REPORT

CAPTURE ZONE FIELD TEST PLAN
GASCO, PORTLAND, OREGON

Prepared for

NW Natural

Prepared by

Anchor QEA, LLC
6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224

September 2009

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1 PURPOSE

NW Natural and Siltronic Corporation (Siltronic) are working with U.S. Environmental Protection Agency (EPA) under an Administrative Settlement Agreement and Order on Consent (Order) for sediments cleanup at the Gasco Sediments Site within Portland Harbor. Anchor QEA is also conducting interim design of groundwater/dense non aqueous phase liquid (DNAPL) source control measures for the Gasco Site working with Oregon Department of Environmental Quality (DEQ) under a separate order governing upland cleanup and source controls. The Preliminary Design Report Groundwater Source Control (Anchor 2008) was submitted to DEQ in June 2008. The primary purpose of this Field Test Plan is to provide information on likely offshore groundwater discharge rates under proposed future source control designs that is necessary for the design of the in-water sediment cleanup.

Under the Order, NW Natural and Siltronic must submit a Work Plan and other documents reviewing data in order to identify data gaps and prepare sampling plans to fill those data gaps. However, there is an obvious data need for more information on offshore groundwater discharge rates. Given the time needed to gather this information, this Field Test Plan is being submitted to EPA in advance of these other documents to expedite the collection of this necessary information and keep the design of the sediment remedy on schedule.

2 GENERAL APPROACH AND GOALS

One of the key Remedial Action Objectives (RAOs) for upland groundwater source control is to reduce upland groundwater gradients to result in near zero groundwater discharge to the river adjacent to the Gasco and Siltronic Sites. This RAO was identified in the June 2008 Preliminary Design Report (Anchor 2008) for upland source control, and the interim design for the extraction well system has focused on attaining groundwater capture along the shoreline.

While the source control design has progressed, NW Natural and Siltronic have signed the Order for sediments cleanup. The development of the Statement of Work (SOW) attached to the Order included evaluation of the interaction of upland source control with the design of the in-water sediment cleanup. Through studies conducted to date for upland groundwater source control design, it is understood that the shoreline extraction wells will control groundwater discharge from the Gasco Site into the river. Shoreline groundwater containment will also reduce groundwater discharge from the sediment mudline into the river channel within an area of the riverbed near the Gasco Site. Because regional groundwater discharge would still continue at some distance from the Gasco Site, the effect of the Gasco groundwater controls on groundwater flux would be expected to diminish to zero at some distance from the Site. At this time, we do not have an accurate estimate of the dimensions and magnitude of diminishing groundwater flux over this offshore area.

We plan to conduct modeling studies to predict the offshore area of groundwater seepage control that would result from operation of the upland shoreline extraction wells. To better inform these modeling efforts and assist in the overall design of the in-water sediment cleanup, it is important to measure the offshore area of seepage control that will be induced by the shoreline source control extraction wells. This information will factor into the dredge and cap design for the sediment cleanup. To accomplish this, we propose to conduct a field test to measure the offshore area of seepage control that results from operation of three extraction wells that are proposed to be constructed in shoreline Segment 2.

Segment 2 is one of three shoreline segments designated by NW Natural and approved by DEQ for identifying potential shoreline areas for source control. As shown on Figure 2, Segment 1 extends across portions of NW Natural and Siltronic property. Segment 2 is located on the north shoreline of NW Natural property. DEQ has designated Segments 1 and 2 as having high priority for source control. Segment 3 is located on the south shoreline of Siltronic property. The *Source Control Evaluation Report "Segment 3" Siltronic Property Related to NW Natural "Gasco" Site* (Anchor QEA 2009) was submitted to DEQ in February 2009, and comments have not yet been received from DEQ.

The findings from this field test in Segment 2 would help adjust and calibrate the groundwater model to better predict the area of offshore seepage control along the entire shoreline where sediment cleanup is expected to occur.

This Field Test Plan describes the process of constructing and testing shoreline extraction wells, upland monitoring wells, and offshore piezometers to accomplish the following goals:

1. Determine the offshore area of seepage control that results from pumping the shoreline wells at the pumping rate identified in goal 2.
2. Confirm the model-predicted pumping rates anticipated to achieve groundwater capture at the shoreline adjacent to the Gasco Site.
3. Determine if adjustments to the extraction well pumping rates are needed to change the area of offshore seepage control to better complement cost-effective offshore sediment cleanup.

The information collected during achievement of these goals would be used for the future design of the in-water cleanup action.

The following sections of this Field Test Plan cover the design and installation of test wells, field capture zone test, capture evaluation, equipment setup, Investigation Derived Waste (IDW) plan, project management, and schedule.

3 DESIGN, INSTALLATION, AND OPERATION OF TEST SYSTEM

The layout of the proposed source control extraction wells is shown on Figure 1. The subsurface profile on Figure 2 shows the current design depth and layout of the extraction well system for shoreline Segments 1 and 2.

Extraction wells PW-7, PW-8, and PW-9 are proposed to be installed for this field test. Those three wells were selected for two reasons: 1) the Fuel and Marine Marketing (FAMM) dock structure is offshore from the three wells, affording locations for installation of offshore piezometers; and 2) there is no upland DNAPL near these three wells, which means that test pumping these wells will have no significant effect on the distribution of DNAPL.

Some additional MODFLOW model runs were recently completed for the purpose of capture analysis and the design of these three extraction wells. The model findings are further discussed in Section 3.1. To calibrate the model, we propose to use offshore piezometers and additional upland monitoring wells to allow hydrology measurements in river sediments during pump testing of the upland extraction wells.

The details of well design and installation are provided in the following sections. Appendix A contains the methods and protocols that will be followed for construction and development of the wells and piezometers.

3.1 Extraction Well Design and Installation

Following submittal of the June 2008 Preliminary Design Report (Anchor 2008), DEQ requested additional groundwater flow modeling evaluations. Additional modeling work in 2008 resulted in the *Groundwater Flow Model and DNAPL Evaluation Supplemental Report* (Anchor and SSPA 2008). Following that work, DEQ requested additional assessment of groundwater gradient changes that would occur under varying extraction well depths and combinations. The additional maps and profiles from that assessment were submitted to DEQ on March 26, 2009.

Since March 26, additional model runs were conducted to help design the appropriate screen depth for the proposed extraction wells PW-7, PW-8, and PW-9. The MODFLOW model runs were conducted at individual well flow rates of 15, 20, 25, and 30 gallons per minute (gpm) to assess the range of effects on upland and offshore capture. These pumping rates were applied using alternate screen elevations of -20 to -50 feet and -50 to -70 feet, City of Portland datum. These two elevation ranges correspond to model layer boundaries in the Alluvial water bearing zone (WBZ). The model results indicate that shoreline extraction wells screened at the shallower -20 to -50 foot elevation, would be more effective at inducing hydraulic head reduction in offshore sediment porewater. Intuitively this makes sense, considering that the navigation channel river bottom elevation is about -40 feet, so pumping in these Alluvial layers has a more direct horizontal connection to shallow river sediments.

Based upon these model findings, extraction wells PW-7, PW-8, and PW-9 will be screened from approximately -25 to -45 foot elevation in the Alluvial WBZ. The proposed extraction wells screen intervals are shown on the subsurface profile on Figure 2a. The borehole geologic logs at each location will be examined in the field to confirm that the geologic units are present as shown on Figure 2a. If the geology is significantly different, a modification to the screen elevation may be made to avoid placing screens in significant silt or clay layers.

Table 1 shows the planned construction details for extraction wells PW-7, PW-8, and PW-9. The planned screen depths are believed to be appropriate to extend hydraulic head reduction out into the river sediments and control upland groundwater discharge to the river.

It is anticipated that operation of these shoreline extraction wells will control groundwater in the overlying upland Surficial Fill WBZ, although field testing of the completed source control system will be required to confirm this.

The wells will be constructed of the same materials used for pilot extraction well PW-4, which performed well in pump tests. Well casings measuring 8 inches in diameter with

Johnson stainless-steel wire wrapped screen will be used. These three wells are not near any DNAPL, so they are not planned to be constructed with annular DNAPL capture cones.

The wells will be constructed using sonic drilling methods. The planned annular seal, and annular backfill material are discussed in Appendix A, Well and Piezometer Construction and Development Plan.

3.2 Upland Monitoring Well Design and Installation

Hydrologic and water quality monitoring during the test will be done in wells from the existing upland monitoring network, plus some new monitoring wells proposed for installation. Table 1 shows the construction details for the existing and proposed wells. Figure 1 shows the locations of the existing and proposed wells. The subsurface profiles on Figures 2 and 3 show the screen depths of the proposed extraction and monitoring wells. The new monitoring wells will be drilled using sonic drilling methods in most cases, but access restrictions may dictate other drilling methods. Minor adjustments to the well locations shown on Figure 1 may be necessary due to access or FAMM leasehold concerns, but EPA will be consulted if a significant change is needed.

3.3 Offshore Piezometer Design and Installation

Hydrologic monitoring in offshore river sediment will be completed using piezometers constructed at the locations shown on Figure 1. Two existing piezometer nests were tested to confirm that the technology provides representative groundwater hydrologic measurement in river sediment.

The existing piezometers are PZ1-5, PZ1-20, PZ2-5, and PZ2-20. The PZ1 and PZ2 pairs are located on the FAMM dock access ramp as shown on Figure 1. Each pair consists of one piezometer screened from 4 to 5 feet and one piezometer screened from 19 to 20 feet below mudline. The subsurface profile on Figure 3 shows the screen depths of the PZ-1 and PZ-2 nested piezometers.

The piezometer construction details are shown on Table 1. The piezometers were installed the last week of March 2009 by Anchor QEA personnel using drive point techniques. The piezometers were equipped with 15 pounds per square inch (psi) In-Situ Mini Troll transducers. A transducer is also installed on the FAMM dock to measure river levels. Additional details on the planned hydrology monitoring equipment and methods are provided in Appendix B.

The PZ-1 and PZ-2 measuring point elevations have been surveyed. Figure 4 is a groundwater elevation hydrograph that also shows the river elevation. Figure 5 is a groundwater and river temperature graph. These show the water level and temperature fluctuations recorded by wells PZ-1, PZ-2, and the river transducers.

Review of the curves on Figure 4 indicates that hydraulic head changes in the four piezometers track concurrently with river level changes. This is consistent with the very short time lag that has been observed between river level changes and fluctuations in groundwater levels in near shore monitoring wells screened in Alluvial WBZ. The curves indicate a general upward vertical gradient in the offshore piezometers during falling and low river tide periods, with a near-neutral vertical gradient at high river tide periods.

Figure 5 shows a temperature graph for each of the four piezometers and the river. Until the fourth week of April, the river water was colder than the groundwater in all four piezometers, but the river water temperature has been slightly warmer than the groundwater temperatures in shallow piezometers PZ1-5 and PZ2-5 since about April 22. The temperatures measured for groundwater in the PZ1-20 and PZ2-20 piezometers are representative of groundwater temperatures measured in upland monitoring wells at the Site. These data are consistent with the conceptual site model of groundwater from the uplands discharging offshore. The cooler groundwater temperatures measured in the two shallow piezometers may be a function of the general cooling effect of the overlying river water.

These data and the observations on groundwater flow described above are consistent with the conceptual site model and indicate that the offshore piezometers are capable of providing accurate and representative hydraulic data for use in the proposed test. Therefore, it is planned to install nested piezometers PZ-3 and PZ-4 on the FAMM dock at the approximate locations shown on Figure 1. The proposed materials and other construction details for proposed piezometers are shown on Table 1.

3.4 Groundwater Treatment

Groundwater pumped from extraction wells PW7, PW-8, and PW-9 during the field testing will be piped to the carbon filtration system that is currently on site and discharged to the City of Portland POTW under the current industrial wastewater discharge permit. Depending upon the flow capacity of the existing carbon units, it may be necessary to rent another carbon unit to increase treatment flow capacity for these tests. The need for additional carbon treatment capacity is currently being evaluated.

4 FIELD CAPTURE ZONE TEST

The field test is designed to be conducted in at least one, and possibly a second, contingency phase. The planned field work is described in the following sections.

4.1 Phase 1 Field Test

The primary goal of Phase 1 is to determine the area of offshore seepage control that results from operating the extraction wells at the pumping rates necessary to achieve containment of upland groundwater at the shoreline.

The Phase 1 findings will also be evaluated to confirm the model-predicted extraction well pumping rates needed to achieve containment of upland groundwater at the shoreline.

The following Phase 1 steps are planned:

1. Record ambient hydrology data through a week of river tidal cycles. This will be done using water level transducers in the offshore piezometers, the river, and selected upland monitoring wells. Having these data will allow better interpretation of the field test data. Table 1 shows which of the wells and piezometers will be instrumented with water level transducers for these tests.
2. Conduct short-term tests of the extraction wells to determine the lag time for the effect of pumping in offshore piezometers. This will be done by operating the extraction wells near the high peak of the tidal cycles. The wells will initially be pumped about 2 hours during the tide peaks. By bracketing the tide peaks, it is hoped to maximize the ability to differentiate water level fluctuations in the offshore piezometers caused by well pumping from fluctuations caused by river tide changes. The pumping period and extraction well pumping rate will be adjusted as needed until a definitive response is measured in the offshore piezometers. The transducer data will allow determination of the lag time for response of water levels in the piezometers caused by pumping and shut down of the extraction wells. Knowing this lag time should facilitate interpretation of the long-term pump test data.

3. Conduct a series of long-term pump tests of the extraction wells. Table 2 lists the pumping rate at each extraction well for each test. The pump rates vary for each test based on the model results described in Section 3.1. Table 2 shows that the pump rates will be increased for each 72-hour test. Between tests the hydrologic data from the monitoring wells and piezometers will be reviewed to determine the degree of upland capture and offshore seepage control that results from each test.
4. Each of the tests shown on Table 2 will be conducted for approximately 72 hours. The rationale for the length of test period is explained in Section 5. The lag time test data derived from Step 2 will be used to determine the optimum time during tidal stages to start and stop the tests. Careful timing of test start and stop times should facilitate differentiation of water level changes in offshore piezometers that are caused by extraction well pumping versus river tide induced fluctuations. There may be adjustments to the pumping rates and the pumping periods shown on Table 2, depending upon the water level responses recorded during the tests.
5. The hydrology data from the tests outlined on Table 2 will be evaluated to determine if sufficient data are available to achieve the Phase 1 goal described in the beginning of this subsection. The data analysis methods that will be used to determine that offshore seepage control is achieved are described in Section 5.
6. If necessary, additional field tests of the extraction wells will be conducted until the data provide sufficient information to achieve the Phase 1 goal. The additional field tests might include pumping the extraction wells at different rates and/or for different test periods.

4.2 Contingency Phase 2 Field Test

As described in Section 4.1 and Section 5, the Phase 1 test data will be assessed to determine what degree of offshore seepage control is achieved at the extraction well pumping rates identified in Phase 1. If the degree and area of offshore seepage control achieved during Phase 1 testing are determined to be too inconclusive to allow model calibration and/or potentially inadequate to support the future in-water sediment

cleanup, further manipulation of extraction well pumping rates may be necessary in Phase 2.

A specific Phase 2 testing plan cannot be devised until the Phase 1 test results have been evaluated. If necessary, the goal of Phase 2 would be to determine if the extraction wells can be used to attain satisfactory offshore seepage control to provide additional information for the Feasibility Study analysis of future in-water sediment cleanup alternatives. If Phase 2 testing is necessary, it will likely include additional pump tests of extraction wells PW-7, PW-8, and PW-9. The Phase 2 pump tests could involve longer duration tests and/or testing the extraction wells at higher pumping rates. The hydrology data evaluation and seepage evaluation methods described in Section 5 would also be used to assess the Phase 2 test data.

5 CAPTURE AND OFFSHORE SEEPAGE EVALUATION

5.1 Phase 1 Evaluation

The primary component of this evaluation is the assessment of offshore seepage control. The Phase 1 data will also be used to confirm the model-predicted extraction well discharge rates required to achieve groundwater containment at the shoreline.

5.1.1 Assessment of Offshore Seepage Control

The offshore piezometer water level data from the Phase 1 field tests will be reviewed to determine the offshore area where seepage control was achieved at varying extraction well pumping rates. The offshore piezometer water level data will be evaluated using the methods described by Serfes (1991), as described in Section 5.1.2.

The offshore area of seepage control will be evaluated to determine the effect on conceptual plans for in-water sediment cleanup. If those results seem insufficient for use in the evaluation of Feasibility Study alternatives for the in-water sediment cleanup plan, a second phase of well testing may be necessary, as described in Section 5.2. Additionally, conducting Phase 2 may be considered if results are too inconclusive to allow adequate model calibration to estimate seepage control across the wider area of impacted in-water sediments.

5.1.2 Assessment of Upland Groundwater Capture

From the hydrology standpoint, uninfluenced upland groundwater only discharges to the river when the mean upland groundwater potentiometric surface elevation exceeds the mean river level elevation. This elevation difference creates a hydraulic gradient resulting in discharge of groundwater from the Site upland to river sediments. When in operation, the shoreline extraction wells will maintain the mean upland groundwater elevation below the mean river elevation, resulting in gradient reversal and near zero net flow of groundwater to the river. Under this condition, there will be flow of river water into the in-water sediments, mixture of river water with groundwater, and capture of the mixed groundwater/river water in the extraction wells.

As described in Section 4.1, water level data will be obtained during the pump tests using electric transducers installed in the river, the monitoring wells, and offshore piezometers. This will include evaluation of upland monitoring wells that are screened in the Surficial Fill and Alluvial WBZs.

Because the river tidal effect on the nearshore Alluvial WBZ is strong, an evaluation method that accounts for river tides will be used for this analysis. For this work, the analysis methods developed by Serfes (1991) will be used for determining the mean hydraulic gradient of groundwater affected by tidal fluctuations. These methods require that river levels and groundwater hydrology measurements be made for a test period of 72 hours. For the Gasco Site work, the transducer measurement interval will initially be set to take water level readings at 15-minute intervals during the 72-hour period. The Serfes method filters the hydrology data to obtain mean groundwater and river elevations. These mean elevations are used to determine groundwater gradients and groundwater flow direction. The transducers are vented to the atmosphere, so that barometric pressure effects on water levels are accounted for.

For example, the mean groundwater elevations measured in monitoring wells MW-22 and MW-23 will be used to determine if capture is being achieved at extraction well PW-9. In the condition that the mean groundwater elevations in those wells are maintained below the mean river elevation, capture will be considered achieved for extraction well PW-9. The same approach will be used for extraction wells PW-7 and PW-8 using the data from the adjacent monitoring wells.

Following each of the Phase 1 72-hour tests, the data will be evaluated using the methods described by Serfes (1991). Depending upon the findings from each 72-hour test, the well pumping rates for the succeeding test could be modified from those shown in Table 2. The groundwater elevation in the monitoring wells will decline as the extraction well pumping rate is increased during each step of Phase 1.

As data comes in during the testing, it may be decided to adjust the pumping rate in individual wells to assess the effect on capture near that well. The test data may

indicate that each well should have a different pumping rate to achieve capture along the shoreline.

5.2 Contingency Phase 2 Evaluation

The need for this contingency work will be determined by the evaluation described in Section 5.1.1. The goal of this work would be to determine how much of an increase in extraction well pumping rate would be needed to enlarge the area of offshore seepage control.

This work would include additional 72-hour well pumping tests at incrementally higher discharge rates. Logically, the increase in rates needed to expand the offshore area of seepage control should not be much higher than the rates that were determined in the earlier pump tests. If needed, this additional work would provide the data necessary to design an increase in pumping rates.

6 SUBSTANTIVE REQUIREMENTS

Typically, permits would be required for offshore monitoring work, as well as for placement of fill material within the greenway setback necessary to provide access for the drilling equipment needed to install extraction wells PW-7, PW-8, and PW-9. Because the in-water work is being conducted under a CERCLA order, no permits are required as long as the work complies with the substantive requirements of the permits normally required. Because work in the uplands for well installation is not physically part of the in-river sediments site, we intend to obtain the actual upland permits for this work. However, because it was not previously known whether the in-water work would proceed under a CERCLA Order, all relevant permits were applied for and have been received.

The following permit applications were submitted in June 2009 and all permits have been received from the respective agencies.

- The USACE Section 10 of the Rivers and Harbors Act of 1899 permit application, received September 14, 2009. This permit is typically required prior to the accomplishment of any work in, over, or under navigable waters of the United States, or work that affects the course, location, condition, or capacity of such waters. The project was authorized under Nationwide Permit #38 (Cleanup of Hazardous and Toxic Wastes). This permit expires September 14, 2011. The Field Test Plan meets all the requirements of the issued permit; therefore, the work can proceed.
- An approved Oregon Department of State Lands (DSL) Removal/Fill permit was received July 22, 2009. The permit expires July 22, 2010. The DSL requires a permit for any removal or fill activities that take place in waters of the state. While there are some exemptions depending on the amount removed or placed as fill, the Willamette River is considered "essential indigenous anadromous salmonid habitat" by DSL, which means a permit is required for removal or fill of any amount of material. This Field Test Plan meets all the requirements of the issued permit; therefore, the test plan can proceed.
- The approved City of Portland Greenway Letter of Determination was received

June 22, 2009 and will not expire. The City determined that Greenway Review was exempted within the code for cleanup related activities, so a modified Greenway Review was used for this project to address activities within the greenway setback. The Portland Bureau of Development issued the Letter of Determination, which concluded that the installation of the wells and placement of access road material in the setback will substantively comply with Greenway Development standards (with possible conditions). This Field Test Plan meets all the requirements of the Letter of Determination; therefore, the upland work described here can proceed.

The substantive requirements for a permit pursuant to the Clean Water Act Section 404 is not expected to be triggered by this activity, as there will be no discharge of materials into waters of the United States. The substantive requirements for an NPDES 1200-C permit is not expected to be triggered for this project because construction of the access road and installation of the wells and piezometers will not disturb more than 1 acre of land. Drilling activities are expected to be covered under the Standard Local Operating Procedures for Endangered Species (SLOPES) IV and therefore preparation of a Biological Assessment is not required. Regardless of whether the in-water work is conducted under a CERCLA order, it must be conducted within the Oregon Department of Fish and Wildlife (ODFW) approved in-water work window (July 1 to October 31, 2009). NW Natural must seek an exemption from ODFW to conduct this work outside of the approved work window. Anchor QEA is currently beginning discussions with ODFW concerning a possible work window exemption. It is anticipated that the exemption will be granted due to the relatively minor impact of the proposed project.

7 SCHEDULE

The following approximate schedule starts with EPA approval of this Work Plan and after required permits are obtained:

1. Construct Extraction wells, monitoring wells, and piezometers, 6 weeks
2. Conduct Phase 1 Testing
   - Phase 1 Ambient monitoring, 1 week
   - Phase 1 Lag Time Testing, 1 week
   - Phase 1 72-hour tests, 2 weeks
   - Phase 2 Contingency Testing, 2 weeks
3. Prepare Preliminary Technical Memorandum of Findings, 3 weeks. Per the requirements of the SOW, we anticipate that the formal results of this investigation would be provided at the same time as results of other data gaps efforts in the project Engineering Evaluation/Cost Analysis (EE/CA). However, the Preliminary Technical Memo can be provided to EPA before the EE/CA submittal, if EPA desires.

The above timelines result in 15 weeks total time from date of EPA Approval.

8 REFERENCES

Anchor Environmental, LLC. 2008. *Preliminary Design Report, Groundwater Source Control, NW Natural Gasco Site*. Prepared for NW Natural. June.

Anchor Environmental, LLC and SS Papadopulos, & Associates, Inc (SSPA). 2008. *Groundwater Flow Model and DNAPL Evaluation Supplemental Report, NW Natural Gasco Site*. Prepared for NW Natural. October.

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Serfes, Michael E. July-August, 1991. *Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations*. Ground Water. Volume 29, No. 4.

TABLES

Table 1
Well and Piezometer Construction Details
Gasco Siltronic, Portland, Oregon

Well Number	Planned Transducer	Water-Bearing Zone	Date Installed	Date De-commissioned	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet msl)	Top of Casing (feet msl)	Top of Casing (feet bgs)	Boring Depth (feet bgs)	Boring Depth (feet msl)	Top Screen (feet bgs)	Top Screen (feet msl)	Base Screen (feet bgs)	Base Screen (feet msl)
Existing Monitoring Well																			
MW-1-22		Surficial Fill	23-Oct-91	-	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020	10-20	2	32.00	34.75	(2.8)	22.0	10.0	11.0	21.0	21.0	11.0
MW-1-55		Alluvial	9-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.10	35.75	(2.7)	57.0	-23.9	45.0	-11.9	55.0	-21.9
MW-1-82		Alluvial	8-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.50	36.08	(2.6)	85.4	-51.9	72.0	-38.5	82.0	-48.5
MW-2-32	X	Surficial Fill	5-Nov-91	-	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	35.80	34.46	1.3	32.5	3.3	21.5	14.3	31.5	4.3
MW-2-61	X	Alluvial	7-Oct-94	-	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	34.70	34.41	0.3	61.5	-26.8	50.0	-15.3	60.0	-25.3
MW-2-104	X	Alluvial	24-Jun-03	-	Sonic	Flush	Continuous wrap stainless steel	0.020	10-20	2	34.90	34.92	(0.0)	116.5	-81.6	94.0	-59.1	104.0	-69.1
MW-3-26		Surficial Fill	31-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.20	34.11	(2.9)	26.0	5.2	15.0	16.2	25.0	6.2
MW-3-56		Alluvial	31-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.20	34.07	(2.9)	56.0	-24.8	45.0	-13.8	55.0	-23.8
MW-4-35		Surficial Fill	30-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	34.54	(2.8)	35.0	-3.3	24.0	7.7	34.0	-2.3
MW-4-57		Alluvial	29-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	34.53	(2.8)	57.0	-25.3	46.0	-14.3	56.0	-24.3
MW-4-101		Alluvial	15-Oct-94	-	Dual Wall Reverse Air	Above-grade	Slotted PVC (pre-pack)	0.010	20-40	2	31.80	34.36	(2.6)	120.0	-88.2	89.5	-57.7	99.5	-67.7
MW-5-32		Surficial Fill/Alluvial	26-Oct-91	-	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020		2	25.10	27.83	(2.7)	32.0	-6.9	21.0	4.1	31.0	-5.9
MW-5-100		Alluvial	22-Oct-94	-	Dual Wall Reverse Air	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	25.40	27.31	(1.9)	100.0	-74.6	88.0	-62.6	98.0	-72.6
MW-5-175		Alluvial	21-Oct-94	-	Dual Wall Reverse Air	Above-grade	Slotted PVC (pre-pack)	0.010	20-40	2	25.20	27.19	(2.0)	175.0	-149.8	163.0	-137.8	173.0	-147.8
MW-6-32		Surficial Fill	8-Nov-91	-	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.80	35.51	0.3	32.0	3.8	21.0	14.8	31.0	4.8
MW-6-61		Alluvial	6-Nov-91	21-Dec-93	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.80	34.50	1.3	61.0	-25.2	50.0	-14.2	60.0	-24.2
MW-8-29		Surficial Fill	25-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.09	(2.6)	29.0	7.5	18.0	18.5	28.0	8.5
MW-8-56		Alluvial	24-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.13	(2.6)	56.0	-19.5	45.0	-8.5	55.0	-18.5
MW-9-29		Surficial Fill/Alluvial	22-Oct-91	-	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	37.90	37.65	0.3	29.0	8.9	18.0	19.9	28.0	9.9
MW-10-25		Surficial Fill	8-Nov-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.22	(2.7)	25.0	11.5	14.0	22.5	24.0	12.5
MW-10-61		Alluvial	7-Nov-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.33	(2.8)	61.0	-24.5	50.0	-13.5	60.0	-23.5

Table 1
Well and Piezometer Construction Details
Gasco Siltronic, Portland, Oregon

Well Number	Planned Transducer	Water-Bearing Zone	Date Installed	Date De-commissioned	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet msl)	Top of Casing		Boring Depth		Top Screen		Base Screen	
												(feet msl)	(feet bgs)	(feet bgs)	(feet msl)	(feet bgs)	(feet msl)	(feet bgs)	(feet msl)
MW-11-32		Surficial Fill	2-Nov-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	35.40	38.39	(3.0)	32.0	3.4	21.0	14.4	31.0	4.4
MW-12-36		Surficial Fill/Alluvial	22-Oct-91	-	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020	10-20	2	35.90	38.69	(2.8)	36.0	-0.1	25.0	10.9	35.0	0.9
MW-13-30		Surficial Fill	18-Dec-93	-	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.23	34.86	0.4	30.0	5.2	19.0	16.2	29.0	6.2
MW-13-61		Alluvial	17-Dec-93	-	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.23	34.78	0.4	61.0	-25.8	50.0	-14.8	60.0	-24.8
MW-13-61R		Alluvial	31-May-03	-	Sonic	Flush	Continuous wrap stainless steel	0.020	38279.00	2	35.31	35.38	(0.1)	63.0	-27.7	51.0	-15.7	61.0	-25.7
MW-14-110		Alluvial	18-Oct-94	-	Dual Wall Reverse Air	Above-grade	Slotted stainless steel (pre-pack)	0.010	20-40	2	35.30	37.41	(2.1)	110.0	-74.7	98.0	-62.7	108.0	-72.7
MW-15-50		Alluvial	30-Jun-95	-	Air Rotary	Flush	Slotted stainless steel (pre-pack)	0.010	10-20	2	36.27	35.97	0.3	50.0	-13.7	40.0	-3.7	50.0	-13.7
MW-15-66		Alluvial	29-Jun-95	-	Air Rotary	Flush	Slotted stainless steel	0.010	10-20	2	36.27	36.06	0.2	66.0	-29.7	60.5	-24.2	65.5	-29.2
MW-16-45		Alluvial	19-Jul-00	-	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.81	33.12	(2.3)	49.0	-18.2	30.0	0.8	45.0	-14.2
MW-16-65	X	Alluvial	18-Jul-00	-	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.60	33.11	(2.5)	68.0	-37.4	55.0	-24.4	65.0	-34.4
MW-16-125	X	Alluvial	14-Jul-00	-	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.49	32.89	(2.4)	130.0	-99.5	115.0	-84.5	125.0	-94.5
MW-17-79		Alluvial	25-Jul-01	-	Sonic	Above-grade	Continuous wrap stainless steel	0.010	10-20	2	32.56	34.83	(2.3)	82.0	-49.4	38.5	-5.9	78.5	-45.9
MW-18-30		Surficial Fill	26-Feb-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.66	34.28	(2.6)	30.0	1.7	19.0	12.7	29.0	2.7
MW-18-180	X	Alluvial	25-Feb-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	33.92	(2.2)	230.0	-198.3	170.0	-138.3	180.0	-148.3
MW-19-22		Surficial Fill	5-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.40	29.82	(2.4)	23.0	4.4	12.0	15.4	22.0	5.4
MW-19-125		Alluvial	11-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.20	29.42	(2.2)	126.0	-98.8	115.0	-87.8	125.0	-97.8
MW-19-180		Alluvial	1-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.28	29.81	(2.5)	227.0	-199.7	170.0	-142.7	180.0	-152.7
MW-20-120		Alluvial	7-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	25.63	27.84	(2.2)	213.0	-187.4	110.0	-84.4	120.0	-94.4
MW-21-12		Surficial Fill	5-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.50	23.47	(3.0)	14.0	6.5	7.0	13.5	12.0	8.5
MW-21-75	X	Alluvial	4-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.50	23.13	(2.6)	77.0	-56.5	65.0	-44.5	75.0	-54.5
MW-21-115	X	Alluvial	1-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.50	23.47	(3.0)	118.0	-97.5	105.0	-84.5	115.0	-94.5
MW-21-166	X	Alluvial	27-Jun-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.50	23.19	(2.7)	193.0	-172.5	156.0	-135.5	166.0	-145.5

Table 1
Well and Piezometer Construction Details
Gasco Siltronic, Portland, Oregon

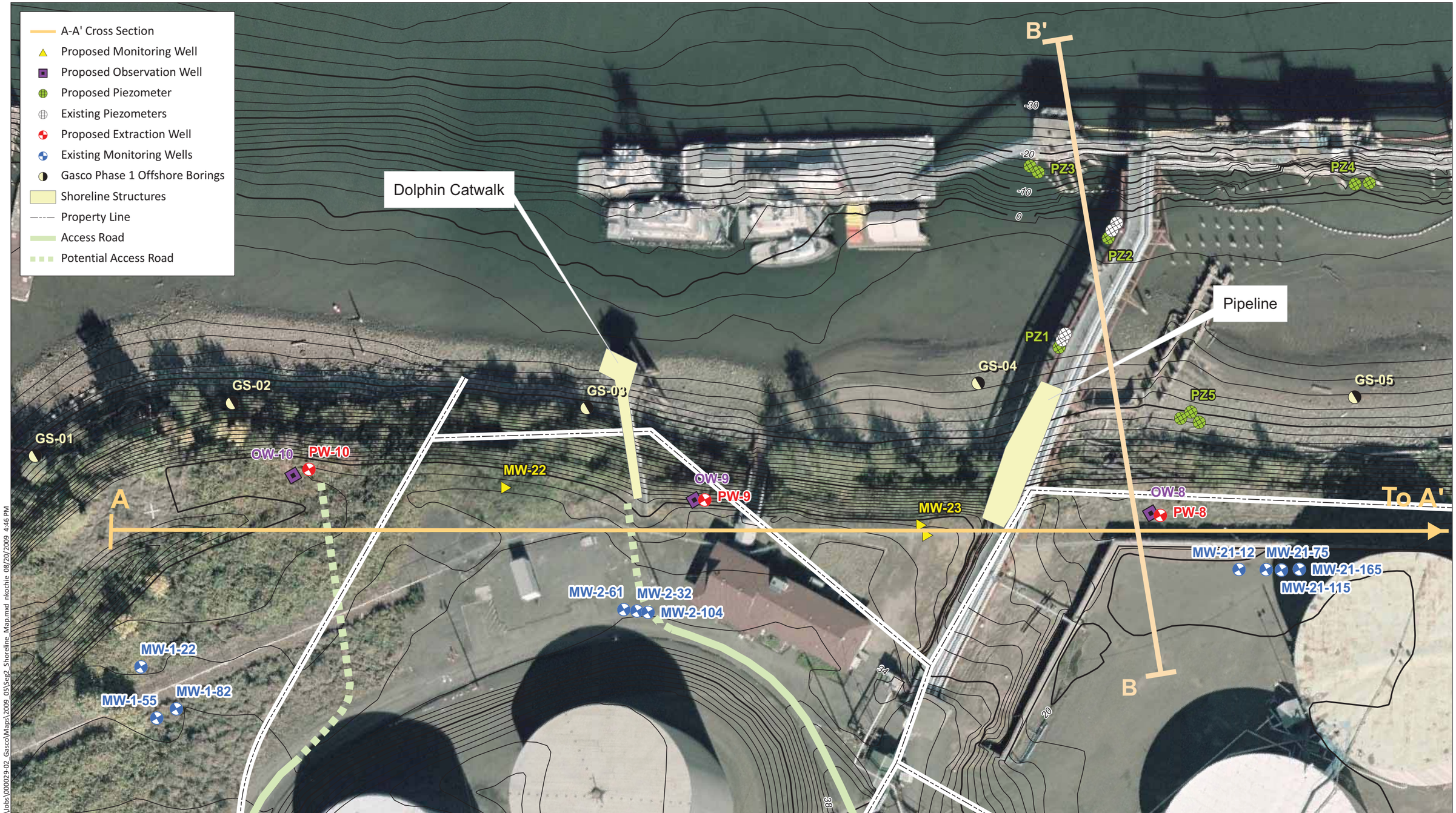
Well Number	Planned Transducer	Water-Bearing Zone	Date Installed	Date De-commissioned	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet msl)	Top of Casing (feet msl)	Top of Casing (feet bgs)	Boring Depth (feet bgs)	Boring Depth (feet msl)	Top Screen (feet bgs)	Top Screen (feet msl)	Base Screen (feet bgs)	Base Screen (feet msl)
PW-01-80		Alluvial	8-Aug-01	-	Sonic	Flush	Continuous wrap stainless steel	0.020	10-20	6	32.00	31.80	0.2	82.0	-50.0	39.5	-7.5	79.5	-47.5
Proposed Monitoring Well																			
MW-22-74	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	34.00	37.00	(3.0)	75.0	-41.0	64.0	-30.0	74.0	-40.0
MW-23-74	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	34.00	37.00	(3.0)	75.0	-41.0	64.0	-30.0	74.0	-40.0
MW-23-130	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	34.00	37.00	(3.0)	130.0	-96.0	119.0	-85.0	129.0	-95.0
MW-24-80	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	30.00	33.00	(3.0)	81.0	-51.0	70.0	-40.0	80.0	-50.0
MW-24-130	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	30.00	33.00	(3.0)	131.0	-101.0	120.0	-90.0	130.0	-100.0
Proposed Observation Well																			
OW-7-20	X	Surficial Fill		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	23.00	26.00	(3.0)	20.0	3.0	13.0	10.0	18.0	5.0
OW-8-20	X	Surficial Fill		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	23.00	26.00	(3.0)	20.0	3.0	13.0	10.0	18.0	5.0
OW-9-27	X	Surficial Fill		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	30.00	33.00	(3.0)	27.0	3.0	20.0	10.0	25.0	5.0
Proposed Extraction Well																			
PW-7	X	Alluvial		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	23.00	26.00	(3.0)	70.0	-47.0	48.0	-25.0	68.0	-45.0
PW-8	X	Alluvial		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	23.00	26.00	(3.0)	70.0	-47.0	48.0	-25.0	68.0	-45.0
PW-9	X	Alluvial		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	30.00	33.00	(3.0)	77.0	-47.0	55.0	-25.0	75.0	-45.0
Existing Piezometer																			
PZ1-5	X	Alluvial	17-Mar-05	-	Manual	Above-grade	Solinst push point		NA	1	9.96	36.08	(26.1)	5.6	4.3	4.5	5.5	5.4	4.6
PZ1-20	X	Alluvial	17-Mar-05	-	Manual	Above-grade	Solinst push point		NA	1	10.15	36.43	(26.3)	20.5	-10.3	19.3	-9.2	20.2	-10.1
PZ2-5	X	Alluvial	18-Mar-05	-	Manual	Above-grade	Solinst push point		NA	1	2.89	37.92	(35.0)	6.7	-3.8	5.5	-2.6	6.4	-3.5
PZ2-20	X	Alluvial	17-Mar-05	-	Manual	Above-grade	Solinst push point		NA	1	3.38	37.90	(34.5)	21.7	-18.4	20.6	-17.2	21.5	-18.1
Proposed Piezometer																			
PZ1-50	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	1	10.00	36.50	(26.5)	50.5	-40.5	45.0	-35.0	50.0	-40.0
PZ2-43	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	1	3.00	38.00	(35.0)	43.5	-40.5	38.0	-35.0	43.0	-40.0
PZ3-10	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	1	-10.00	40.00	(50.0)	10.5	-20.5	5.0	-15.0	10.0	-20.0
PZ3-40	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	1	-10.00	40.00	(50.0)	40.5	-50.5	35.0	-45.0	40.0	-50.0
PZ4-10	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	1	-10.00	40.00	(50.0)	10.5	-20.5	5.0	-15.0	10.0	-20.0
PZ4-40	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	1	-10.00	40.00	(50.0)	50.5	-60.5	35.0	-45.0	40.0	-50.0
PZ5-5	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	1	10.00	13.00	(3.0)	5.5	4.5	4.0	6.0	5.0	5.0
PZ5-20	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	1	10.00	13.00	(3.0)	20.5	-10.5	15.0	-5.0	20.0	-10.0
PZ5-50	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	1	10.00	13.00	(3.0)	50.5	-40.5	45.0	-35.0	50.0	-40.0

Notes:
bgs = below ground surface; btc = below top of casing; msl = mean sea level (City of Portland Datum); PVC = polyvinyl chloride

Table 2
Phase 1 Pilot Plan Test Details
Gasco Siltronic, Portland, Oregon

Pumping Well Designation	Pumping Rate (GPM)	Test Duration (Hours)
Test 1		
PW-7	15	72
PW-8	15	72
PW-9	15	72
Test 2		
PW-7	20	72
PW-8	20	72
PW-9	20	72
Test 3		
PW-7	25	72
PW-8	25	72
PW-9	25	72
Test 4		
PW-7	30	72
PW-8	30	72
PW-9	30	72

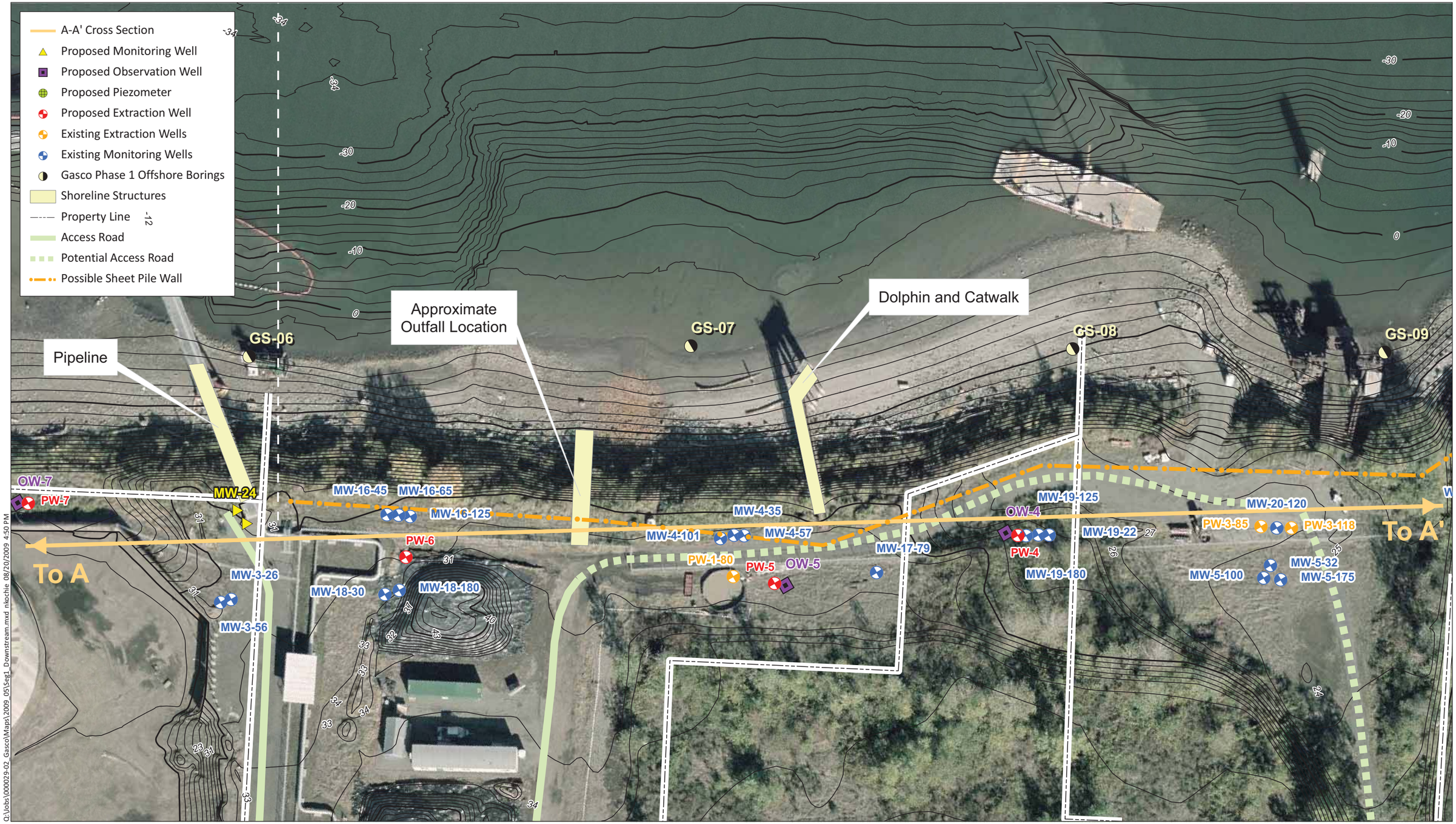
FIGURES



ANCHOR QEA

Feet
0 50 100

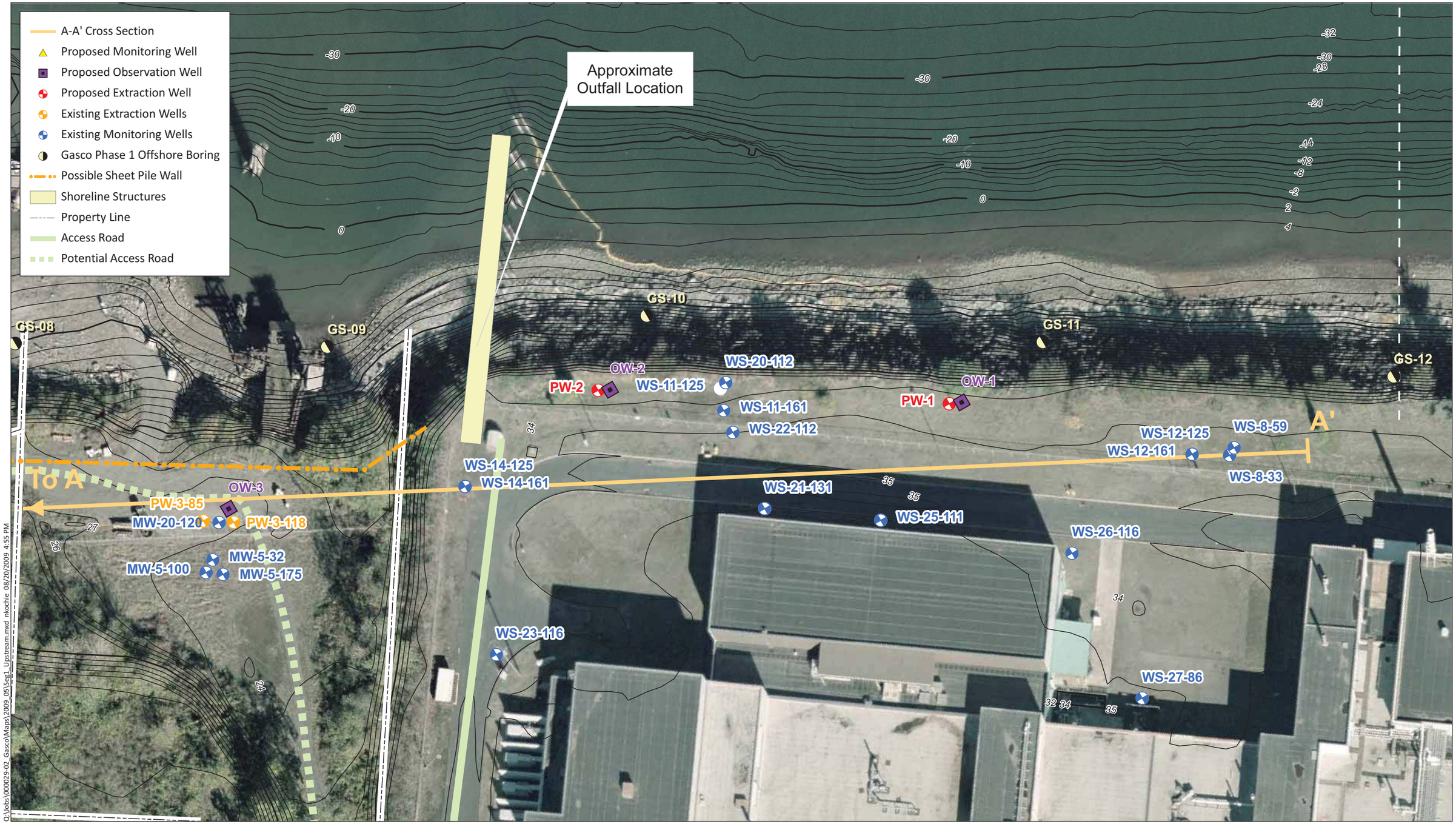
Figure 1a
Shoreline Map
Gasco Capture Zone Field Test Plan



ANCHOR QEA

Feet
0 50 100

Figure 1b
Shoreline Map
Gasco Capture Zone Field Test Plan

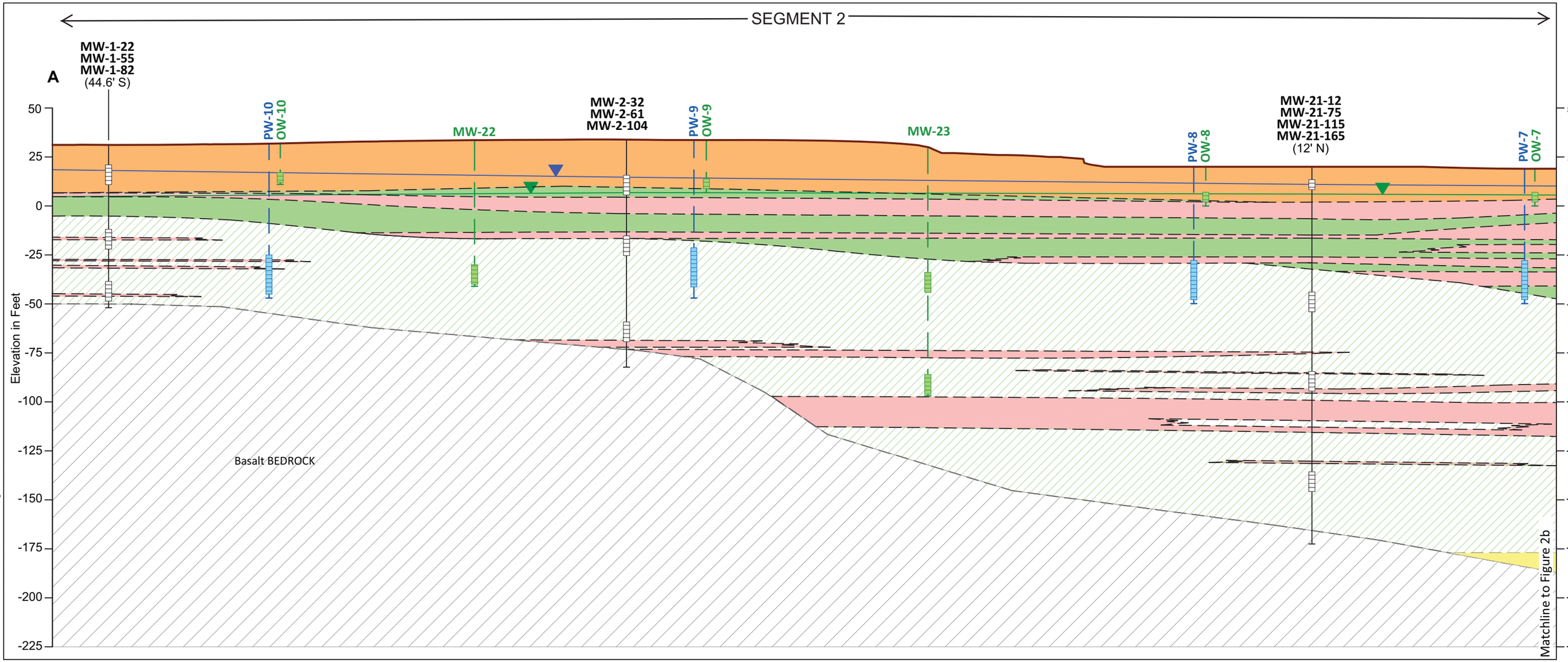


Q:\Jobs\000029-02_Gasco\Maps\2009_05\Seg1_Upstream.mxd nkochie 08/20/2009 4:55 PM

ANCHOR QEA

Feet
0 50 100

Figure 1c
Shoreline Map
Gasco Capture Zone Field Test Plan



LEGEND:

- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured 9/07)
- Potentiometric Surface of Alluvium (measured 9/07)
- Existing Ground Surface

MW-21-116 — Boring ID

xx — Boring ID

Proposed Extraction Well — Proposed Well or Piezometer — Existing Well or Piezometer — Well Screen

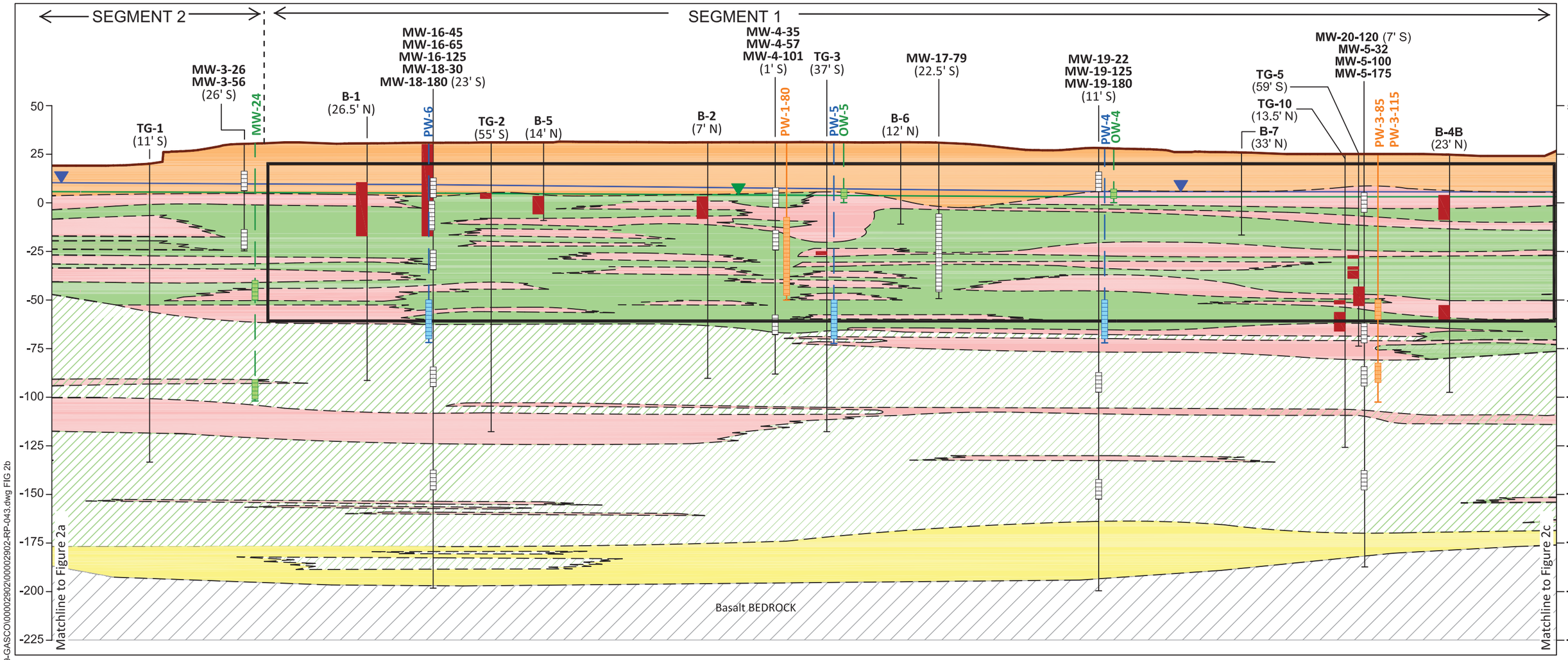
0 50
Scale in Feet

NOTES:
Geologic contacts are inferred between borings.

Aug 13, 2009 12:44pm Sang W Park K:\Jobs\000029-GASCO\00002902\000029\02902-RP-043.dwg FIG 2a

ANCHOR QEA

Figure 2a
Geologic Cross Section A-A'
Gasco Capture Zone Field Test Plan



LEGEND:

- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured 9/07)
- Potentiometric Surface of Alluvium (measured 9/07)
- Existing Ground Surface
- Possible Vertical Barrier Wall

MW-24 — Boring ID

xx — Boring ID

Existing Extraction Well
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

NAPL and/or Tar Interval

Well Screen

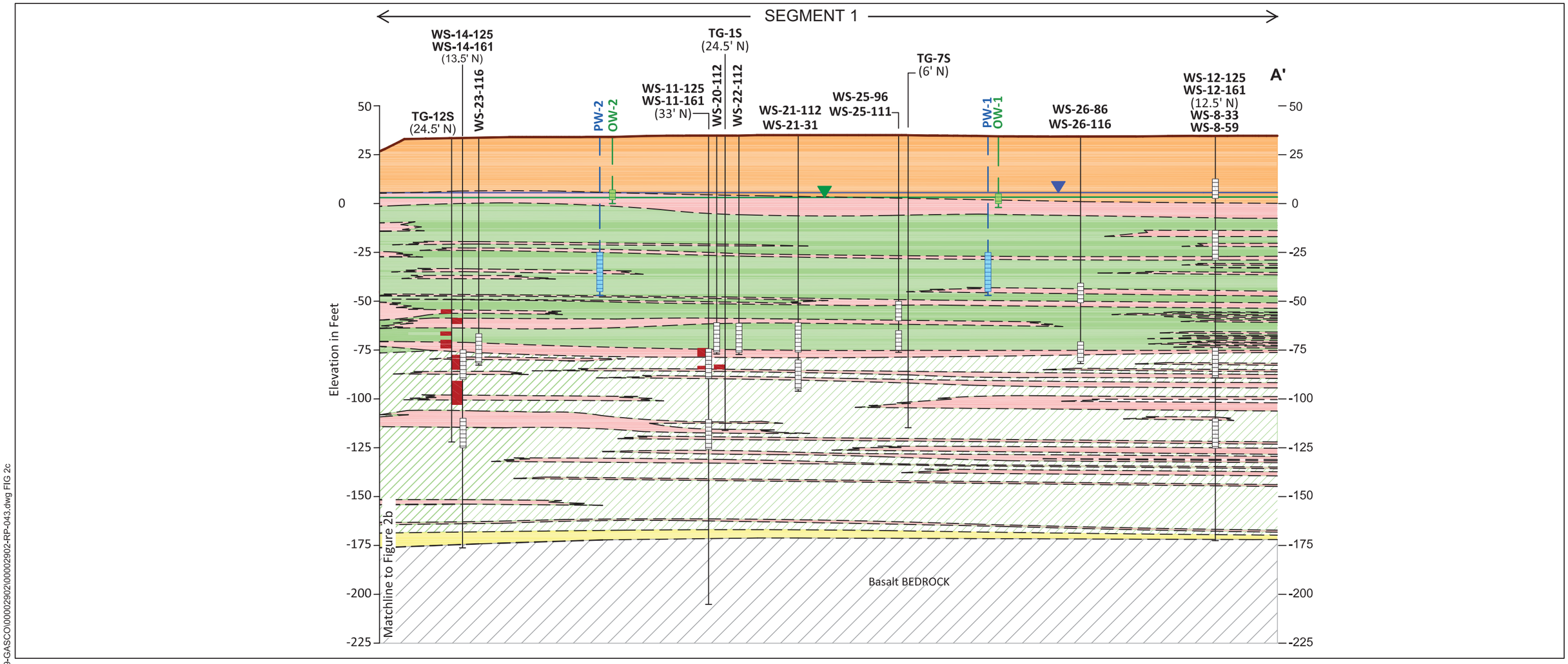
0 50
Scale in Feet

NOTES:
Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\000002902-RP-043.dwg FIG 2b
Aug 18, 2009 11:21am cdavidson

ANCHOR QEA

Figure 2b
Geologic Cross Section A-A'
Gasco Capture Zone Field Test Plan



LEGEND:

- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured 9/07)
- Potentiometric Surface of Alluvium (measured 9/07)
- Existing Ground Surface

MW-24 — Boring ID

xx — Boring ID

Proposed Extraction Well

Proposed Well or Piezometer

Existing Well or Piezometer

NAPL and/or Tar Interval

Well Screen

0 50

Scale in Feet

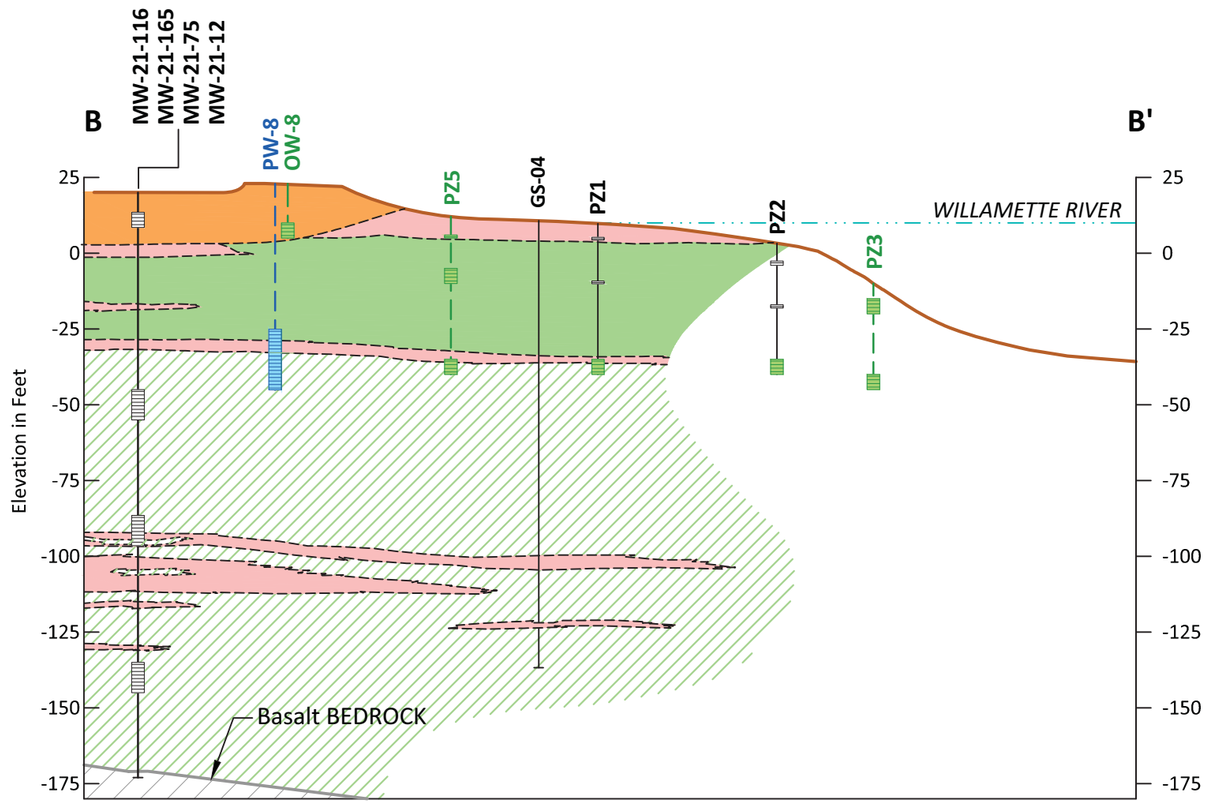
NOTES:
Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-043.dwg FIG 2c

Aug 10, 2009 2:30pm tgriga

ANCHOR QEA

Figure 2c
Geologic Cross Section A-A'
Gasco Capture Zone Field Test Plan



LEGEND:

- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface
- Approximate Willametter River Elevation

MW-21-116 — Boring ID

xx — Boring ID

Proposed Extraction Well

Proposed Well or Piezometer

Existing Well or Piezometer

Well Screen

0 50

Scale in Feet

NOTES:

1. City of Portland vertical datum
2. Geologic contacts are inferred between borings.

Aug 13, 2009 11:52am Sang W Park K:\Jobs\000029-GASCO\00002902\00002902-RP-044.dwg FIG 3

ANCHOR QEA

Figure 3

Geologic Cross Section B-B'

Gasco Capture Zone Field Test Plan

Figure 4
Offshore Piezometer Hydrographs
Gasco Siltronic
Portland, Oregon

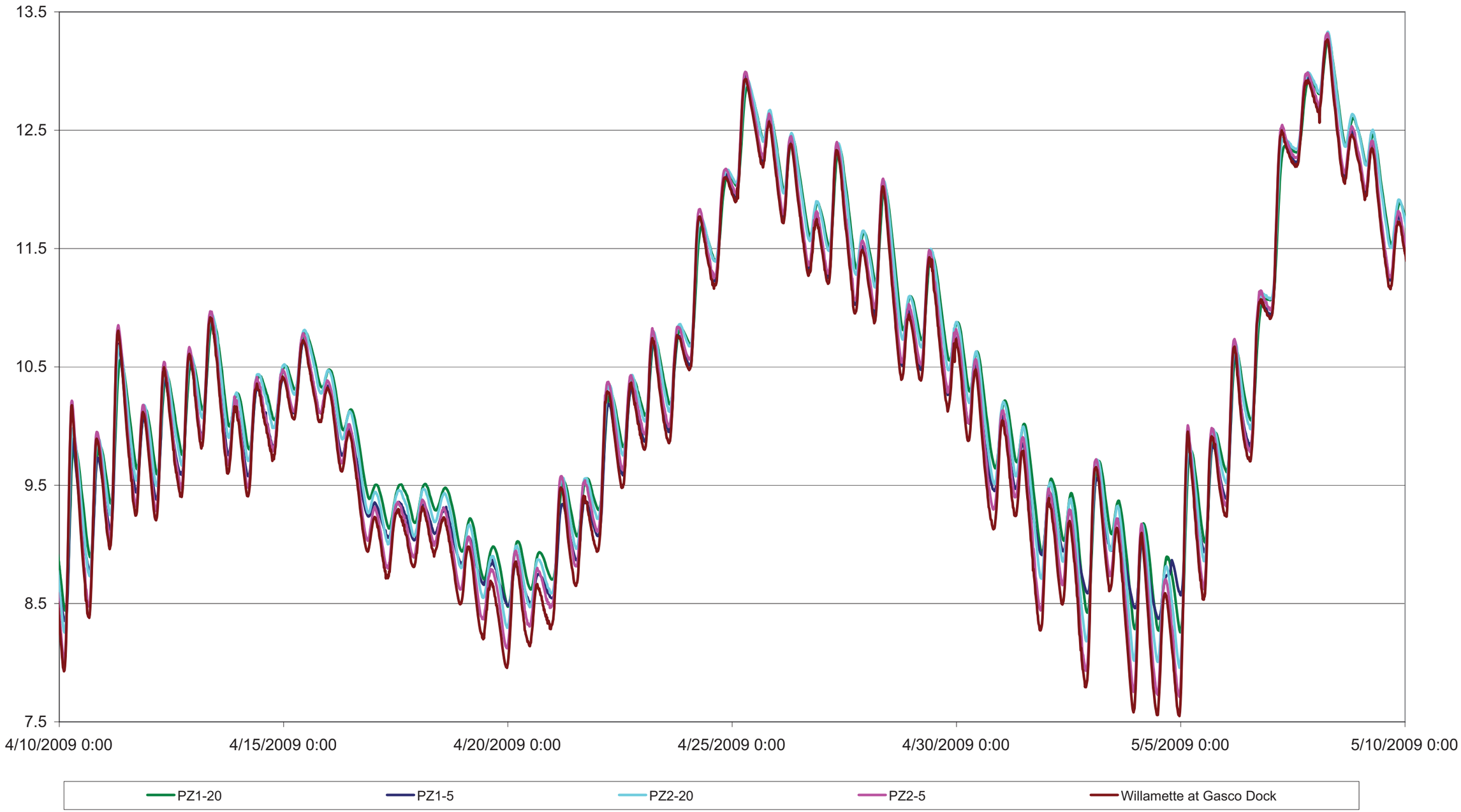
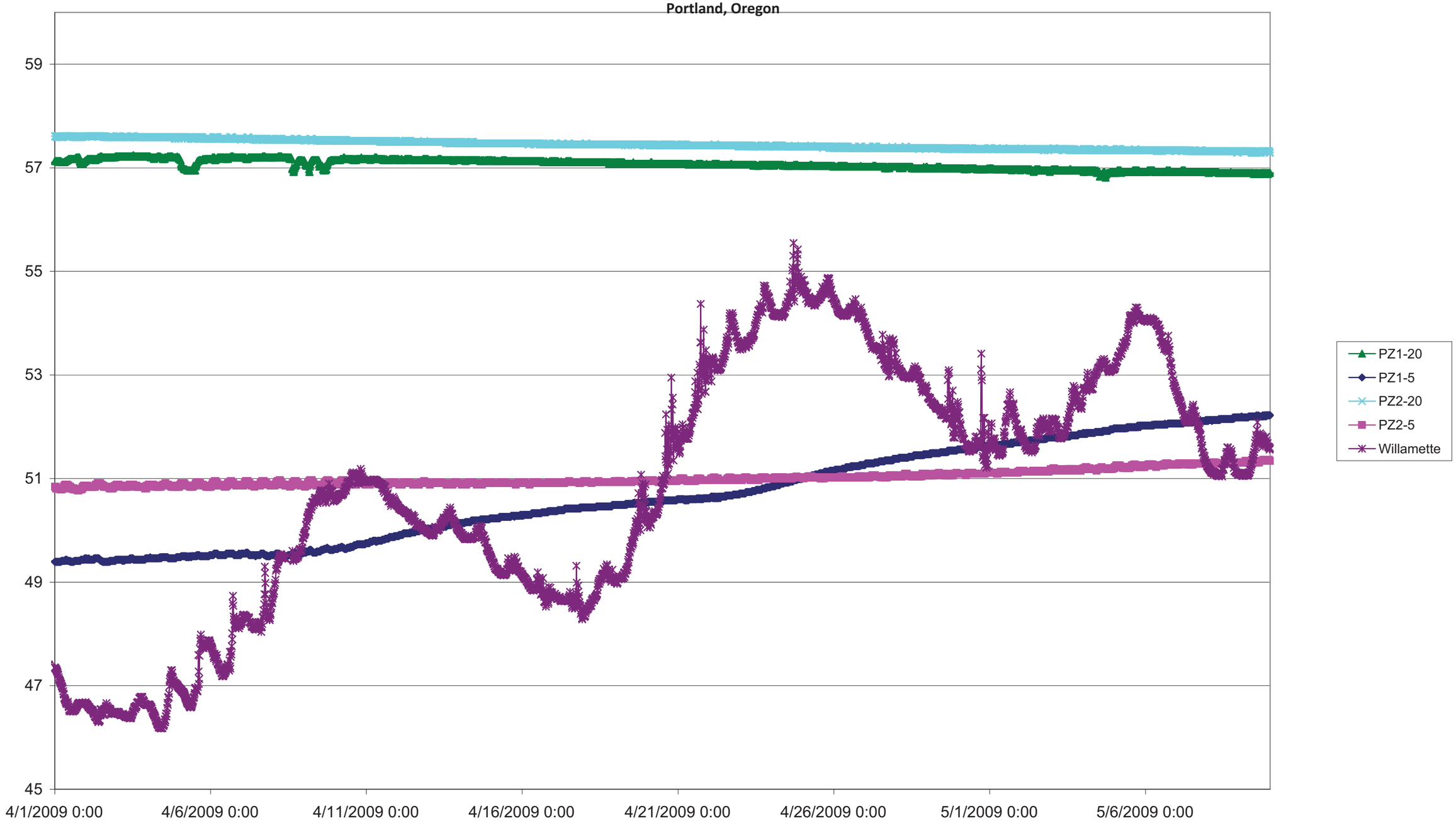


Figure 5
Offshore Piezometer Temperature Graphs
Gasco Siltronic
Portland, Oregon



APPENDIX A
WELL AND PIEZOMETER CONSTRUCTION AND DEVELOPMENT PLAN

ANCHOR QEA

6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128
www.anchorqea.com

MEMORANDUM

To:	Gasco Project File	**Date:**	August 14, 2009
From:	John J. Renda, R.G.	**Project:**	000029-02
Cc:			
Re:	Well and Piezometer Construction and Development Plan		

INTRODUCTION

Extraction wells, observation wells, and piezometers will be drilled and installed as part of the scope of the Capture Test Plan. Prior to installation of each well or piezometer, a borehole will be drilled using Sonic drilling techniques. The drilling contractor will obtain Oregon Start Cards for each well or piezometer. Each location will be checked for underground and above ground utilities prior to the start of drilling. For sites where the location of underground utilities is uncertain, a NW Natural representative will pre-approve those drilling locations. The well construction and development work will be done under the direction of an Oregon Registered Geologist. During drilling activities continuous cores will be obtained from the deepest boring at each location. The cores will then be photographed and a geologic log created in the field to assist in selection of the appropriate screened interval.

EXTRACTION WELL DESIGN

The extraction wells will be constructed of 8-inch diameter steel casing with 20 feet of Johnson stainless steel wire-wrapped screen with 0.035-inch slots and a 2-foot bottom sump. Upon completion of drilling activities, the well screen and casing will be placed in the borehole to the desired depth. A filter pack consisting of 10-20 Colorado silica sand will be installed in the annulus from the total depth of the borehole to approximately 2 feet above the top of the screened interval. A filter pack seal of at least 3 feet thickness consisting of 3/8-inch bentonite chips will then be installed in the annulus on top of the filter pack. A bentonite grout annular seal mixed to a weight of at least 9.5 pounds per gallon will be pumped in the remaining annulus via tremie pipe from the top of the bentonite seal until

grout returns are observed at the surface, ensuring a complete grout column. A well monument and concrete surface seal will then be installed at the ground surface.

OBSERVATION WELL DESIGN

A surficial fill observation well will also be installed adjacent to each pumping well. Construction of the surficial fill observation wells will follow the design of the monitoring wells described below.

MONITORING WELL DESIGN

Monitoring wells will be installed between extraction wells to monitor water level drawdown effects at various depths in the aquifer due to pumping. The monitoring wells will be constructed of 2-inch diameter PVC casing with Johnson stainless steel wire-wrapped screen with 0.020-inch slots and a 1-foot bottom sump. Upon completion of drilling activities, the well screen and casing will be placed in the borehole to the desired depth. A filter pack consisting of 10-20 Colorado silica sand will be installed in the annulus from the total depth of the borehole to approximately 2 feet above the top of the screened interval. A filter pack seal of at least 3 feet thickness consisting of 3/8-inch bentonite chips will then be installed in the annulus on top of the filter pack. A bentonite grout annular seal mixed to a weight of at least 9.5 pounds per gallon will be pumped in the remaining annulus via tremie pipe from the top of the bentonite seal until grout returns are observed at the surface, ensuring a complete grout column. A well monument and concrete surface seal will then be installed at the ground surface.

PIEZOMETER DESIGN

Piezometers will be installed in the river sediments at locations along the existing FAMM dock and on the shoreline down-gradient of the extraction wells. The purpose of the piezometers will be to measure ground water levels in the river sediments during testing of the shoreline extraction wells. The piezometers will be drilled using sonic techniques and installed from a barge. The piezometers will consist of 2-inch diameter PVC casing with 5-feet of 0.020-inch slotted screen with a pre-packed sand filter pack and a one-half foot sump. Granular bentonite will then be added to the annulus to provide a filter pack seal from the top of screen to mudline. The piezometers to be installed adjacent to the FAMM dock will be attached to the dock structure for stability and access. The piezometers installed on the

shoreline will be completed with locking above ground pipe casings, surrounded by protective casing monuments.

WELL DEVELOPMENT

Following installation, the wells and piezometers will be developed to clean out the wells of drilling materials remove fine materials from the annular sand pack.

Monitoring wells and piezometers will be surged for at least 10 minutes with a device equipped with a surge-block in order to move water in and out of the well screen to loosen and flush out sediment from the well screen and from the filter sand pack. The well will then be pumped until at least 10 casing volumes of water have been removed, water quality parameters (pH, specific conductivity, and temperature) have stabilized (pH +/- 0.1, conductivity +/-0.3%, and temperature +/-1% for 3 consecutive casing volumes), and all sediment is removed from the well.

Extraction wells will undergo a more rigorous development process to obtain the best practical condition of the annular sand pack. The development of the extraction wells be completed by the driller while the rig is still in location on the borehole. The drilling contractor will select the development method, but the well screens will be surged and pumped until the water is clear or the turbidity of the water is acceptable to the Anchor geologist present at the site. This may take up to 24 hours of development activities. Following well screen development, the well casing, screen, and annular material will be exposed to a chlorine solution of at least 1,500 ppm for a period of 24 hours to minimize the potential for biofouling of the well. The well will then be pumped to remove at least ten casing volumes to remove the added chlorine solution. The Health and Safety Plan will include procedures to protect field staff to prevent the potential for being exposed to cyanide gas that could be generated during chlorination of the well.

EQUIPMENT DECONTAMINATION AND INVESTIGATION DERIVED WASTE PROTOCOLS

Between borehole locations all drilling and downhole sampling equipment will be decontaminated at a prepared location onsite. The drilling equipment will be decontaminated by steam-cleaning or a hot-water pressure wash.

Residual soils, groundwater, and decontamination fluids (commonly referred to as investigation-derived waste [IDW]) will be handled as specified in this section. Generally, material generated during this scope of work will be contained, identified, and characterized. Holding containers will be labeled with their contents, the date of collection, and the origin of the material. The holding containers will be secured and stored in a designated area on the site until it has been characterized.

After the work is complete and analytical results are received, residual soils and liquids will be evaluated for disposal method consistent with DEQ regulations.

Soil Cuttings

Soil cuttings originating from the soil borings will be contained in 55-gallon drums or lined drop boxes, which will be stored in the designated area. Each storage container will be labeled to include the source of the soil.

Groundwater

Water generated during well development and sampling will be contained in 55-gallon drums or temporarily transferred to the onsite decon pond before being pumped through the onsite treatment system.

Decontamination Water

Water generated by equipment decontamination will be properly contained during decontamination activities. Decontamination water will be transferred to the decon pond before being pumped through the onsite treatment system.

APPENDIX B
HYDROLOGY MONITORING PLAN

ANCHOR QEA

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MEMORANDUM

To:	Gasco Project File	**Date:**	April 30, 2009
From:	John J. Renda, R.G.	**Project:**	000029-02
Cc:			
Re:	Hydrology Monitoring Plan		

HYDROLOGY MONITORING

Manual Water Level Monitoring

Following the procedures described herein, manual water level measurements will be made in selected monitoring wells, pumping wells, observation wells, and piezometers before and after the water level transducers are in place. The manual measurements will be used as reference points for the data generated by the transducer equipment. Measurements will be taken with an electronic water level indicator. Levels will be measured to the nearest 0.01 foot from a surveyed notch or mark at the top of the polyvinyl chloride (PVC) casing or other reference point. Measurements will be recorded immediately on a water level record sheet with the date, time (on a 24-hour clock), reference point, and initials of the person who made the measurements. The manual measurements will be used to calibrate the pressure transducers and monitor for "drift" of the readings. The water level indicator will be decontaminated in between wells as specified below.

Transducer Water Level Monitoring

Accurate, time coincident measurements are needed for evaluating performance of the extraction well pumping system. Pressure transducers will be installed in selected wells and in the Willamette River to collect time coincident water level data for several depth intervals. Data will be downloaded weekly and checked for accuracy. Manual water level measurements will also be made when the weekly transducer checks are made. If the manual measurement is off by more than 0.1 foot from the transducer reading, the transducer will be corrected and a new test will be started.

Pressure Transducer Installation

Pressure transducers (15 PSI, In-Situ mini-TROLL professional or In-Situ level TROLL) will be installed at the selected locations. The pressure transducers will be installed using cables that extend from the surface to the instrument that is submerged in the well or river water. The cables allow in situ calibration of depth-to-water measurements from the surface. The full-length cables also allow for venting to the atmosphere, eliminating the need for barometric data correction.

The following procedure will be used to install the transducers:

1. Each instrument will be connected to a communication/vent cable of the appropriate length
2. The instrument and cable will be decontaminated before and after installation using the procedures described in Section 5
3. The instrument will be calibrated to zero in ambient air conditions
4. The instrument and cable will be slowly fed down into the well to a depth that will insure submersion throughout the monitoring period
5. The instrument cable will be securely attached to the well casing
6. The instrument and cable will cause the displacement of water in the well casing; therefore, the water level in the well will be allowed to equilibrate for 30 to 60 minutes before depth-to-water reference measurements are entered into the instrument
7. The installer will connect to the instrument cable with a portable personal computer
8. The installer will use an electric water level indicator to measure the depth-to-water from the monitoring point and enter the result into the instrument as a real-time refrence value
9. The installer will program the instrument to collect one measurement of temperature and depth-to-water(pressure) every 15 minutes
10. The above-ground connector on the cable will be protected by a dessicant filter that is designed specifically for this application

Equipment Cleaning and Decontamination Procedures

Decontamination procedures are specified in this section for the various types of field work conducted. The objective for decontamination is to reduce the chance of cross-contamination of samples.

Groundwater sampling equipment includes items used during reconnaissance groundwater sampling. All equipment that contacts sampled groundwater will be decontaminated before its first use and between sampling locations. Decontamination will proceed as follows:

- Distilled water rinse
- Non-phosphatic detergent (e.g., Liquinox) and water wash
- Distilled water rinse
- Final distilled water rinse

APPENDIX C
HEALTH AND SAFETY PLAN

HEALTH AND SAFETY PLAN

NW NATURAL "GASCO" SITE FIELD ACTIVITIES FOR CAPTURE ZONE FIELD TEST PLAN

Prepared for

Oregon Department of Environmental Quality
2020 SW Fourth Avenue, Suite 400
Portland, Oregon 97201

Prepared by

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6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224

On behalf of:

NW Natural
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September 2009

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ATTTACHMENT A – Safety Record Forms

LIST OF ACRONYMS AND ABBREVIATIONS

AST	Aboveground Storage Tank
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
DNAPL	Dense Non-Aqueous Phase Liquid
EPA	United States Environmental Protection Agency
FC	Field Coordinator
FSP	Field Sampling Plan
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSM	Health and Safety Manager
HSO	Health and Safety Officer
ID	Inner Diameter
Order	Administrative Order on Consent
OSHA	Occupational Safety and Health Administration
OVM	Organic Vapor Monitor
PAH	Polycyclic Aromatic Hydrocarbon
PEC	Project Emergency Coordinator
PFD	Personal Flotation Device
PM	Project Manager
PPE	Personal Protective Equipment
ppmv	Parts Per Million by Volume
RAA	Removal Action Area
RAWP	Removal Action Work Plan
TPH	Total Petroleum Hydrocarbons
VOC	Volatile Organic Compound

1 INTRODUCTION

NW Natural is conducting an investigation to evaluate the extent of groundwater capture and to measure groundwater gradients induced by the pumping of extraction wells installed along the Gasco shoreline. Field activities covered under this HASP include subsurface drilling and well installation conducted from a drill rig operated from both a barge and onshore, well development, and well pump test activities.

2 SITE DESCRIPTION AND PROJECT SCOPE

The "Gasco site" is a former oil gasification plant located at 7900 NW St. Helens Road, Portland, Oregon, 97210 and is bounded on the northeast by the Willamette River at River Mile 6 and on the southwest by State Highway 30 (St. Helens Road). The site is within the initial study area of the Portland Harbor Superfund site. It is adjacent to Wacker Siltronics Corporation and the U.S. Army Corps of Engineers U.S. Moorings facilities. The site is currently used as a storage facility for liquefied natural gas.

Prior to 1941, wastewater effluent and tar-stills from the gasification process and by-product refining at the site were discharged to a stream channel leading from the production area to the Willamette River, or to low-lying areas of the "Gasco site." Previous investigations identified the approximate limits of the tar residue on the river sediments adjacent to the site, "tar body," and characterized sediment conditions along the rest of the shoreline of the site. The scope of the current investigation is to drill and install extraction wells, observation wells, and offshore piezometers and to evaluate the extent of groundwater capture created by performing pumping tests with varying rates in the extraction wells.

3 HAZARD EVALUATION AND CONTROL MEASURES

This section covers potential chemical and physical hazards that may be associated with the proposed field activities and presents control measures to address these potential hazards. A recent risk assessment study identified the presence of metals, volatile organic compounds (VOCs), total petroleum hydrocarbons (TPH), and polycyclic aromatic hydrocarbons (PAHs) in sediments in the vicinity of the Removal Action Area (RAA; Anchor, 2001).

Section 4.3 presents the activity hazard analysis which lists the potential hazards associated with each site activity and the recommended site control to be used to minimize each potential hazard. Confined space entry will not be necessary for this project; therefore, hazards associated with this activity are not discussed in this HASP.

3.1 Exposure Routes

Potential routes of exposure to the chemicals include inhalation, dermal contact, and ingestion of dust, mist, gas, vapor, or liquid. Exposure will be minimized by using safe work practices and by wearing the appropriate personal protective equipment (PPE). Further discussion of PPE requirements is presented in Section 7.0.

3.1.1 Inhalation

Inhalation of particulates, dust, mist, gas, or vapor during coring and sampling activities is possible. Whenever possible the coring equipment will be oriented so that personnel are upwind of the coring location. An organic vapor monitor (OVM) will be used to monitor ambient air and the breathing zone within the work area for organic compounds. Section 8.2 describes OVM action levels and response procedures.

3.1.2 Dermal Contact

Dermal contact with potentially contaminated soil, sediment, or groundwater during shoreline and vessel-based coring operations is possible. Direct contact will be minimized through the use of appropriate PPE and decontamination procedures.

3.1.3 Ingestion

Ingestion of contaminants is a less likely route of exposure than inhalation or dermal contact for many of the contaminants of concern. Direct ingestion of contaminants can occur by inhaling

airborne dust, mist, or vapors or swallowing contaminants trapped in the upper respiratory tract. Indirect ingestion can occur by introducing the contaminants into the mouth by way of food, tobacco, fingers, or other carriers. Although ingestion of contaminants can occur, proper decontamination/contamination reduction procedures should eliminate the probability of this route of exposure.

3.2 Chemical Hazards

Contaminants of concern in the RAA to be sampled include benzene, PAHs, and potentially TPH. Low levels of metals may also be associated with sediment samples, and as a precaution, are assumed to be present for the purposes of this HASP. In addition, there is some potential for exposure to hydrogen sulfide gas from native soil and hexane, which in rare cases may be used as a decontamination liquid.

3.2.1 Metals

The primary exposure routes for metals during coring activities are inhalation or ingestion of dust particles. Metals may also be indirectly ingested, as described in Section 4.1.1.3. A secondary route of exposure to metals is dermal contact. The target organs primarily affected by prolonged exposure to metals are the respiratory tract, gastrointestinal tract, central nervous system, kidneys, and liver.

Prolonged exposure to metals through any of the potential routes of exposure is not expected. Skin will be washed immediately when exposed to soil, sediment, dust, or water potentially impacted by metals.

3.2.2 Total Petroleum Hydrocarbons

Petroleum hydrocarbons likely at the site include tar and oil related materials in sediments and soils, which contain benzene and aromatic hydrocarbons. Gasoline, diesel, fuel, and waste oil, and heavier hydrocarbons such as grease may also be present associated with sampling equipment. Volatile components of gasoline include benzene, toluene, ethylbenzene, and xylenes (BTEX). The primary exposure routes for petroleum hydrocarbons during coring activities are inhalation, dermal contact, and ingestion of contaminated soil, sediment, dust, or water. Lighter petroleum hydrocarbons such as gasoline and benzene readily volatilize and are primarily an inhalation concern, whereas the primary route of exposure to heavier petroleum hydrocarbons such as aromatic hydrocarbons, oil, and grease is dermal contact. The target

organs primarily affected by prolonged exposure to petroleum hydrocarbons are the respiratory system, central nervous system, kidneys, liver, and skin. Prolonged dermal contact with petroleum hydrocarbons can cause irritation or dermatitis. The BTEX compounds are known or suspected human carcinogens. An OVM equipped with a photo-ionization detector will be used to monitor ambient air and the breathing zone for VOCs such as benzene and naphthalene (an aromatic hydrocarbon). Respiratory protection will be employed if elevated levels of organic compounds are measured by the OVM, if odors are present, or other conditions warrant its use.

Petroleum hydrocarbons such as gasoline are also flammable and can be a physical hazard when present in high concentrations. Physical hazards associated with flammable compounds are addressed in Section 4.3.9. Combustion of petroleum hydrocarbons can produce carbon dioxide, carbon monoxide, aldehydes, fumes, smoke (particulate matter), and other products of incomplete combustion. Intentional and inadvertent combustion of petroleum hydrocarbons is not expected during sampling activities; however, personnel will be removed from the area should a fire occur.

3.2.3 Polycyclic Aromatic Hydrocarbons

PAHs are petroleum hydrocarbons which are relatively nonvolatile due to their large molecular structure and high molecular weight. Consequently, the primary route of exposure to PAHs is through dermal contact. PAHs may also be indirectly ingested as described in Section 4.1.3. Inhalation of PAHs is unlikely due to their nonvolatile nature. Dermal or eye contact with PAHs can cause irritation or burning.

3.2.4 Hydrogen Sulfide

Hydrogen sulfide is a naturally occurring gas often associated with organic clay and peat. Hydrogen sulfide gas is potentially toxic through inhalation, ingestion, and contact with the skin and eyes. Inhalation can result in respiratory irritation, rhinitis, and edema of the lungs. Inhalation of hydrogen sulfide gas can result in headache, dizziness, and agitation. Acute exposure at high concentrations may result in coma and death as a result of respiratory failure. Hydrogen sulfide gas has a distinct rotten egg odor, and will be noted if encountered in the field.

3.2.5 Hexane

If necessary to achieve adequate decontamination of equipment, a hexane rinse may be applied to remove hydrocarbon-type compounds. Exposure to high concentrations of hexane usually occurs by inhalation. Effects of inhalation may be slow and shallow breathing, possible tachycardia, vertigo or giddiness, nausea, and vomiting. Dermal exposure may result in dermatitis or conjunctival irritation. Eye exposure will cause irritation and requires irrigation.

3.3 Physical Hazards

3.3.1 Slips Trips and Falls

As with all fieldwork sites, caution should be exercised to prevent slips on slick surfaces. In particular, sampling from a floating platform requires careful attention to minimize the risk of falling down or falling overboard. The same care should be used in rainy conditions. Wearing boots with good tread, made of material that does not become overly slippery when wet, can minimize slips.

Trips are always a hazard on the uneven deck of a boat or in a cluttered work area. The deck of the vessel may have numerous stationary fittings and tie-downs that present potential tripping hazards. Personnel will keep work areas as free as possible from items that interfere with walking and will be aware of stationary obstacles on deck.

Falls may be avoided by working as far away from exposed edges as possible. For this project, the potential for falling is associated primarily with deployment and recovery drill rig pipes, rods, and well casing through the “moonhole” of the vessel, boarding and disembarking the vessel at the dock, and while walking along the shoreline composed of loose rocks. Personnel will keep walkways and work areas clear when possible and use caution when walking along the shoreline.

3.3.2 Coring and Sampling Equipment

Soil and sediment samples will be collected using a direct-push or Rotosonic drill rig operated onshore or from a barge. Prior to initiation of sampling on the barge, there will be a training session for all field personnel pertaining to the equipment that will be onboard the sampling vessel. The captain will review vessel-specific hazards and safety procedures and will point out the location and proper use of all safety equipment. For example, field personnel will be shown

the locations of all fire extinguishers, flotation rings, and first aid kits and their appropriate uses.

3.3.3 Falling Overboard

It is anticipated that the majority of the sampling will be conducted from a vessel. As with any work from a floating platform, there is a chance of falling overboard. A personal flotation device (PFD) for each crew person will be available in the boat at all times. PFDs will be worn while working from the vessel.

3.3.4 Manual Lifting

Equipment and samples must be lifted and carried both aboard the vessel and along the shoreline. Back strain can result if lifting is done improperly. During any manual handling tasks, personnel should lift with the load supported by their legs and not their backs. For heavy loads, an adequate number of people will be used, or if possible, a mechanical lifting/handling device.

3.3.5 Heat Stress

Scheduled sampling operations will be occurring in late Summer or Fall, so high temperatures may be encountered. The potential for heat stress may occur if impermeable PPE is worn or if strenuous work is performed under hot conditions with inadequate water. When the core body temperature rises above 100.4° F, the body cannot sweat to cool down, and heat stress can occur. Heat stress may be identified by the following symptoms: dizziness, profuse sweating, skin color change, vision problems, confusion, nausea, fatigue, fainting, and clammy skin. Personnel exhibiting such symptoms will be removed to a cool shady area, given water, and allowed to rest. Fresh drinking water will be provided aboard the vessel. All field team members will monitor their own condition and that of their co-workers to detect signs of heat stress.

3.3.6 Hypothermia

Hypothermia is abnormal lowering of the core body temperature caused by exposure to a cold environment. Wind chill as well as wetness or water immersion can play a significant role. Typical signs of hypothermia include fatigue, weakness, lack of coordination, apathy, and drowsiness. Confusion is a key symptom of hypothermia. Shivering and pallor are usually absent, and the face may appear puffy and pink.

Body temperatures below 90° F require immediate treatment to restore the temperature to normal. Current medical practice recommends slow warming of the individual followed by professional medical care. Moving the person to a sheltered area and wrapping them in a blanket can accomplish this portion of the task. If possible, the person should be placed in a warm room. In emergency situations where body temperature falls below 90° F and shelter is not available, a sleeping bag, blankets, and body heat from another individual can be used to help raise body temperature.

3.3.7 Weather

In general, field team members will be equipped for the normal range of weather conditions. The FC will be aware of current weather conditions, and of the potential for those conditions to pose a hazard to the field crew. Some conditions that might force work stoppage are electrical storms, high winds, or high waves resulting from winds.

3.3.8 Flammable Hazards

Petroleum hydrocarbons are flammable in moderate to high concentrations. Therefore smoking, open flames, and unprotected ignition sources will not be allowed in the work area. An OVM will be used to measure concentrations of organic vapors (i.e., benzene) in the work area. If elevated OVM measurements persist, work will be suspended until corrective measures are taken to ensure a safe work environment.

3.4 Activity Hazard Analysis

The activity hazard analysis summarizes the field activities to be performed during borehole drilling and soil sampling activities, outlines the hazards associated with each activity, and presents controls that can reduce or eliminate the risk of the hazard occurring.

Table 1 presents the activity hazard analysis for the following activities:

- Drilling activities including soil sample collection and well installation
- Well development groundwater purging
- Equipment decontamination

4 WORK ZONES AND ACCESS CONTROL

The vessel captain, onshore coring operator, and the FC will delineate the boundaries of the work zones aboard the vessel and shoreline and will inform the field crews of the arrangement. The purpose of the zones is to limit the migration of sample material out of the zones and to restrict access to active work areas by defining work zone boundaries.

4.1 Work Zones

Two work zones will be observed aboard the vessel. One will encompass the "moonhole" of the vessel where the samplers will be deployed and recovered. Only the coring crew may enter this zone unless assistance is required by other personnel. The second work zone will be a sample processing area on the vessel. The drill contractor crew will deliver sediment core tubes to this zone and open them. Anchor QEA LLC personnel will log and process the sediment cores.

Two work zones will be observed while working onshore. One will enclose the track-rig where sampling is taking place. Only the coring crew may enter this zone unless assistance is required by other personnel. The second work zone will be a nearby core processing area along the shoreline or on top of the bank area. The drill contractor coring crew will transport the sediment core tubes to this zone and open them. Anchor QEA personnel will log and process the sediment cores.

Both the collection and processing areas on the vessel and onshore will have a support (i.e., exclusion) zone outside the contamination reduction zone to stage clean equipment, don PPE, take rest breaks, or perform any other site activities that do not involve potentially contaminated materials.

4.2 Decontamination Area

A station will be set up for decontaminating sample processing equipment and personnel gear such as boots or PPE. The station will have the buckets, brushes, soapy water, rinse water, or wipes necessary to perform decontamination operations. Plastic bags will be provided for expendable and disposable materials. The decontamination fluids will be stored in sealable containers and will be disposed of in accordance with the procedures presented in Section 9.4.

4.3 Access Control

Security and control of access to the sampling vessel and onshore area will be the responsibility of the captain, FC and/or HSO. Additional security measures may be placed into affect by NW Natural, as required by national security threat levels determined by the federal government. Access to the vessel and onshore areas will only be granted to necessary project personnel and authorized visitors. Any security or access control problems will be reported to the client or appropriate authorities.

5 SAFE WORK PRACTICES

Following common sense rules will minimize the risk of exposure or accidents at a work site. These general safety rules will be followed on site:

- Always use the buddy system
- Be aware of overhead and underfoot hazards at all times
- Do not eat, drink, smoke, or perform other hand-to-mouth transfers in the work zones
- Get immediate first aid for all cuts, scratches, abrasions, or other minor injuries
- Report all accidents and close calls, no matter how minor, to the FC
- Be alert to your own and other workers' physical condition
- Do not climb over or under obstacles of questionable stability
- Make eye contact with equipment operators before moving into the range of their equipment
- Work during daylight hours

6 PERSONAL PROTECTIVE EQUIPMENT AND SAFETY EQUIPMENT

Appropriate PPE will be worn as protection against potential hazards. In addition, a PFD will be required when working on the vessel. Prior to donning PPE, the workers will inspect their equipment for any defects that might render the equipment ineffective.

Fieldwork will be conducted in Level D, modified Level D, or Level C PPE as discussed below in Sections 7.1, 7.2, and 7.3, respectively. Situations requiring PPE beyond Level C are not anticipated for this project. Should the FC determine that PPE beyond Level C is necessary at a given sampling station, the FSC will notify the HSM to select an appropriate corrective action.

6.1 Level D Personal Protective Equipment

Workers performing general activities in which skin contact with contaminated materials is unlikely and in which inhalation risks are not expected will wear Level D PPE. Level D PPE includes the following:

- Chemical-resistant, steel-toed boots
- Leather, cotton, or chemical-resistant gloves, as the type of work requires
- Safety glasses
- Hard hat (if overhead hazard exists)
- Hearing protection, if necessary

6.2 Modified Level D Personal Protective Equipment

Workers performing activities where skin contact with contaminated materials is possible will wear chemical-resistant outer gloves and an impermeable outer suit. The type of outerwear will be chosen according to the types of chemical contaminants that might be encountered.
Modified Level D PPE includes the following:

- Outer garb such as rain gear or rubber or vinyl aprons
- Chemical-resistant steel-toed boots
- Surgical rubber inner gloves
- Chemical-resistant outer gloves
- Safety glasses (or face shield, if significant splash hazard exists)
- Hard hat (if overhead hazard exists)
- Hearing protection, if necessary

6.3 Level C Personal Protective Equipment

If elevated (see Section 8.2) concentrations of vapors are measured with the OVM, significant contaminant odors are noted, or significant amounts of airborne particulate matter are generated, health and safety requirements may be upgraded to Level C if implementation of engineering controls (i.e., fans) do not decrease the airborne concentrations to acceptable levels. Level C PPE includes the equipment listed under modified Level D plus the following:

- Half-face or full face respirator
- Organic vapor/acid gas cartridges, if appropriate
- Particulate filter cartridge, if appropriate

6.4 Safety Equipment

In addition to PPE that will be worn by shipboard personnel, basic emergency and first aid equipment will also be provided. Equipment will include:

- A copy of this HASP
- PFD
- First aid kit adequate for the number of personnel
- Emergency eyewash

Anchor QEA and/or subconsultants will provide this equipment, which must be at the location(s) where field activities are being performed. Equipment will be checked daily to ensure its readiness for use.

7 MONITORING PROCEDURES FOR SITE ACTIVITIES

A monitoring program that addresses the potential site hazards will be maintained. The monitoring program includes self-monitoring by the field crew and monitoring with instruments.

7.1 Crew Self Monitoring

All personnel will be instructed to look for and inform each other of any deleterious changes in their physical or mental condition during the performance of all field activities. Examples of such changes are as follows:

- Headaches
- Dizziness
- Nausea
- Blurred vision
- Cramps
- Irritation of eyes, skin, or respiratory system
- Changes in complexion or skin color
- Changes in apparent motor coordination
- Increased frequency of minor mistakes
- Excessive salivation or changes in papillary response
- Changes in speech ability or speech pattern
- Symptoms of heat stress or heat exhaustion (Section 4.2.6)
- Symptoms of hypothermia (Section 4.2.7)

If any of these conditions develop, the affected person(s) will be moved from the immediate work location and evaluated. If further assistance is needed, personnel at the local hospital will be notified, and an ambulance will be summoned if the condition is thought to be serious. If the condition is the result of sample collection or processing activities, procedures and/or PPE will be modified to address the problem.

8 DECONTAMINATION

Decontamination is necessary to prevent the migration of contaminants from the work zone(s) into the surrounding environment and to minimize the risk of exposure of personnel to contaminated materials that might adhere to PPE. The following sections discuss personnel and equipment decontamination. The following supplies will be available to perform decontamination activities:

- Wash and rinse buckets
- Tap water and phosphate-free detergent
- Scrub brushes
- Distilled/deionized water
- Deck pump with pressurized freshwater hose (aboard the vessel)
- Paper towels and plastic garbage bags

8.1 Minimization of Contamination

The following measures will be observed to prevent or minimize exposure to potentially contaminated materials:

Personnel:

- Do not walk through spilled sediment
- Do not handle, touch, or smell sediment directly
- Make sure PPE has no cuts or tears prior to use
- Protect and cover any skin injuries
- Stay upwind of airborne dusts and vapors
- Do not eat, drink, chew tobacco, or smoke in the work zones

Sampling Equipment and Vessel:

- Use care to avoid getting sampled media on the outside of sample containers
- If necessary, bag sample containers before filling with sampled media
- Place clean equipment on a plastic sheet to avoid direct contact with contaminated media
- Keep contaminated equipment and tools separate from clean equipment and tools
- Fill sample containers over a plastic tub to contain spillage
- Clean up spilled material immediately to avoid tracking around the vessel

8.2 Personal Decontamination

The FC will ensure that all site personnel are familiar with personnel decontamination procedures. Personnel will perform decontamination procedures, as appropriate, when exiting work areas. Following is a description of the procedure:

Decontamination Procedure:

- Wash and rinse outer gloves and boots in portable buckets
- If suit is heavily soiled, rinse it off
- Remove outer gloves, inspect and discard if damaged, leave inner gloves on
- Remove inner gloves and wash hands if taking a break
- Don necessary PPE before returning to work
- Dispose of soiled PPE before leaving for the day

8.3 Handling of Investigation-Derived Waste

All remaining sediment, fluids used for decontamination of sampling equipment, and core collection disposable wastes (e.g., gloves, paper towels, foil, etc.) will be placed into appropriate containers and staged on-site for disposal. Sediments remaining following collection and processing will be placed into sealable containers and disposed offsite. The decontamination fluids will be stored in sealable containers and will be disposed based on the amount of visibly apparent oil. If the fluid contains only a small amount of visibly apparent oil it will be transferred into an on-site aboveground storage tank (AST) for treatment via the Gasco facility carbon treatment unit. Alternatively, fluids containing a visibly appreciable amount of oil will be transferred into an AST located at the MW-6 dense non-aqueous phase liquid (DNAPL) extraction system. All disposable wastes will be placed into two heavy duty plastic bags (i.e., double-bagged) and disposed at a permitted solid waste disposal facility.

9 TRAINING REQUIREMENTS

Individuals performing work at locations where potentially hazardous materials and conditions may be encountered must meet specific training requirements. It is not anticipated that personnel will encounter hazardous concentrations of contaminants in sampled material, so training will consist of site-specific instruction for all personnel and oversight of inexperienced personnel for one working day. The following sections describe the training requirements for work at this site.

9.1 Project Specific Training

All Anchor QEA personnel must read this HASP and be familiar with its contents before beginning work. They shall acknowledge reading the HASP by signing the field team HASP review form contained in Attachment A. The form will be kept in the project files.

The FC or a designee will provide and document project-specific training during the project kickoff meeting and whenever new Anchor QEA workers arrive for fieldwork. Anchor QEA personnel will not be allowed to begin work until project-specific training is completed and documented by the FC. Training will address the HASP and all health and safety issues and procedures pertinent to field operations. Training will include, but will not be limited to, the following topics:

- Activities with the potential for chemical exposure
- Activities that pose physical hazards, and actions to control the hazards
- Ship access control and procedures
- Use and limitations of PPE
- Decontamination procedures
- Emergency procedures
- Use and hazards of sampling equipment
- Location of emergency equipment on the vessel
- Vessel safety practices

In addition, since field activities are occurring within the Portland Harbor Superfund Site, all workers must have 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training in accordance with Occupational Safety and Health Administration (OSHA), and an updated 8-hour refresher training certification, if applicable.

9.2 Daily Safety Briefings

The FC or a designee will present safety briefings before the start of each day's activities. These safety briefings will outline the activities expected for the day, update work practices and hazards, address any specific concerns associated with the work location, and review emergency procedures and routes. The safety briefings will be documented in the logbook.

10 RECORDING AND RECORD KEEPING

The FC or a designee will record health- and safety-related details of the project in the field logbook. The logbook must be bound and the pages must be numbered consecutively. Entries will be made with indelible ink. At a minimum, each day's entries must include the following information:

- Project name or location
- Names of all personnel
- Level of PPE worn and any other specifics regarding PPE
- Weather conditions
- Type of fieldwork being performed

The person maintaining the entries will initial and date the bottom of each completed page. Blank space at the bottom of an incompletely filled page will be lined out. Each day's entries will begin on the first blank page after the previous workday's entries.

As necessary, other documentation will be obtained or initiated by the FC. Other documentation may include field change requests, medical and training records, exposure records, accident/incident report forms, OSHA Form 200s, and material safety data sheets. Attachment A contains copies of key health and safety forms.

11 EMERGENCY RESPONSE PLAN

As a result of the health and safety hazards associated with the field sampling and sample handling activities, the potential exists for an emergency situation to occur. Emergencies may include personal injury, exposure to hazardous substances, fire, explosion, or release of toxic or non-toxic substances (spills). OSHA regulations require that an emergency response plan be available for use onboard to guide actions in emergency situations.

Onshore organizations will be relied upon to provide response in emergency situations. The local fire department and ambulance service can provide timely response. Anchor QEA personnel and subcontractors will be responsible for identifying an emergency situation, providing first aid if applicable, notifying the appropriate personnel or agency, and evacuating any hazardous area. Shipboard personnel will attempt to control only very minor hazards that could present an emergency situation, such as a small fire, and will otherwise rely on outside emergency response resources.

The following sections address pre-emergency preparation, identify individual(s) who should be notified in case of emergency, provide a list of emergency telephone numbers, offer guidance for particular types of emergencies, and provide directions and a map for getting from any sampling location to a hospital.

11.1 Pre-Emergency Preparation

Before the start of field activities, the FC will ensure that preparation has been made in anticipation of emergencies. Preparatory actions include the following:

- Meeting with the captain and equipment handlers concerning the emergency procedures in the event that a person is injured. Appropriate actions for specific scenarios will be reviewed. These scenarios will be discussed and responses determined before the sampling event commences.
- A training session given by the captain informing all field personnel of emergency procedures, locations of emergency equipment and their use, and proper evacuation procedures.
- A training session given by senior staff operating field equipment, to apprise field personnel of operating procedures and specific risks associated with that equipment.
- Ensuring that field personnel are aware of the existence of the emergency response plan, its location as Section 12 of the HASP, and ensuring that a copy of the HASP

accompanies the field team(s).

11.2 Site Emergency Coordinator

The FC will serve as the Project Emergency Coordinator (PEC) in the event of an emergency. The FC will designate a replacement for times when he is not onboard or is not serving as the PEC. The designation will be noted in the logbook. The PEC will be notified immediately when an emergency is recognized. The PEC will be responsible for evaluating the emergency situation, notifying the appropriate emergency response units, coordinating access with those units, and directing interim actions onboard before the arrival of emergency response units. The PEC will notify the HSM and the PM as soon as possible after initiating an emergency response action. The PM will have responsibility for notifying the client.

11.3 Emergency Response Contacts

All personnel must know whom to notify in the event of an emergency situation, even though the FC has primary responsibility for notification. Table 2 lists the names and phone numbers for emergency response services and individuals.

11.4 Recognition of Emergency Situations

Emergency situations will generally be recognizable by observation. An injury or illness will be considered an emergency if it requires treatment by a medical professional and cannot be treated with simple first-aid techniques.

11.5 Decontamination

In the case of evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. If an injured individual is also heavily contaminated and must be transported by emergency vehicle, the emergency response team will be told of the type of contamination. To the extent possible, contaminated PPE will be removed, but only if doing so does not exacerbate the injury. Plastic sheeting will be used to reduce the potential for spreading contamination to the inside of the emergency vehicle.

11.6 Fire

Shipboard personnel will attempt to control only small fires, should they occur. If an explosion appears likely, personnel will follow evacuation procedures specified by the captain in the

training session. If a fire cannot be controlled with a fire extinguisher on board that is part of the required safety equipment, personnel will either withdraw from the vicinity of the fire or use additional fire fighting equipment, or evacuate the boat as specified by the captain in the training session.

11.7 Personal Injury

In the event of serious personal injury, including unconsciousness, possibility of broken bones, severe bleeding or blood loss, burns, shock, or trauma, the first responder will immediately do the following:

- Administer first aid, if qualified
- If not qualified, seek out an individual who is qualified to administer first aid, if time and conditions permit
- Notify the PEC of the incident, the name of the individual, the location, and the nature of the injury

The PEC will immediately do the following:

- Notify the captain and the appropriate emergency response organization
- Assist the injured individual
- Follow the emergency procedures for retrieving or disposing equipment reviewed in the training session, and leave the site en route to the predetermined land-based emergency pick-up
- Designate someone to accompany the injured individual to the hospital
- If an emergency situation (i.e., broken bones or injury where death is imminent without immediate treatment) occurs, the FC or captain will call 911 and arrange to meet the response unit at the nearest accessible dock
- Notify the HSM and the PM

If the PEC determines that emergency response is not necessary, he may direct someone to decontaminate and transport the individual by vehicle to the nearest hospital. Directions and a map showing the route to the hospital are in Section 12.10.

If a worker leaves the ship to seek medical attention, another worker should accompany him or her to the hospital. When in doubt about the severity of an injury or exposure, always seek medical attention as a conservative approach and notify the PEC.

The PEC will have responsibility for completing all accident/incident field reports, OSHA form 200s, and other required follow-up forms.

11.8 Overt Personal Exposure or Injury

If an overt exposure to toxic materials occurs, the first responder to the victim will initiate actions to address the situation. The following actions should be taken, depending on the type of exposure:

Skin Contact:

- Wash/rinse the affected area thoroughly with copious amounts of soap and water
- If eye contact has occurred, eyes should be rinsed for at least 15 minutes using the eyewash that is part of the emergency equipment onboard and in the lab
- After initial response actions have been taken, seek appropriate medical attention

Inhalation:

- Move victim to fresh air
- Seek appropriate medial attention

Ingestion:

- Seek appropriate medical attention

Puncture Wound or Laceration:

- Seek appropriate medical attention

11.9 Spills and Spill Containment

Sources of bulk chemicals are not expected to be used during this project. Accordingly, a spill containment procedure is not required for this project.

11.10 Emergency Route to the Hospital

The name, address, and telephone number of the hospital that will be used to provide medical care is as follows:

Legacy Good Samaritan Hospital and Medical Center
1015 NW 22nd Avenue
Portland, Oregon 97210
(503) 413-7711

Figure 1 is a map of the route from the project site (7900 NW St. Helens Road, Portland, Oregon, 97210) to the Legacy Good Samaritan Hospital and Medical Center. Directions are as follows (travel time is approximately 11 minutes):

1. Start out going Southeast on NW ST HELENS RD/LOWER COLUMBIA RIVER HWY/US-30 toward NW BRIDGE AVE/US-30 BYP W/ST JOHN BRIDGE. Continue to follow NW ST HELENS RD/US-30.
2. Turn SLIGHT RIGHT onto NW ST HELENS RD/COLUMBIA RIVER HWY/US-30. Continue to follow COLUMBIA RIVER HWY/US-30.
3. Turn SLIGHT RIGHT onto NW WARDWAY ST. Turn LEFT on MARIONA ST.
4. NW WARDWAY ST becomes NW VAUGHN ST. Turn LEFT onto JAMES ST.
5. Turn RIGHT onto NW 23RD AVE.
6. Turn LEFT onto NW NORTHRUP ST.
7. Turn RIGHT onto NW 22nd Ave.
8. End at 1015 NW 22nd Ave.

12 HEALTH AND SAFETY PLAN APPROVAL RECORD

By their signature, the undersigned certify that this HASP is approved and that it will be used to govern health and safety aspects of fieldwork conducted by Anchor QEA personnel to investigate areas associated within the RAA.

Anchor QEA Project Health and Safety Manager (HSM) Date

Anchor QEA Field Coordinator (FC) Date

Anchor QEA Health and Safety Officer (HSO) Date

13 REFERENCES

Anchor Environmental, L.L.C., 2001. "Northwest Natural 'Gasco' Site Ecological and Human Health Risk Assessment – Level II Screening Report." Prepared for Oregon Department of Environmental Quality, February 2001.

Anchor Environmental, L.L.C., 2004. "NW Natural 'Gasco' Site – Removal Action Work Plan." Prepared for the US Environmental Protection Agency, May 2004.

U.S. Environmental Protection Agency (EPA), 2004. Administrative Order on Consent for Removal Action between NW Natural and the U.S. Environmental Protection Agency. April 28, 2004.

U.S. Environmental Protection Agency (EPA), 2001. Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual. EPA/823/B-01-022, October 2001.

TABLES

Table 1
Activity Hazard Analysis

Activity	Hazard	Control
Drilling activities including soil sample collection and well installation on barge or on land	Falling overboard	Avoid working near the edge of the vessel, if possible. Stay away from edge of barge deck.
	Back or muscle strain	Use appropriate lifting technique when handling heavy equipment. Enlist help if necessary.
	Skin or eye contact with potentially contaminated sediments or liquids	Wear modified Level D PPE, including eye protection.
	Slipping/tripping on slick or uneven deck	Wear steel-toed boots with gripping tread. Be aware of obstacles and wet patches on deck and select a path to avoid them.
	Injury from equipment falling or swinging	Wear a hard hat and steel-toed boots at all times; be in the appropriate position on deck when equipment is in operation.
	Fire	Avoid fueling operations near hot engines. Mop up any spilled flammable liquids and dispose of absorbent. No smoking or flame sources on the vessel. Evacuate the vessel according to procedures outlined in the training session given by the captain.
	Rotating or percussive drilling equipment	Stay clear of area around borehole while drilling activities are underway.
Purging of groundwater during well development	Skin or eye contact with potentially contaminated liquids	Wear modified Level D PPE, including eye protection
	Inhalation of vapors	Use an OVM, and benzene sample tubes as necessary, to determine if VOC levels remain below identified thresholds.
Decontaminating equipment	Inhalation of, or eye contact with, airborne mists or vapors	Wear safety glasses. Perform decontamination activities outdoors or in a well-ventilated area. Stay upwind when spray-rinsing equipment.
	Skin contact with potentially contaminated materials	Wear modified Level D PPE.
	Ingestion of contaminated materials	Decontaminate clothing and skin prior to eating, drinking, smoking, or other hand-to-mouth activities. Follow the decontamination procedure for personal decontamination.

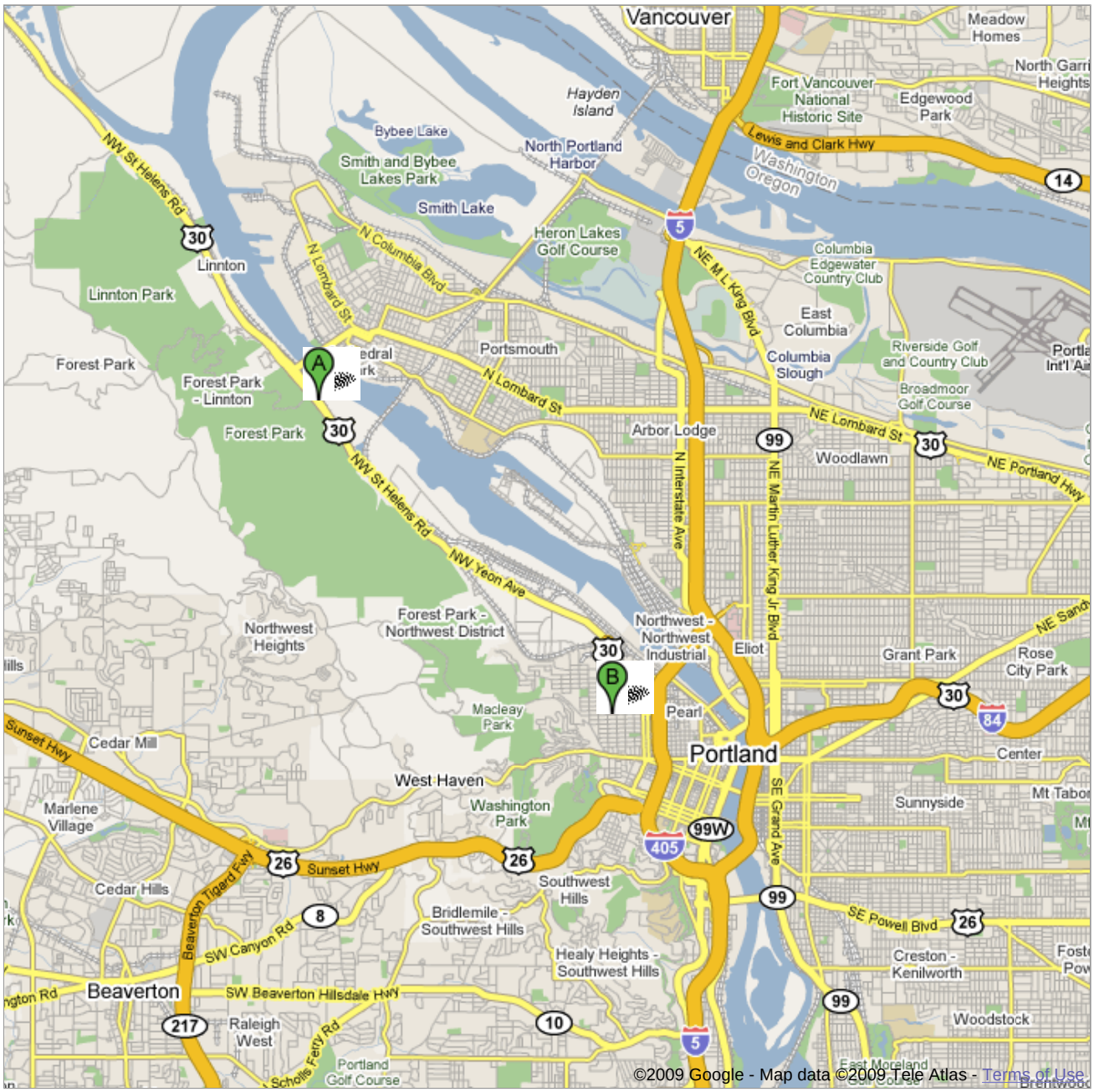
Table 2
Emergency Response Contacts

Contact	Telephone Number
Emergency Numbers	
Ambulance	911
Police	911
Fire	911
Legacy Good Samaritan Hospital and Medical Center	(503) 413-7711
Emergency Responders	
U.S. Coast Guard Willamette River Station General information	 (503) 240-9311 (503) 247-4018
National Response Center	(800) 424-8802

FIGURE

Directions to Legacy Good Samaritan Hospital & Medical Center
1015 NW 22nd Ave, Portland, OR 97210 - (503) 413-7711
6.4 mi – about **13 mins**

Save trees. Go green!
Download Google Maps on your phone at **google.com/gmm**



7900 NW St Helens Rd, Portland, OR 97210

1.	Head **northwest** on **NW St Helens Rd/US-30** toward **NW Knappton-General Rd** About 1 min	go 0.6 mi total 0.6 mi
2.	Make a **U-turn** at **NW Knappton-General Rd** Continue to follow US-30 About 8 mins	go 4.7 mi total 5.3 mi
3.	Turn **right** at **NW Nicolai St**	go 0.2 mi total 5.5 mi
4.	Turn **left** at **NW 24th Ave** About 4 mins	go 0.8 mi total 6.2 mi
5.	Turn **left** at **NW Lovejoy St** Destination will be on the left	go 0.1 mi total 6.4 mi

Legacy Good Samaritan Hospital & Medical Center
1015 NW 22nd Ave, Portland, OR 97210 - (503) 413-7711

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

Map data ©2009 , Tele Atlas

ATTACHMENT A

SAFETY RECORD FORMS

FIELD TEAM HEALTH AND SAFETY PLAN REVIEW

ANCHOR QEA, LLC

NW NATURAL GASCO SITE

I have read a copy of the HASP, which covers field activities that will be conducted to investigate specified areas on and adjacent to the NW Natural Gasco Site, Portland, Oregon. I understand the health and safety requirements of the project, which are detailed in this HASP.

Signature Date

Signature Date

Signature Date

Signature Date

Signature Date

ANCHOR QEA

1423 Third Avenue, Suite 300
Seattle, Washington 98101
Phone 206.287.9130
Fax 206.287.9131

October 23, 2009

Sean Sheldrake
USEPA, Region 10
1200 Sixth Avenue, M/S ECL-111
Seattle, Washington 98101

Dana Bayuk
Oregon Department of Environmental Quality
2020 SW 4th Avenue, Suite 400
Portland, OR 97201

Re: Response to USEPA and DEQ Comments – Capture Zone Field Test Plan;
Gasco, Portland Oregon
Administrative Settlement Agreement and Order on Consent for Removal Action
USEPA Region 10, Docket No. CERCLA 10-2009-0255
Gasco Sediments Site within the Portland Harbor Superfund Site

Project Number: 000029-02, BG 23

Dear Sean:

This letter presents NW Natural's responses to the U.S. Environmental Protection Agency's (USEPA) and Oregon Department of Environmental Quality's (DEQ) comments on the *Capture Zone Field Test Plan* (Test Plan) prepared by Anchor QEA, LLC (Anchor QEA), dated October 8, 2009. We have recently discussed these comments with DEQ and understand it is DEQ's position that this work requires formal DEQ approval in addition to the approval that NW Natural is requesting from EPA.

The primary purpose of the Test Plan is to provide information on likely offshore groundwater discharge rates under proposed future source control designs that is necessary

to support the design of the in-water sediment cleanup that will be developed under the Administrative Settlement Agreement and Order on Consent (Order; Docket No. CERCLA 10-2009-0255) for sediment cleanup at the Gasco Sediments Site. Under the Order, NW Natural must submit documents screening the available media quality data, identify data gaps necessary to complete the screening and support development of the remedial design, and develop field sampling plans to fill the identified data gaps. Prior to completion of this data screening, NW Natural identified an obvious data need for more information on offshore groundwater discharge rates. Given the time needed to gather this information, the Test Plan was submitted to USEPA in advance of these other documents to expedite the collection of this necessary information and keep the design of the sediment remedy on schedule. Given that the current in-water work window closes October 31, 2009, NW Natural requested USEPA's expedited review of the Test Plan to facilitate implementation of the Test Plan prior to the end of the work window. USEPA reviewed the Test Plan and provided comments and approval in their email dated October 9, 2009.

The Test Plan also provides information relevant to groundwater/dense non aqueous phase liquid (DNAPL) source control measures that are currently being developed by NW Natural under a separate order with the DEQ. Therefore, the Test Plan was also provided to DEQ concurrent with the USEPA review to obtain their comments on issues relevant to the source control process. DEQ reviewed and provided comments on the Test Plan in a joint letter with USEPA dated October 9, 2009 to expedite their response and further facilitate expedited implementation of the Test Plan prior to the end of the in-water work window. As noted above, DEQ written approval is also anticipated for this work.

Many of the comments received from USEPA and DEQ were duplicative so a single response document was selected as the most efficient method to provide clear and consistent responses to both agencies. Comments from the USEPA and DEQ are provided below in bold and italic text, respectively, followed by NW Natural's response.

NW NATURAL RESPONSES TO USEPA GENERAL COMMENTS

Comment 1 – Information related to design and construction of the offshore piezometers should be more descriptive and provided in a separate set of drilling, well completion and

development specifications. These specifications should be provided to the Driller and field crew so that there is a clear understanding of what is and is not acceptable during all phases of offshore piezometer installation. Examples of specificity include: Products to be used (casing, screens, sealing/backfill materials, tolerances, purity, etc…) and Execution which outlines proper use of the specified products for installation of the offshore piezometers and containment of waste generated from the drilling equipment.

NW Natural Response: The required well materials and borehole drilling, sampling, and sealing protocols were provided to the drilling contractors in our request for bids. Additional written clarifications will be made to the drillers if anything changes. See the responses to the DEQ comments below for additional information on drilling protocols.

Comment 2 – The discussion on piezometer well installation does not reference State of Oregon well construction regulations. These regulations should be referenced as necessary to confirm that all well construction materials and methods meet these regulations.

NW Natural Response: Agreed.

NW NATURAL RESPONSE TO USEPA SPECIFIC COMMENTS

Comment 1 (multiple-parts) – Bullet #3, October 2, 2009 email response: The response does not provide enough information to ensure there will be no bridging, improper filter pack placement (native slough) and potential sonic borehole casing lock during piezometer installation. Guidelines should address:

- **Criteria for the borehole to be considered stable prior to initiating piezometer installation.**

NW Natural Response: A weighted line will be used by the drilling contractor to confirm the depth of the borehole prior to piezometer installation.

- **Contingency plans for drill cutting settlement and/or heaving sediment conditions within the borehole at completion depth.**

NW Natural Response: One of the advantages of the sonic drilling method is a reduction in the problem of heaving soils compared to other rotary drilling methods. If heave is encountered that interferes with sampling or well installation, it will be up to the drilling contractor to use methods that meet with Oregon Water Resource regulations. Based on past experience at this site, we will likely add water during drilling to minimize the hydraulic head difference between the water level inside the casing and outside the casing. Adding water in this way usually minimizes heave to an acceptable degree to complete the boring.

- **Threshold footage of material allowed and maintained within the annular space (either filter pack, or seal materials) between borehole casing and 2-inch piezometer during the completion phase.**

NW Natural Response: Tremie methods will be used for grout installation. Tremie methods may be used for installation of annular sand, depending upon the professional judgment of the drilling contractor. A weighted line will be used to check the depth of annular backfill during well installation.

- **Instruction for the field personnel/driller to measure and maintain the threshold footages. For example, the sonic casing borehole pullback should be limited to a distance (to be specified) much smaller than the total footage of material allowed inside the annular space (to be specified) and measured to ensure material remains within annular space at all time during borehole casing extraction.**

NW Natural Response: Agreed.

- **Pre-build volume calculations based on the design depth of the piezometers for the field crew to confirm that a proper amount of material (sealant and filter pack) was used to fill the annular space and is completed at specified thicknesses across the entire length of the installed 2-inch piezometer.**

NW Natural Response: See previous response to Comment 1.

- **Thresholds for rejection, abandonment and redrilling of piezometer. For example – compromised screen placement of a specified depth.**

NW Natural Response: The decision to abandon a boring and re-drill will be based on best professional judgment of the Anchor QEA geologist (registered in Oregon) and the drilling contractor.

- **Abandonment contingency plan and procedures.**

NW Natural Response: If it becomes necessary to abandon a boring, the boring will be grouted using Tremie methods as the drill casing is withdrawn.

Comment 2 – Table 1: There is concern that the current design depth for the piezometers as shown on Table 1 is rigid and will not be revised based on subsurface characteristics logged and encountered in the field during drilling. Although important to show anticipated depths, they need to be qualified in Table 1 that actual depths may differ depending on actual lithology during drilling.

NW Natural Response: The plan is to install the screens at the approximate elevations shown on Table 1 in the Test Plan. We will review the geologic log after drilling each location prior to installing the piezometer. If the geologic log shows that the zone that is designated for the screen has a significant percentage of silt beds, we will use the log to see if the screen depth could be shifted up or down to reduce the percentage of silt in the screen zone. If the soil above and below the designated zone also contains a high percentage of silt, we will not change the screen depth from the guideline shown on Table 1 in the Test Plan.

Comment 3 – Response to first question in October 2, 2009 email: Details on the methodology and sampler chosen for collecting the continuous cored borings should be provided.

NW Natural Response: A sonic core barrel will be advanced into the sediment and a larger diameter casing will be driven over the core barrel to keep the borehole open during sample retrieval. The core barrel will be withdrawn from the borehole, the sample retrieved for logging and analysis, the core barrel will then be advanced to the next interval. This cycle will continue until the designated depth is encountered.

Comment 4 – Section 3.3, page 6, Paragraph 2: The rationale and criteria (e.g. lithology) used to determine in the field when the desired completion depth was reached for the existing piezometers and will be for the proposed piezometers should be provided.

NW Natural Response: See response to USEPA Specific Comment 2.

Comment 5 – Section 3.3: As-built drawings for the existing piezometers (PZ1-5, PZ1-20, PZ2-5, and PZ2-20) should be provided.

NW Natural Response: These four piezometers were installed using drive point methods. A fence post driver was used to drive the stainless steel screen tip into the sediment. The attached Table 1 shows the screen elevation. Each piezometer is constructed of a 1-foot-long, 0.75-inch Solinst Model 615 drive point threaded to 1-inch diameter steel casing. The threads were sealed with gray stainless steel Teflon-thread seal tape.

Comment 6 – Section 3.3, page 6, Paragraph 1: Elaborate on the testing of the existing piezometers and how they "confirmed the technology provides representative groundwater hydrologic measurement in the river sediment"

NW Natural Response: The Test Plan provides a description of the consistent hydraulic response of the piezometers to water level changes in the river. The text describes how the head differences measured in the piezometers indicate that the groundwater is discharging to the river on a net basis. The Test Plan also describes how the temperature contrast between the river and the groundwater is consistent with groundwater discharging into the river. All of this information leads us to believe that the hydrology data from the piezometers is representative of groundwater conditions in the river sediment. If USEPA has a specific technical question about the information provided, we will try to answer.

Comment 7 – Figure 3: There is a concern that the deeper piezometer completions, as they are currently shown, only screen the upper, more permeable and thicker sand unit and will not properly represent the entire flux within this unit. It is possible that the shallow piezometers would respond, even show a gradient reversal, to shallow pumping in this sand unit, but not represent complete capture of potentially deeper contaminated groundwater flux towards the river through this thick unit. NW Natural should consider the potential for a deeper groundwater flow component to the river within this thick sand unit and present a piezometer installation plan that accounts for this possible flow.

NW Natural Response: Anchor QEA is adding the additional piezometers at locations PZ2 and PZ5 to be screened near the -75 ft elevation, depending upon the geology as determined in the field core logs.

Comment 8 – Table 1, Figures 2 and 3: references to "msl" need to represent a consistent datum and be consistent with the Siltronic datum. Table 1 and Figure 3 indicate City of Portland Datum while Figure 2 has no datum reference. It is important that a consistent datum be used and cross referenced to known datums used in the area. An example of a cross reference is provided below from Port of Portland maps Early Action Characterization Report Figure 5-27, September 2004

NW Natural Response: Anchor QEA is aware that these two datums are not the same. All groundwater work for this project is being done using the City of Portland datum, because that is the datum that was used by Hahn Associates for the Remedial Investigation, and changing now would require modification of previous water level and geological information. However, the in-water sediment work uses different datums, depending upon the purpose of the study. Some drawings and tables mistakenly use "MSL" as a catch-all acronym. The elevation reference will be clarified as USEPA suggests.

NW NATURAL RESPONSE TO DEQ GENERAL COMMENTS

NW Natural proposes installing piezometers at depths ranging between -5 and -50 feet elevation using the City of Portland vertical datum [CoP]). It is unclear how this approach will provide data to assess uplands and in-water groundwater capture given groundwater contamination occurs at depths greater than -50 feet CoP. For example, data collected in the northern portion of Segment 2 indicate total cyanide concentrations beneath the shoreline exceed the screening criterion of 0.140 milligrams per liter down to at least approximately –75 feet CoP. Based on the vertical distribution of groundwater impacts, NW Natural should add deeper piezometers to the Test Plan scope of work at selected locations (e.g., PZ2 and PZ5). The purpose of installing deeper piezometers is to collect data to assess the vertical influence of pumping extraction wells over depth intervals of contaminated groundwater (e.g., greater than -75 feet CoP). The actual depths of the deeper piezometers should be based on observations made in the field during drilling (e.g., the depth and thickness of silt layers, depth of occurrence of "medium grained sand" unit). DEQ considers additional deeper piezometers necessary for achieving the data collection objectives of the Test Plan, and expects the installations to be included in the in-water drilling effort currently being organized by NW Natural.

NW Natural Response: See NW Natural response to USEPA Specific Comment 7.

NW NATURAL RESPONSE TO DEQ SPECIFIC COMMENTS

Section 3.3, 2nd paragraph. NW Natural indicates piezometers PZ1-5, PZ1-20, PZ2-5, and PZ2-20 were completed in March 2009 to assess whether the installation provide representative groundwater measurements in river sediment. DEQ understands the data collected from these existing piezometers is graphically compiled on Figure 4. To date, DEQ has not received documentation of this work. NW Natural should provide drilling and installation procedures and as-built drawings for the existing piezometers for our information and files prior to initiating the piezometer drilling and installation work described in the Test Plan.

NW Natural Response: See NW Natural's response to USEPA Specific Comment 5.

Figure 1a. Topographic and bathymetric contour line labels are missing from the figure and should be added for reference and completeness.

NW Natural Response: Agreed.

Figures 1a, 1b, and 1c. Offshore drilling and sampling locations along in-water transects B and C should be added to the figures for reference and completeness.

NW Natural Response: Agreed.

Figures 1, 2, and 4. Table 1 and Figure 3 indicate that elevations in the Test Plan are referenced to the CoP. This information appears to be missing from figures 1 (a, b, c), 2 (a, b, c), and 4. The figures should be reviewed and revised to include this information.

NW Natural Response: Agreed.

Additionally, Table 1 suggests elevations referenced to the CoP are equal to "mean sea level" (MSL) elevations. For clarification, elevations referenced to the CoP are not equivalent to MSL. DEQ refers NW Natural to USEPA's attached Comment 8 for additional details regarding vertical datums. Figures 1 through 4 should be reviewed in the context of this

comment to ensure elevations are correct for the vertical datum used. The figures should be revised as appropriate.

NW Natural Response: See NW Natural's response to USEPA Specific Comment 8.

Appendix A. DEQ has numerous comments regarding Appendix A as follows.

- *Based on previous drilling work completed in the river, piezometers are going to be constructed in offshore areas potentially impacted by MGP waste directly discharged and/or deposited as a result of historic Gasco MGP operations. Consistent with in-water drilling work completed previously, where piezometers will be installed at depths greater than approximately 25 to 30 feet below mudline, NW Natural should be prepared to use the double-case method if visible evidence of MGP waste (e.g., product or sheen) is observed during drilling. The double-case method will reduce the potential for downward vertical migration of contamination during drilling and piezometer installation.*

NW Natural Response: The drilling contractor is planning to install an outer casing that will be driven 10 feet into the sediment. Only a few of the offshore borings completed in the dock area in 2007 encountered DNAPL, and at all locations the DNAPL did not extend deeper than ten feet below the mudline. Following installation of the outer casing, the sonic drill pipe will be inserted into the outer casing during drilling, sampling, and well installation. This outer casing is intended to prevent downward movement of DNAPL that might be encountered in shallow sediments.

- *Although not specified in the Test Plan, given the potential for NW Natural to encounter heavily impacted sediment during drilling, DEQ presumes boreholes will be sealed using the organoclay-bentonite slurry approved for use at the site by the Oregon Water Resources Department and DEQ.*

NW Natural Response: The organoclay-bentonite slurry will be installed using Tremie methods only in areas where heavily impacted sediment is encountered.

- *In-water work conducted previously offshore from the Gasco Site encountered heave during drilling. Heave could make the collection of representative geologic samples difficult. Furthermore, heave has the potential to interfere with constructing piezometers at the designated depths, and could prevent construction materials (e.g., sand, organoclay-bentonite) from being placed over the desired depth intervals. NW Natural should provide details regarding how heave will be controlled to ensure piezometers are constructed as designed (see USEPA Specific Comment 1 for related comments).*

NW Natural Response: See NW Natural response to USEPA Specific Comment 1, Second Bullet.

Additionally, NW Natural has specified completion depths for each of the nearshore/offshore piezometers. Although not specifically discussed in the Test Plan, DEQ understands certain piezometers will be installed in the upper "fine to medium grained sand and silty sand" (e.g., PZ3-10, PZ5-20) and deeper "medium grained sand" (e.g., PZ1-50, PZ043, PZ3-40, PZ5-50). As such, actual depths of completion will be based on geologic observations made during drilling. The criteria for selecting the actual depth of installation should be described.

NW Natural response: See NW Natural's response to USEPA Specific Comment 2.

If you have any questions regarding the above responses please do not hesitate to contact me at rbarth@anchorqea.com or (206) 287-9130.

Sincerely,

Ryan Barth, PE
Anchor QEA, LLC

Cc: Dana Bayuk, DEQ
Matt McClincy, DEQ
Lance Peterson, Camp Dresser McKee
Robert Wyatt, NW Natural
Patty Dost, Pearl Legal Group PC
Carl Stivers, Anchor QEA
Tom McCue, Siltronic
Alan Gladstone and Hanne Eastwood, Davis Rothwell Earle and Xochihua
James Peale, Maul Foster Alongi, Inc.

Attachments
Table 1 – Revised Well and Piezometer Construction Details to Include Additional Piezometers Requested by DEQ

Table 1
Well and Piezometer Construction Details
Gasco Siltronic, Portland, Oregon

Well Number	Planned Transducer	Water-Bearing Zone	Date Installed	Date De-commissioned	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet cop)	Top of Casing (feet cop)	Top of Casing (feet bgs)	Boring Depth (feet bgs)	Boring Depth (feet cop)	Top Screen (feet bgs)	Top Screen (feet cop)	Base Screen (feet bgs)	Base Screen (feet cop)
Existing Monitoring Well																			
MW-1-22		Surficial Fill	23-Oct-91	-	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020	10-20	2	32.00	34.75	(2.8)	22.0	10.0	11.0	21.0	21.0	11.0
MW-1-55		Alluvial	9-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.10	35.75	(2.7)	57.0	-23.9	45.0	-11.9	55.0	-21.9
MW-1-82		Alluvial	8-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.50	36.08	(2.6)	85.4	-51.9	72.0	-38.5	82.0	-48.5
MW-2-32	X	Surficial Fill	5-Nov-91	-	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	35.80	34.46	1.3	32.5	3.3	21.5	14.3	31.5	4.3
MW-2-61	X	Alluvial	7-Oct-94	-	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	34.70	34.41	0.3	61.5	-26.8	50.0	-15.3	60.0	-25.3
MW-2-104	X	Alluvial	24-Jun-03	-	Sonic	Flush	Continuous wrap stainless steel	0.020	10-20	2	34.90	34.92	(0.0)	116.5	-81.6	94.0	-59.1	104.0	-69.1
MW-3-26		Surficial Fill	31-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.20	34.11	(2.9)	26.0	5.2	15.0	16.2	25.0	6.2
MW-3-56		Alluvial	31-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.20	34.07	(2.9)	56.0	-24.8	45.0	-13.8	55.0	-23.8
MW-4-35		Surficial Fill	30-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	34.54	(2.8)	35.0	-3.3	24.0	7.7	34.0	-2.3
MW-4-57		Alluvial	29-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	34.53	(2.8)	57.0	-25.3	46.0	-14.3	56.0	-24.3
MW-4-101		Alluvial	15-Oct-94	-	Dual Wall Reverse Air	Above-grade	Slotted PVC (pre-pack)	0.010	20-40	2	31.80	34.36	(2.6)	120.0	-88.2	89.5	-57.7	99.5	-67.7
MW-5-32		Surficial Fill/Alluvial	26-Oct-91	-	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020	10-20	2	25.10	27.83	(2.7)	32.0	-6.9	21.0	4.1	31.0	-5.9
MW-5-100		Alluvial	22-Oct-94	-	Dual Wall Reverse Air	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	25.40	27.31	(1.9)	100.0	-74.6	88.0	-62.6	98.0	-72.6
MW-5-175		Alluvial	21-Oct-94	-	Dual Wall Reverse Air	Above-grade	Slotted PVC (pre-pack)	0.010	20-40	2	25.20	27.19	(2.0)	175.0	-149.8	163.0	-137.8	173.0	-147.8
MW-6-32		Surficial Fill	8-Nov-91	-	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.80	35.51	0.3	32.0	3.8	21.0	14.8	31.0	4.8
MW-6-61		Alluvial	6-Nov-91	21-Dec-93	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.80	34.50	1.3	61.0	-25.2	50.0	-14.2	60.0	-24.2
MW-8-29		Surficial Fill	25-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.09	(2.6)	29.0	7.5	18.0	18.5	28.0	8.5
MW-8-56		Alluvial	24-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.13	(2.6)	56.0	-19.5	45.0	-8.5	55.0	-18.5
MW-9-29		Surficial Fill/Alluvial	22-Oct-91	-	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	37.90	37.65	0.3	29.0	8.9	18.0	19.9	28.0	9.9
MW-10-25		Surficial Fill	8-Nov-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.22	(2.7)	25.0	11.5	14.0	22.5	24.0	12.5
MW-10-61		Alluvial	7-Nov-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.33	(2.8)	61.0	-24.5	50.0	-13.5	60.0	-23.5

Table 1
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Gasco Siltronic, Portland, Oregon

Well Number	Planned Transducer	Water-Bearing Zone	Date Installed	Date De-commissioned	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet cop)	Top of Casing		Boring Depth		Top Screen		Base Screen	
												(feet cop)	(feet bgs)	(feet bgs)	(feet cop)	(feet bgs)	(feet cop)	(feet bgs)	(feet cop)
MW-11-32		Surficial Fill	2-Nov-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	35.40	38.39	(3.0)	32.0	3.4	21.0	14.4	31.0	4.4
MW-12-36		Surficial Fill/Alluvial	22-Oct-91	-	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020	10-20	2	35.90	38.69	(2.8)	36.0	-0.1	25.0	10.9	35.0	0.9
MW-13-30		Surficial Fill	18-Dec-93	-	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.23	34.86	0.4	30.0	5.2	19.0	16.2	29.0	6.2
MW-13-61		Alluvial	17-Dec-93	-	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.23	34.78	0.4	61.0	-25.8	50.0	-14.8	60.0	-24.8
MW-13-61R		Alluvial	31-May-03	-	Sonic	Flush	Continuous wrap stainless steel	0.020	20-40	2	35.31	35.38	(0.1)	63.0	-27.7	51.0	-15.7	61.0	-25.7
MW-14-110		Alluvial	18-Oct-94	-	Dual Wall Reverse Air	Above-grade	Slotted stainless steel (pre-pack)	0.010	20-40	2	35.30	37.41	(2.1)	110.0	-74.7	98.0	-62.7	108.0	-72.7
MW-15-50		Alluvial	30-Jun-95	-	Air Rotary	Flush	Slotted stainless steel (pre-pack)	0.010	10-20	2	36.27	35.97	0.3	50.0	-13.7	40.0	-3.7	50.0	-13.7
MW-15-66		Alluvial	29-Jun-95	-	Air Rotary	Flush	Slotted stainless steel	0.010	10-20	2	36.27	36.06	0.2	66.0	-29.7	60.5	-24.2	65.5	-29.2
MW-16-45		Alluvial	19-Jul-00	-	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.81	33.12	(2.3)	49.0	-18.2	30.0	0.8	45.0	-14.2
MW-16-65	X	Alluvial	18-Jul-00	-	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.60	33.11	(2.5)	68.0	-37.4	55.0	-24.4	65.0	-34.4
MW-16-125	X	Alluvial	14-Jul-00	-	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.49	32.89	(2.4)	130.0	-99.5	115.0	-84.5	125.0	-94.5
MW-17-79		Alluvial	25-Jul-01	-	Sonic	Above-grade	Continuous wrap stainless steel	0.010	10-20	2	32.56	34.83	(2.3)	82.0	-49.4	38.5	-5.9	78.5	-45.9
MW-18-30		Surficial Fill	26-Feb-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.66	34.28	(2.6)	30.0	1.7	19.0	12.7	29.0	2.7
MW-18-180	X	Alluvial	25-Feb-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	33.92	(2.2)	230.0	-198.3	170.0	-138.3	180.0	-148.3
MW-19-22		Surficial Fill	5-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.40	29.82	(2.4)	23.0	4.4	12.0	15.4	22.0	5.4
MW-19-125		Alluvial	11-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.20	29.42	(2.2)	126.0	-98.8	115.0	-87.8	125.0	-97.8
MW-19-180		Alluvial	1-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.28	29.81	(2.5)	227.0	-199.7	170.0	-142.7	180.0	-152.7
MW-20-120		Alluvial	7-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	25.63	27.84	(2.2)	213.0	-187.4	110.0	-84.4	120.0	-94.4
MW-21-12		Surficial Fill	5-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.50	23.47	(3.0)	14.0	6.5	7.0	13.5	12.0	8.5
MW-21-75	X	Alluvial	4-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.50	23.13	(2.6)	77.0	-56.5	65.0	-44.5	75.0	-54.5
MW-21-115	X	Alluvial	1-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.50	23.47	(3.0)	118.0	-97.5	105.0	-84.5	115.0	-94.5
MW-21-166	X	Alluvial	27-Jun-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.50	23.19	(2.7)	193.0	-172.5	156.0	-135.5	166.0	-145.5

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PW-01-80		Alluvial	8-Aug-01	-	Sonic	Flush	Continuous wrap stainless steel	0.020	10-20	6	32.00	31.80	0.2	82.0	-50.0	39.5	-7.5	79.5	-47.5
Proposed Monitoring Well																			
MW-22-74	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	34.00	37.00	(3.0)	75.0	-41.0	64.0	-30.0	74.0	-40.0
MW-23-74	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	34.00	37.00	(3.0)	75.0	-41.0	64.0	-30.0	74.0	-40.0
MW-23-130	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	34.00	37.00	(3.0)	130.0	-96.0	119.0	-85.0	129.0	-95.0
MW-24-80	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	30.00	33.00	(3.0)	81.0	-51.0	70.0	-40.0	80.0	-50.0
MW-24-130	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	30.00	33.00	(3.0)	131.0	-101.0	120.0	-90.0	130.0	-100.0
Proposed Observation Well																			
OW-7-20	X	Surficial Fill		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	23.00	26.00	(3.0)	20.0	3.0	13.0	10.0	18.0	5.0
OW-8-20	X	Surficial Fill		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	23.00	26.00	(3.0)	20.0	3.0	13.0	10.0	18.0	5.0
OW-9-27	X	Surficial Fill		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	30.00	33.00	(3.0)	27.0	3.0	20.0	10.0	25.0	5.0
Proposed Extraction Well																			
PW-7	X	Alluvial		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	23.00	26.00	(3.0)	70.0	-47.0	48.0	-25.0	68.0	-45.0
PW-8	X	Alluvial		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	23.00	26.00	(3.0)	70.0	-47.0	48.0	-25.0	68.0	-45.0
PW-9	X	Alluvial		-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	30.00	33.00	(3.0)	77.0	-47.0	55.0	-25.0	75.0	-45.0
Existing Piezometer																			
PZ1-5	X	Alluvial	17-Mar-05	-	Manual	Above-grade	Solinst push point		NA	1	9.96	36.08	(26.1)	5.6	4.3	4.5	5.5	5.4	4.6
PZ1-20	X	Alluvial	17-Mar-05	-	Manual	Above-grade	Solinst push point		NA	1	10.15	36.43	(26.3)	20.5	-10.3	19.3	-9.2	20.2	-10.1
PZ2-5	X	Alluvial	18-Mar-05	-	Manual	Above-grade	Solinst push point		NA	1	2.89	37.92	(35.0)	6.7	-3.8	5.5	-2.6	6.4	-3.5
PZ2-20	X	Alluvial	17-Mar-05	-	Manual	Above-grade	Solinst push point		NA	1	3.38	37.90	(34.5)	21.7	-18.4	20.6	-17.2	21.5	-18.1
Proposed Piezometer																			
PZ1-50	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	36.50	(26.5)	50.5	-40.5	45.0	-35.0	50.0	-40.0
PZ2-43	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	3.00	38.00	(35.0)	43.5	-40.5	38.0	-35.0	43.0	-40.0
PZ2-78	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	3.00	38.00	(35.0)	78.5	-75.5	73.0	-70.0	78.0	-75.0
PZ3-10	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	-10.00	40.00	(50.0)	10.5	-20.5	5.0	-15.0	10.0	-20.0
PZ3-40	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	-10.00	40.00	(50.0)	40.5	-50.5	35.0	-45.0	40.0	-50.0
PZ4-10	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	-10.00	40.00	(50.0)	10.5	-20.5	5.0	-15.0	10.0	-20.0
PZ4-40	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	-10.00	40.00	(50.0)	50.5	-60.5	35.0	-45.0	40.0	-50.0
PZ5-5	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	13.00	(3.0)	5.5	4.5	4.0	6.0	5.0	5.0
PZ5-20	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	13.00	(3.0)	20.5	-10.5	15.0	-5.0	20.0	-10.0
PZ5-50	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	13.00	(3.0)	50.5	-40.5	45.0	-35.0	50.0	-40.0
PZ5-85	X	Alluvial		-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	13.00	(3.0)	85.5	-75.5	80.0	-70.0	85.0	-75.0

Notes:
bgs = below ground surface; btc = below top of casing; COP = City of Portland Datum; PVC = polyvinyl chloride