SUPPLEMENTAL SITE ASSESSMENT WORK PLAN
CHEVRON SERVICE STATION NO. 9-6590
232 East Woodin Avenue
Chelan, Washington

June 12, 2013

Prepared for:
Washington State Department of Ecology
15 West Yakima Avenue, Suite 200
Yakima, Washington 98902

Prepared by:
SAIC Energy, Environment & Infrastructure, LLC
18912 North Creek Parkway, Suite 101
Bothell, Washington 98011

On Behalf of:
Chevron Environmental Management Company
6101 Bollinger Canyon Road
San Ramon, California 94583

SAIC®

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SAIC

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1. INTRODUCTION

SAIC Energy, Environment & Infrastructure, LLC (SAIC) prepared this work plan, on behalf of Chevron Environmental Management Company (CEMC), to perform supplemental site assessment activities at the Chevron service station located at 232 East Woodin Avenue in Chelan, Washington (the Site). A site map is included as Figure 1.

This work plan presents the justification and proposed methodology to perform the following assessment activities at the Site:

- Conduct an additional vapor intrusion assessment to supplement the results of previous soil vapor sampling performed in 2003;
- Perform an assessment of light non-aqueous phase liquid (LNAPL) mobility and recovery through baildown testing at selected monitoring wells; and
- Abandon 13 soil vapor monitoring wells that were previously constructed at the Site.

2. OBJECTIVE

The primary objective of this supplemental site assessment effort is to collect additional data to support future decision making regarding cleanup of the Site. Specifically, this data will be used to reassess the potential for vapor intrusion risks at the Site, in order to determine whether future cleanup alternatives will be required to address contaminated soil vapor. Additionally, results of the LNAPL mobility and recoverability assessment will be used to evaluate the appropriateness of LNAPL recovery alternatives that may be considered for the Site.

Performance of these supplemental site assessment activities are considered to be the first steps in addressing the Washington State Department of Ecology's (Ecology) current concerns (as presented by letter dated November 1, 2012) regarding their 2006 approval of Alternative 2C (manual bailing) as the preferred cleanup alternative for this Site.

3. SUPPLEMENTAL VAPOR INTRUSION ASSESSMENT

3.1 BACKGROUND

As presented in the Final Remedial Investigation/Feasibility Study (RI/FS) Report for the Site, dated December 2006, SAIC installed 13 soil vapor monitoring wells and performed a single round of vapor sampling at the Site in June/July 2003. One soil vapor sample was also collected from a dry 2-inch diameter monitoring well (MW-33). Sample collection and data evaluation methods were consistent with generally accepted professional practices of that time. Vapor sampling results were modeled with location-specific input parameters using the Johnson and Ettinger Model, which predicted that conditions at the Site would result in an excess cancer risk of less than $1x10^{-6}$ and a noncarcinogenic combined-chemical hazard index (HI) of less than one. Results and conclusions of the 2003 vapor intrusion assessment were accepted by Ecology, as indicated by their January 2007 approval of the 2006 RI/FS.

Since 2003, vapor intrusion assessment methodology has evolved significantly, and in 2009 Ecology issued specific guidance for evaluating soil vapor intrusion in Washington State (Ecology, 2009), which remains in draft form to date. Due to the changes in best practices for soil vapor intrusion assessment, CEMC proposes to perform additional vapor intrusion assessment at the Site.

Within the tiered vapor intrusion evaluation process that is recommended by Ecology's vapor intrusion guidance, the soil vapor sampling performed by SAIC in 2003 would be consistent with a Tier 1 vapor intrusion assessment. Although modeling results performed at that time indicated that vapor intrusion was not an exposure pathway of concern, soil gas sampling results from 2003 indicate that benzene, toluene, and ethylbenzene were detected at concentrations exceeding Ecology's current draft Method B soil gas screening levels. Therefore, additional vapor intrusion evaluation, in the form of a Tier 2 assessment, is proposed for the Site.

3.2 TIER 2 ASSESSMENT

The objective of a Tier 2 vapor intrusion assessment is to determine whether volatile organic compounds (VOCs) in soil vapor are present beneath building foundations, and if so, are impacting indoor air in existing buildings at a site. To accomplish this, samples are collected of sub-slab soil vapor, indoor air, and outdoor (ambient) air, and the results are evaluated to determine whether hazardous substances are present in indoor air, and if so, whether they can be attributed to subsurface soil or groundwater contamination at a site.

In performing a Tier 2 assessment, it is typical to begin assessment efforts within existing buildings constructed with subgrade basement areas for the following reasons:

- Subgrade areas are likely to be closer in vertical proximity to subsurface contamination.
- Subgrade basement foundations may restrict oxygen diffusion to the vadose zone and therefore limit aerobic biodegradation. Several empirical studies demonstrate that where open soil is present, such as a crawlspace, oxygen diffusion into the vadose zone prevents flux of biodegradable petroleum hydrocarbons to the surface (Abreu and Johnson, 2006; Davis, 2009; Lavis et al., 2013; and Roggemans et al., 2001)
- Basements (unlike crawlspaces) are sufficiently large to be normally occupied for significantly long exposure durations.

Based on evaluation of currently available petroleum contamination distribution data for this Site, and previously gathered information regarding the construction of buildings within this area of concern, SAIC has identified the following properties to be evaluated as potential sampling locations for the Tier 2 assessment:

- 140 East Woodin Avenue
- 142 East Woodin Avenue
- 108 South Emerson Street
- 113 South Emerson Street
- 204 East Woodin Avenue
- 205 East Woodin Avenue
- 206 East Woodin Avenue
- 208 East Woodin Avenue
- 209 East Woodin Avenue
- 212 East Woodin Avenue
- 216 East Woodin Avenue
- 222 East Woodin Avenue
- 233 Sanders Street

Actual sampling locations will be determined based on the results of a preliminary evaluation of sampling locations, which is described in greater detail in the following section. Following completion of this evaluation, SAIC will prepare an addendum to this work plan that identifies the proposed locations of all sampling locations for the Tier 2 assessment. The work plan addendum will be submitted to Ecology for review and approval prior to performing additional Tier 2 assessment activities.

3.2.1 Preliminary Evaluation of Sampling Locations

The preliminary evaluation of sampling locations would consist of contacting the owner of each of the above-referenced properties to determine their interest or agreement with allowing installation of one or more sub-slab soil vapor probes and/or the collection of indoor air samples within their building(s). Upon gaining access to the properties, SAIC will perform an assessment of each property in order to determine its appropriateness for Tier 2 sampling. Property assessments will consist of a physical inspection of the property and building interior spaces, as well as interviews with property owners, residents, or workers, in order to determine the following:

- Property use;
- Building construction and condition, including foundation characteristics;
- Heating, ventilation, and air conditioning system details;
- Locations of utilities; and
- Possible locations for installation of sub-slab soil vapor probes.

The findings of the preliminary evaluation will be documented in the addendum to this work plan.

3.2.2 Sub-Slab Soil Vapor Sampling Probe Construction

Upon Ecology approval of the Tier 2 assessment sampling locations, and pending legal access to the associated properties, SAIC will begin construction of the proposed sub-slab soil vapor probes.

Prior to actual probe construction, SAIC, will subcontract a utility locating firm to survey the proposed locations for subgrade utilities or other infrastructure that could potentially be damaged during installation of the sampling probes.

Following final clearance of the probe location by the utility locate, SAIC will construct a permanent sampling probe similar to the example presented in Figure 2. The probe will be constructed by first using a rotary hammer drill to bore a 1-inch diameter hole approximately 1 to 1.5 inches deep in the concrete floor slab. A 5/16 inch diameter hole will then be bored at the center of the initial boring, to a depth of approximately 3 inches into the sub-slab material. Advancing the smaller diameter hole into the sub-slab material will create an open cavity that will prevent obstruction of the probe by small pieces of the sub-grade material.

Following completion of the boring, the sampling probe casing will be inserted in the completed hole. The sampling probe casing will consist of a stainless steel Swagelok fitting (1/4 inch Swagelok tube fitting x ¼ inch female NPT) that will be fitted with a short length of ¼ inch outside diameter (O.D.) stainless steel or nylon tubing. The female pipe thread side of the fitting will be plugged with a stainless steel pipe plug wrapped in Teflon thread sealing tape. The sampling probe casing will then be sealed in the boring using quick-drying Portland cement that will be hydrated with deionized water. The cement seal will be allowed to cure for a minimum of 24 hours prior to sampling.

3.2.3 Sub-Slab Soil Vapor Sample Collection

3.2.3.1 Sampling Equipment and Setup

Sub-slab soil vapor samples will be collected in 1-liter stainless-steel Summa canisters, which will be provided by Eurofins Air Toxics Laboratory, Inc. (Air Toxics) of Folsom, California. Each Summa canister used for sample collection will be individually certified (100-percent certified) to contain less than the reporting limit for each of the target compounds (see Section 3.2.7).

Prior to sample collection, the initial vacuum of each Summa canister will be measured to verify that the canister has not leaked or been inadvertently opened prior to the sampling event. The initial vacuum, which should be approximately 29 inches of mercury vacuum, will be recorded on the canister's identification tag and on a field data form.

Following the initial canister vacuum check, the sampling canister will be fitted with a sampling manifold, which will allow the canister to be connected to a second Summa canister that will be used to purge the soil vapor monitoring well and the associated sample collection train. The manifold will also be equipped with a filter and flow controller that will be calibrated to provide a sample collection flow rate of less than 200 milliliters per minute (mL/min). Where duplicate samples are to be collected (see Section 3.2.6), the sampling manifold will also allow connection of an additional Summa canister for simultaneous collection of a duplicate sample.

Sampling manifolds will be provided by Air Toxics and are 100-percent certified and matched to a specific Summa canister. The sampling manifolds are constructed using stainless steel tubing and Swagelok® valves and fittings. In order to ensure that matched canister/manifold combinations are used, both the canister and manifold identification numbers will be recorded on the field data form.

After connecting the sampling manifold to the sampling canister(s), a "shut-in" test will be performed as a preliminary leak check of the manifold connections. The shut-in test will be conducted by capping the inlet fitting of the manifold with a Swagelok® cap fitting. Vacuum will then be briefly applied to the manifold using the auxiliary Summa canister and then the valve between the manifold and vacuum source will be shut in order to seal the manifold under vacuum. Initial vacuum readings will then be recorded from the two vacuum gauges on the sampling manifold. After a period of approximately five minutes, the vacuum gauges will be checked again to verify that the initial vacuum levels have been maintained. If vacuum readings between the initial and final readings differ, it is an indication that one or more of the manifold connections has leaked. In that case, an attempt will be made to tighten the manifold connections, or otherwise remedy the manifold leak(s). However, if after a third attempt, a leak-free connection cannot be maintained, the Summa canister and sampling manifold will be removed from service and not used for sample collection.

3.2.3.2 Helium Tracer Leak Detection Setup

In order to verify the integrity of the sample collection system, helium gas will be used as a tracer to determine whether vapor samples have been compromised by leakage of ambient air. To accomplish this, a temporary shroud will be placed over the sample collection train, as shown in Figure 3. The shroud will be placed over the entire sample collection train, including the surface-seal of the sub-slab sampling probe. Laboratory-grade helium gas will then be introduced into the shroud to maintain a helium concentration of approximately 10 percent throughout the duration of the purge cycle and sample collection. A Mark 9822, or equivalent, helium detector will be used to monitor the concentration of helium in the sampling shroud. Laboratory results containing detectable concentrations of helium will be indicative of leakage in the sample train or at the surface seal of the sampling location.

3.2.3.3 Pre-Sample Purging

Prior to collecting a soil vapor sample, the sub-slab sampling probe and sampling train will be purged to remove stagnant air that would otherwise be drawn into the sample. This step is performed to ensure that the soil vapor sample is representative of actual soil vapor conditions beneath the building slab.

Purging will consist of removal of three volumes of the "dead-air volume" at each sampling location. The dead-air volume will be calculated by determining the volume of the casing in the sampling probe, plus the volume of the above-ground tubing and sampling manifold used to connect the sampling canister to the vapor well. Based on the total purge volume calculated, a purge time will be calculated by assuming a purge flow rate of 167 mL/min, which will be controlled by the flow controller on the sampling manifold. The purge cycle will then be completed by applying vacuum to the manifold, using the purge canister, for the duration of the calculated purge time. Upon completion of the purge cycle, the purge connection valve will be closed to reseal the sampling manifold.

3.2.3.4 Sample Collection

Following completion of the purge cycle, the valve on the sampling canister will be opened to begin sample collection. The start time, initial canister vacuum, and initial sample point vacuum will be recorded on the field data form. Collection of the single samples should require approximately 10 minutes, and approximately 20 minutes for a duplicate sample. During this time, the sampling technician will periodically check the canister vacuum to verify that the canister is filling at the expected rate, and monitor/maintain the helium concentration in the shroud. All observations will be recorded on the field data form. Sample collection will be stopped when the vacuum gauge on the sampling canister indicates that approximately 5 inches of mercury vacuum is remaining on the canister.

3.2.4 Indoor Air Sample Collection

Indoor air samples will be collected within building spaces where sub-slab soil vapor samples have also been collected. Samples will be collected in 6-liter stainless steel Summa canisters, which will be 100-percent certified by Air Toxics. Each canister will be fitted with a flow controller, which will ensure the proper sample collection duration, and an inlet "sampling cane" which will extend the sample collection inlet of the canister to a height of 3 to 5 feet above the floor level to provide a sample that is representative of the breathing zone.

Samples collected within commercial/industrial buildings will be collected over an 8-hour sampling duration in order to mimic the anticipated daily exposure by inhalation. Samples collected in residential buildings will be collected over a 24-hour period.

Prior to the start of indoor air sample collection, the initial vacuum of each Summa canister will be checked to verify that the canister has not leaked or been inadvertently opened prior to the sampling event. The initial vacuum, which should be approximately 29 inches of mercury vacuum, will be recorded on the canister's identification tag and on a field data form. During the sample collection period, the sampling technician will periodically check the canister vacuum to verify that the canister is filling at the expected rate. All observations will be recorded on the field data form. Sample collection will be stopped when the vacuum gauge on the sampling canister indicates that approximately 5 inches of mercury vacuum is remaining on the canister.

3.2.5 Outdoor Ambient Air Sample Collection

Outdoor ambient air samples will be collected at the same time that indoor air samples are collected, in order to evaluate whether ambient air quality may be influencing indoor air quality in buildings near the site. Ambient air sampling equipment will be the same as for collection of indoor samples. Ambient air sample canisters will be placed upwind of indoor air sampling locations, in an area that will be protected from weather elements, such as wind, rain, snow, or ice. Sample collection procedures for ambient air samples will be the same as for the indoor air samples.

3.2.6 Quality Assurance/Quality Control Sample Collection

In order to ensure quality assurance and quality control (QA/QC) of sample collection and laboratory methods, the following additional sampling will be performed:

- One equipment blank sample will be collected. The QA/QC equipment blank will be collected by passing laboratory-certified nitrogen through a representative length of nylon tubing, and a sampling manifold, into a 1-liter Summa canister.
- Two duplicate samples will be collected. The QA/QC duplicate samples will be collected using a duplicate sampling manifold, which allows two Summa canisters to be filled simultaneously in a parallel configuration.

3.2.7 Laboratory Analysis

Following collection of all sub-slab, indoor air, ambient air, and QA/QC samples, the samples will be submitted to Air Toxics for the following analyses:

- Benzene, toluene, ethylbenzene, and xylenes (BTEX); methyl tert-butyl ether (MTBE); and naphthalene by USEPA Method TO-15 (low level); and
- Oxygen carbon dioxide, methane, nitrogen, and helium by ASTM D1946.

Standard laboratory turn-around-time will be requested for each of the above-referenced analytical methods.

3.2.8 Sampling Event Scheduling

In order to account for seasonal variations that may affect subsurface conditions and/or conditions within the buildings, the Tier 2 assessment will consist of two discrete sampling events. One sampling event is anticipated to be performed during the summer "cooling season" and a second event will be performed during the winter "heating season."

Because soil vapor migration can also be impacted by fluctuations in barometric pressure, SAIC will also attempt to perform sampling events during periods of falling barometric pressure in order to collect samples under a conservative "worst case" scenario in which the pressure gradient would tend to induce migration of subsurface soil vapors toward the surface. However, due to weather pattern variability, and the logistical challenges associated with scheduling access to sample inside multiple building spaces, it may not be practical to ensure this condition is met.

4. LNAPL MOBILITY AND RECOVERABILITY ASSESSMENT

To facilitate further evaluation of LNAPL cleanup alternatives, SAIC proposes to perform LNAPL baildown testing at selected monitoring wells in order to quantify the current range of LNAPL transmissivity values at the Site.

LNAPL transmissivity represents the volume of LNAPL that will flow through a unit width of aquifer per unit of time and per unit of drawdown. Although it is dependent on formation (i.e., soil) properties, LNAPL transmissivity is also dependent upon additional variables, including LNAPL type, LNAPL saturation, and the thickness of mobile LNAPL present. LNAPL transmissivity is commonly determined by direct field-scale measurements through baildown testing, which measure the recovery of LNAPL to a well following a baildown event. Therefore, it is considered to be a directly proportional metric for LNAPL recoverability, whereas other metrics such as apparent LNAPL thickness gauged in wells do not exhibit a consistent relationship to recoverability. Because of the dependence of LNAPL transmissivity on multiple variables, it is expected that LNAPL transmissivity values will vary throughout the Site, due to variability in formation and/or LNAPL properties that are likely present. In addition, LNAPL transmissivity values are expected to change over the lifetime of a cleanup as LNAPL saturation levels are reduced.

Because LNAPL transmissivity represents an effective indicator of LNAPL recoverability, it is considered to be an important component in development of a Conceptual Site Model for LNAPL impacted sites. In addition to using LNAPL transmissivity data for evaluation of LNAPL recovery alternatives, transmissivity data collected over the lifetime of a cleanup action can also be used to evaluate the progress of a cleanup and to determine when further LNAPL recovery is no longer practicable.

To establish a baseline of LNAPL transmissivity values that are representative of current conditions at the Site, SAIC proposes to perform baildown testing at monitoring wells MW-10, MW-12, MW-15, MW-16, MW-25 and MW-36. This set of wells was selected to be representative of the variability in LNAPL occurrence that has been observed throughout the Site. Specifically:

- MW-10, MW-12, and MW-16 were selected because these wells have consistently displayed the greatest LNAPL thicknesses over time;
- MW-10 and MW-12 were also selected to be representative of the formation properties in the vicinity of the service station property, and of the alkylate rich LNAPL, with low lead content, that has typically been encountered in this area;
- MW-15, MW-16, MW-25 and MW-36 were selected to be representative of the formation properties in the vicinity of Emerson Street, and the alkylate poor LNAPL, with high lead content, that has typically been encountered in this area of the Site.

4.1 BAILDOWN TESTING METHODS

Baildown testing will be scheduled to be performed approximately one month following the previous LNAPL bailing event performed by Gettler-Ryan, Inc., in order to ensure that fluid levels in each of the wells have returned to equilibrium conditions.

Prior to the start of baildown testing, SAIC will record the borehole diameter, casing diameter, screen interval, and total depth of each well to be tested. All test data will be recorded on a field data form specific to the well being tested. An example field data form is included in Appendix A.

To begin each test, an interface probe will be used to measure the pre-test air/LNAPL and LNAPL/water interfaces of the test well. This data will then be used to calculate the approximate total LNAPL volume within the well casing and borehole, using the following equations:

1. $V_{fp} = S_{yf} * b * \pi * (r_b^2 - r_c^2) * 7.481$
2. $V_c = b * \pi * r_c^2 * 7.481$
3. $V_t = V_{fp} + V_c$

Where:

V_{fp} = Volume of LNAPL in the filter pack (gallons)

V_c = Volume of LNAPL in the casing (gallons)

V_t = Total effective LNAPL volume (gallons)

b = Gauged LNAPL thickness in the well (feet)

r_b = Borehole radius (feet)

r_c = Well casing radius (feet)

S_{yf} = Specific yield or storage coefficient of well filter pack (assumed to be 0.175)

7.481 = Factor to convert volume in cubic feet to gallons.

Following calculation of the total effective LNAPL volume, LNAPL will be removed from the well using a disposal bailer, or by peristaltic pump until the approximate total effective volume is removed. LNAPL and water removed from the well will be placed into a container that is graduated to measure within 10 percent of the total estimated recovery volume. The start time, end time, volume of LNAPL removed, and volume of water removed from the well will be recorded on the field data form.

Upon completing removal of the approximate total effective volume of LNAPL in the well, the time will be noted, and recorded as the starting point for observation of LNAPL recovery. Recovery monitoring will consist of collecting air/LNAPL and LNAPL/water interface measurements on a logarithmic-interval monitoring frequency. After 100 minutes, LNAPL thickness data will be plotted versus the log of time in order to determine whether the LNAPL thickness in the well has reached equilibrium conditions, or whether additional monitoring is necessary. For the purpose of this test, LNAPL thickness will be considered to be at equilibrium conditions when the plotted data indicate a plateau for approximately one quarter to one half of a log cycle, which consists of at least three measurements over that period.

4.2 BAILDOWN TESTING DATA ANALYSIS

Following collection of baildown testing measurements in the field, data from the tests will be analyzed using one or more of the methods presented in the technical paper "Analytic Determination of Hydrocarbon Transmissivity from Baildown Tests" (Huntley, 2000).

5. SOIL VAPOR MONITORING WELL DECOMMISSIONING

Currently, there are 13 existing soil vapor monitoring wells (VW-1A through VW-7B) at the Site, which were installed during remedial investigation activities performed in June and July 2003 (Figure 1). The existing soil vapor monitoring wells were installed within the sidewalk and parking areas along East Woodin Avenue and South Emerson Street, adjacent to selected buildings with subsurface basement areas.

Each soil vapor monitoring well was constructed using ¾-inch diameter PVC well casing and a 2.5 foot long section of 0.010" slot well screen, which was installed using a hollow-stem auger drill rig. The top of each vapor well is sealed with a petcock type valve that is enclosed in a flush-mount style wellbox. Boring/well construction logs for each of the soil vapor monitoring wells are included in Appendix B.

Construction of the existing soil vapor monitoring wells is not consistent with current best practices for soil vapor sampling; therefore, these wells are being proposed for decommissioning as part of the supplemental site assessment activities planned for the Site. The wells will be decommissioned under the supervision of a Washington State Licensed Driller by pressure grouting the entire casing length with bentonite slurry, neat cement grout, or neat cement, per the requirements of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." The wellbox for each well will then be removed and the top of the well column to the ground surface will be sealed with Portland cement. Restoration of sidewalk and street surfaces will be performed per the requirements of the City of Chelan Public Works Department.

6. REFERENCES

Abreu, L.D.V. and Johnson, P.C. (2006). "Simulating the Effect of Aerobic Biodegradation on Soil Vapor Intrusion into Buildings: Influence of Degradation Rate, Source Concentration, and Depth." *Environmental Science & Technology,* Vol. 40, pages 2304 – 2315.

API (2012). "A User Guide for API LNAPL Transmissivity Spreadsheet: A Tool for Baildown Test Analysis." American Petroleum Institute. January 2012.

ASTM (2012). ASTM Standard E2856, 2011e1, "Standard Guide for Estimation of LNAPL Transmissivity."

Davis, R. (2009). Bioattenuation of Petroleum Hydrocarbons in the Subsurface: Update on Recent Studies and Proposed Screening Criteria for the Vapor Intrusion Pathway." LUSTLine Bulletin 61, May 2009, pages 11-14.

Ecology (2009). "Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action" – Review Draft. Washington State Department of Ecology Publication No. 09-09-047. October 2009.

Huntley (2000). "Analytic Determination of Hydrocarbon Transmissivity from Baildown Tests." *Ground Water*, Vol. 38, No. 1, 2000, pages 46-52.

ITRC (2009). "Evaluating LNAPL Remedial Technologies for Achieving Project Goals." Interstate Technology & Regulatory Council. December 2009.

Lavis, M.A., Hers, I., Davis, R., Wright, J., and DeVaull, G.E. (2013). "Vapor Intrusion Screening at Petroleum UST Sites." Groundwater Monitoring & Remediation 33, No. 2, pages 53-67.

Roggenmans, S., Bruce, C.L., Johnson, P.C., and Johnson, R.L. (2001). "Vadose Zone Natural Attenuation of Hydrocarbon Vapors: An Empirical Assessment of Soil Gas Vertical Profile Data." American Petroleum Institute. December 2001.

SAIC (2006). "Final Remedial Investigation / Feasibility Study Report, Chevron Service Station No. 9-6590." December 2006.

7. LIMITATIONS

This technical document was prepared on behalf of Chevron and is intended for its sole use and for use by the local, state or federal regulatory agency that the technical document was sent to by SAIC. Any other person or entity obtaining, using, or relying on this technical document hereby acknowledges that they do so at their own risk, and SAIC shall have no responsibility or liability for the consequences thereof.

Site history and background information provided in this technical document are based on sources that may include interviews with environmental regulatory agencies and property management personnel and a review of acquired environmental regulatory agency documents and property information obtained from CEMC and others. SAIC has not made, nor has it been asked to make, any independent investigation concerning the accuracy, reliability, or completeness of such information beyond that described in this technical document.

Recognizing reasonable limits of time and cost, this technical document cannot wholly eliminate uncertainty regarding the vertical and lateral extent of impacted environmental media.

Opinions and recommendations presented in this technical document apply only to site conditions and features as they existed at the time of SAIC's site visits or site work and cannot be applied to conditions and features of which SAIC is unaware and has not had the opportunity to evaluate.

All sources of information on which SAIC has relied in making its conclusions (including direct field observations) are identified by reference in this technical document or in appendices attached to this technical document. Any information not listed by reference or in appendices has not been evaluated or relied upon by SAIC in the context of this technical document. The conclusions, therefore, represent our professional opinion based on the identified sources of information.

Figures

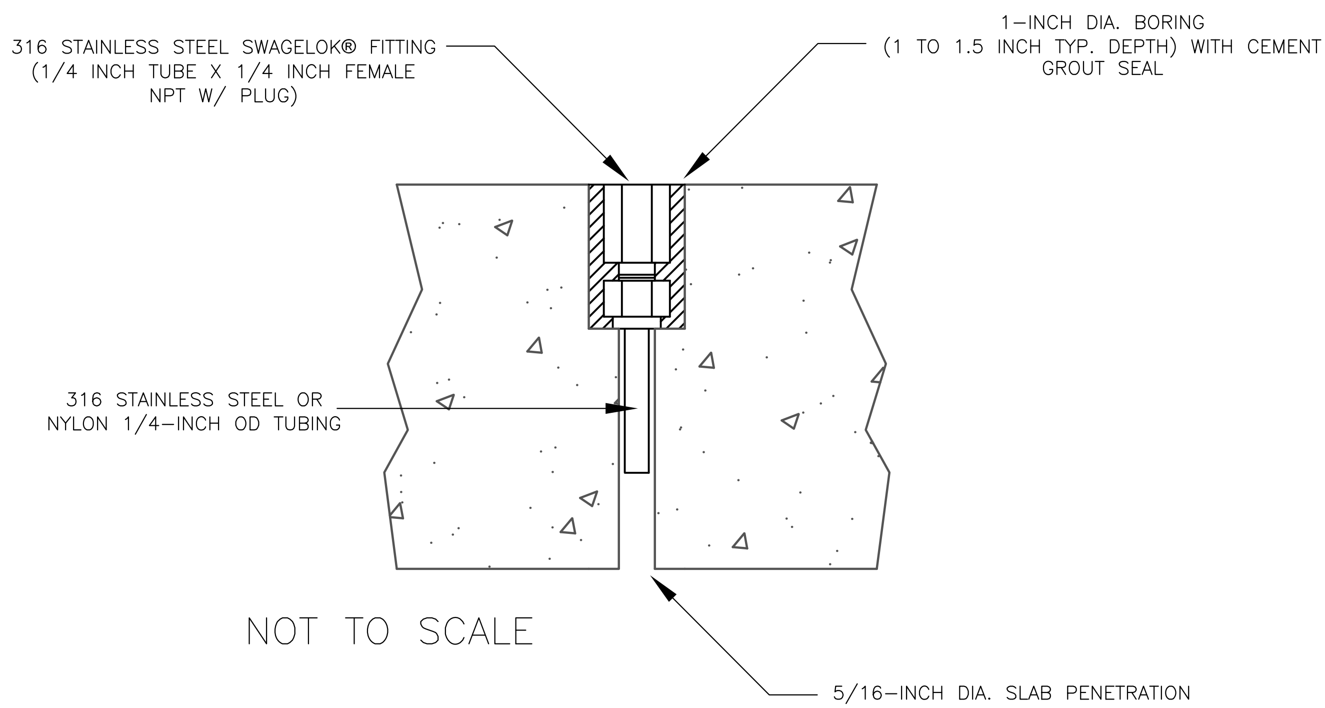
SAIC

Chevron Service Station No. 9-6590
232 East Woodin Avenue
Chelan, Washington

FIGURE 1
Site Map

FILE NAME: 96590_G-R Site Map.dwg

DATE: 06/10/2013



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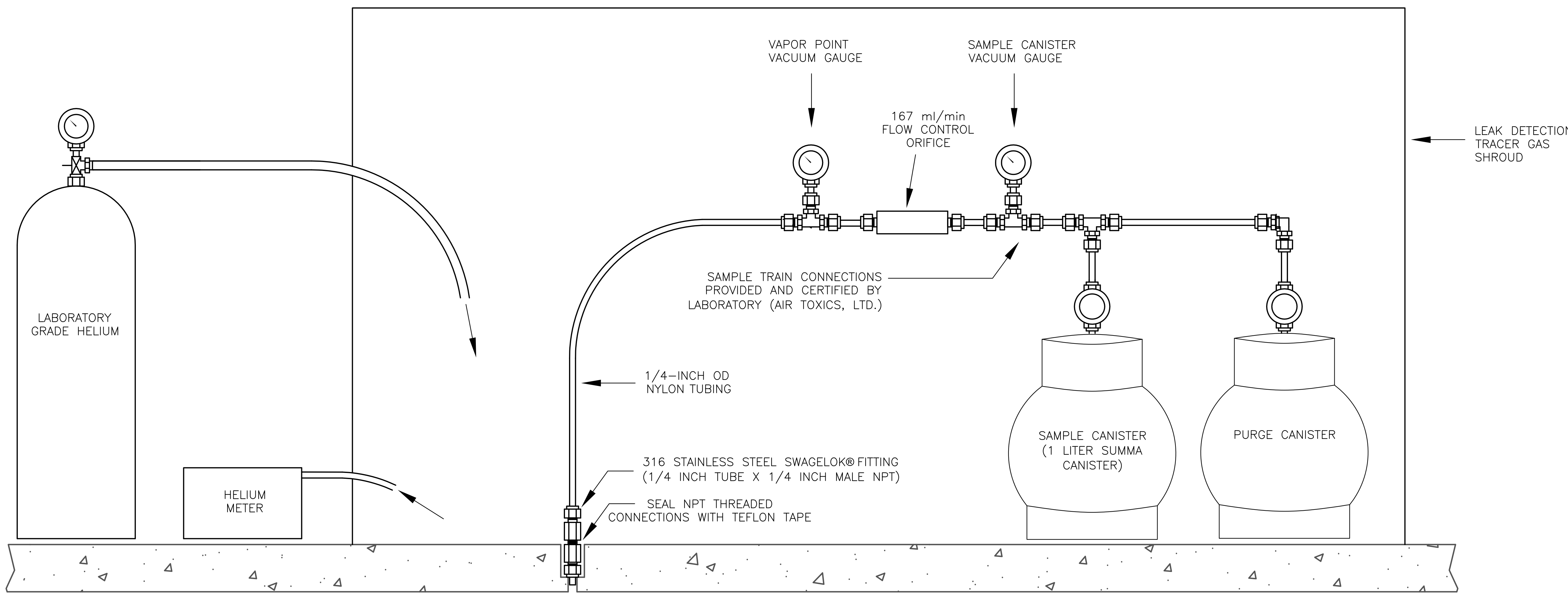
Chevron Service Station No. 9-6590
232 East Woodin Avenue
Chelan, Washington

FIGURE 2

Typical Sub-Slab Soil Vapor Probe Construction

FILE NAME:	DATE:
96590_VSE.dwg	04/26/2013



NOT TO SCALE

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Chevron Service Station No. 9-6590 232 East Woodin Avenue Chelan, Washington	FIGURE 3 Typical Sub-Slab Soil Vapor Sampling Equipment Setup
FILE NAME: 96590_VSE.dwg	DATE: 04/26/2013

Appendix A:
Field Data Forms

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LNAPL Baildown Test
Field Data Form
Chevron Service Station No. 9-6590
232 E. Woodin Avenue, Chelan, WA

Yellow Cells = Input Data; Blue Cells = Calculated Values

Test Well ID		Screen Slot Size (in)	
Data Collector(s)		Filter Pack	
Top of Casing Elevation (ft)		Specific Yield of Filter Pack*	
Total Well Depth (ft)		Well Radius (ft)	
Well Screen Interval (ft btc)		Boring Radius (ft)	
Well Diameter (in)		Effective Radius (ft)	
Boring Diameter (in)		T/K Correction Factor	
LNAPL Density (g/cm^3)*			

* = Assumed Values

Initial Test Conditions			
Initial Depth to LNAPL (ft)		Total Eff. LNAPL Volume (gal)	
Initial Depth to Water (ft)		Bailing Start Time	
Initial LNAPL Thickness (ft)		Amount of LNAPL Removed (gal)	
Corrected Water Table El. (ft)		Recovery Start Time	

Baildown Test Data

Elapsed Time (minutes)	Depth to LNAPL (ft)	Depth to Water (ft)	LNAPL Thickness (ft)
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
12			
14			
16			
18			
20			
25			
30			
35			
40			

45			
50			
55			
60			
70			
80			
90			
100			
110			
120			
140			
160			
180			
210			
240			
360			
720			
1440			

Notes:

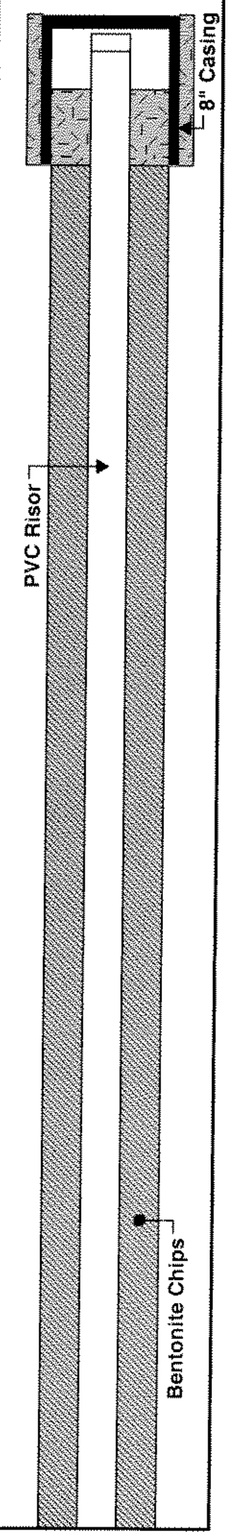
Appendix B:
Soil Vapor Monitoring Well Bore/Well Construction Logs

VAPOR BORING/WELL: VB-1A/VW-1A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 25'-27.5'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled 6-24-03	HOLE DIAMETER/DEPTH: 8"/34'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	DESCRIPTION
			0	Ground Surface Asphalt pavement. Airknife to 6' Silt with Sand and Gravel to 5'.
			5	Coarse cobbles up to 10"
Dry	0	26 50	9.5–10.5	**Silty, Gravelly SAND (SM)** Silty, gravelly fine SAND. Loose, no HC odor. Grayish brown color.
Moist	0	14 5 6	12.5–14	**SILT (ML)** Silt, with some clay-rich layers. Firm, no odor. Dark, grayish-brown color.
Moist	0	5 6 10	15–16.5	**SILT (ML)** Same as above, less clay. No odor. Olive-gray color.
Moist	0	5 5 8	17.5–19	**SILT (ML)** Same as above. Olive-gray color.
			20	

WELL COMPLETION DETAILS



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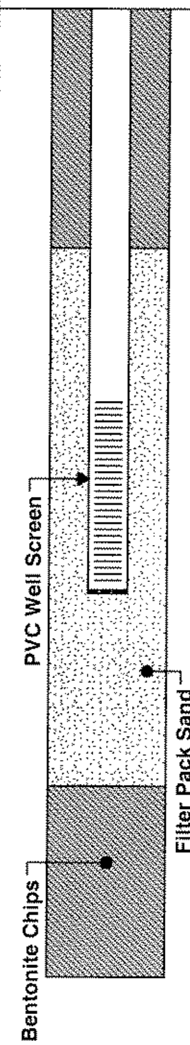
VAPOR BORING/WELL: VB-1A/VW-1A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 25'-27.5'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled 6-24-03	HOLE DIAMETER/DEPTH: 8"/34'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION
Very Moist	0	7 7 14	20 21			**SILT (ML)** Same as above (Silt with clay, 5%). Laminated, no odor.
			22			
Wet	0	5 4 7	23 24			**SILT (ML)** Same as above (Silt with minor clay). Firm to stiff, no odor.
Very Moist to Wet	0	2 3 5	25 26			**SILT (ML)** Silt, no evident clay nor sand. Firm to stiff, no odor.
			27			
Very Moist to Wet	0	3 3 5	28 29			**SILT (ML)** Same as above, but with 7-8% clay estimated.
Very Moist	0	6 7 9	30 31			**SILT (ML)** Same as above with 5% clay. Stiff, no odor. Olive-gray color.
			32			
Very Moist to Moist	30	3 4 7	33 34			**Clayey SILT (ML/CL)** Clayey Silt. Estimated 40% clay. Firm, weak to moderate HC odor. Olive-gray color.
			35 36 37 38 39			

WELL COMPLETION DETAILS



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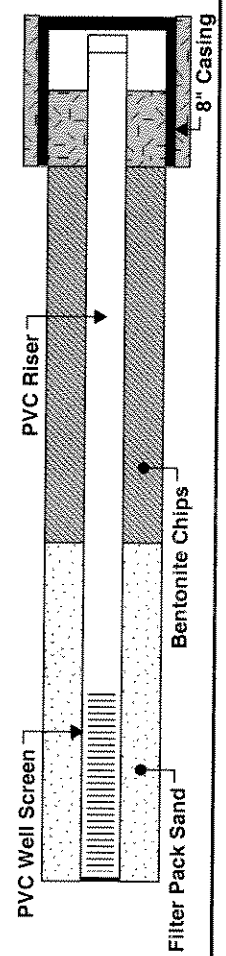
VAPOR BORING/WELL: VB-1B/VW-1B

SITE No: 9-6590	**DRILLER:** Cascade Drilling	**WELL SCREEN:** 0.75" 0.010" Slots
LOCATION: Chelan, WA	**DRILL METHOD:** Hollow-Stem Auger	**SCREEN INTERVAL:** 9'-11.5'
CLIENT: Chevron	**SAMPLE METHOD:** Split-Spoon	**WELL CASING:** 0.75" SCH 40 PVC
DATE: Drilled on 6-24-03	**HOLE DIAMETER/DEPTH:** 8"/11.5'	**FILTER PACK:** #2/12 Monterey Sand
LOGGED BY: Tom Dube'	**HAMMER WEIGHT:** 300 lbs	**TOC ELEVATION:** na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION	WELL COMPLETION DETAILS
						Ground Surface	
			0			**No Samples Collected** Airknife to 6' See log VB-1A/VW-1A for stratigraphy.	
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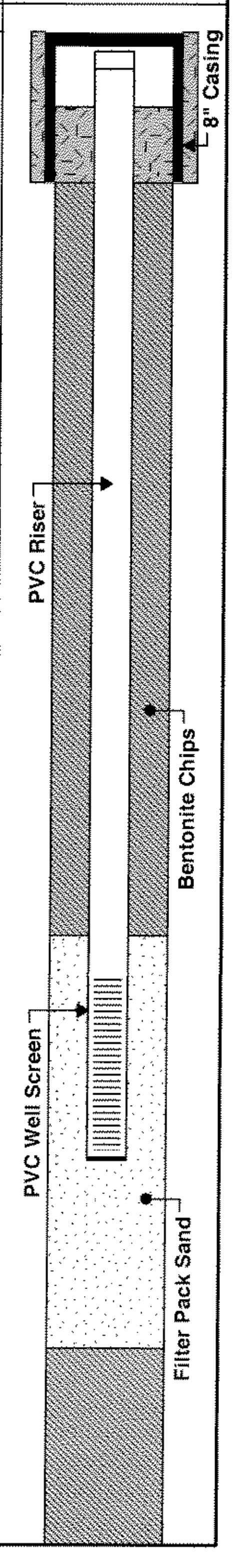
			19				
			20				

VAPOR BORING/WELL: VB-2/VW-2

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 12.5'-15'
CLIENT: Chevron	SAMPLE METHOD: Split-Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-24-03	HOLE DIAMETER/DEPTH: 8"/24'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	DESCRIPTION
			0	Ground Surface Asphalt pavement. Airknife to 8.5 ft. Silt with some gravel to 5 ft.
			5	**Gravel and Cobbles**
			7.5	**Natural Pea Gravel**
			8.5	**Gravelly Drilling**
Dry	0	28 50	10	**GRAVEL and SAND (GW-SW)** Gravel and Sand. Gravel up to 3". No odor. Olive-brown color.
Dry to Moist	0	12 20 28	12.5	**SILT (ML)** Silt with interbeds (15%) of sand and fine gravel (at base) with oxidized orange-brown silt, gravel, and plant debris. Stiff, no odor.
Damp	0	7 11 11	15	**Clayey SILT (ML/CL)** Silt with 40% clay, interbedded, laminated. Minor plant debris and trace gravel. Firm, no odor. Olive color.
Wet to Saturated	0	3 3 4	17.5	**Clayey SILT (ML/CL)** Same as above, wetter with depth and saturated in lower half of core. Firm.

WELL COMPLETION DETAILS



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VAPOR BORING/WELL: VB-2/VW-2

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 12.5'-15'
CLIENT: Chevron	SAMPLE METHOD: Split-Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-24-03	HOLE DIAMETER/DEPTH: 8"/24'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION	WELL COMPLETION DETAILS
Moist	0	5 5 7	20–21.5			**CLAY (CL)** Clay with lesser silt (about 30%). Interbedded and laminated. Clay is firm, and Silt is stiff to hard. No odor and no sand. Olive color.	Bentonite Chips
Wet to Moist	0	3 3 6	22.5–24			**CLAY (CL)** Similar to above, but some silt layers are wet. Clay is firm and Silt is firm to stiff. No odor. Olive color.	

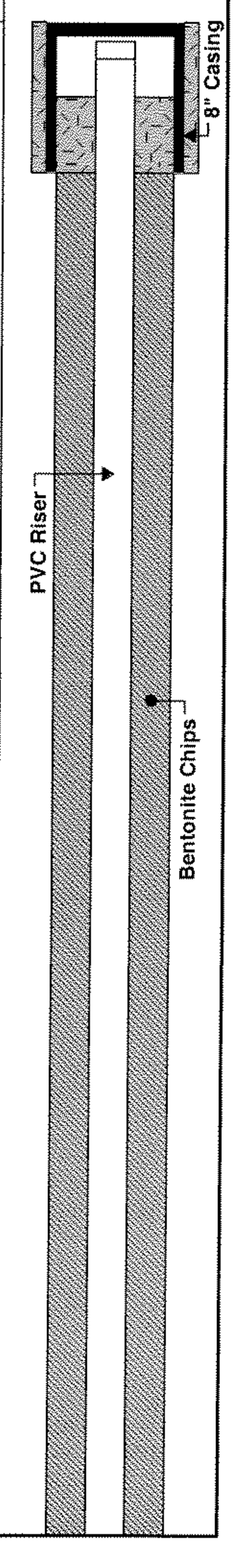
Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39

VAPOR BORING/WELL: VB-3A/VW-3A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 22.5'-25'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-25-03	HOLE DIAMETER/DEPTH: 8"/31.5'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION
			0			Ground Surface
			0–8			Concrete pavement. Airknife to 8 ft. Silt, gravel, and sand.
			8–10			Gravelly Drilling
Dry	5	12, 16, 19	10–14		10–11.5	**SAND (SP)** Medium Sand with minor gravel. Loose, no HC odor.
Dry	13	5, 7, 11	14–17		15–16.5	**SILT (ML)** Silt with trace clay (<5%). Laminated, firm, no odor.
Dry to Very Moist	14	5, 6, 10	17–19.5		17.5–19	**Silty CLAY (CL/ML)** Silty Clay, about 60% clay, laminated. Firm to stiff, no odor.
			20			

WELL COMPLETION DETAILS



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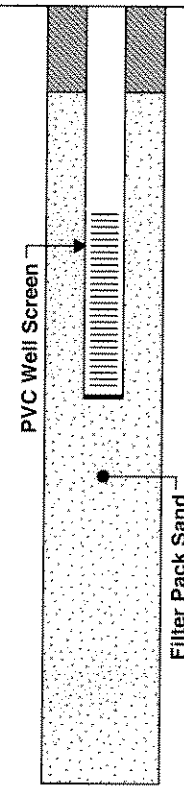
VAPOR BORING/WELL: VB-3A/VW-3A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 22.5'-25'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-25-03	HOLE DIAMETER/DEPTH: 8"/31.5'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	DESCRIPTION
Damp to Dry	14	9, 9, 9	20–21.5	**SILT (ML)** Silt with some very fine sand. Dry to damp, stiff, no odor.
			21–22	**Silty CLAY (CL/ML)** Silty Clay. Firm, no odor.
Moist to Wet	10	8, 12, 15	22.5–24	**CLAY and SILT (CL-ML)** Silt and Clay, about equal amounts. Moist to wet, wetter in silty zones. More clay in the lower half, silt in the upper half. Firm to stiff, no odor.
Very Moist to Wet	10	4, 4, 5	25–26.5	**CLAY and SILT (ML-CL)** Clay and Silt, about equal amounts with finer material in lower half. Firm, no odor.
Very Moist to Wet	5	3, 3, 11	27.5–29	**SILT (ML)** Silt with some clay (15%-20%). Firm to stiff, no odor.
Wet	450	5, 7, 12	30–31.5	**Clayey SILT (ML/CL)** Clayey Silt about 30% clay. Firm, strong HC odor.

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39

WELL COMPLETION DETAILS



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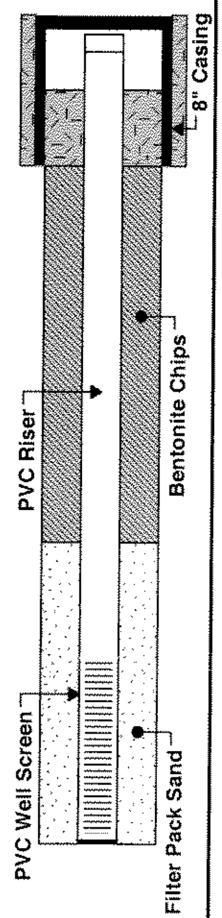
VAPOR BORING/WELL: VB-3B/VW-3B

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 8.5'-11'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-25-03	HOLE DIAMETER/DEPTH: 8"/11'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION	WELL COMPLETION DETAILS
						Ground Surface	
			0			**No Samples Collected** Airknife to 8 ft. See log VB-3A/VW-3A for stratigraphy.	
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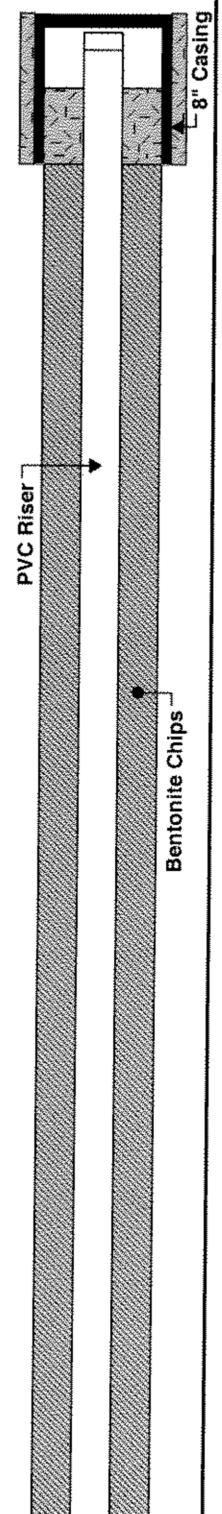
VAPOR BORING/WELL: VB-4A/VW-4A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 22.5'-25'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-26-03	HOLE DIAMETER/DEPTH: 8"/26.5'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	SAMPLE INTERVAL	DESCRIPTION
			0		Ground Surface
			0–8		Concrete pavement. Airknife to 8 ft. No samples, silt, gravel, sand; gravelly and cobbly near base.
			8–10		Gravelly Drilling
Dry	15	15	10–14.5	10–10.5	**Gravelly SAND (SW)** Gravelly Sand, loose, no odor. Grayish-brown color.
Dry	29	8 12 14	14.5–20	15–16.5	**SILT (ML)** Silt mostly coarse, but not true sand. Clay in lower 2 inches, with silt. Stiff, no odor. Olive-gray color.

WELL COMPLETION DETAILS



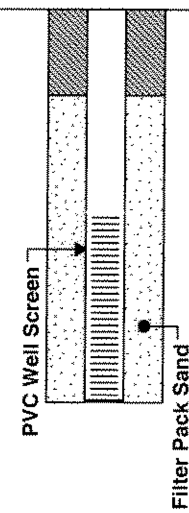
VAPOR BORING/WELL: VB-4A/VW-4A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 22.5'-25'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-26-03	HOLE DIAMETER/DEPTH: 8"/26.5'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION
Dry	28	3, 6, 5	20–21.5			**SILT (ML)** Silt with some clay (30%). Silt is fine. Firm, no odor. Olive-gray color.
Damp	152	x, x, x	25–26.5			**SILT (ML)** Silt with clay (25%) and some very fine sand/coarse silt layers (5%). Firm, strong HC odor. Olive color.

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39

WELL COMPLETION DETAILS



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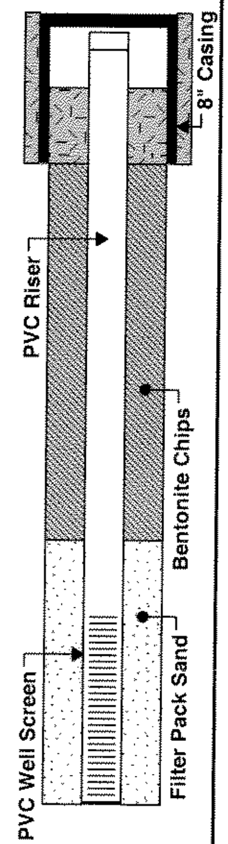
VAPOR BORING/WELL: VB-4B/VW-4B

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 8'-10.5'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-26-03	HOLE DIAMETER/DEPTH: 8"/10.5'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION	WELL COMPLETION DETAILS
			0			Ground Surface **No Samples Collected** Airknife to 8 ft. See log VB-4A/VW-4A for stratigraphy.	
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			19				
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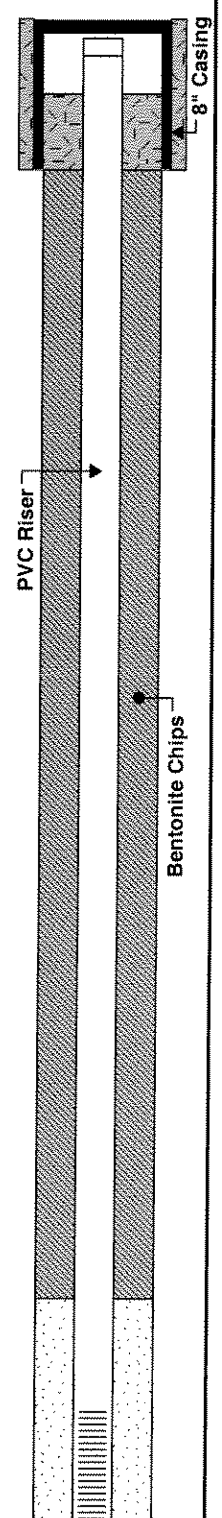
VAPOR BORING/WELL: VB-5A/VW-5A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 18.5'-21'
CLIENT: Chevron	SAMPLE METHOD: Split-Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-27-03	HOLE DIAMETER/DEPTH: 8"/24'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION
			0			Ground Surface
			0–7			Asphalt pavement. Airknife to 8 ft. Silt, gravel, and sand.
			7–13		10–11.5	Cobbly/gravelly with depth. **Sandy Gravel (GW)** Sandy Gravel, gravel up to 1 inch, but greater in formation. Loose, no odor. Grayish brown color.
Moist to Damp	25	3 5 5	13–20		15–16.5	**SILT (ML)** Silt with some clay (25%). Silt is mostly coarse, clay all in lower 8 inches. Firm to Stiff, no HC odor. Olive-gray color.

WELL COMPLETION DETAILS



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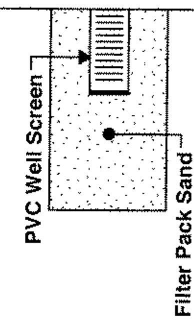
VAPOR BORING/WELL: VB-5A/VW-5A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 18.5'-21'
CLIENT: Chevron	SAMPLE METHOD: Split-Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-27-03	HOLE DIAMETER/DEPTH: 8"/24'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION
Damp to Moist	25	10 5 5	20 21 22			**SILT (ML)** Silt with minor clay (7%), silt is medium to coarse (almost very fine sand). Stiff, HC odor: weak in upper foot, strong in lower part. Greenish olive-gray color. (Sample labeled VB-5B-20; Duplicate Sample is VB-062703-D)
Moist	40	4 7 7	23 24			**Clayey SILT (ML/CL)** Silt with some clay (30%). Firm, Strong HC odor. Olive-gray color.
			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39			

WELL COMPLETION DETAILS

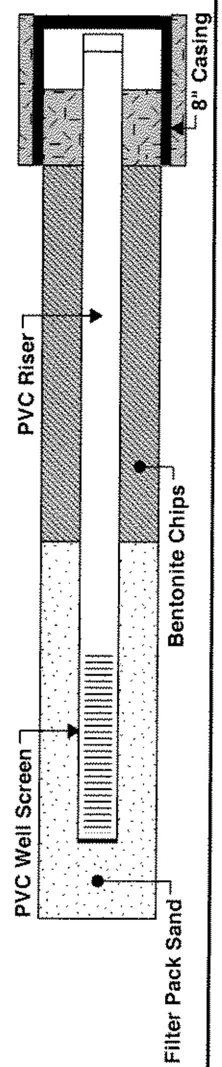


VAPOR BORING/WELL: VB-5B/VW-5B

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 8.5'-11'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-27-03	HOLE DIAMETER/DEPTH: 8"/12'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION
			0			Ground Surface Asphalt pavement. Airknife to 8 ft. Silt, gravel, and sand; cobbly/gravelly with depth.
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			Gravelly/Cobbly drilling. Less cobbles at 9.5'.
			9			
Dry	0	18 31 10	10 11			**Sandy Gravel (GW)** Sandy Gravel, gravel up to 1 inch, but greater in formation. Loose, no odor. Grayish-brown color. Very gravelly drilling, refusal at 12 feet, decide to set shallow well in this borehole further from building. (Sample is labeled as VB-5A-10)
			12			
			13			
			14			
			15			
			16			
			17			
			18			
			19			
			20			

WELL COMPLETION DETAILS



VAPOR BORING/WELL: VB-6A/VW-6A

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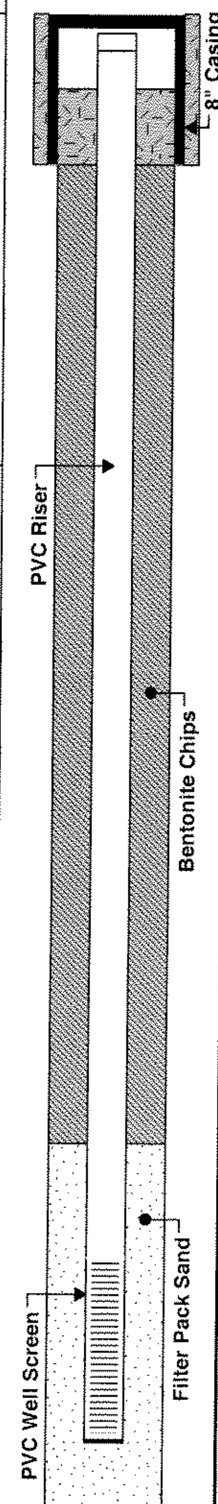
SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 16.5'-19'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split-Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-30-03	HOLE DIAMETER/DEPTH: 8"/21.5'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	SAMPLE INTERVAL	DESCRIPTION
			0		Ground Surface Asphalt pavement. Airknife to 8 ft. Silt with minor gravel and sand; cobbly/gravelly with depth.
			6		Cobbly
			8		**SAND** Sandy material.
Dry	10	12 14 15	10–11.5	10–11.5	**SAND (SP)** Grayish brown, fine to medium SAND, no odor, loose. Cobbly near 12 feet.
Moist to Very Moist to Damp	60	5 9 14	15–16.5	15–16.5	**Clayey SILT (ML)** Upper half is clayey SILT, firm, gray brown, no odor. Lower half (10) is medium to coarse silt, moderate HC odor. Greenish olive-gray color.
Moist to Very Moist	>2000	5 6 9	17.5–19	17.5–19	**SILT (ML)** Silt with some clay (20-25%). Some silt is coarse, almost very fine sand. Firm to stiff, Strong HC odor throughout (possible sheen). Greenish olive-gray color.
			20		

WELL COMPLETION DETAILS



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VAPOR BORING/WELL: VB-6A/VW-6A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 16.5'-19'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split-Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-30-03	HOLE DIAMETER/DEPTH: 8"/21.5'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION	WELL COMPLETION DETAILS
Very Moist	192	7 7 7	20 21			**SILT (ML)** Silt with little clay (10%). Silty very fine sand (olive) in upper few inches. Moderate odor throughout core. Olive-gray color.	
			22				
			23				
			24				
			25				
			26				
			27				
			28				
			29				
			30				
			31				
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			39				

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VAPOR BORING/WELL: VB-6B/VW-6B

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 9.5'-12'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split-Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 6-30-03	HOLE DIAMETER/DEPTH: 8"/12'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION	WELL COMPLETION DETAILS
						Ground Surface	
			0			**No Samples Collected**	
			1			See log VB-6A/VW-6A for stratigraphy.	
			2				
			3				
			4				
			5				
			6				
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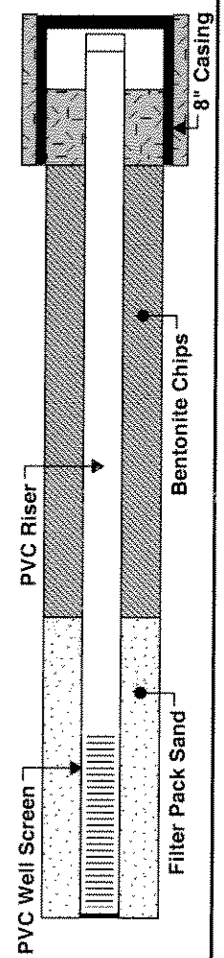
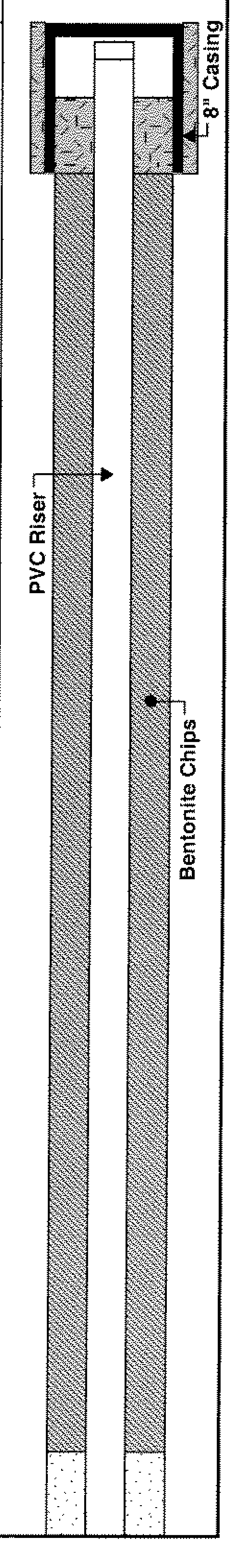


VAPOR BORING/WELL: VB-7A/VW-7A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 21'-23.5'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 7-1-03	HOLE DIAMETER/DEPTH: 8"/26.5'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	DESCRIPTION
			0	Ground Surface Asphalt pavement. Airknife to 8 ft. Silt, gravel, and sand; cobbly/gravelly with depth.
			7	Cobbly drilling.
Damp Dry	9	19 21 23	9.5–10.5	**SILT (ML)** Top of sample: silt, soft to firm; no odor. Chocolate brown color.
			10.5	**SAND (SW)** Bottom of sample: gravelly fine to coarse Sand. Gravel up to 1.5". Loose; no odor. Brown color.
			13.5	**Silty SAND (SM)** Upper part of sample: silty, very fine Sand, homogeneous; no odor.
Dry to Damp	7	12 19 15	15.75	**Sandy Gravel (GW)** Lower 9+ inches: Sandy Gravel, up to 1 inch, mostly <1/4 inch. Dense, no odor or a very weak HC odor. Light olive-brown color.
			18–20	



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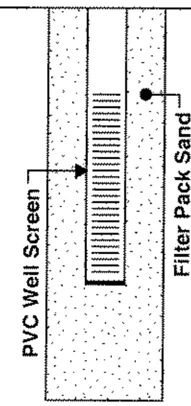
VAPOR BORING/WELL: VB-7A/VW-7A

SITE No: 9-6590	DRILLER: Cascade Drilling	WELL SCREEN: 0.75" 0.010" Slots
LOCATION: Chelan, WA	DRILL METHOD: Hollow-Stem Auger	SCREEN INTERVAL: 21'-23.5'
CLIENT: Chevron	SAMPLE METHOD: 3" OD Split Spoon	WELL CASING: 0.75" SCH 40 PVC
DATE: Drilled on 7-1-03	HOLE DIAMETER/DEPTH: 8"/26.5'	FILTER PACK: #2/12 Monterey Sand
LOGGED BY: Tom Dube'	HAMMER WEIGHT: 300 lbs	TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION
Damp	64	12 7 9	20 21			**SILT (ML)** Silt with minor clay (10%). Silt is med-coarse, some is close to very fine sand. Firm to stiff; strong HC odor in lower half or 2/3 of core. Olive gray color.
			22			
Very Moist to Wet	281	3 4 6	23 24			**Clayey SILT (ML/CL)** Clayey Silt (30% clay); interbedded. Firm; moderate to weak HC odor throughout. Olive-gray color.
Very Moist to Wet	101	3 4 5	25 26			**Clayey SILT (ML/CL)** Same as above. Moderate to strong HC odor throughout. Olive-gray; clay is pale olive.
			27 28 29 30 31 32 33 34 35 36 37 38 39			

WELL COMPLETION DETAILS

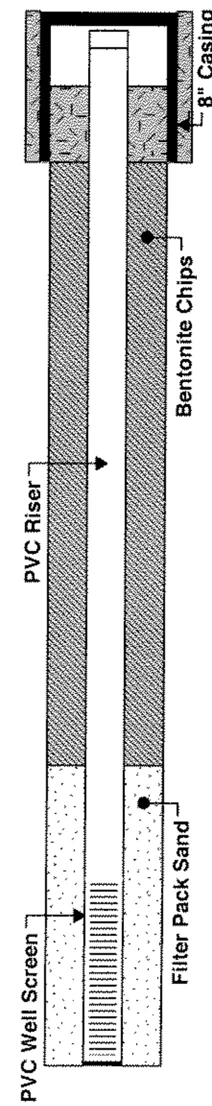


VAPOR BORING/WELL: VB-7B/VW-7B

SITE No: 9-6590
LOCATION: Chelan, WA
CLIENT: Chevron
DATE: Drilled on 7-1-03
LOGGED BY: Tom Dube'

DRILLER: Cascade Drilling
DRILL METHOD: Hollow-Stem Auger
SAMPLE METHOD: 3" OD Split Spoon
HOLE DIAMETER/DEPTH: 8"/14'
HAMMER WEIGHT: 300 lbs

WELL SCREEN: 0.75" 0.010" Slots
SCREEN INTERVAL: 11.5'-14'
WELL CASING: 0.75" SCH 40 PVC
FILTER PACK: #2/12 Monterey Sand
TOC ELEVATION: na

MOISTURE	PID (ppm)	BLOWS/6"	DEPTH	GRAPHIC LOG	SAMPLE INTERVAL	DESCRIPTION	WELL COMPLETION DETAILS
						Ground Surface	
			0			**No Samples Collected** Airknife to 8' See log VB-7A/VW-7A for stratigraphy.	
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