field forms.
- Verify that the canister valve is closed tightly, remove the flow controller, and replace the threaded cap at the top of the canister. Discard all sample tubing.
- Replace the vapor point cap using Teflon tape to seal the threads if permanently installed.

Post-Sample-Collection Procedures

Label all sample containers with the following information: sample identification, date and time sample was collected, the starting and ending canister pressure, the site name, and the company name.

Include all this information in the field book plus the ending time of sample collection, and transfer pertinent information to the Chain-of-Custody record. Pack all Summa canisters in the original shipping containers, sealed with a custody seal, and send to the lab for analysis. The official holding time for this analysis is 30 days. However, attempt to get samples to the lab as soon as possible to allow lab time to conduct re-runs, dilutions, and low-level analyses, as necessary prior to sample expiration.

Analysis

The soil gas samples should be analyzed using EPA Methods TO-14 or TO-15, and when necessary/possible, low-level analysis or Selective Ion Mode (SIM) analysis to obtain the lowest achievable detection and reporting limits. When leak testing is performed, samples should additionally be analyzed for helium. Other analysis will be included on a project-specific basis. Note the desired analytical methods on the Chain-of-Custody form, and be sure analysis for helium is specified for leak-tested samples.

Decontamination

Temporary vapor points must be decontaminated prior to re-use. Decontamination procedures include Alconox® wash, deionized water rinse, and heated in an oven to 130C for 30 minutes.

The Summa canisters will be individually cleaned and certified to 0.02 ppbv THC for the project-specific analyte list by the contract laboratory prior to shipment. Ensure that documentation of this certification is included on a tag attached to the canister and in the paperwork that accompanies the canister shipment from the lab.

Documentation

Record all field activities, environmental and building conditions, and sample documentation on the appropriate field forms and field notebook.

2 References

Department of Environmental Protection, Commonwealth of Massachusetts, Indoor Air Sampling and Evaluation Guide, WSC Policy #02-430, Boston, Massachusetts, April 2002.

EPRI, Reference Handbook for Site Specific Assessment of Sub-Surface Vapor Intrusion to Indoor Air, March 2005.

New Jersey Department of Environmental Protection, Vapor Intrusion Guidance, October 2005.

New York State Department of Health, Guidance for Evaluation Soil Vapor Intrusion in the State of New York, October 2006.

USEPA, Center for Environmental Research Information, Office of Research and Development, Compendium of Methods for Determination of Toxic Organic Compounds in Ambient Air, Second Edition, Compendium Method To-14A, Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography, January 1999.

USEPA, Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway Form Groundwater and Soils, EPA530-F-02-052, November 2002.

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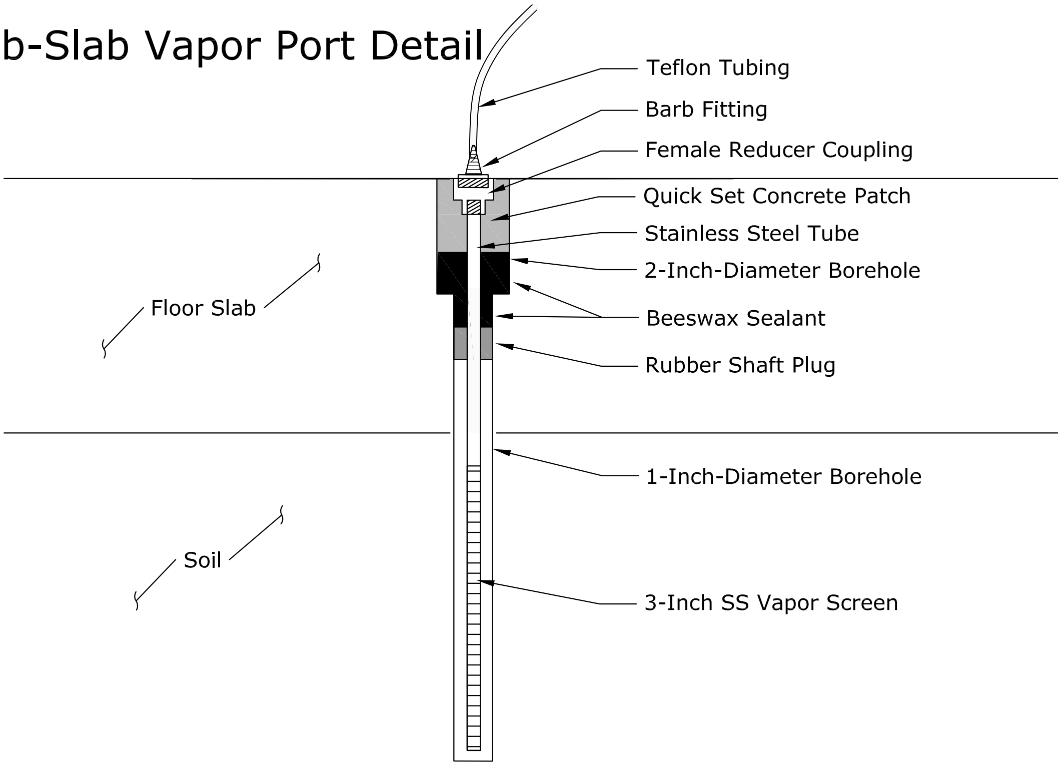
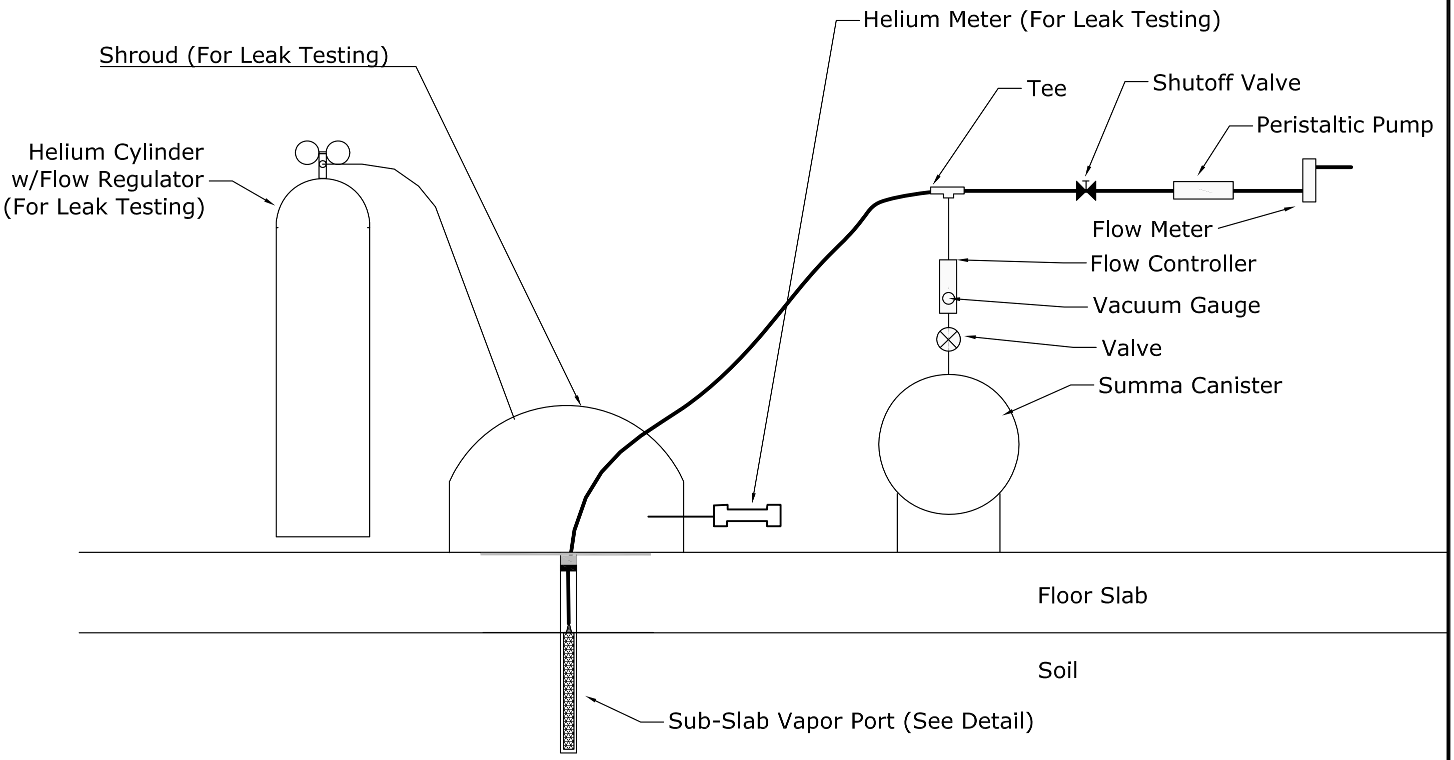
AMS Sub-Slab Vapor Port Detail



Sub-Slab Vapor Sampling Train



Aspect
CONSULTING

Sub-Slab Soil Vapor Sampling Apparatus
Standard Operating Procedures
Aspect Consulting, LLC
Seattle, Washington

DATE:	November 2015
DESIGNED BY:	EJM/ELG
DRAWN BY:	SCC
REVISED BY:	SCC/ELG
PROJECT NO.	XXXXXX
FIGURE NO.	1

U:\Vapor SOP\Figure 1_SS vapor point.dwg 8.5x11 Portrait

Nov 05, 2015 8:47am egeissinger