REPORT

REVISED GROUNDWATER SOURCE CONTROL CONSTRUCTION DESIGN REPORT NW NATURAL GASCO SITE

Prepared for

NW Natural

Prepared by

Anchor QEA, LLC

In Association with

Sevenson Environmental Services, Inc.

Advanced Remediation Technologies, Inc.

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CERTIFICATION STATEMENT

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Anchor QEA, LLC

1/30/2012

Date

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LIST OF ACRONYMS AND ABBREVIATIONS

3D	three dimensional
µg	microgram
Anchor Environmental	Anchor Environmental, L.L.C.
Anchor QEA	Anchor QEA, LLC
BES	City of Portland Bureau of Environmental Services
bgs	below ground surface
CDR	Revised Groundwater Source Control Construction Design Report
COI	chemical of interest
COP	City of Portland datum
CPT	cone penetrometer
CVOC	chlorinated volatile organic compound
delta H	Difference in elevation between groundwater and river at a control well
DEQ	Oregon Department of Environmental Quality
DNAPL	dense nonaqueous phase liquid
EPA	U.S. Environmental Protection Agency
FAMM	Fuel and Marine Marketing
FDR	Final Design Report
FEMA	Federal Emergency Management Agency
FS	Feasibility Study
gpm	gallon per minute
GWFFS	Groundwater/DNAPL Source Control and NAPL Focused Feasibility Study
HAI	Hahn and Associates, Inc.
HC&C	hydraulic control and containment
HMI	human machine interface
IDR	Groundwater Source Control Interim Design Report
L	liter
LNG	liquefied natural gas
LWG	Lower Willamette Group
MGP	manufactured gas plant
NAPL	nonaqueous phase liquid
NPDES	National Pollutant Discharge Elimination System

OPDR	Groundwater Source Control Operations and Performance Monitoring Design Report
PacTerm	Pacific Terminal Services, Inc.
PAH	polycyclic aromatic hydrocarbon
PGE	Portland General Electric
PLC	programmable logic control
POTW	publicly owned treatment works
QA	quality assurance
QC	quality control
ORP	oxidation reduction potential
RAO	remedial action objective
RI	Remedial Investigation
SCM	source control measure
Sevenson	Sevenson Environmental Services, Inc.
Siltronic	Siltronic Corporation
Site	Gasco Site in Portland, Oregon
SSPA	SS Papadopoulos and Associates
STI	Subsurface Technologies, Inc.
SVOC	semivolatile organic compound
TarGOST	tar-specific green optical screening tool
TCE	trichloroethene
TZW	transition zone water
USACE	U.S. Army Corps of Engineers
UV	ultraviolet
VFD	variable frequency drive
VOC	volatile organic compound
WAD	weak acid dissociable
WBZ	water bearing zone
WSE	Water Systems Engineering, Inc.

1 INTRODUCTION

As directed by the Oregon Department of Environmental Quality (DEQ), NW Natural has completed this revised construction design of the groundwater and dense nonaqueous phase liquid (DNAPL) source control measure for the Gasco Site in Portland, Oregon (Site). This is a 100-percent design for a complete hydraulic containment system that can be constructed and tested upon approval by DEQ. The overall source control design process and how this report fits into that process is described in the Background Section 1.1.

This source control work is being completed consistent with the requirements of: 1) the Joint Order (DEQ Order No. ECVC-NWR-00-27 to NW Natural and Siltronic Corporation (Siltronic), dated October 4, 2000); and 2) the Voluntary Agreement (DEQ No. WMCVM-NWR-94-13, dated August 8, 1994, as amended July 19, 2006). The Site location is shown on Figure 1-1. On March 21, 2008, DEQ selected source control actions to address potential impacts to the Willamette River from manufactured gas plant (MGP) and solvent contamination at the Gasco and Siltronic properties. This Revised Groundwater Source Control Construction Design Report (CDR) incorporates the findings from numerous design studies, as requested by DEQ. This report includes the following:

- Existing Conditions (Section 2)
- Groundwater Extraction and Treatment System (Section 3)
- Permits (Section 4)
- Construction Schedule and Sequencing (Section 5)

1.1 Background

On behalf of NW Natural, Anchor Environmental, L.L.C. (Anchor Environmental) prepared and submitted the *Preliminary Design Report, Groundwater Source Control Report* to DEQ in June 2008 (Anchor 2008a). Due to a recent merger, Anchor Environmental is now known as Anchor QEA, LLC (Anchor QEA). This CDR describes groundwater and DNAPL source control measures (SCMs) for Segments 1 and 2. These two shoreline segments cover the entire length of the NW Natural shoreline and a portion of the Siltronic shoreline. The Site map showing the locations of source control Segments 1 and 2 is on Figure 1-2.

The *Groundwater Source Control Interim Design Report* (IDR; Anchor QEA 2009a) was provided to DEQ in November 2009. DEQ provided comments on the IDR on March 26, 2010. A copy of the March 26 comment letter is in Appendix A. Following a series of meetings with

NW Natural, DEQ sent NW Natural a June 11, 2010, email directing NW Natural to defer hydraulic control and containment (HC&C) along a portion of Segment 1 and proceed with design and implementation of HC&C in Segment 2 and the remainder of Segment 1. In a July 14, 2010, email, NW Natural invoked dispute resolution for the source control direction detailed in DEQ's June 11 email. NW Natural then sent DEQ a Request for Formal Dispute Resolution on July 20, 2010. A comprehensive technical response to DEQ's March 26 comment letter was attached to the July 20 letter, along with a number of drawings and other information requested by DEQ. A copy of the July 20 letter with attachments is in Appendix B. Several meetings and information exchanges then occurred between NW Natural and DEQ in an effort to resolve the dispute. During this period, NW Natural suspended source control design activities. A meeting was held between DEQ and NW Natural on December 13, 2010, which laid the groundwork for settling the dispute. In email correspondence dated December 15, 2010 (Jim Anderson with DEQ to Bob Wyatt with NW Natural), December 17, 2010 (Bob Wyatt to Jim Anderson), and December 22, 2010 (Jim Anderson to Bob Wyatt), DEQ and NW Natural summarized agreements reached during the December 13 meeting (see Appendix B). The conditions of the December 2010 settlement that influenced the final design are further described in Section 1.2.

The groundwater source control design process is illustrated in the diagram on Figure 1-3. The *Draft Groundwater Source Control Final Design Report* (FDR; Anchor QEA 2011c) was submitted to DEQ in May 2011. DEQ provided a letter on September 22, 2011, that consolidated the comments of DEQ and Region 10 U.S. Environmental Protection Agency (EPA). A copy of the DEQ letter is in Appendix A. NW Natural's November 4, 2011, response to that letter, *Response to September 22, 2011, commenting on the May, 2011 Draft Source Control Final Design Report, NW Natural Gasco Site* (Anchor QEA 2011a) is in Appendix B. In addition to providing a response to DEQ's September 22 comment letter, the November 4 letter provided a detailed proposal for expedited completion of the groundwater source control design process. DEQ provided a letter on December 7, 2011, responding to the November 4 letter, which requested that the source control design process include five steps and for NW Natural to respond within 2 weeks. A copy of the December 7 letter is located in Appendix B.

Anchor QEA submitted a December 21, 2011, letter to DEQ agreeing to DEQ's requested five steps with some clarifications, which is described in the subsequent paragraphs. The five steps are also illustrated on Figure 1-3.

Step 1 – Submit Revised Treatment System Design. The treatment system design report will be revised as requested, including identification and flow estimates of the individual sources of water to the treatment plant. DEQ's requested reassessment of groundwater flux through the Fill water bearing zone (WBZ) will be provided in the Step 4 Groundwater Source Control Operations and Performance Monitoring Design Report (OPDR).

Step 2.1 – Submit Revised Design Report. NW Natural will prepare the CDR, as described in the November 4, 2011, letter. NW Natural will also prepare a document describing the technical approach to conduct the DEQ-requested evaluation of available drawdown in the Upper Alluvium extraction wells. The approach will include installation of push probe borings at all proposed Upper Alluvium extraction wells to obtain soil samples for grain size testing. The grain size data will be used to determine the appropriate extraction well screen and annular backfill design. The approach will include construction of a subset of Upper Alluvium extraction wells, followed by step-drawdown field tests of the new wells. Aquifer parameters derived from the step-drawdown tests will be used in the MODFLOW model to assess the issue of available drawdown. The model will be updated to include hydraulic parameters determined from the step-drawdown tests. Following startup of the HC&C system, the model will be re-calibrated to water levels recorded during startup, and the recalibrated model will be used to assess capture of groundwater in the shallow, intermediate, and deep Alluvium WBZ.

Step 2.2 – Assess Baseline Conditions. NW Natural will prepare a document describing the technical approach for assessing baseline conditions that is consistent with the November 4, 2011, letter and DEQ's December 7, 2011, letter.

Step 2.3 – Prepare "Initial Operation (Short-term Testing) Work Plan." This DEQ-requested work plan will be included in the CDR.

Step 2.4 – HC&C Construction. NW Natural will construct the entire HC&C system after receiving DEQ approval of the CDR, including the DEQ-requested components in Steps 2.1 through 2.3.

Step 3 – Initial Operation. NW Natural will conduct short-term tests of the completed extraction system, consistent with the DEQ-approved CDR.

Step 4 – Preparation of OPDR. NW Natural will prepare the OPDR to be consistent with the CDR and the findings of the Step 3 field tests.

Step 5 – Startup of HC&C System. Long-term operation of the completed HC&C system will begin as soon as possible, following DEQ approval of the OPDR and receipt of the approved National Pollutant Discharge Elimination System (NPDES) permit for discharge of treated groundwater.

NW Natural prepared work plan letters that describe the technical approaches requested in DEQ's Steps 2.1 and 2.2. The Step 2.1 letter is entitled "Upper Alluvium Extraction Well Design Work Plan" and the Step 2.2 letter is entitled "Work Plan to Assess Baseline Groundwater Conditions." The two work plan letters will be submitted to DEQ on the January 31, 2012, submittal of the CDR. The short-term testing work plan requested in DEQ's Step 2.3 is provided in Section 3.2.3 of this CDR. The short-term testing described in the work plan will be conducted in Step 3.

As proposed in the November 4 letter, the revised Wastewater Treatment Final Design Report was submitted by Sevenson Environmental Services, Inc. (Sevenson), to DEQ for review on January 31, 2012. It was submitted to DEQ under separate cover from this CDR, so DEQ could provide an expedited review and approval, which will allow NW Natural to order long-lead components of the treatment system. The revised Wastewater Treatment Final Design Report is also provided in Appendix E of this CDR.

Submittal of this CDR for DEQ's review is a key step in the process of completing the source control design. When this CDR receives agency approval, NW Natural will construct the extraction system and conduct short-term hydraulic tests of the system using the protocols and procedures described in this CDR. The groundwater MODFLOW model will be updated using the information from those tests. Information from the updated model and extraction system tests will be used to prepare the OPDR. The information from the updated model and extraction system tests will also be used in the design of the in-river sediment remedy.

After DEQ has approved the OPDR, NW Natural will be ready to implement long-term operation of the extraction system.

1.2 Remedial Action Objectives

The source control physical removal action goals identified in the IDR for Segments 1 and 2 are as follows:

- Groundwater – Prevent discharge of upland groundwater to the Willamette River, as measured by analyzing groundwater hydrology data from Site wells and the river.
- DNAPL – Prevent the migration of upland DNAPL to the river.

At DEQ's request, the following clarifications apply to the above remedial action objectives (RAOs):

- Source control measure alternatives have been evaluated specific to mitigating migration to the Willamette River along shoreline Segments 1 and 2 by DNAPL in the Fill WBZ and Alluvium WBZ and contaminated groundwater in the Alluvium WBZ.
- DNAPL removal will be included to the extent necessary to control and contain the potential movement of DNAPL from former effluent management areas on the NW Natural and Siltronic properties that could result from the operation of the hydraulic containment system.

According to the December 2010 settlement, DEQ and NW Natural agree that uplands DNAPL removal and the vertical barrier will be evaluated during the uplands Feasibility Study (FS). As requested by DEQ, the vertical barrier that is carried forward into the FS will be 625 feet long and constructed using sheet pile methods to a depth of -60 feet City of Portland datum (COP).

The December 2010 settlement provided some additional detail related to the source control final design and the uplands FS, as follows:

- DEQ's technical issues with the IDR, as expressed in the March 26, 2010, comment letter and written comments issued by DEQ during dispute resolution, must be addressed during final design. Appendix A includes a copy of the March 26, 2010, letter. Appendix A also includes a table that identifies each of DEQ's requests, as presented in the letter, and where those requests are addressed in this CDR.
- The uplands FS must fully evaluate remedial action alternatives for DNAPL associated with former tar pond area(s), such as DNAPL management systems, removal, and solidification or stabilization. As requested by DEQ, NW Natural will carry all DEQ comments on the vertical barrier in the March 26, 2010, letter into the upland FS.

On page 7, paragraph 1, of DEQ's September 22 comment letter, DEQ states that the RAOs for groundwater source control are in place to prevent migration of contaminated groundwater from the uplands to the Willamette River along shoreline Segments 1 and 2, in a manner that minimizes DNAPL mobilization resulting from groundwater SCMs along the portion of Segment 1 where DNAPL occurs. In general, NW Natural agrees with this concept, but the protocols for operating the extraction system to get full hydraulic containment while simultaneously controlling gradients to reduce the potential for DNAPL migration will be developed in the forthcoming OPDR.

1.3 Integration with In-river Cleanup

In September 2009, EPA, NW Natural, and Siltronic signed an Administrative Settlement Agreement and Order of Consent that includes a Statement of Work, which describes how the riverbank cleanup work will be part of the in-river cleanup.

The details of source controls presented in this CDR show that the construction of the extraction wells would not restrict future riverbank cleanup options. As discussed in Section 5, it is NW Natural's goal to commence system operation in 2011, well in advance of riverbank and in-river sediment cleanup. This CDR includes an interceptor trench to provide groundwater source control for the Fill WBZ. As explained further in this report, the Fill WBZ interceptor trench source control action would present a potential limiting factor on the design of riverbank cleanup actions that could occur during the river sediment cleanup. For that reason, it is proposed that the Fill WBZ interceptor system be installed coincident with the riverbank cleanup during the future river sediment cleanup. By taking that approach, the design of the Fill WBZ source control action presented herein can be integrated with the riverbank remedy and river sediment cleanup.

1.4 Integration with Upland Cleanup

On page 6, paragraph 4, of the September 22 letter, DEQ requests that the CDR include a discussion of sequencing and implementation of groundwater SCMs with the final upland remedy, especially with regard to the former Tar Ponds area. As mentioned in Section 1.1, NW Natural will be ready to implement long-term operation of the source control extraction system after DEQ has approved the OPDR. NW Natural currently plans to be able to implement long-term operation of the extraction system in early 2014.

Per DEQ direction, the upland Field Sampling Plan and Risk Assessment Work Plan are currently in preparation. Following DEQ approval of those two documents, the DEQ-directed upland soil investigation will be conducted, and the Risk Assessment report will be revised and resubmitted. Following DEQ approval of the upland Risk Assessment, the upland FS Work Plan will be prepared. The upland FS will be prepared after receiving DEQ approval of the FS Work Plan. The upland FS will include an assessment of DNAPL remediation alternatives, including the DNAPL present in the former Tar Pond Area. The design for upland cleanup will be prepared following issuance of DEQ's Record of Decision and public comment. Implementation of upland cleanup will occur after DEQ approval of the upland cleanup design, including the DNAPL cleanup component approved by DEQ. The upland FS will provide an evaluation of remedial alternatives for the Gasco Uplands and will incorporate all existing groundwater source control and DNAPL management systems.

1.5 Integration with U.S. Moorings Site

On page 11, paragraph 4, of the September 22 letter, DEQ requests that the CDR discuss how timing of DEQ-requested additional soil and groundwater investigations on the Site to evaluate potential off-site impacts at the U.S. Moorings site may affect the groundwater SCMs design or implementation for the Fill and Alluvium WBZs. Additional site characterization near the border of the Site and U.S. Moorings properties prior to design and implementation of Segment 1 and 2 SCMs would unnecessarily delay control of sources to the river and potentially delay implementation of the sediment remedy. NW Natural will submit a proposal for the additional characterization as soon as possible after the OPDR is submitted. The existing design of the interceptor trench and extraction well system could be supplemented in the future, with additional trench length and extraction wells (if needed), to address new sources identified near the boundary with U.S. Moorings.

2 EXISTING CONDITIONS

2.1 Hydrogeology and Conceptual Site Model

2.1.1 General Geology and Groundwater Occurrence

The upland hydrogeology was described in the *Remedial Investigation Report* (HAI 2007). DEQ has requested extensive additional investigations as part of source control evaluations that have provided more detail on the Site hydrogeology, particularly near the Willamette River shoreline. These additional investigations were conducted along the shoreline and offshore and were reported in the *Phase 1 Report and Phase 2 Field Sampling Approach, Gasco Siltronic Groundwater Source Evaluation* (Anchor 2007b) and the *Offshore Investigation Report* (Anchor 2008b). The findings of the offshore investigations are described in Section 3.2.1.1. DEQ also requested that tar-specific green optical screening tool (TarGOST) investigations be conducted to further define the nature and extent of upland DNAPL. The TarGOST investigations are described in Section 3.2.1.6.

Figure 2-1 shows the locations of the monitoring wells on Segments 1 and 2, including both NW Natural and Siltronic properties. Table 2-1 lists the construction details of the existing and proposed monitoring wells, extraction wells, and piezometers. Figures 2-2a, b, c, and d are detailed maps showing well locations, pipelines, roads, buildings, and other features along Segments 1 and 2.

Figures 2-3a, b, and c through 2-8a and b are detailed geologic cross sections, focused on the shoreline area. The locations of these cross sections are shown in plan view in Figure 2-1. Figures 2-3a, b, and c depict three portions of the A-A′ cross section that is parallel to the river shoreline covering Segments 1 and 2. Cross sections B-B′ through F-F′ on Figures 2-4 through 2-8a and b extend from the upland into the river. Cross sections G-G′ and H-H′ on Figures 3-10a and b and 3-11a and b are discussed in the DNAPL monitoring Section 3.2.2.5.3. Per DEQ's request in the September 22 comment letter the cross sections on Figures 2-8a and b, 3-10a and b, and 3-11a and b were lengthened to extend further into the river. These cross sections were constructed using the geologic information from several sources, including the following:

- Upland remedial investigation borings and monitoring wells (HAI 2007)
- Shoreline and offshore borings (Anchor 2008b)
- Supplemental monitoring wells (Anchor 2008a)

- TarGOST borings (HAI 2008)
- Siltronic borings and monitoring wells (MFA 2007)
- Monitoring wells, extraction wells, and piezometers installed for the Segment 2 capture zone tests (see Appendix I for well logs)

The Site hydrogeology and conceptual site model is based on the findings described in the Remedial Investigation (RI) Report (HAI 2007) and in subsequent reports (Anchor 2007a, 2008a; Anchor QEA 2009b). The three upland hydrogeologic units are the Fill WBZ, Alluvium WBZ, and the underlying Columbia River Basalt. Groundwater in the Fill and Alluvium WBZs is recharged from underflow originating in the hills west of the Site and from infiltration of incident precipitation on the Site. Figures 2-9a and b are groundwater potentiometric surface maps completed in the Fill and Alluvium WBZs. Per DEQ request in the September 22 comment letter attachment, the elevation contours on Figure 2-9b have been extended to include water level data from Siltronic monitoring wells. These contour maps illustrate the groundwater elevation patterns that result in groundwater discharge to the river.

Groundwater in the Fill WBZ is recharged primarily from infiltration of precipitation because much of the Site is unpaved. Groundwater in the Fill WBZ both recharges the underlying alluvium and travels laterally with discharge to the river. Groundwater in the Alluvium WBZ discharges to the river. Upland groundwater flow has been simulated by a site-specific MODFLOW model developed for the Site. The use of the MODFLOW model in designing the SCMs is described in Section 3.2.1.4.

2.1.2 Fill Water Bearing Zone

The Fill WBZ is comprised of dredge spoils pumped from the river, combined with upland derived fill, including soil, bricks, concrete, and other debris. Figures 2-3a, b, and c through 2-8a and b show the lateral extent and thickness of the fill. At the river shoreline, the bank is armored with conventional riprap boulders. Most of the upland fill surface is unpaved. The fill overlies a silt layer that is the uppermost sedimentary unit of the underlying alluvium. The top of the silt was the former ground surface prior to fill placement. The depth to groundwater in the Fill WBZ increases toward the river, so the saturated thickness in the Fill WBZ nearshore monitoring wells is much less than the saturated thickness of monitoring wells on the west side of the Site. Many of the nearshore Fill WBZ monitoring wells dry up during the late summer and fall. The horizontal hydraulic conductivity of the Fill WBZ is variable, but the average horizontal hydraulic conductivity is very low, less than 1 foot per day. This conductivity is

based on slug tests performed in 2010 on nine nearshore Fill WBZ monitoring wells. A report of the slug test findings is in Appendix C.

2.1.3 Alluvium Water Bearing Zone

As a result of the paleochannel in the basalt bedrock shown on Figures 2-3a, b, and c, the depth of the Alluvium WBZ ranges from about 50 to 200 feet below ground surface (bgs) at the river shoreline. The alluvium is thinnest near the north (downstream) property line with the U.S. Moorings site. The subsurface profiles on Figures 2-3a, b, and c through 2-8a and b show that the interbedded silts and sands in the upland alluvium are similar to those present in the offshore alluvium.

The upper silt unit is the hydrogeologic boundary between the alluvium and the overlying fill. Subsurface profiles on Figures 2-3a, b, and c through 2-8a and b show that the upper silt is quite variable in thickness but generally continuous across the Site. The subsurface profiles also show that the Alluvium WBZ underlying the silt unit is comprised of two sand units: the upper alluvium and the lower alluvium. The upper alluvium is fine sand with numerous discontinuous silt layers, indicated on the profiles with a solid green color. The lower alluvium is primarily medium sand with fewer silt beds, indicated on the profiles with a green diagonal hatch pattern. Figures 2-3a, b, and c show that the thickness of the upper and lower alluviums increases from north to south along the shoreline as the depth to bedrock increases. The hydraulic conductivity of the upper alluvium is much lower than the lower alluvium.

Aquifer tests have been conducted at wells PW-1-80, PW-3-85, PW-3-118, PW-7-93, PW-8-39, PW-8-68, and PW-9-92. Slug tests have also been conducted in nine Fill WBZ wells and 15 upper alluvium wells. The findings from the test of PW-1-80 were reported by HAI (2006). The findings from the tests of PW-3-85 and PW-3-118 were reported by Anchor Environmental and SS Papadopulos and Associates (SSPA; 2008). The results of testing the well PW-3 are further described in Section 3.2. The findings from the tests of PW-7-93, PW-8-39, and PW-9-92 are incorporated into the MODFLOW model. The findings from the slug tests are in the technical memorandum in Appendix C. The hydraulic conductivity data from the slug tests have also been incorporated in the Site groundwater MODFLOW model. The MODFLOW model is further described in Section 3.2. Based on the pump and slug tests, the hydraulic conductivity of the upper alluvium is higher in Segment 1 than in Segment 2. From the area of well PW-3 north to the area of well PW-8, the hydraulic conductivity of the upper alluvium decreases from

about 10 feet per day to about 1 foot per day. The hydraulic conductivity parameter in the MODFLOW model is 300 feet per day for the lower alluvium.

In some areas, an alluvial gravel layer is present at the contact between the base of the Alluvium WBZ and the basalt bedrock.

2.1.3.1 Alluvium Water Bearing Zone Aquitard

During the interim design of source controls, the Site geologic cross sections (Figures 2-3a, b, and c through 2-8a and b) were revised based on the new geologic information obtained from the TarGOST borings and new monitoring well borings. It was determined that an aquitard (silt layer) is present within the lower alluvium between elevations -100 and -120 feet. As shown on Figure 2-3a, the aquitard is composed of a single silt bed on the north portion of the shoreline and is generally more than 10 feet thick. In the southern portion of the shoreline, the aquitard is somewhat lower in elevation and consists of either a single silt bed or multiple closely spaced silt interbeds. The aquitard silt is likely a geomorphic over-bank deposit that was placed during historic river flood events when the floodplain was at a lower elevation.

Figure 2-10 is an isopach map showing the thickness of the aquitard. The Site geologic information indicates that the aquitard is thickest on the north portion of the NW Natural property and the north portion of the Siltronic property. These areas were likely historic floodplain areas at lower elevation that accumulated more silt during flood events. Table 1 in Appendix D provides the geologic data used at each upland boring location to map the presence of the aquitard. The geologic data in Table 1 was also used to add the aquitard layer to the Site MODFLOW model. As shown on Table 1, the cone penetrometer (CPT) geologic logs from the TarGOST borings were also used to delineate the aquitard. Appendix D contains a memorandum that assesses the TarGOST CPT geologic data, compares the CPT data with conventional drill log data, and concludes that the TarGOST CPT data are reliable for the purpose of delineating geologic units at the Site. The memorandum in Appendix D provides the information requested by DEQ on page 1 of the attachment to the September 22 comment letter.

Review of the Site groundwater quality data shows that the aquitard has a significant effect on groundwater quality in the Alluvium WBZ. Table 2-2 shows a comparison of the concentrations of benzene, naphthalene, free cyanide, and total cyanide in monitoring wells screened in the Alluvium WBZ above and below the aquitard. The concentrations of each of the

four analytes are also shown on Figure 2-11. The data shown on Figure 2-11 are compiled from several well sampling events and from one-time groundwater grab samples obtained from exploratory borings. The notes provided on Figure 2-11 indicate the sampling event used for each well. On page 2 of the September 22 letter attachment, DEQ asked for additional groundwater quality data in a cross section, parallel to the shoreline. To respond to this request, Figure 2-11 was modified in several ways. The length of the cross section on Figure 2-11 was extended north to the NW Natural property line and analytes cis 1,2-dichloroethene, vinyl chloride, and toluene were added to the figure. These data are generally representative of the data in Table 2-2.

The monitoring wells used for comparison are wells clustered at the same location at the Site but screened above and below the aquitard. With few exceptions, the concentrations of benzene and naphthalene in wells screened below the aquitard are less than 1 microgram per liter (µg/L), which is typically an order of magnitude or more lower than the concentration in wells screened above the aquitard. The average benzene concentration from the September 2008 sampling event was 99.5 percent lower in samples taken from below the aquitard than samples taken from above the aquitard. The average naphthalene concentration from the September 2008 sampling event was 99 percent lower in samples from below the aquitard than samples taken from above the aquitard. Free cyanide concentrations are generally present at trace concentrations in the Alluvium WBZ and are even lower below the aquitard. The average free cyanide concentration from the September 2008 sampling event was 94 percent lower in samples from below the aquitard than samples taken from above the aquitard. For total cyanide, there is also a substantial decrease in concentration below the aquitard. Total cyanide concentrations are generally at least an order of magnitude higher above the aquitard than below the aquitard. The average total cyanide concentration from the September 2008 sampling event was 85 percent lower in samples from below the aquitard than in samples taken from above the aquitard. The groundwater quality data shows that more than 99 percent of the mass of MGP-related contamination is located above the aquitard.

2.1.4 Offshore Groundwater

The offshore investigation found that a groundwater plume of dissolved MGP-related chemicals of interest (COIs) extends from upland source areas into the river channel sediments. The three dimensional (3D) subsurface profiles on Figures 2-12a, b, and c show that the MGP-related groundwater plume is present in the upland Alluvium WBZ and extends into the alluvium under the river channel. These 3D profiles of the shoreline show the offshore extent of

cyanide, benzene, toluene, benzo(a)pyrene, and naphthalene in groundwater (Anchor 2008b). A seepage evaluation conducted in the late summer and fall of 2007 when the river levels were at their seasonal low estimated that the range of groundwater seepage from Site upland Segments 1 and 2 into the river ranged from about 225 to 253 gallons per minute (gpm) at the time of the investigation (Anchor 2008b). Because the low seasonal river level results in a higher head difference between upland groundwater and the river, it is expected that the measured seepage amount is near the maximum that is expected to occur on a seasonal basis. The findings from the offshore investigations were considered in establishing the source control RAO of preventing discharge of upland groundwater into the river.

The offshore investigations included a detailed assessment of the nature and extent of DNAPL in the river sediments. Figures 2-13a and b show the extent of dissolved free cyanide and total cyanide in groundwater, as measured in groundwater grab samples obtained in river shoreline borings drilled in river sediments along the base of the riverbank in 2007. The borings were extended from the river sediment mudline to basalt bedrock. Sonic drilling methods were used to obtain continuous sediment cores, which were screened for nonaqueous phase liquid (NAPL) using several screening techniques. The profiles on Figures 2-13a and b also show that DNAPL was detected in shallow river sediment in several of the borings. DNAPL was not detected in any of the borings below an elevation of approximately 17 feet COP datum. However, DNAPL has been detected in the upland alluvial WBZ at elevations down to -70 feet COP.

On page 2 of the September 22 letter, DEQ requested preparation of cross sections representative of upland groundwater data where source control will occur, including total cyanide, free cyanide, benzene, naphthalene, toluene, cis-1,2-dichloroethene, and vinyl chloride. To respond to this request, Figure 2-11 was extended north to the NW Natural property line and data for the requested analytes were added.

On page 2 of the September 22 letter attachment, DEQ commented that evidence of DNAPL was found at Boring GS-09 at an elevation of -25 feet COP, and Figures 2-8a and b should be revised accordingly. Anchor QEA researched the matter and found that the presence of DNAPL was identified with ultraviolet (UV) light field screening methods in the 33- to 35-foot depth interval. However, no visual evidence of sheen, tar, or oil was identified, nor was a strong hydrocarbon-like odor identified in the 33- to 35-foot interval during the drilling of GS-09. Many naturally occurring substances in soil fluoresce when subjected to UV light other than hydrocarbons. Because the finding of the UV test was not confirmed by either visual or

olfactory evidence of DNAPL, it is believed that the UV test was reacting to a naturally occurring material in the soil. Based on this analysis, it was determined that Figure 2-8b shows the correct interpretation.

A release or releases of spent trichloroethene (TCE) on the Siltronic property have resulted in groundwater contamination. Siltronic has defined the nature and extent of the chlorinated volatile organic compound (CVOC) plumes (MFA 2007). Figure 2-14 shows the approximate width of the combined CVOC plume at the riverbank. On page 13 of the September 22 letter attachment, DEQ commented that the interpreted width of the Siltronic CVOC plume should extend beyond the MW-5 monitoring well cluster because detections of cis-1,2-dichloroethene in monitoring well MW-5-100 exceed 300 µg/L. The northern extent of the plume on Figure 2-14 was adjusted accordingly. Siltronic is currently implementing an in situ source removal action (MFA 2007).

2.2 Current Land Use

The entire Site is zoned industrial, and a detailed description of historic and current industrial operations is in Section 2 of the RI Report (HAI 2007). This description of current land use is summarized from the RI Report. The industrial facilities are shown on Figure 1-2. Segment 1 extends across the NW Natural and Siltronic property line and includes about 400 feet of the northern end of the Siltronic property. Segment 2 is all on NW Natural property and extends from Segment 1 to the northern boundary of the NW Natural property. The Fuel and Marine Marketing (FAMM) terminal and NW Natural liquefied natural gas (LNG) storage and distribution facility are upland of Segment 1.

Koppers, Inc., leases the southwestern portion of the NW Natural property at 7540 Northwest St. Helens Road. The Koppers plant location is outside of the footprint of source control activities proposed in this report. However, the Koppers coal tar pitch pipeline does cross the shoreline in Segment 1, so a description of the Koppers operation is included herein. Koppers operates a coal tar pitch distillation plant and imports coal tar pitch and related products via rail tank cars and bulk cargo ships. Koppers either stores or remanufactures these products prior to distribution. As of 2005, the management of solid pencil pitch has reportedly been primarily phased out. Liquid coal tar pitch is received by Koppers at the NW Natural dock where it is pumped from the vessel, through an aboveground heated pipeline, to a storage tank on the Koppers lease area (HAI 2007). The location of the Koppers pipeline is shown on the maps in Figures 1-2 and 2-1.

Pacific Terminal Services, Inc. (PacTerm), under contract with FAMM, operates a fuel storage and distribution facility at the northern portion of the NW Natural property. The terminal receives, stores, blends, and ships marine fuels and lubricants, using both barge and truck for shipment (HAI 2007).

Siltronic operates a silicon wafer manufacturing plant adjacent to the NW Natural property. The U.S. Moorings facility adjoins the NW Natural property to the north.

3 GROUNDWATER EXTRACTION AND TREATMENT SYSTEM

3.1 Basis of Design

3.1.1 Extraction System Performance Goals

As described in Section 1.2, the source control RAOs are as follows:

- Source control physical removal action goals for Segments 1 and 2 are the following:
  - Groundwater – Prevent discharge of upland groundwater to the Willamette River, as measured by analyzing groundwater hydrology data from Site wells and the river.
  - DNAPL – Prevent the migration of upland DNAPL to the river.
- At DEQ's request, the following clarifications apply to the above RAOs:
  - Source control measure alternatives have been evaluated specific to mitigating migration to the Willamette River along Segments 1 and 2 by DNAPL in the Fill and Alluvium WBZs and contaminated groundwater in the Alluvium WBZ.
  - DNAPL removal will be included to the extent necessary to control and contain the potential movement of DNAPL from former effluent management areas on the NW Natural and Siltronic properties that could result from the operation of the hydraulic containment system.

The overall goal of these RAOs is hydraulic containment to protect the river. Procedures for assessing the performance of source controls will follow the guidelines, as described in *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 2008). The EPA guidance contains recommendations for assessing system performance to achieve capture using methods that measure hydraulic containment and water quality performance.

The RAOs are designed to achieve hydraulic containment; therefore, the performance monitoring methods described in Section 3.2.2.5 are primarily those that use hydrology data to confirm capture. Because groundwater is contaminated on both the upland and the river sides of the shoreline extraction wells, there is no plume boundary that can be used to measure water quality performance. However, Section 3.2.2.5 includes plans to monitor groundwater quality for the purpose of assessing trends of specific parameters. The shoreline extraction well system is designed to contain upland groundwater and minimize vertical and horizontal gradients that could mobilize DNAPL. To monitor the potential for DNAPL migration, a monitoring program has been designed (see Section 3.2.2.5.3).

3.1.2 Treatment System Performance Goals

The groundwater treatment system is designed to achieve the DEQ-mandated effluent criteria listed in Table 3-1. Although the effluent criteria are the key discharge permit conditions that must be met, other permit conditions must be met as well. The NPDES permit application was submitted to DEQ in February 2011, and all of DEQ's information requests related to the permit have been met. When the treatment system discharge permit is provided by DEQ, all permit conditions will be assessed to determine how they affect the treatment system performance goals and operating protocols. An approved NPDES permit is needed before the treatment system can be constructed.

3.1.3 Extraction/Treatment System Shutdown

The groundwater extraction system is designed to operate continuously to achieve hydraulic containment. Individual wells would be temporarily shut down for maintenance or repair, but the rest of the extraction wells would continue to operate for those periods. Replacement well pumps will be kept in inventory on site at all times. With replacement pumps available on site, the replacement of a well pump should be completed within 24 hours of shutdown. When a well is shut down for maintenance, the system will automatically increase the pumping rate on the adjacent wells to maintain capture. On page 3 of the September 22 letter attachment, DEQ comments that NW Natural should discuss the ability of the extraction system to maintain capture during single-well repair shutdowns in the context of DEQ's general comments on the long-term operation/effectiveness of the HC&C system and DNAPL movement. This comment is addressed in the revisions to the Extraction System Design Section 3.2.2, which evaluates issues of available drawdown, specific capacity, and capture potential of the extraction well system. However, the modeling aspect of this analysis will be done in the forthcoming OPDR.

The pipeline system is designed to allow cleaning of the pipeline from each well without shutting down the adjacent wells. Section 3.2.2.5.5 addresses maintenance and repair of the treatment system.

The entire well system might experience temporary shutdown that could result from the following factors:

- River flooding above an elevation of 28 feet COP
- Power outage
- Treatment system shutdown
- Other force majeure events

As explained below, the treatment system is designed with a high degree of component redundancy to prevent system shutdown for repair and maintenance.

Due to hydraulic gradient reversal, river level rises that cause the river elevation to be higher than the nearshore upland groundwater elevation will cause river water to temporarily recharge nearshore groundwater, thereby preventing groundwater discharge to the river. These natural gradient reversals will occur seasonally during daily river tidal fluctuation or during increases in river levels due to upstream precipitation or hydraulic damming caused by high levels in the Columbia River. Under these gradient reversal conditions, the extraction well discharge rate will be reduced accordingly. Extraction well pumping rates will be reduced and may temporarily stop during extended periods of gradient reversal, but the wells will restart to maintain capture as the river level declines.

The 100-year Federal Emergency Management Agency (FEMA) flood elevation is 28 feet COP. River flooding above this level rarely occurs and is generally temporary, lasting a few hours or days at most. Under such extreme flood conditions, there will be extenuating circumstances associated with Site access, Site flooding, and personnel travel, as well as other issues that could dictate a shutdown of the source control system.

The northwest industrial area is a high Portland General Electric (PGE) priority for restoration of power in the event of an outage. Based on records from PGE, the longest historic power outage that has occurred in the northwest industrial area is less than 12 hours. However, to ensure the continuous operation of the extraction wells and treatment system, a backup diesel generator is incorporated into the treatment system design. The generator would start up in the event of a PGE power failure. On page 3 of the September 22 letter attachment, DEQ comments that given the potential for flooding at the Site and the extenuating circumstances associated with flooding, including system shutdown, NW Natural should clarify whether backup generators are intended to keep the HC&C operating under these conditions. In response to this comment, in the rare event that shoreline extraction well locations are flooded by the river, the river elevations will be higher than groundwater elevations, which means that groundwater

is not discharging to the river and the extraction system does not have to be operated until river levels recede. Nevertheless, the treatment plant and backup power system are designed to operate under flood conditions up to the elevation of the 100-year flood event, if necessary. The backup generator is further described in Appendix E.

The treatment system is designed with redundant treatment system components, such as pumps and filters. This redundancy should prevent shutdown of the plant during normal maintenance or replacement of these components. The redundancy built into the treatment system design is further described in Appendix E.

DEQ requested an evaluation of the period of time that system shutdown could occur before an unacceptable water quality impact in the river occurs. However, the final design of the extraction and treatment system includes a backup generator to provide power in the event of a PGE power failure. As explained in the previous paragraphs, the extraction and treatment system's final design allows maintenance and repair of the components during continued operation of the overall system. The extraction and treatment system design now includes redundant components, a backup power system, and the ability to repair or maintain components while maintaining overall system operation. These design changes largely mitigate the system shutdown conditions under which DEQ requested that a water quality assessment be conducted. On page 3 of the September 22 letter attachment, DEQ acknowledged NW Natural's plans for responding to HC&C system shutdowns caused by equipment and agreed that an assessment of water quality changes under selected shutdown scenarios is no longer warranted.

3.2 Groundwater Extraction System

3.2.1 Design Studies

3.2.1.1 Offshore Investigations

On behalf of NW Natural, Anchor QEA conducted a series of investigations in the Willamette River, offshore of the Site, during the period from July 2006 to October 2007. This work was required by DEQ to determine the nature and extent of contamination in offshore groundwater and river sediments. DEQ required this work to inform the source control design as it relates to the connection between upland sources and the river. The investigations included comprehensive sampling and testing of groundwater, sediments, and river water. The

following summary of work completed and findings is from the Executive Summary of the *Offshore Investigation Report* (Anchor 2008b).

The primary objectives of the investigations were to assess the following issues:

- Understand how the vertical and horizontal extent of chemicals in groundwater beneath the river and transition zone water (TZW) may be related to chemical concentrations measured in upland groundwater.
- Understand how groundwater and TZW concentrations may be related to direct historical deposition of materials in the river.
- Determine if the chemical concentrations in the biologically active TZW in navigation channel sediments have been directly impacted by historical deposition of waste materials in the river.
- Determine the potential variability in measured shallow sediment TZW chemical concentrations due to tidal fluctuations in the Willamette River.
- Provide additional lines of evidence for verifying groundwater discharge and providing general level estimates of groundwater discharge rates within river sediments adjacent to the Site.
- Evaluate the potential for transport of cyanide measured in groundwater and TZW to surface water and any conversion to free cyanide under select river conditions.
- Collect data that may be useful for assessing in-river risks from cyanide (i.e., low tide versus high tide conditions and river current velocity and direction).

Following is a summary of the work completed to achieve these objectives:

- Barge-mounted drilling equipment was used to complete borings along four offshore transects: Transects A, B, C, and D. Transect A is located at the edge of the shoreline, and Transect D is located approximately 550 feet from the shoreline.
- A total of 106 groundwater samples and 83 sediment samples were tested for cyanide species, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), and metals.
- A total of 30 borings were drilled along Transects B, C, and D. A total of 105 groundwater samples and 21 sediment samples were tested for cyanide species, SVOCs, VOCs, and metals.

Ultrasonic seepage meters were installed at seven offshore locations to measure seepage rates over a 5-day period. Mini-piezometers were installed at three offshore locations. A total of 30 TZW porewater samples were obtained over multiple tidal cycles. A total of 12 near-bottom river water samples were obtained at the mini-piezometer locations. Willamette River water samples were collected at 20 offshore locations. A total of 180 river water samples were tested for total cyanide, amenable cyanide, free cyanide, selected metals, and conventional parameters.

For the purpose of describing the nature and extent of MGP-related COIs, this summary focuses on free cyanide, total cyanide, benzene, toluene, naphthalene, and benzo(a)pyrene. These six target analytes have a wide range of subsurface fate and transport properties, and their distribution are generally representative of the MGP-related COIs.

Free cyanide was detected in trace concentrations in a very small percentage of the groundwater samples. These results are significant because the free cyanide compound is considered the toxic form of cyanide. The detected concentrations were generally below 10 μg/L.

Total cyanide is present in groundwater in all offshore transects at generally all depths sampled. Total cyanide is very soluble and chemically stable and does not adsorb significantly to the sediment matrix. Therefore, total cyanide is one of the most widely distributed of the MGP-related COIs.

Benzene, toluene, and naphthalene are also widely distributed, but their plume patterns are variable, reflective of both historical overland transport of effluent to the river and groundwater transport from upland sources. Consistent with a much higher tendency of benzo(a)pyrene to adsorb to organic carbon, its distribution in groundwater is quite limited compared to naphthalene (another polycyclic aromatic hydrocarbon [PAH]), which is much more mobile in groundwater. The presence of elevated benzo(a)pyrene concentrations in offshore groundwater is primarily associated with the occurrence of NAPL in shallow sediments. Although trace concentrations of benzo(a)pyrene are detected in some of the deeper groundwater samples, these concentrations are likely associated with the suspended solids in the groundwater grab samples obtained during this investigation.

Seepage data from the 2005 Lower Willamette Group (LWG) investigations at the NW Natural and Siltronic properties were combined with seepage data from the 2007 Gasco seepage

investigation to estimate a range of total seepage rates from 225 to 253 gpm from the area offshore of the NW Natural and Siltronic properties. This rate is comparable to the extraction well pumping rate that modeling indicates would be necessary to achieve upland groundwater source control.

No free cyanide was detected in any surface water sample. There was one detection of free cyanide (unfiltered) in shallow TZW (1.5 to 2.5 feet below mudline), but all other TZW samples were non-detect for free cyanide. In response to DEQ's comment on page 2 of the September 22 letter attachment, it is noted that dissolved total cyanide was detected in only 4 of 180 samples, at concentrations ranging from less than 10 to 140 μg/L.

3.2.1.2 Pilot Extraction Well PW-3 Testing

Pilot extraction wells PW-3-85 and PW-3-118 were installed for field testing to obtain site-specific aquifer properties to inform the MODFLOW model and, ultimately, the design of the groundwater/DNAPL source control system. In previous reports, these wells were named PW-4-85 and PW-4-118 but were renamed, so the well names are sequential according to their spatial orientation. This description of the test procedures and findings is summarized from Appendix F of the *Groundwater/DNAPL Source Control and NAPL Focused Feasibility Study* (GWFFS; Anchor 2007a). The two PW-3 extraction wells are located near the Siltronic property line.

The PW-3 pump test consisted of pumping the shallow screen interval (PW-3-85) and intermediate screen interval (PW-3-118) both individually and together. The test included separate step-drawdown tests on each screen interval and a combined constant rate test on both screen intervals. The tests were conducted in July 2007 and included extensive continuous (1-minute frequency) monitoring of water levels in the pumping wells and observations wells for extended periods before, during, and after pumping. A summary of the rate and duration of tests is provided in Table 3-2.

Water levels during the tests were affected by river stage changes, which were primarily due to tidal fluctuations during the test period.

Analysis of the constant rate test at PW-3-85 shows two responses: an early time response and a later time response. The early time response is indicative of conditions close to the pumping

well before the influence of the river boundary becomes significant. The later time response is likely influenced by the river boundary.

Analyses of the PW-3-85 and PW-3-118 step-drawdown and constant rate tests show a considerable difference in the hydraulic conductivity in the upper and lower alluvium. In both tests, the influence of the river boundary appears to affect the pump tests, as seen in the rapid equilibration of the water levels with time. These variations in aquifer properties are accounted for in the properties assigned to the MODFLOW model layers. Analysis of the pump test data provided the aquifer properties of hydraulic conductivity and storage coefficient that were used in development and calibration of the MODFLOW model.

Water level data collected by transducers after the PW-3 pump test are shown on Figure 3-1. This figure illustrates the high tidal efficiencies at the various wells. Water levels at the wells closely follow the stage fluctuations in the river and are only slightly attenuated and delayed in time compared to the river stage fluctuation. The attenuated fluctuation in the wells compared to the river tidal fluctuation is referred to as the tidal efficiency and is usually reported as a percentage of the river stage fluctuation. The Segment 2 Capture Zone Test Report in Appendix I provides more detail on tidal efficiency in the nearshore alluvium. The delay in the peak water levels in the well compared to the timing in the river is referred to as the lag time.

3.2.1.3 2010 and 2011 Well Pump and Slug Tests

Aquifer tests have been conducted at wells PW-1-80, PW-3-85, PW-3-118, PW-7-93, PW-8-39, PW-8-68, and PW-9-92. Slug tests have also been conducted in nine Fill WBZ wells and 15 upper alluvium wells. The findings from the test of PW-1-80 were reported by Hahn and Associates, Inc. (HAI; 2006). The findings from the tests of PW-3-85 and 118 were reported by Anchor Environmental and SSPA (2008). The results of testing the PW-3 wells are further described in Section 3.2.1.2. The findings from the tests of PW-7-93, PW-8-39, and PW-9-92 are reported in the Segment 2 Capture Zone Test Report in Appendix I. The findings from the slug tests are in the technical memorandum in Appendix C. The slug tests reported in Appendix C indicate that the average hydraulic conductivity of the Fill WBZ is less than 1 foot per day. The hydraulic conductivity data from the upper alluvium slug tests have been incorporated in the Site groundwater MODFLOW model. The MODFLOW model is further described in Section 3.2.1.4. Based on the pump tests and the slug tests, the hydraulic conductivity of the upper alluvium is higher in Segment 1 than in Segment 2. From the area of well PW-3 north to the area of well PW-8, the hydraulic conductivity of the upper alluvium decreases from about

10 feet per day to about 1 foot per day. The hydraulic conductivity of the lower alluvium is about 300 feet per day.

3.2.1.4 Groundwater MODFLOW Model

Following submittal of the Preliminary Design Report (Anchor 2008a), DEQ requested additional groundwater flow modeling as part of source control design. The additional modeling work was reported in the following documents:

- *Groundwater Flow Model and DNAPL Evaluation Supplemental Report* (Anchor and SSPA 2008)
- *NW Natural Gasco, Pump Test Analysis and MODFLOW Model Summary* (SSPA 2008a; updated from the version in the *Groundwater/DNAPL Source Control Focused Feasibility Study*, Appendix E.)
- *NW Natural Gasco: Additional Groundwater Flow Analysis* (SSPA 2008b)
- *Supporting information on Groundwater Modeling related to the Groundwater Source Control Interim Design Report, NW Natural Gasco Site, Portland, OR* (SSPA 2009)
- Additional figures, based on additional model runs, as requested by DEQ in 2009

These reports are provided in Appendix F.

For the May 2011 design report, the model was modified to address DEQ comments, specifically for the following:

- The model area was extended to include the U.S. Moorings site.
- The model grid spacing was redefined from 40 by 40 feet to 20 by 20 feet. As in the original model, uniform grid spacing is used throughout the model area.
- The hydraulic conductivity of the shallow alluvium was modified to represent the spatial heterogeneity observed in pumping test results at PW-1-80, PW-3-85, and PW-8-39.

These model changes are described in Appendix F.

Model parameters of various hydrostratigraphic units are provided in the following table.

Unit	Hydraulic Conductivity (feet per day)	Vertical Anisotropy (dimensionless)	Specific Storage (feet[1])	Specific Yield[1] (dimensionless)
Fill	10	0.01	1.00E-05	0.05
Silt	0.5	0.01	1.00E-05	0.05
Upper Alluvium	1 to 10[2]	0.1	1.00E-05	0.05
Lower Alluvium above Aquitard	300	0.2	1.00E-05	0.05
Lower Alluvium below Aquitard	300	0.2	1.00E-05	0.05

Notes:
1 - Applies to the top-most active unconfined layer only. The relatively low value of 0.05 was used during tidal cycle simulations and therefore represents dewatering over tidal cycles.
2 - Varies based on pumping test results at PW-1-80, PW-3-85, and PW-8-39, and on slug test results, as shown in Appendix C.

Section 3.2.1.3 describes the slug tests completed at the Site. The hydraulic conductivity findings of the slug tests completed in the Fill WBZ were not used in the MODFLOW model. As shown in the previous table a hydraulic conductivity of 10 feet per day was used for the model, whereas the slug test results indicate an average hydraulic conductivity of less than 1 foot per day. The model was not modified to reflect the slug test findings because the model calibrated well with the Site groundwater water level data using a hydraulic conductivity value of 10 feet per day (see Appendix F). Using 10 feet per day also results in higher recharge to the Fill WBZ, which is more conservative from the standpoint of determining flow to the Fill WBZ interceptor trench and sizing of the pump and treat system.

Per the DEQ request in the September 22 letter attachment, Figures 3-2a through 3-2e were prepared showing particle track maps of the model-predicted capture zone at various depths in the Alluvium WBZ, induced from pumping at the 14 extraction well locations. The modeled total extraction flow rate for this analysis was 260 gpm. The modeling was conducted for steady-state conditions calibrated to the March 2000 water level data, which represents a reasonable worst-case condition based on Site water level data. As described in this report, the model will be updated following construction and testing of the HC&C system.

Figure 3-3 shows a cross section view at the PW-5 extraction wells. The particle tracks show groundwater flow to the wells from the shallow, intermediate, and deep alluvium. Groundwater flow from the deep alluvium below the aquitard flows around the deep silt aquitard layer and flows back to the lower extraction well. Only the PW-5 cross section is

shown, as particle paths and can only be reasonably shown when they are oriented approximately along model rows or columns. Strongly curved particle paths or path lines that cross rows and columns cannot be shown on a model cross section along a row or column.

Per the DEQ request in the September 22 letter attachment, the results of the MODFLOW groundwater flow budget for the HC&C area of the model are presented in Figure 3-4. Groundwater inflows consist primarily of upland boundary flow, recharge, and flow from the east side of the Willamette River. With groundwater pumping, the flow budget shows a complex system across and around silt layers.

The modeled design presented in this CDR includes paired upper and lower alluvium wells in Segment 1 with additional upper alluvium wells between the well pairs. This provides for horizontal gradients from the river to the wells and upward vertical gradients from the lower to the upper alluvium. The inward and upward vertical gradients are designed to provide full capture of Site groundwater while not exacerbating offshore or vertical migration of DNAPL.

The model used for the HC&C design included reduced recharge based on the expectation that the Site will be largely paved in the future. The HC&C model also includes a cut-off trench in the Fill Unit to collect groundwater flow before it reaches the river. Groundwater flows shown in Figure 3-4 represent flows with both the trench and paving in place.

A transient model simulation of the variable rate pumping test conducted in April 2011 is presented in Appendix F. The transient simulation represents pumping rates that vary over tidal and stage changes to maintain inward and upward gradients from the river to the extraction wells. The analysis examines how outflow variation is expected to change with stage and tide changes and show that the treatment system design capacity is flexible enough to account for seasonal and tidal flow variation.

3.2.1.5 Groundwater Gradient Analysis

Predicted groundwater gradients are shown on Figures 3-5a and b for cross sections through PW-13 and PW-4U-L, respectively. The gradients are directed upward and upland on the river side of the extraction wells to avoid exacerbating potential movement of DNAPL. Vertical gradients are greater in the upper alluvium than in the lower alluvium, even though upper alluvium wells are pumping at lower rates. This is due to the lower hydraulic conductivity of the upper alluvium. The vertical gradient decreases more rapidly with distance from the

pumping wells in the upper alluvium than in the lower alluvium, which is also due to the lower hydraulic conductivity of the upper alluvium.

3.2.1.6 TarGOST DNAPL Investigations

The nature and extent of DNAPL at the Site was presented in the RI Report (HAI 2007). DEQ requested further delineation of the extent of DNAPL using TarGOST technology. On behalf of NW Natural, HAI conducted TarGOST investigations in 2007 and 2008. For this project, the term DNAPL is defined to include tar, mobile oil, and residual oil. DEQ requested this information to help evaluate the design of nearshore source control alternatives and to refine the delineation of DNAPL in the former effluent pond area and on the Siltronic property.

The TarGOST exploration technology uses a CPT drill tool equipped with a detector that is pushed to selected subsurface sampling depths. The detector measures the fluorescent signature and magnitude to identify the presence of various petroleum compounds. The device was specifically calibrated to respond to DNAPL tar and oil at the Site by conducting test borings at locations where the DNAPL occurrence was known from previous investigations. The technology is reliable for the detection of the presence of tar and oil but cannot differentiate between tar and oil or determine if the material is mobile. The CPT measures the change in earth resistance as it is pushed into the ground, and the magnitude of resistance is correlated to soil types, such as sand, silt, and clay. Thus, the penetrometer logs are used to determine soil type.

Figure 3-6a shows the nature and extent of DNAPL (tar and oil) in the fill. Figure 3-6b shows the areal extent of tar and oil detected in the alluvium above the depth of 100 feet bgs. Figure 3-6c shows the areal extent of tar and oil detected in the alluvium below 100 feet. The TarGOST investigation generally confirmed the findings of the previous RI investigation but did refine the DNAPL boundaries in some areas of the Site. The detections of DNAPL and the thickness of geologic materials detected in the TarGOST borings were used to refine the geologic profiles in Figures 2-3a, b, and c through 2-8a and b. The TarGOST boring logs are provided in Appendix G.

DEQ requested in the March 26, 2010, letter that NW Natural add the detection of sheen to the subsurface profiles in the design report because DEQ believes that sheen is an indicator for the presence of DNAPL. Both Anchor QEA and HAI have been using prescribed techniques for delineating the presence of DNAPL, including the methods such as, field visual logging of soil

core, field UV light screening of soil core samples, and TarGOST explorations. Detections of DNAPL using these prescribed methods are the basis of the DNAPL delineated on subsurface profiles and on the DNAPL maps on Figures 3-6a, b, and c in this CDR. These combined methods for DNAPL detection are considered to be consistent and accurate. NW Natural does not agree that sheen is a consistent or otherwise reliable indicator for the presence of DNAPL, so interpretation of the differing magnitudes of sheen as the equivalent of a DNAPL observation does not enhance its understanding of the distribution of DNAPL.

On pages 5 and 6 of the September 22 letter attachment, DEQ requests the development of cross sections, indicating the depth intervals where sheen was visually identified by the field geologist during sample logging. DEQ's comment provides an option for the cross sections to be included as an attachment. Therefore, the figures in Appendix Q have been prepared to fulfill DEQ's request. The sheen zones shown on these cross sections do not provide a technically valid basis for defining the extent of DNAPL, and visual evidence of sheen in a soil sample is not technically valid evidence of DNAPL migration.

3.2.1.7 DNAPL Movement

At the request of DEQ, Anchor QEA evaluated the potential for DNAPL mobilization in the former effluent pond area as a result of future source control groundwater pumping. The findings of this modeling were presented to DEQ in a March 18, 2009, technical memorandum that is summarized in this report and described in detail in Appendix H.

The model results, summarized in Table 3-3, show that changes in the groundwater gradient in the former effluent pond area due to upper alluvium depth extraction well pumping, would cause maximum distances traveled over a 3-year period to range between approximately 3.3 to 7.3 feet at distances of 90 and 50 feet upgradient of the extraction well. The data in Table 3-3 refer to the behavior of DNAPL pools, not residual DNAPL. The evaluation concluded that mobilization of residual DNAPL (as opposed to pools) would not occur at the Site in the former effluent pond area because groundwater gradients that result from pumping, and the material properties of the aquifer matrix and DNAPL, produce a capillary number that is well below the critical value.

From this analysis, enhanced groundwater movement in the former effluent pond area due to shoreline extraction wells is minimal and would not substantially change DNAPL distribution over time. These calculations are conservative approximations of the potential distances that

DNAPL could travel, and the true estimate would be less if the capillary term was factored into the calculation.

On page 6 of the September 22 letter attachment, DEQ states that "*the Draft Final Groundwater SCMs Design should acknowledge the results of DNAPL wettability testing near the river.*"
NW Natural agrees that wettability is a factor that affects the mobility of DNAPL and requested a meeting with DEQ in Appendix B to NW Natural's November 4 letter in order to learn the specifics of how DEQ would like this testing acknowledged. If the DEQ is satisfied this request has been sufficiently addressed in the design, the meeting is no longer necessary. As a clarification, numerical modeling was not used to predict DNAPL mobility. Only the change in gradient from the model was used as an input to the separate evaluation of DNAPL mobility.

3.2.1.8 DNAPL Removal Pilot Plan

A *DNAPL Removal Pilot Plan* (Anchor 2008c) was submitted to DEQ in October 2008. The first objective of the plan was to conduct a field test using pilot DNAPL extraction wells to determine how pumping of shoreline source control wells would affect DNAPL migration in the former effluent pond area. This test was designed to respond to DEQ's concern about DNAPL migration under the influence of the shoreline extraction wells. The second objective of the test was to provide information to aid in future design of a DNAPL extraction system. DEQ issued a January 22, 2009, comment letter stating that it was unlikely that the first objective of the test would be met but recommended that NW Natural proceed with the test to achieve the secondary objective. Because DEQ did not support conducting the test for its first objective, NW Natural informed DEQ in a February 10, 2009, letter of its intent to postpone implementation of DNAPL pilot testing until it can be conducted in the context of the upland FS process.

Since submittal of the *DNAPL Removal Pilot Plan* (Anchor 2008c), NW Natural conducted the evaluation of potential DNAPL mobilization as described in Section 3.2.1.7. The predicted migration distances shown in Table 3-3 indicate that the migration of DNAPL is expected to be insignificant under the influence of the shoreline extraction wells. The findings of that analysis further support NW Natural's plan to evaluate DNAPL removal as part of the upland FS process, not as part of shoreline source control activities.

In a letter to NW Natural dated June 5, 2009, DEQ commented on the DNAPL Removal Pilot Plan and approved moving forward with developing plans and schedules to implement

uplands DNAPL removal after shoreline SCMs are constructed. In a letter to NW Natural dated March 26, 2010, DEQ commented on the IDR and accepted NW Natural's recommendation to evaluate the vertical barrier and DNAPL removal SCMs in the uplands FS.

3.2.1.9 Segment 2 Extraction Well Pilot Test

On September 23, 2009, the *Segment 2 Capture Zone Field Test Plan* (Anchor QEA 2009c) was submitted to EPA for review. The revised and approved plan included the installation of four shoreline extraction wells, upland monitoring wells, and offshore piezometers in Segment 2. The Segment 2 field test was completed in 2010; the findings were provided to EPA and DEQ (Anchor QEA 2011b), and the report is provided in Appendix I. The extraction wells, monitoring wells, and piezometers were equipped with electric water level transducers. The three extraction wells were pumped at varying rates with concurrent measurement of gradient changes in the wells. The purpose of the test was to assess how operation of the extraction wells affect offshore seepage of groundwater in the river to support the development and evaluation of sediment remedial alternatives (e.g., sediment capping). The findings of the evaluation will be used for design of the in-river sediment cleanup to be conducted under the authority of EPA.

In summary, the Segment 2 Capture Zone Field Test Plan (Anchor QEA 2009c) showed that conventional extraction wells operated near the shoreline can successfully contain offshore seepage at least as far offshore as the FAMM dock and likely beyond. The tests provided the information needed for future modeling of seepage control in the river, as it will apply to design of the in-river sediment cleanup.

The Segment 2 capture zone tests also provided some information for upland source control design. The tests showed that the upper alluvium in the vicinity of pilot wells PW-7, 8, and 9 has lower hydraulic conductivity than the upper alluvium in Segment 1. The aquifer properties derived from the Segment 2 field tests have been incorporated into the MODFLOW model being used for source control design. The tests also showed that in the vicinity of extraction wells PW-7, PW-8, and PW-9, pumping of lower alluvium extraction wells has little or no short-term measurable water level effect on nearby wells screened in the overlying Fill WBZ.

Field tests of the programmable logic control (PLC) and variable frequency drive (VFD) well pumps for pilot extraction wells PW-7, PW-8, and PW-9 were conducted in March and April 2011. The work was completed and findings were provided in the report *Segment 2 Field*

Tests of the Programmable Logic Control and Variable Frequency Drive Well Pumps, Gasco Sediments Site (Anchor QEA 2011b). The field tests of the PLC and VFD interface showed that the system was successful at controlling extraction well discharge rates concurrent with groundwater level changes to maintain a consistent condition of offshore seepage control throughout the tidal cycles. That report also includes responses to EPA's April 25, 2001, comments on the *Segment 2 Capture Zone Field Test Report* (Anchor QEA 2011b).

3.2.2 Extraction System Design

There are two main components of the groundwater containment system. Groundwater in the Fill WBZ will be captured in an interceptor trench constructed near the top of the riverbank. Groundwater in the Alluvium WBZ will be captured by an extraction well system that will be constructed upon DEQ approval of the CDR. The extraction well system design is presented in Section 3.2.2.2. The groundwater flow rate from the Fill WBZ interceptor trench is anticipated to be approximately 10 percent of the total flow from the alluvium. Implementation of the alluvium pump and treat system is, therefore, a higher priority than groundwater source control in the Fill WBZ. Both the Fill WBZ interceptor trench and the Alluvium WBZ extraction well system will pump groundwater to the treatment plant for discharge to the river under an NPDES permit.

3.2.2.1 Fill Water Bearing Zone Interceptor Trench

On pages 11 and 12 of the September 22 letter, DEQ accepts the use of a fully penetrating interceptor trench for controlling and containing groundwater in the Fill WBZ. However, DEQ's comments do not approve the interceptor trench design, and the letter includes numerous comments on the trench length, alignment, construction sequence, and construction schedule. For the reasons stated on pages 4 through 7 of the November 4 comment letter, NW Natural needs further information to enable a technical evaluation of DEQ's requests to redesign the trench and construct it before the implementation of the sediment remedy. An extensive geotechnical investigation would be required to evaluate the feasibility of the design changes requested by DEQ. Conducting the investigation and design evaluations will take a substantial amount of time that would result in an unnecessary delay in implementation of the Alluvial WBZ HC&C system. On page 6 of DEQ's December 7, 2011, letter, DEQ requests that construction of the interceptor trench should be initiated within 6 months of starting up the Alluvium WBZ HC&C system for long-term operation. NW Natural is unable to commit to a construction schedule for a system that has not yet been designed.

NW Natural acknowledges DEQ's expectation that construction of the Fill WBZ interceptor trench should begin within a reasonable timeframe of the long-term startup of the HC&C system. However, NW Natural believes that many considerations, including coordination with the sediment and bank design work being performed for EPA, must be factored into the determination of when it is reasonable to begin construction of a Fill WBZ trench. NW Natural also views implementation of the Alluvium WBZ HC&C system as its highest priority. The groundwater flow rate from the Fill WBZ interceptor trench is anticipated to be approximately 10 percent of the total flow from the alluvium and thus is not a critical source control priority. Immediately following submittal of the revised OPDR, NW Natural will submit a work plan for a geotechnical investigation, designed to determine the feasibility of relocating the interceptor trench or constructing the trench in sections, as suggested by DEQ. NW Natural also acknowledges strong concerns raised by Siltronic, related to DEQ's proposed relocation and redesign, and recognizes the need to build those considerations into any field work and design decisions. Following completion of the field work, NW Natural will submit an evaluation of the Fill WBZ trench construction alternatives requested in DEQ's December 7, 2011, letter, including an evaluation of whether it would be beneficial to accelerate construction of the trench in the segments north and south of the FAMM leasehold on the Site. This alternatives evaluation will recommend a schedule for construction of all or portions of the trench; this schedule may propose that construction commence more or fewer than 6 months following HC&C startup, depending upon all relevant information available at the time of the evaluation.

To expedite the preparation of this CDR, the design of the Fill WBZ interceptor trench has not been revised, pending the outcome of the steps outlined in the previous paragraph. Therefore, the Fill WBZ interceptor trench design drawings and text are the same as they were in the May 2011 FDR. DEQ's September 22, 2011, and December 7, 2011, letters will be addressed in the future Fill WBZ interceptor trench design evaluations. The Fill WBZ interceptor trench design will be revised, as appropriate, based on the findings of the planned geotechnical investigation and design evaluations.

The planned location of the Fill WBZ interceptor trench is shown on Figures 2-2a, b, c, and d. The purpose of the trench is to intercept groundwater in the Fill WBZ before it discharges to the river. The trench will be constructed near the top of the riverbank in Segments 1 and 2. The trench is designed to be located between the extraction well system and the top of the

riverbank. The trench construction methods and materials are described in Appendix J. The interceptor trench design drawings and subsurface profiles are also in Appendix J.

As described in Appendix J, a horizontal collector pipe will be installed at the bottom of the trench, which will be backfilled with permeable gravel. Each segment of the trench collector pipe will drain by gravity to a sump. There will be a manhole at each sump, and each sump will be equipped with a pump that is hooked by pipeline to the treatment system. Figures 2-2a, b, c and d show the locations of the manholes and connecting pipelines. The depth of the collector pipe will be in the upper portion of the alluvial silt layer underlying the fill. Placing the collector pipe just below the base of the fill is intended to allow the trench to capture all of the groundwater in the Fill WBZ.

As described in Section 2.1.2, the average hydraulic conductivity of the Fill WBZ is quite low, less than 1 foot per day. Therefore, the expected total flow from the trench is expected to be very low, with wet season total flow not more than 20 gpm.

Construction of the trench on both properties is expected to be very difficult in many shoreline areas because of the presence of shoreline structures. The FAMM tank farm, FAMM office building, Siltronic outfall, and docking and mooring structures are all very difficult to work around from an equipment access standpoint. In these areas, the trench will be constructed at the top of the riverbank or partially on the riverbank slope, due to the presence of the shoreline structures.

Riverbank cleanup will coincide with the in-river sediment cleanup, as described in the EPA Scope of Work. A number of riverbank cleanup options will be considered in the sediment cleanup Engineering Evaluation/Cost Analysis that would require earthwork at or near the top of the riverbank. The presence of the interceptor trench near the top of the riverbank would, therefore, limit the range of riverbank cleanup alternatives that could be considered. The sediment cleanup will likely include dredging of sediment at or near the toe of the riverbank. The sediment cleanup design will include an analysis of riverbank stability as part of the dredging design. The presence of an interceptor trench near the top of the riverbank could restrict dredging options from the riverbank stability standpoint. Total flow from the Fill WBZ interceptor trench is anticipated to be less than 20 gpm. The expected flow from the interceptor trench is approximately 10 percent of the anticipated total flow from the Alluvium WBZ HC&C system, and implementation of the alluvium source control system is, therefore, a higher

priority than the Fill WBZ interceptor trench. For these reasons, the Fill WBZ interceptor trench source control action is recommended to be constructed at the same time as the in-river sediment and riverbank cleanup occurs. This sequence will have the benefit of allowing integration of the interceptor trench design into the overall riverbank cleanup design. The interceptor trench design presented in Appendix J will likely require modification when it is integrated with the riverbank cleanup design.

3.2.2.2 Alluvium Extraction Wells

3.2.2.2.1 Well Location and Screen Depth

Figures 2-1 and 2-2a, b, c, and d show the locations of the planned shoreline extraction wells. These maps show 14 extraction well locations, PW-1 through PW-14. Locations PW-1 through PW-10 were in the preliminary and interim design reports. Locations PW-11 through PW-14 were added during final design to reduce the horizontal and vertical gradients in the upper alluvium, as previously discussed in Sections 3.2.1.4 and 3.2.1.5. The original 10 well locations are numbered sequentially from south to north, starting with well location PW-1 on the Siltronic property, to location PW-10 near the north end of Segment 2. As shown on Figure 2-2c, the new locations PW-11 through PW-14 are located between the original wells on Segment 1.

Hydraulic gradient control and stratigraphy are the two primary design factors controlling well spacing and screen elevation. In comments on the IDR (see Appendix A), DEQ withheld approval of the design of proposed extraction wells PW-3 through PW-6 because of concerns about the potential for these wells to mobilize and spread DNAPL. DEQ also withheld approval of the design of wells PW-1 and PW-2 because it felt that the design of the well screen depths did not adequately consider groundwater quality. For the reasons explained below, this CDR contains significant changes to the Segment 1 well spacing, number of wells, and screen depth.

The Segment 1 extraction well final design adds well screens in the upper alluvium at locations PW-1 through PW-6. The design also added to Segment 1 upper alluvium wells at PW-11, PW-12, PW-13, and PW-14. The upper alluvium screens in Segment 1 were added for the following reasons:

- The average thickness of the upper alluvium in Segment 1 is more than double the thickness of the upper alluvium in Segment 2, so placement of upper alluvium well screens in Segment 1 will help attain capture. The presence of numerous silt layers are expected to restrict flow in the upper alluvium.
- Most of the mass of contamination in Segment 1 is in the upper alluvium, so placement of well screens in the upper alluvium will provide closer access to the zones of higher contaminant concentrations.
- In the DNAPL zones on the NW Natural portion of Segment 1, the placement of wells in the upper alluvium will allow a greater degree of vertical gradient control, which will minimize the potential to mobilize and spread DNAPL.
- Adding upper alluvium wells PW-11 through PW-14 greatly reduces the horizontal spacing between extraction wells in the zones of shallow DNAPL. These additional wells reduce the pump rate at the individual shallow wells from 8 gpm to 5 gpm and, thereby, reduce the horizontal hydraulic gradient in the vicinity of each well. This reduction of horizontal gradient helps minimize the potential for inducing migration of DNAPL.

Two factors were considered when selecting the elevation of the upper alluvium well screens in Segment 1. The wells are placed shallow in the upper alluvium to facilitate control of vertical gradients and, thereby, reduce the potential to mobilize DNAPL. The well screens are also placed deep enough to allow sufficient drawdown to attain the pumping rates needed for gradient control. The screen bottom elevations were set at the approximate elevation of the nearest detected DNAPL, as shown on the cross sections. The base of the well screens could be set lower, but this would increase the depth of the downward vertical gradient in the vicinity of the nearby DNAPL. The tops of the well screens could be placed at a higher elevation, but this would increase the potential for inducing drawdown into the well screen, which could exacerbate the formation of iron slimes and precipitates that can result from exposure of the well screens to cascading water in the casing.

Tables 3-4a and 3-4b provide specific capacity and estimated pumping rates for existing and planned extraction wells. These tables were added to respond to DEQ and EPA comments in the September 22 letter regarding the ability of the upper alluvium extraction wells to provide sufficient drawdown to maintain hydraulic containment under seasonal water level conditions. Table 3-4a shows the estimated maximum sustained pumping rates for the existing extraction wells based on field tests conducted at each well. Table 3-4b shows the estimated range of

sustained pumping rates for the planned upper alluvium extraction wells. The estimated pumping rates in Table 3b range from 7.5 to 21 gpm as a function of the range in specific capacity. The MODFLOW model has estimated that each of the upper alluvium extraction wells should pump approximately 5 gpm to maintain hydraulic containment of the upper alluvium. The maximum sustained rates in Table 3-4b are based on a range of specific capacity from 1 to 2 gpm per foot of drawdown, which is derived from the field pumping tests conducted at existing upper alluvium wells PW-1-80 and PW-3-85. Those specific capacity data are shown on Table 3-2. The specific capacity data from upper alluvium well PW-8-39 was not used for this analysis because that well was installed using a hollow stem auger, which may have resulted in smearing of the borehole wall. If that occurred, it would have resulted in reducing the permeability of the soil, thereby reducing the well specific capacity.

The calculated maximum sustained pumping rates on Table 3-4b are based on the estimated dry season low water table elevation. To provide a conservative number for available drawdown, the upper alluvium well pump intake elevation is based on pump placement in the casing, just above the top of the well screen. If the specific capacity needs to be increased in any of the wells, additional potential drawdown could be obtained by resetting the pump at a lower depth in the screen zone.

A table similar to Table 3-4b was not prepared for the planned lower alluvium extraction wells because the calculated maximum sustained pumping rates shown on Table 3-4a for the existing lower alluvium wells are quite high and more than adequate to provide the sustained pumping rates needed for hydraulic containment under seasonal low groundwater elevations.

Until the extraction wells are installed and tested, it is not possible to accurately determine if the current well spacing will provide hydraulic containment under all future seasonal conditions. Therefore, it is planned to install and test all of the extraction wells to determine if the well spacing is sufficient. The planned testing of the extraction well system and subsequent modeling are described in Section 3.2.3.

If testing of the completed extraction system indicates that the well network needs to be modified to maintain capture under all seasonal and river level conditions, the following two potential contingency measures could be taken: 1) increase pumping rates of the existing well(s); and 2) install additional extraction wells. Both of those contingency measures would be

evaluated, including a combination of the two measures (i.e., adding wells and increasing the pumping rate of existing wells).

Regarding DEQ's request to further consider groundwater quality in the design of extraction well screen locations, it is felt that the placement of upper alluvium well screens in Segment 1 will provide greater access to contaminant mass than the interim design. However, this design does not attempt to place screens in the absolute highest zones of contamination because this placement would impair the performance of the wells from the standpoint of attaining hydraulic capture and maintaining gradient control. At the request of DEQ (see Appendix A), the proposed extraction well screens have been added to Figures 2-11b and c, which are subsurface profiles showing groundwater quality data for selected COIs. These revised figures afford DEQ the opportunity to review the well screen locations in conjunction with groundwater quality data.

Figures 2-11a, b, c, and d also serve to respond to DEQ's IDR comment (see Appendix A) that the need for an additional extraction well adjacent to PW-1 be evaluated in the final design report. In other words, DEQ requested that NW Natural evaluate the need to extend Segment 1 farther on the Siltronic property. In response to DEQ's request, CDR Figure 2-11 has been created by modifying IDR Figure 2-10 in two ways: 1) groundwater quality data was added from groundwater grab samples obtained in one-time borings completed by NW Natural and Siltronic; and 2) the figure was extended to include approximately 450 additional feet of Siltronic shoreline. The COIs benzene, naphthalene, vinyl chloride, total cyanide, and free cyanide were selected for these figures because they are indicative of both the MGP dissolved plume and the Siltronic dissolved plume. The naphthalene and total cyanide COIs have lower attenuation factors than the other organic and inorganic COIs, and therefore, are representative of the maximum extent of the MGP plume. The additional data were reviewed by NW Natural in conjunction with the information in the Source Control *Evaluation Report "Segment 3" Siltronic Property Related to NW Natural Gasco Site* (Anchor 2009b). NW Natural has not yet received comments from DEQ on the Segment 3 source control evaluation report. Based on review of Figure 2-11 and the Segment 3 source control evaluation report, NW Natural does not see a technical basis for extending Segment 1 further on the Siltronic property. On page 7 of the September 22 letter attachment, DEQ concurs with this conclusion.

The extraction well locations and spacing are also based upon the findings of the design studies described in Section 3.2.1 and specifically the MODFLOW model work described in

Section 3.2.1.4. From these 14 locations, the extraction well system will prevent groundwater in the Alluvium WBZ from migrating to the river, as represented on Figure 3-2a, b, c, d, and e. Due to equipment access or underground utility considerations, the well locations may be modified slightly from those shown on the maps in this report. The well locations are spaced a suitable distance from the shoreline to accommodate the installation of the Fill WBZ interceptor trench.

Table 2-1 lists construction details of all existing and proposed wells. The existing and proposed source control wells are also shown on Figures 2-3a, b, and c through 2-8a and b. The proposed well numbers with the U designation will have an upper alluvium screen and the well numbers with the L designation will have a lower alluvium screen. As shown in Table 2-1 and on Figures 2-3a, b, and c through 2-8a and b, the following locations are planned to have paired wells. The wells that already exist are noted as the following:

- PW-1-U, 1-L
- PW-2-U, 2-L
- PW-3-U, 3-118 (3-118 installed)
- PW-4-U, 4-L
- PW-5-U, 5-L
- PW-6-U, 6-L
- PW-8-39, 8-68 (both installed)

The following locations are planned to have one well:

- PW-7-93 (installed)
- PW-9-92 (installed)
- PW-10-L
- PW-11-U
- PW-12-U
- PW-13-U
- PW-14-U

Per the DEQ request in the September 22 letter attachment, pumping rates at these wells, based on the steady-state MODFLOW analysis, are presented in the following table. During operation, the wells will operate at variable rates to accommodate changing tides and river stage.

Well ID	Predicted Steady-State Pump Rate (gpm)
PW-1-U	5
PW-1-L	15
PW-2-U	5
PW-2-L	15
PW-3-U	5
PW-3-L	15
PW-4-U	5
PW-4-L	15
PW-5-U	5
PW-5-L	15
PW-6-U	5
PW-6-L	15
PW-7	25
PW-8	25
PW-9	35
PW-10	35
PW-11	5
PW-12	5
PW-13	5
PW-14	5

Note:
gpm = gallon per minute

At each well location, the anticipated screen length will be between 15 and 20 feet. The screen length was selected for each location based on the need to have low entrance velocity of groundwater into the well screen. Maintaining a low entrance velocity is considered beneficial for minimizing the rate of formation of mineral deposits and bacterial slimes that will accumulate in the well screen and alluvial sands/silts in the soil outside the well screens.

In the May 2011 design report, some of the well screens were shown to bisect a silt layer on the subsurface profiles shown on Figures 2-3a, b, and c. On page 8 of the September 22 letter attachment, DEQ requests that the well screen depths be adjusted to avoid bisecting the silt layer(s). The design intent is to keep the upper and lower alluvium extraction well screens in approximately the same elevation range. Per DEQ's request, Figures 2-3a, b, and c have been revised by shifting the well screens to avoid the silt areas, where feasible. In some cases, it was not feasible to move the screen, such as for PW-1-L, PW-5-U, and PW-14-U. For PW-1-L, the

deeper alluvium also shows the presence of silt layers, so that screen was not moved. For PW-5-U and PW-14-U, those well screens could be deepened, but that would place the screens deeper with respect to the detected DNAPL in the area. This would increase the depth of the vertical gradient relative to the depth of the DNAPL. Therefore, those well screen depths have not been revised. For all future well installations, the geologic well log will be reviewed in the field to determine if the silt layer is actually at the elevation shown on the profile. If it is, the screen elevation will be shifted up or down to avoid placing the screen across the silt. If the silt is very thin and there is no reasonable way to avoid placing the screen across the silt, the screen will be placed across the silt layer.

3.2.2.2.2 Well Materials, Construction, and Development

The components of the proposed extraction wells are shown on Figure 3-7. The primary components are as follows:

- Six-inch diameter steel casing
- Six-inch diameter Johnson wire-wrapped stainless screen
- Fifteen to 20 feet total screen length at each location with a screen slot size of 0.035 inch
- Gradation 10 x 20 annular backfill sand
- Five-foot-long stainless steel casing sump below the screen

On page 8 of the September 22 letter attachment, DEQ requests confirmation of the selection of a 6-inch-diameter well screen, including the rationale for selecting a 6-inch- versus 8-inch-diameter screen. Extraction Wells PW-3, 7, 8, and 9 were installed with 8-inch-diameter well screen and casing. The 8-inch-diameter was selected primarily to accommodate the larger diameter of the Blackhawk DNAPL pump that was specified for the interim source control design (Anchor QEA 2009a). During subsequent design evaluations, it was decided to specify a pneumatic product recovery pump with smaller diameter downhole assembly. This allows the use of a 6-inch-diameter casing and well screen. Rotosonic drilling is the preferred method for installing the extraction wells, and most of the Rotosonic rigs in use do not have the tooling to install 8-inch-diameter production wells. For the existing PW wells, it was necessary to mobilize a drill rig from California to accommodate the larger diameter casing, and the drilling process was much slower than installing a 6-inch-diameter casing and screen.

The annular backfill sand grain size was designed based on grain size analyses completed on the "GS" borings completed in 2006 and was also based on grain size data from the installation

of monitoring wells MW-18-180, MW-19-180, and MW-20-120. The annular backfill sand recommended herein was used in the construction of extraction wells PW-3, PW-7, PW-8, and PW-9 and was determined to be appropriate based on the results of well screen development and pump tests. In response to comments by DEQ and EPA in the September 22 letter and attachments, further explanation is provided herein regarding the basis of design of the well screen and annular filter pack. In the process of designing the well screen and annular sand pack, Anchor QEA sent the grain size curves to UOP Johnson and the construction contractor, Boart Longyear, for review. The technical reasons for the selection of the 10 x 20 filter pack sand and 0.035-inch well screen slot size were summarized in a May 18, 2007, email from John Edwards with Anchor QEA to Dana Bayuk with DEQ (see Appendix K).

In EPA's specific comment number 18 (EPA 2011), it was stated that EPA believes the gradation of the 10 x 20 filter pack includes too small a gradation for the selected 0.035-inch slot size and that the lower end of this sand gradation may have plugged the screen slots and contributed greatly to the lower efficiency (well losses) seen in these wells. EPA recommends that NW Natural reconsider its pack selection and choose a filter pack gradation that does not reach the size of the screen slots.

The filter pack gradation and well screen slot size selected for the existing wells is appropriate. In production wells, screen slot size is generally chosen on the basis of its ability to retain between 85 to 100 percent of the filter pack materials (EPA 1975). Appendix K includes the grain size analysis and grain size distribution curve for Oglebay Norton 10 x 20 filter pack sand. The grain size curve shows that only 0.1 percent of the sand is finer grained than the number 18 mesh sieve (0.0394-inch openings). With a well screen slot size of 0.035-inch (finer than the number 18 mesh), 99.9 percent of the filter pack sand is retained. It is, therefore, highly unlikely that the well screen is clogged by annular filter sand installed in the existing extraction wells. As discussed further in this report, the variation in specific capacities of the existing extraction wells is due to the range in magnitude of hydraulic conductivity in the alluvium between well locations. As explained later in this section, soil samples are planned to be obtained at each of the planned screen zones of the upper alluvium wells. Grain size analyses will be conducted for each of those samples for the purpose of designing the well screen slot size and annular sand pack gradation for each well.

EPA's comment number 18 also stated that the grain size of the filter pack sand may have contributed greatly to the lower efficiency (well losses) seen in the Site extraction wells. To

evaluate this comment, the efficiencies of the Site extraction wells were calculated using the methods recommended by EPA, and an evaluation was conducted of the findings. Table 3-2 lists the efficiencies that were calculated for the extraction wells. The methods recommended by EPA result in low efficiencies for some of the Site extraction wells, but the calculated efficiencies are not the result of the well construction design, as explained in the following summary:

- According to the description of EPA's recommended methodology for calculating well efficiency (Driscoll 1968), the method is only valid when used in a confined aquifer, where the well screen penetrates the full saturated thickness of the aquifer. The Site alluvium is not a fully confined aquifer and the Site extraction wells are partially penetrating wells, so the extraction wells are not appropriate for calculating well efficiency.
- Most of the pump tests conducted at the Site had more than one well pumping simultaneously, with overlapping drawdown at the monitoring wells. Therefore, much of the drawdown data used in the calculations is not appropriate for calculating efficiency because it is caused by multiple pumping wells.
- If the aquifer hydraulic conductivity is low, drawdown in the pumping well will be high, causing the calculated well efficiency to be low.

In summary, the use of calculated well efficiency does not appear to be a valid way to assess the suitability of the well screen and annular backfill design. For example, the calculated well efficiencies shown on Table 3-2 for wells PW-9-92, PW-8-68, and PW-7-93 are 11, 40, and 91 percent. All three of these wells have exactly the same screen slot size of 0.035 inch and annular backfill gradation of 10 x 20 sand. Therefore, the well efficiency calculation is not affected by the screen or backfill sand design, but it is affected by the hydraulic conductivity of the aquifer and the other criteria explained above, adjacent to the screen zone. From a review of the specific capacity data in Table 3-2 for those three wells, it is apparent that there is a direct correlation of calculated well efficiency with well specific capacity that is unrelated to the well screen and annular backfill design. The wells with low specific capacity also have low calculated well efficiency.

Regardless of the validity of the well efficiency methodology for this Site, NW Natural will be designing the well screen and annular backfill for the planned upper alluvium extraction wells based on the results of grain size tests of soil samples obtained from the planned screen zones.

In the past DEQ has requested that a "DNAPL funnel" be installed at the junction of the base of the well screen and the casing sump. DEQ has requested this device to be installed to funnel DNAPL migrating in the annulus down into the well sump. Such a device can be installed on the extraction and monitoring wells that are located in the upper alluvium of Segment 1 on NW Natural property where DNAPL may enter the borehole. However, once the well assembly is placed in the borehole, there is no feasible way to place annular backfill material around the sump because the funnel blocks the annular space.

On page 3 of the September 22 letter attachment, DEQ recommends adding a predetermined amount of slurry to the bottom of the borehole before the well is set in place (i.e., within the outer casing). According to DEQ, the amount of sealant should allow for displacement caused by insertion of the well's sump. DEQ also recommends that during placement of the sand pack, in addition to surging the well to settle the sand sealing materials that may have migrated around the funnel and into the sand pack, fluids in the sump should be removed through bailing.

The addition of a predetermined quantity of grout may be feasible in a stable borehole; however, there are several potential installation problems to consider that could affect the quality of well construction. These issues are outlined in the following bullets:

- Heaving sands are common at the Site. In the amount of time it takes to assemble and lower the tremie pipe into the borehole and pump the grout, it is likely that sand will heave from the bottom of the borehole, changing the calculated area and potentially pushing the added grout into the screen zone. NW Natural can try loading the borehole with water to prevent heave, but this method is not always successful. If heave occurs prior to well installation, the bottom of the borehole will have to be redrilled, which can result in an enlarged annular space, project delay, and possibly cause the borehole to be decommissioned.
- The grout is mixed to a thick consistency and the tremie pipe will retain an undetermined quantity of grout, ranging from a thin film inside the pipe to the complete inside diameter of the tremie pipe. The residual grout in the pipe may drop out of the end of the pipe during retrieval from the well and may dissolve and remain in suspension, which could lower the effective permeability of the annular sand pack.
- Bailing and surging may be effective in removing grout that may migrate around the funnel and into the sump but may not be as effective at removing grout from the sand pack.

It appears that DEQ's recommended tremie grout method could result in construction problems that would affect the proper function of the extraction well. Upon further evaluation, NW Natural now recommends the use of a prefabricated seal that will be attached to the sump before installation. The seal will consist of bentonite granules, chips, or pellets. Upon immersion, the bentonite will swell, providing a permanent annular seal in the annulus surrounding the sump. Anchor QEA will communicate with the Oregon Water Resources Department, DEQ, and the drilling contractor regarding the details of this sealing method and to obtain a variance, as needed.

The wells are planned to be drilled using sonic drilling technology. This technology was selected because cable-drilling methods are very slow; air rotary drilling can result in personnel health and safety issues, due to contaminated return air; and mud rotary drilling methods generate larger volumes of contaminated drilling wastes that require off-site disposal. Sonic drilling methods were used to install pilot extraction wells PW-7, PW-8, and PW-9 and provided good results.

The sonic drill will obtain a continuous soil core, which will be examined in the field by an Anchor QEA geologist to create a complete geologic log. This log will be used to determine the extraction well screen depths. Table 2-1 lists the currently planned extraction well screen intervals.

As shown on Figure 3-7, the annulus above each screen will be sealed with bentonite grout per Oregon Water Resource well construction requirements. For all wells that will penetrate known DNAPL zones, the bentonite grout will be mixed with organoclay. The planned ratio of bentonite to organoclay is 90 to 10 by volume. A variance from Oregon Water Resources well construction requirements will be obtained prior to initiating field work. Such a variance has previously been obtained at the Site for other borings drilled in DNAPL zones.

Appendix K describes how solid waste materials derived from well drilling, well construction, and screen development activities will be characterized and disposed. Contaminated water from drilling and development activities will be treated in the on-site carbon treatment system and discharged to the City of Portland publicly owned treatment works (POTW) under the facility Industrial Wastewater Discharge Permit.

Appendix K also describes the procedures for construction and screen development for the extraction, monitoring, and observation wells.

3.2.2.3 Conveyance and Control System

A process and instrumentation diagram of the extraction well conveyance and control system is shown on Figure 3-8. The lower alluvium extraction wells will be equipped with 5 horsepower centrifugal pumps, and the upper alluvium wells will be equipped with 1 to 2 horsepower centrifugal pumps. The centrifugal pumps will be powered by motors controlled by VFDs that are directed from a panel equipped with a PLC system. The PLC system will be equipped with human machine interface (HMI) data acquisition, programmable for alarm condition notification and capable of future expandability, if needed.

Being powered by VFD allows the pump discharge to be continuously adjusted, as controlled by the PLC system. Figure 3-8 shows that water level transducers will be installed to monitor the groundwater elevation in selected wells. A water level transducer has already been installed on the FAMM dock to monitor the Willamette River elevation.

April 2011 field testing of the VFD system on extraction wells PW-7-93, PW-8-68, and PW-9-92 showed that the VFD system was successful at maintaining groundwater capture by real time adjustment of extraction well pump speed in concert with the tide induced groundwater elevation changes. The capture assessment discussion in Section 3.2.2.5.2 describes how water elevation data from the control wells will be used to change the extraction well discharge rates to maintain capture.

A water level transducer will be installed in each of the extraction wells. Transducers will also be installed in the new monitoring wells shown on Figures 2-2a, b, c and d and 2-3a, b, and c and listed in Table 3-5. As shown in Table 3-5, a subset of the transducers will be used to monitor groundwater elevations for the purpose of controlling the extraction well discharge rate. In Table 3-5, those wells are termed control wells.

The well field controls and piping diagram on Figure 3-8 also shows that the upper alluvium extraction wells located in the NW Natural portion of Segment 1 will have installed DNAPL recovery pumps. Based on existing information on DNAPL occurrence, it is possible that DNAPL will enter these wells and accumulate in the bottom sump below the screen. If DNAPL accumulates in the well sumps, an air actuated piston pump will be used for DNAPL recovery.

In response to DEQ's comment in the September 22 letter on page 9 of the attachment, Figure 3-9a shows that the air actuated piston pump is installed in the 2-inch-diameter downpipe. Figure 3-9b shows that the downpipe will also be built into the well head assembly for the lower alluvium extraction wells. If DNAPL is detected in the sump of any of the lower alluvium extraction wells, a piston pump will be installed through the 2-inch downpipe within 1 or 2 days of detecting DNAPL. Spare piston pumps will be kept in storage on site.

The DNAPL will be pumped to holding tanks and removed for off-site recycling, as is current practice for DNAPL recovered from Site monitoring wells MW-6-32 and MW-13-31. All extraction well sumps will be regularly monitored for the presence of DNAPL, and a DNAPL recovery pump will be added to any wells where DNAPL accumulates in the sump.

In response to DEQ's comment in the September 22 letter on page 9 of the attachment, it is possible that DNAPL recovered from wells on or adjacent to the Siltronic site could contain F002-listed hazardous waste. If DNAPL is recovered from the extraction wells on or adjacent to the Siltronic site, the DNAPL will be tested to determine if it is F002 waste. DNAPL that is determined to be F002 waste will be containerized for temporary storage at appropriately designed storage facilities on the Siltronic and NW Natural properties. From those storage locations, the F002 waste will be properly disposed or recycled off site by licensed contractors.

3.2.2.4 Anti-Fouling Design and Maintenance

Under the direction of Anchor QEA, Water Systems Engineering, Inc. (WSE), conducted laboratory testing of representative groundwater samples from MW-1-55, PW-4-85, and PW-3-118. The purpose of the testing was to determine how susceptible the wells would be to the formation of minerals and bacterial slime that would reduce the permeability of the well screens, annular backfill, and aquifer formation sands. The WSE study found that the aquifer chemistry suggests a moderate to high potential for fouling from the formation of mineral deposits and bacterial growth.

Until recently, it was planned to use chemical treatment, as recommended by WSE to maintain the well screens, annular backfill, and formation sands in permeable condition. However, there has been concern that the use of traditional chlorine-based, acid, and caustic chemicals for this purpose could cause the formation of cyanide gas, creating a potential worker health and safety issue.

Therefore, a different method for maintaining well performance is planned to be used at the Site. This method is available under the trade name of Aqua Gard and was developed by Subsurface Technologies, Inc. (STI). Information on the Aqua Gard technology is in Appendix L.

The Aqua Gard system uses an injection pipe that is permanently installed in the well to inject liquid carbon dioxide into the well screen, surrounding annulus, and aquifer formation materials. Because the Aqua Gard injection system is permanently installed on the well head, the well pump does not have to be removed to perform the Aqua Gard treatment. Prior to injection of the liquid carbon dioxide, the extraction well pump is turned off. The physical agitation that occurs during vaporization of the liquid carbon dioxide dislodges accumulated mineral deposits and bacterial slimes. Carbonic acid also forms during this process, which dissolves some of the material. Following injection of the liquid carbon dioxide, a suitable period of time (generally several hours) is allowed to elapse to ensure that all of the liquid carbon dioxide has vaporized; then the pump in the treated well is restarted. Within a short period following restart of the well pump, the affected groundwater, dislodged minerals, and organic materials will be pumped to the facility groundwater treatment system.

In response to DEQ's comment in the September 22 letter on page 9 of the attachment, the same 1-inch-diameter tube that will hold the transducer cable will be used for the Aqua Gard treatments. The transducer tube is shown on Figures 3-9a and 3-9b. The transducer cable will be temporarily removed during well treatment.

Based on the experience of STI at other sites, it is estimated that semi-annual treatment will maintain the well screens and formation sands in good condition. The frequency of maintenance required to attain efficient operation of the well system will not be certain until 1 or 2 years of well operation have been experienced.

To determine if semi-annual treatment is sufficient, the performance of the well system will be reviewed monthly during the first year of operation by preparing a specific capacity graph for each well that is updated monthly. Well specific capacity is the ratio of drawdown to discharge. If regular monitoring of specific capacity indicates that well performance is declining, that could mean that more frequent Aqua Gard treatment is needed.

Another more direct way to assess the need for treatment is to use a downhole camera to visually inspect the well screen and casing for the presence of mineral deposits and bacterial slime. A downhole camera may be used for this purpose but only if semi-annual Aqua Gard treatment does not seem to maintain well performance. It would be necessary to remove the well pump and transducer assemblies from the well casing to allow the use of a downhole camera, so this assessment method will not be used unless necessary.

3.2.2.5 Performance Monitoring

3.2.2.5.1 Monitoring Well Network

Monitoring of the performance of the extraction well system requires the installation of additional monitoring wells and piezometers. The proposed monitoring wells and piezometers are listed on Table 2-1 and shown on the Figures 2-2a, b, c and d and 2-3a, b, and c. The rationale for the location and screen depth for these monitoring points are described in Section 3.2.2.5.2. Table 3-5 shows the proposed performance well monitoring network, consisting of existing and proposed wells to be used for assessing extraction system performance, as described in the following sections. In general, the piezometers are designed to monitor groundwater levels offshore and at the river edge, riverward of the extraction wells. The observation wells are designed to monitor water levels in the fill adjacent to the extraction wells. Monitoring wells are designed to monitor the upland alluvium. Most of the observation wells, piezometers, and nearshore monitoring wells will be equipped with water level transducers. A subset of the monitoring wells will function as water level control wells for designated extraction wells.

3.2.2.5.2 Capture Assessment

This plan for measuring the capture performance of the source control system is designed to meet or exceed EPA guidance in *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 2008). The extraction well system will be operated to maintain an average hydraulic condition of gradient reversal, so upland groundwater is not discharging to the river. As explained herein, the average gradient reversal will be maintained by controlling the extraction well discharge rate based on transducer monitoring of groundwater elevations at designated control wells. Site-specific groundwater discharge and groundwater elevation data will also be used in the DEQ-approved Site MODFLOW and PATH3D models to produce particle track maps for assessing capture.

Table 3-5 lists the existing and proposed shoreline monitoring wells, extraction wells, and piezometers that are in the performance monitoring plan. The network of existing shoreline monitoring wells was carefully evaluated to determine which wells have suitable location and screen elevation to be useful to assess the capture performance of the extraction well system. As shown in Table 3-5, many of the existing monitoring wells were suitable for this purpose. Because the current shoreline monitoring well network was designed primarily to characterize the nature and extent of contamination, some of the existing well locations are not suitable for capture evaluation. Therefore, Table 3-5 lists the proposed monitoring wells, extraction wells, and piezometers that are needed to provide the necessary water level data to fully evaluate capture performance of the entire source control system.

Following preparation of the May 2011 FDR (Anchor QEA 2011), Anchor QEA noted that the extraction well locations in Segment 1 could be adjusted so that the spacing between wells is more consistent. Therefore, the locations of the planned Segment 1 extraction wells were slightly modified to achieve more even spacing, and those locations are shown on the Figure 2-2 maps and Figure 2-3 cross sections. The locations of the planned monitoring wells associated with the extraction wells were also slightly adjusted, as needed.

In response to DEQ's requests on page 10 of the September 22 letter and page 10 of the attachment, several changes were made to the groundwater monitoring network, which are listed as follows:

- Monitoring well MW-17-79 will be decommissioned and control well MW-29U will be used between extraction wells PW-4-U and PW-13-U.
- Control well MW-37U will be installed between extraction wells PW-5-U and PW-14-U.
- Monitoring wells MW-34U, MW-31U, MW-28U, and MW-27U will be added to the network adjacent to extraction wells PW-11-U, 12-U, 13-U, and 14-U.
- Piezometers PZ8-50 and PZ8-5 will be added offshore from extraction well PW-10.
- Piezometers PZ9-150, PZ9-50, and PZ9-5 will be added offshore from extraction well PW-2.

These additions to the monitoring network are shown on Figures 2-2 and 2-3 and in Tables 2-1 and 3-5. In Table 2-1, additions to the monitoring network are shaded to aid the reviewer.

Table 3-5 shows the wells that will be equipped with water level transducers. All the water level transducers will also measure water temperature. In the interim design, it was planned to

have the extraction well transducers also measure groundwater conductance. During final design, it was determined that the transducers would have to be removed on a frequent basis to calibrate the conductance meter that is built into the transducer probe. In order to remove the transducer it would be necessary to disconnect it from the PLC system, and during that period, it would not be functioning as a control transducer. Therefore, it is impractical to have any of the transducers measure conductance because it would be necessary to disconnect the transducers frequently for calibration.

On page 9 of the September 22 letter, DEQ requests further information on the data collection objectives and how the data will be used to assess capture performance of the extraction well system. To respond to this request Table 3-5, Source Control Monitoring Plan, has been revised to indicate the data collection objective of each of the monitoring wells, piezometers, and observation wells. The table also indicates which water level control monitoring well is assigned to each extraction well. The water level data from the monitoring wells, piezometers, and observation wells will be used in the MODFLOW model to assess capture in the upper and lower alluvium.

On page 9 of the September 22 letter, DEQ requests that a representative subset of performance monitoring wells include temperature and specific conductance measurements. In response to that request, specific conductance will be measured by the field sampler during groundwater sample collection at the extraction wells, monitoring wells, observation wells, and piezometers scheduled for groundwater chemistry performance monitoring. As described in the previous paragraph, the water level transducers also measure temperature, so that parameter is already included in the performance monitoring program.

Groundwater elevation data from the control monitoring wells is measured by the PLC system and will be used to control the extraction well discharge rate. Each extraction well will be surrounded on two sides by monitoring wells containing water level transducers. Each extraction well will be assigned to one control well. Based on the findings from initial startup and testing, it may be necessary to change the control well that is assigned to some of the extraction wells. The control well locations are roughly equidistant between extraction wells. In some cases, existing monitoring wells will be used, but in many cases, new monitoring wells must be installed for this purpose. For example, extraction well PW-4-U is flanked by monitoring wells MW-29U, and MW-30U, as shown on Figure 2-3b and in Table 3-5. Table 3-5 indicates which wells will be equipped with transducers and those that will be designated as

control wells. On the Figure 2-3 subsurface profiles the control wells are designated with an asterisk. The control function is generally assigned to the monitoring wells that are screened in approximately the same elevation of the aquifer as the extraction well.

The PLC system will continuously monitor the real time elevation of groundwater in each of the control wells compared to the real time elevation of water in the Willamette River. The PLC continuously adjusts the well pumping rate using the VFD system to maintain the groundwater elevation in the control wells below the river elevation to maintain the condition of capture. The groundwater elevation will naturally change constantly in response to river-induced tidal effects. This constant change requires the transducer-controlled system to adjust the well pump discharge rate to maintain the condition of capture. Although the monitoring transducers are not used to control the well pumping rate, they are used to make sure that the capture that is measured in the control wells also occurs in the deeper portion of the aquifer. After initial startup of the system, a period of monitoring will be required to ensure that the correct wells are being used as control wells. In some cases, it may be necessary to change control wells if they better reflect the capture at that location.

The PLC system is designed to allow a unique elevation delta to be assigned to each control well transducer. The assigned elevation delta is the elevation difference between the river elevation and the groundwater elevation at the control well. The heterogeneous nature of the geology means that each control well responds in a unique way to pumping from the extraction wells. Having a larger delta means that the extraction well has to pump at a higher discharge rate to achieve the assigned delta. Based upon field observations made during the April 2011 VFD testing, it is anticipated that some tuning of the control well elevation deltas will be done during startup to balance the pumping rates between the extraction wells.

Following construction of the entire extraction system there will be a series of tests conducted to evaluate the capture performance of the system. These steps are described in Section 3.2.3. The findings from those tests will be used to prepare the OPDR. The OPDR will provide system operating parameters. Agency approval of the OPDR will be obtained before long-term operation of the extraction system begins.

In a March 2011 meeting with Anchor QEA, DEQ suggested that monitoring wells with screens below the aquitard be designated as control wells, specifically MW-21-165, MW-24L, MW-27L, MW-28L, MW-31L, and MW-34L. Based on the results of the VFD testing of wells PW-7-93,

PW-8-68, and PW-9-92 completed in April 2011, it is not feasible to use those wells as control wells. A report of the VFD test findings was provided to EPA and DEQ on May 25, 2011. Those wells are separated from the extraction wells by a significant vertical distance and by the low permeability aquitard. This means that the water level response in those wells is significantly smaller than control wells installed at the same elevation as the extraction wells. Due to the vertical distance and the presence of the aquitard, the timing of the water level response is also somewhat delayed relative to the response time of a closer well at the same elevation as the extraction well. For these reasons, the wells proposed by DEQ will not provide adequate information for the PLC system to effectively control the gradient conditions. Therefore, this final design does not use the monitoring wells below the aquitard as control wells. Accordingly, the screen elevations of proposed control wells MW-24L, 27L, 28L, 31L, and 34L are above the aquitard, as shown on Figure 2-3b. Existing monitoring wells MW21-165, 18-180, 19-180, 5-175, 14-161, and 11-161 screened below the aquitard will be equipped with water level transducers and the water level elevations will be monitored to make sure that capture below the aquitard is achieved. This may require adjustment of the elevation delta at some of the control wells to cause a higher pump rate in some extraction wells to achieve capture below the aquitard.

Table 3-5 also lists a number of piezometers that have been installed or are planned to be installed in the river. Some will be installed along the shoreline and others are already constructed and attached to the FAMM dock, as shown on Figure 2-2. The piezometers will be installed at multiple depths below the river mudline. The subsurface profiles on Geologic Cross Sections B-B′ and C-C′ (see Figures 2-4 and 2-5) show the depths and locations of several of the existing river piezometers. These piezometers are equipped with water level transducers. As provided in the description of the Segment 2 capture zone test in Section 3.2.1.9, the groundwater elevation data from the river piezometers will be used to assess the effect on offshore seepage that is achieved by the shoreline extraction wells. This information will be used for design of the in-water river sediment cleanup plan.

As previously described in this section, offshore piezometer nests PZ-8 and PZ-9 have been added in response to DEQ's September 22 comments. An additional piezometer, PZ6-115 was also added to address a request made by both DEQ and EPA during a teleconference that occurred on November 30, 2011. During that teleconference, the agencies requested that a piezometer be added at a depth just above the aquitard at one of the offshore piezometer nests. The agencies requested this addition to help assess the change in gradient near the top and

bottom of the aquitard. PZ-6 was selected because the geology in the area appears representative of average conditions along the shoreline.

3.2.2.5.3 DNAPL Monitoring

In comments to the IDR (see Appendix A), DEQ stated that operation of the extraction wells could potentially mobilize and spread DNAPL and that potential expansion of the distribution of DNAPL is a significant factor for SCMs planning and design. As described in Section 3.2.2.2.1, the number, depth, and locations of Segment 1 extraction wells were redesigned to minimize the potential for DNAPL mobilization. Mobile DNAPL is expected to migrate into shallow Segment 1 extraction wells that are inadvertently screened in mobile DNAPL. However, the reduced horizontal and vertical gradients that will result from the currently proposed extraction well network are not expected to mobilize DNAPL beyond a distance of a few feet from each extraction well.

To further address DEQ's concerns, a DNAPL monitoring component has been added to the system performance monitoring program. The DNAPL monitoring program consists of the following three main elements:

- TarGOST sampling
- Monitoring and recovery of DNAPL entering wells
- Monitoring of DNAPL entering the treatment system oil-water separators

These elements are described in the subsequent sections, followed by a summary of the reporting to be prepared for submittal to DEQ to document the DNAPL monitoring program results and conclusions.

TarGOST Sampling

TarGOST sampling methods will be used to monitor for the migration of DNAPL into areas adjacent to the former effluent ponds where DNAPL has not been detected to date. DNAPL observations in this area are shown on cross-sections D-D', E-E', F-F', G-G', and H-H', depicted in Figures 2-6, 2-7, 2-8a and b, 3-10a and b, and 3-11a and b, respectively. Per DEQ's request on page 10 of the September 22 letter, Site cross sections have been revised to show sheen zones noted on soil cores from Site borings. The revised cross sections are in Appendix Q. The sheen zones shown on these cross sections do not provide a technically valid basis for defining the

extent of DNAPL, and visual evidence of sheen in a soil sample is not technically valid evidence of DNAPL migration.

Three general zones (shown on Figure 3-12) have been selected for TarGOST sampling based on the following criteria:

- Previous borings in the area have had no DNAPL observations in the upper alluvium
- Adjacent to the estimated extent of DNAPL in the upper alluvium (shown on Figure 3-12)
- Adjacent to source control pumping wells (two of the three zones)

An approximately 10-foot-by-10-foot portion of each zone will be selected for monitoring. These areas will be selected based on their proximity to pumping wells (areas closer to pumping wells will be targeted) and proximity to localized geological conditions that may increase the likelihood of DNAPL migration. Potential TarGOST monitoring areas are shown on Figure 3-12.

Baseline borings will be advanced in each area to confirm the absence of DNAPL in the upper alluvium prior to start up of the extraction well system. Three TarGOST borings will be advanced along the periphery of each of the three targeted areas. If DNAPL is detected, then the area will be rejected, a new 10-foot-by-10-foot portion of the TarGOST sample area will be selected, and additional baseline borings will be installed. If DNAPL is not detected in the upper alluvium of each of the three baseline borings, then the location will be retained as a TarGOST monitoring area.

The three TarGOST monitoring areas will be retested for the presence of DNAPL in the upper alluvial at the end of Years 1, 3, and 5 of operation of the source control system. One TarGOST boring will be installed in each area within the triangle formed by the baseline borings. After 5 years of extraction system operation, the monitoring program will be evaluated to determine if continued TarGOST monitoring is needed.

In the event of DNAPL detection during TarGOST monitoring, the following assessment steps would be taken:

- Advancement of an additional confirmation TarGOST boring
- If confirmed, advancement of a push probe within the monitoring area to collect soil core across the depth of DNAPL detection
- Shipment of the core to a laboratory for physical description and photography under white light and UV light
- Testing of select subsamples from the core for DNAPL saturation and mobility testing

Data obtained from the preceding tests would be used to support conclusions and recommendations regarding the need for adjustments to either the hydraulic control or to the DNAPL monitoring program.

Per DEQ's request on page 10 of the September 22 letter, TarGOST borings will also be advanced and sampled in the vicinity of four extraction well locations prior to operation of the extraction wells. The four extraction well locations that will be monitored were recommended by DEQ and include PW-6, PW-14, PW-3, and PW-2, shown on Figure 3-12. The purpose of the borings is to assess baseline DNAPL conditions near the extraction well to monitor possible lateral and vertical DNAPL migration during extraction well operation. The objectives of these four monitoring locations are different than the three TarGOST monitoring areas previously described. At these four locations, DNAPL has been previously detected, whereas DNAPL has not previously been detected in the other three TarGOST monitoring areas. For these four areas, the goal is to conduct borings on the same 1-, 3-, and 5-year schedule, but in this case, the results will be evaluated to determine if there is evidence of a measurable change in DNAPL thickness or depth, compared to the baseline boring. The initial baseline borings will be advanced to a depth of 20 feet below the proposed total depth of the extraction well to detect and establish baseline conditions concerning the presence of DNAPL. The subsequent borings at 1-, 3-, and 5-year intervals will be used to compare the nature and extent of DNAPL compared with the baseline boring. The TarGOST borings will not be placed closer than a radius of 20 feet of the proposed extraction well. This minimum distance between the TarGOST boring and the extraction well is established to prevent the bentonite grout that will be injected during abandonment of the TarGOST boring from reducing the permeability of the soils in the immediate vicinity of the extraction well screen zone.

The TarGOST sampling results will be included in the DNAPL monitoring report discussed later in this section. Appendix M presents further detail on protocols to be followed during TarGOST boring installation.

Monitoring and Recovery of DNAPL Entering Wells

The low per-well pumping rate of approximately 5 to 10 gpm for each of the upper alluvium wells in Segment 1 is not expected to generate a high enough hydraulic gradient to cause DNAPL migration, with the exception of mobile DNAPL adjacent to the well screen. As shown on Figure 3-13, DNAPL is thought to be present near the proposed location of wells only in select areas of Segment 1 (including wells PW-6-U, PW-6-L, PW-14-U, PW-5-U, PW-5-L, PW-3-U, and PW-11-U). Nevertheless, all pumping wells have been designed to facilitate the collection and removal of any DNAPL that enters the well. Each well will be installed with a sump to collect DNAPL. All of the upper alluvium extraction wells in Segment 1 will be outfitted with a pneumatic DNAPL recovery pump. All of the lower alluvium extraction wells will have the capacity for installation of a dedicated DNAPL removal pump, should it become necessary. The pumping wells will be monitored for DNAPL entry according to the schedule discussed later in this section. DNAPL will be removed from the wells, to the extent practicable, and the volume will be recorded.

Although DNAPL is not expected to enter control and monitoring wells, each well included in the system performance monitoring program (described in Section 3.2.2.5.2 and designated in Table 3-5) will be monitored for DNAPL entry. As with pumping wells, monitoring and control wells installed as part of this program will be fitted with a sump below the screen. DNAPL entry will also be monitored in several existing wells along the Segment 1 riverbank where DNAPL entry has previously been detected. These include wells MW-16-45, PW-1-80, and MW-18-30. Accumulated DNAPL will be removed from the wells, to the extent practicable, and the volume will be recorded.

The monitoring and control wells will be installed ahead of source control system startup to allow a period of time for observing whether DNAPL enters the wells under natural non-pumping conditions. This period, as well as observations collected during well drilling, will be used to evaluate the potential for DNAPL to enter the well during source control system operation. However, it should be noted that DNAPL entry into some on-site monitoring wells under natural gradients was first observed several years after installation. Thus, the presence of

DNAPL in a control or monitoring well during system operation does not in itself indicate that the source control system is causing DNAPL to enter the well.

Upon system startup, the pumping, control, and monitoring wells listed on Table 3-5 will be closely monitored for DNAPL entry. Wells will be monitored daily during the first week of operation and weekly for the following 3 weeks. In response to DEQ's request on page 10 of the September 22 letter attachment, after the first month of operation, DNAPL monitoring will occur every other week for the remainder of the first quarter. DNAPL monitoring would then occur monthly for the remainder of the first year of operation. After the first year of operation, and subject to DEQ's approval, the DNAPL monitoring frequency will be concurrent with the water quality trend monitoring program described in Section 3.2.2.5.4. These wells will be monitored quarterly for Year 2; semi-annually for Years 3, 4, and 5; and then annually, thereafter. After 5 years of source control operation, the monitoring program would be evaluated to determine if continued monitoring is needed.

The frequency of DNAPL removal, where needed, will be based on the rate of DNAPL entry into the well. As previously discussed, DNAPL entry is only expected in pumping wells installed in select areas of Segment 1. An air actuated piston pump designed for DNAPL removal will be installed in each of upper alluvium extraction wells in Segment 1. The 1-inch-diameter sounder tube shown on Figures 3-9a and b can accommodate the piston pump. If DNAPL is detected in the sump of a lower alluvium extraction well, the piston pump can easily be installed. A small number of standby piston pumps will be kept in storage on site to allow rapid installation in the event of a DNAPL detection in one of the lower alluvium extraction wells. Manual and other pumping methods may be selected for DNAPL removal, as appropriate. DNAPL removed from each well will be containerized separately for each well, so a removal volume can be estimated for each well.

Observations of DNAPL entry and DNAPL removal volumes will be included in the DNAPL monitoring reporting discussed later in this section.

Monitoring of the Oil-Water Separators

The low per-well pumping rate of approximately 5 gpm for each of the upper alluvium wells in Segment 1 is not expected to generate a high enough hydraulic gradient to cause DNAPL migration, with the exception of mobile DNAPL adjacent to the well screen. Thus, DNAPL entering a well is expected to collect in the well sump and not be pulled into the pumping

system itself. DNAPL that does enter the system will be recovered in the oil-water separators at the beginning of the treatment system. The amount of DNAPL collected in each oil-water separator will be observed and recorded as part of the routine monitoring of the treatment system performance. As necessary, DNAPL will be removed from the separators and disposed of off site. The estimated amount of DNAPL observed in the system and removed from the system for off-site disposal (if any) during each monitoring period will be included in the DNAPL monitoring reporting discussed in the following section.

DNAPL Monitoring Reporting

Results from the previously described groundwater well monitoring and oil-water separator monitoring activities will be included in the system operation quarterly reports to be prepared for submittal to DEQ.

A more detailed DNAPL Monitoring Report will be prepared for submittal to DEQ, following completion of each TarGOST monitoring event. This report will summarize the results for all DNAPL monitoring activities, including a trends analysis of the data.

3.2.2.5.4 Water Quality Trend Monitoring

Groundwater quality trends will be monitored at selected wells during operation of the source control system. Because both upland and nearshore groundwater is contaminated with the same COIs at similar concentrations, there is no chemical plume boundary or water quality compliance boundary to assess. The groundwater quality data will not be used for assessing whether the source control actions are successful at achieving shoreline containment. Therefore, the water quality monitoring plan is not intended to be used to judge the success of the source control action but rather to measure water quality changes that occur during operation of the extraction well system. Based on these conditions, the May 2011 FDR proposed that the shoreline area monitoring wells that are currently sampled twice per year be reduced to annual sampling and that the planned extraction wells will be used for water quality trend monitoring purposes. In DEQ's comments in the September 22 letter on page 11 of the attachment, DEQ did not approve the proposed performance monitoring plan. In the September 22 comments, DEQ requested that the current biannual sampling program be continued and that other changes be made to the proposed performance monitoring program, as described in the remainder of this section.

Table 3-5 lists the components of the performance monitoring plan, including existing and proposed shoreline monitoring wells, piezometers, observation wells, and extraction wells. The field sampling procedures, sample handling protocols, analyte testing, and quality assurance/quality control (QA/QC) plans are described in detail in the Sampling and Analysis Plan, which is available in Appendix O. Table 3-5 shows that the existing shoreline monitoring wells are sampled semi-annually in the current upland monitoring program. With the addition of the planned new wells shown in Table 3-5, the May 2011 FDR proposed that the sampling frequency for the existing wells be reduced to annual for the next 5 years. This reduction is justified because the new proposed wells provide additional spatial coverage of the shoreline zone, which makes semi-annual monitoring of the currently existing wells unnecessary. After 5 years of source control operation, the monitoring program would be evaluated to determine if continued monitoring of the existing wells is needed.

In the September 22 letter, DEQ disagreed with the proposed reduction in monitoring frequency and instead proposed that the first sampling round of existing and newly constructed wells occur within 3 months of extraction system startup, and the second round would occur within 6 months of system startup. DEQ requested this approach for the first year of operation to enable evaluation of the effects of pumping on water quality trends in the monitoring wells. Under this DEQ-recommended approach, both of the biannual sampling events would occur within 6 months of startup of the completed extraction system. Table 3-5 has been revised to show that both of the biannual sampling rounds will occur in the first 6 months of operation of the completed extraction system. NW Natural agrees to conduct these two sampling rounds within 6 months of system startup; however, it is not clear how this data will be evaluated by DEQ or what use the data will be with regard to operation of the HC&C system. In the interest of moving forward with this program, it is agreed that the DEQ-requested sampling will occur during the first year of long-term system operation, but the sampling frequency will be re-evaluated at the end of the first year to determine if the data are of value with respect to assessing the performance of the HC&C system. Following that review, NW Natural will likely propose revisions to the performance monitoring plan.

The proposed new wells on Table 3-5 are divided into those with a recommended tiered monitoring frequency and those with a biannual monitoring frequency. The extraction wells at all 14 locations will be on the tiered monitoring plan. As explained in the footnote on Table 3-5, the extraction wells in the tiered plan will be sampled monthly for Year 1 of source control operation; quarterly for Year 2; semi-annually for Years 3, 4, and 5; and then annually thereafter.

The main purpose of the frequent monitoring in the first 5 years is to assess changes in influent groundwater quality that could affect the operation of the treatment plant.

The proposed new monitoring wells, observation wells, and piezometers will be sampled following well construction and development. The new wells will then be sampled twice during the first year of system operation, as described above, for the purpose of documenting trends in analyte concentrations. The groundwater sampling and laboratory testing protocols are described in the Sampling and Analysis Plan in Appendix O.

In the March 26, 2010, comment letter (see Appendix A) DEQ recommended that the source control groundwater quality trend monitoring program be expanded to include the following analytes:

- Typical field-measured water quality parameters
- NW Natural and Siltronic facility COI
- All parameters on groundwater treatment system discharge list and any additional constituents that could influence extraction well and groundwater treatment system operation and performance
- 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene
- Inorganic indicators of river water, including calcium, potassium, sodium, iron (total and dissolved), magnesium (total and dissolved), sulfate, chloride, bicarbonate, carbonate, and nitrate

Each of DEQ's recommendations have been evaluated for possible addition to the source control monitoring program, and following is an assessment of each recommendation. The DEQ-requested plan to test groundwater for PAHs, VOCs, metals, total cyanide, free cyanide, and available cyanide is based on the following goals:

- Test for a representative list of the MGP-related and Siltronic VOCs that are driving the source control actions at the Site.
- The purpose of the testing is to evaluate groundwater quality trends that will occur over time, not to evaluate whether groundwater containment is achieved. The design of performance monitoring for groundwater containment is described in Section 3.2.2.5.2.

Regarding DEQ's recommended measurement of typical field water quality measurements, the field samplers will test for pH, conductance, temperature, and oxidation reduction potential

(ORP) as part of the sampling process. Per DEQ's request on page 11 of the September 22 letter attachment, field measurements of sample turbidity have been added to the project Sampling and Analysis Plan in Appendix O.

Per DEQ's request on page 11 of the September 22 letter attachment, dissolved metals and total cyanide have been added to the analyte list, and available cyanide will be tested instead of weak acid dissociable (WAD) cyanide. The analytes planned for the first year of system operation are listed as follows:

- EPA Method 8260 for VOCs
- EPA Method 8270 SIM for PAHs
- EPA Method 335.4 for total cyanide
- EPA Method OIA-1677 for available cyanide
- EPA Method D-4282 for free cyanide
- EPA Method 6000 Series for total metals

The DEQ-requested monitoring of PAHs, VOCs, metals, total cyanide, free cyanide, and WAD cyanide will provide a comprehensive picture of the trends of water quality changes that occur during operation of the extraction/treatment system. After the first year of system operation, the monitoring program will be evaluated to determine if the scope of monitoring can be reduced without affecting the ability of the source control system to meet its hydraulic containment goals.

Regarding DEQ's recommended addition of all of the constituents on the groundwater permit discharge list and any constituents that could affect the operation of the extraction/treatment system, there is potential value in testing the influent to the treatment system for these additional parameters. To accomplish this, it is proposed to test the combined influent to the treatment system but not all of the wells in the monitoring program. If an analyte is detected in the combined influent that seems to be an issue for the treatment system, it can then be determined if sampling of individual extraction wells is needed to determine the source. NW Natural will wait for DEQ to provide the recommended NPDES monitoring plan before preparing this additional analyte list. This proposal for sampling the combined influent to the treatment system was approved by DEQ in the September 22 letter attachment.

Per DEQ's recommendation, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene have been added to the VOC reporting list.

Regarding DEQ's recommendation to test the wells for inorganic indicators of river water, it is agreed that the issue of river inflow to the extraction wells is a matter of general interest but is not an important factor for judging the success of the source control system. To satisfy DEQ's information request the following is proposed in the subsequent paragraph.

During the initial month of operation each of the extraction wells will be sampled weekly, and the samples will be tested for the analytes recommended by DEQ. Samples from each extraction well will then be tested monthly during the first 6 months of operation. This proposal to test for inorganic indicators of river water was approved by DEQ in the September 22 letter attachment.

3.2.2.5.5 Maintenance, Repair, and Reporting

The operation of the extraction well system will be instrumented for remote monitoring of water elevation and flow. Fiber optics will be used for communication of water elevation and flow rates in each extraction well. The system will have automatic alarms that will be triggered for water level changes outside of the set point differential level in the control wells and for sustained extraction well pump shutdowns. The extraction well system will also be connected to treatment system alarms that indicate a shutdown of treatment operations. The extraction well system will have the capability for remote monitoring of system functions; automatic notification of alarms to email, pager, and phone message to designated response personnel; and adjustment to system operational parameters. Per DEQ's request on page 12 of the September 22 letter attachment, DEQ will have remote access to view system monitoring displays and will be copied on alarm notifications that affect system operation or require equipment repair. When alarm conditions occur, NW Natural will respond to make the necessary adjustments or repairs.

An extraction system operations and maintenance manual will be prepared for DEQ review prior to startup of the system. The manual will have a description of the alarm systems.

For the first 5 years of system operation, quarterly reports will be prepared for submittal to DEQ. These reports will describe the system capture performance, as measured using the methods described in Section 3.2.2.5.2. The reports will describe system operational events, including temporary well shutdowns for equipment repair or maintenance, and provide the groundwater quality data from the monitoring program, including updated trend graphs.

After the first year of quarterly reporting, there will be an evaluation of reporting requirements and reporting frequency.

There will also be the reports required by DEQ for the discharge permit for treated groundwater. It is assumed that DEQ will specify the reporting requirements when the agency issues the permit.

3.2.3 Extraction System Testing and Design

As described in Section 1.1, NW Natural's November 4, 2011, letter described a design plan that adds a step of conducting short-term field pump tests of the completed extraction system and using the findings from those tests to prepare the OPDR. In DEQ's December 7, 2011, comment letter, that testing process was designated Step 2.3, and in the letter, DEQ requested that a plan for the tests be provided in the CDR. This section provides the plan for the testing process.

The primary field testing steps will be conducted after all of the extraction wells, monitoring wells, piezometers, extraction system pipelines, and control systems have been installed. The only exception is the individual extraction well step-drawdown tests, which will likely be conducted before all of the extraction wells have been installed. If the Gasco groundwater treatment plant is constructed by this time, the pipelines will be connected to the treatment plant. If the treatment plant is not yet ready or the NPDES discharge permit has not yet been approved, the extraction system will be connected to the Site granular activated carbon treatment system, and the effluent will be routed to the POTW under the existing Industrial Wastewater Discharge Permit. City of Portland Bureau of Environmental Services (BES) has agreed to extend the permit period to February 15, 2014.

Following are the planned steps for the extraction system field testing program:

1. **Step-drawdown Tests.** Step-drawdown tests will be conducted at each of the newly constructed extraction wells. The flow rates for the upper alluvium extraction wells will be 2.5, 5, 7.5, and 10 gpm. The flow rates for the lower alluvium extraction wells will be 15, 30, 40, and 50 gpm. The step-drawdown tests will be conducted with only one well pumping at a time. The purpose of these tests is to assess the potential yield of each new extraction well and to estimate aquifer transmittivity and storativity.
2. **System Start Test.** After the entire extraction system has been constructed, short-term system tests at minimal individual well flow rates will be conducted for a few days to

ensure that all of the extraction system pumps, transducers, control systems, and the PLC are working and interfacing properly. This will likely require multiple short-term starts of the system, lasting from a few minutes to a few hours each.

3. **Combined System Tests.** Combined system tests will be conducted with all extraction wells operating simultaneously. These tests are not designed to test the maximum pumping capacity of the system, so it is planned to minimize pumping rates, while achieving hydraulic containment. Tests are planned to be conducted at three delta H (difference in elevation between groundwater and river at a control well) settings: 0.1 feet, 0.15 feet, and 0.2 feet. According to the manufacturer, the transducer measurements are accurate to plus or minus 0.1 percent, with a resolution of plus or minus 0.005 percent or better. Therefore these proposed delta H settings are well within the accuracy of the transducers. For each of these tests, the control wells will initially be set at the same delta H, so for Test 1, all control wells will have the delta H set at 0.1 feet. The entire system will be turned on for each test. For Test 1 the extraction well VFDs will be working to maintain the delta H setting for groundwater elevation at the control wells to be 0.1 feet below the river elevation. During the test, the field operators will be able to view online in real time the groundwater elevations in nearby monitoring wells and piezometers to determine what elevation is being maintained at those locations. The operators will be able to adjust the delta H settings at any of the control wells to balance the system or to increase the drawdown in nearby monitoring wells. This monitoring and tuning of the system may take up to 3 days at each of three delta H settings. Depending upon the findings from the initial tests at the delta H settings of 0.1 or 0.15 feet, it may be recommended, in conjunction with DEQ, to conduct additional tests at different delta H settings. This entire process of testing the well system at different delta H settings and tuning the system at each setting is estimated to take approximately 2 weeks of field testing.
4. **MODFLOW Model Update.** The project MODFLOW model will be updated with the aquifer property information derived from the step-drawdown tests conducted in Step 1. This will allow the model to reflect the varying aquifer properties across the full length of the extraction system.
5. **Capture Evaluation.** The updated MODFLOW model will be used to assess the groundwater elevation data from the Step 3 combined system tests. The model will be used to determine the lateral extent and depth of capture that was achieved during the combined system tests. The model will be recalibrated to the upland groundwater elevation data and the elevation data from the river piezometers. The recalibrated

model will be used to determine the extent of offshore capture in the river sediments by mapping areas where predicted net fluxes at the sediment water interface are from the river to upland groundwater. The data should show that full containment was achieved in the upland alluvium and extending well out into the river, similar to what was shown in the April 2011 well tests.

6. **Additional Field Tests.** This step is added as a contingency in case the Step 5 evaluation indicates that additional field tests are needed to adjust the delta H at some control wells or to change control wells to enhance capture in some areas. Based on the April 2011 test results, it is anticipated that the well network will be capable of achieving full containment of the alluvium. However, in the unlikely event that additional field tests show that the existing well network cannot achieve full containment, even by adjusting the pumping rates, it may be necessary to implement the second contingency action of adding an extraction well or wells.

The findings from the combined system field testing and model analysis will be used to prepare the OPDR. If necessary, contingency actions that are indicated by these test results will be described in the OPDR. The findings from these tests will also inform the sediment remedy design.

3.3 Groundwater Treatment System Design

Sevenson's 100-percent Wastewater Treatment Final Design Report is in Appendix E. The interim treatment system design was prepared following the treatment system pilot test, which was completed in September 2009. The *Wastewater Pilot Plant Testing Plan* (Sevenson 2009) was provided to DEQ on May 4, 2009. DEQ provided a preliminary comment letter on May 13, and Sevenson prepared a May 15 response letter addressing DEQ's comments. A revised pilot plan was provided to DEQ on June 29, 2009. Sevenson constructed and operated the pilot treatment system and the Pilot Plant Report was provided to DEQ in December 2010 (see Appendix N). The wastewater treatment final design (see Appendix E) is based on both the findings of the Pilot Plant operation and subsequent bench scale testing, as described in Appendix E.

The treatment plant is designed to treat a maximum day flow of 666 gpm and a maximum hour flow of 817 gpm, significantly more than the interim design. The determination of the design flows is described in the Basis of Plant Design section of Appendix E. The wastewater treatment plant design and materials balance is in Attachment A of Appendix E. The treatment

plant design drawings are in Attachment A to Appendix E. The treatment system process flow diagram is on Figure 3-13.

Sevenson submitted the revised treatment system design report to DEQ on January 31, 2012. DEQ was requested to expedite review of the treatment system design to enable NW Natural to order the long-lead system components and begin construction as soon as possible. The treatment system design in Appendix E follows logically the design predicted in the December 2010 Pilot Plant Report, so NW Natural is anticipating that DEQ will find that the design is consistent with that report.

4 PERMITS

As discussed in Section 3.1.2, Sevenson submitted to DEQ the application for an NPDES permit to discharge treated groundwater to the Willamette River in February 2011. As of the date of this report, DEQ is still preparing a formal response to the permit application concerning final standards and an approach to a possible mixing zone for the source control treatment plant discharge.

The source control project will require a stormwater permit, expanded consultation with the City of Portland on Greenway requirements, and access to the Siltronic property. Some of the permits and authorizations have already been received; all of the regulatory requirements are described in this section. Permit information is also summarized in Table 4-1.

The City of Portland Bureau of Development issued a Greenway Letter of Determination on June 22, 2009, related to the installation of wells and placement of access road material in the Greenway setback (Phase I); the determination will not expire. The City of Portland concluded that Greenway Review was exempted within the code for cleanup-related activities, so a modified Greenway Review was (and will be) used for this project to address any activities within the Greenway setback (i.e., wells installed in the Greenway and roads installed to access those well locations) to ensure that the activities are in substantive compliance. This Letter of Determination does not cover installation of an interceptor trench, the treatment buildings, or any work on the Siltronic property. While these activities would still be considered exempt, a separate consultation and modified Greenway Review will be required for additional source control activities within the zone from the top of bank or ordinary high water and landward 200 feet that fall under the authority of DEQ (Phase II). A copy of this design report will be provided to the City of Portland for their review and their determination on what additional Greenway requirements may exist for this phase of the project.

An NPDES 1200-C permit will also be required for potential uplands construction-related stormwater impacts of this project. This stormwater construction permit is required for projects that disturb more than 1 acre of land on site due to any combination of clearing, grading, excavation, or stockpiling of fill material. DEQ issues the NPDES stormwater permits.

Finally, permits will be required at the state and federal level to address construction of the NPDES outfall pipe/diffuser. A General Authorization for minimal disturbance is likely to be

granted by the Oregon Department of State Lands to permit the installation of the outfall pipe under the state's waterway removal/fill rules. At the federal level, the installation of the outfall pipe would be covered under a Nation-wide Permit #7 from the U.S. Army Corps of Engineers (USACE) to address requirements under the Rivers and Harbors Act Section 10, as well as Clean Water Act Section 404 requirements and Endangered Species Act consultation.

5 CONSTRUCTION SCHEDULE AND SEQUENCING

Figure 5-1 depicts the current working schedule for the groundwater source control design and implementation. The schedule is termed "working" because findings of design level studies, DEQ review cycles, and DEQ decisions could impact the schedule in terms of alleviating the need for certain tasks, highlighting the need for additional design tasks, and causing duration changes to particular tasks. With the understanding that ongoing work could impact even major milestones within the schedule, key estimated target dates for design and construction are described in this section.

One important factor that affects the treatment system construction schedule is the ordering of long-lead components of the treatment system. These components have to be built to order and require several months to deliver. To fast-track construction of the treatment system, NW Natural should order the long-lead treatment system components in April 2012, as shown on the schedule in Figure 5-1. To enable order of the long-lead items, NW Natural is requesting that DEQ review the revised Wastewater Treatment Final Design Report (see Appendix E) on an expedited schedule, compared to the overall CDR. The treatment system design report was submitted to DEQ on January 31, 2012. If DEQ could review and approve the treatment system design by April 2, 2012, or sooner, as shown on the schedule, then the long-lead items could be ordered in time to largely construct the system in 2012. It is also important that the DEQ NPDES discharge permit be issued on schedule so that construction mobilization of the treatment system can take place.

As shown on the Figure 5-1 schedule chart, the key dates for the source control design and implementation are as follows:

- Submittal of the CDR to DEQ – January 31, 2012
- DEQ review and approve Treatment System Design – April 2, 2012
- NW Natural order treatment system long-lead components – April 2012
- DEQ complete review of CDR – March 26, 2012
- NW Natural submit Final CDR to DEQ – May 22, 2012
- DEQ review and approve Final CDR – July 11, 2012
- Finish construction and testing of Extraction Well System – December 24, 2012
- Finish construction of Treatment System – February 7, 2013
- Obtain Treatment System NPDES Permit approval – August 31, 2012
- Submittal of the OPDR to DEQ – March 25, 2013

- DEQ complete review of OPDR – June 21, 2013
- NW Natural submit Final OPDR to DEQ – August 26, 2013
- DEQ review and approve Final OPDR – October 18, 2013
- DEQ Report submit – December 9, 2013
- Startup extraction and Treatment System – January 14, 2014

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TABLES

Table 2-1
Existing and Proposed Shoreline Area Monitoring Wells, Extraction Wells, and Piezometers

Well Number	Water-Bearing Zone	Date Installed	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)	Well Depth[1] (feet bgs)	Well Depth[1] (feet COP)	Top Screen (feet bgs)	Top Screen (feet COP)	Base Screen (feet bgs)	Base Screen (feet COP)
Existing Monitoring Wells																	
MW-1-22	Surficial Fill	24-Oct-95	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	10-Jul-07	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	9-Jul-07	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	Surficial Fill	6-Nov-95	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	34.83	34.50	0.3	32.5	2.3	21.5	13.3	31.5	3.3
MW-2-61	Alluvial	8-Oct-98	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	34.61	34.42	0.2	61.5	-26.9	50.0	-15.4	60.0	-25.4
MW-2-104	Alluvial	25-Jun-07	Sonic	Flush	Continuous wrap stainless steel	0.020	10-20	2	34.86	34.88	(0.0)	116.5	-81.6	94.0	-59.1	104.0	-69.1
MW-3-26	Surficial Fill	1-Nov-95	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.30	34.13	(2.8)	26.0	5.3	15.0	16.3	25.0	6.3
MW-3-56	Alluvial	1-Nov-95	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.51	34.10	(2.6)	56.0	-24.5	45.0	-13.5	55.0	-23.5
MW-4-35	Surficial Fill	31-Oct-95	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	30-Oct-95	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	16-Oct-98	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	27-Oct-95	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	23-Oct-98	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	22-Oct-98	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-16-45	Alluvial	20-Jul-04	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	Alluvial	19-Jul-04	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.75	33.21	(2.5)	68.0	-37.3	55.0	-24.3	65.0	-34.3
MW-17-79[2]	Alluvial	26-Jul-05	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	27-Feb-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.61	34.27	(2.7)	30.0	1.6	19.0	12.6	29.0	2.6
MW-18-125	Alluvial	22-Apr-10	Soinc	Above-grade	Continuous wrap stainless steel	0.010	10-20	2	31.93	34.65	(2.7)	126.0	-94.1	115.0	-83.1	125.0	-93.1
MW-18-180	Alluvial	26-Feb-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	33.90	(2.2)	230.0	-198.3	170.0	-138.3	180.0	-148.3
MW-19-22	Surficial Fill	6-Mar-07	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	12-Mar-07	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	2-Mar-07	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	8-Mar-07	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	6-Jul-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.34	23.25	(2.9)	14.0	6.3	7.0	13.3	12.0	8.3
MW-21-75	Alluvial	5-Jul-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.22	23.11	(2.9)	77.0	-56.8	65.0	-44.8	75.0	-54.8
MW-21-115	Alluvial	2-Jul-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.32	23.43	(3.1)	118.0	-97.7	105.0	-84.7	115.0	-94.7
MW-21-166	Alluvial	28-Jun-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.35	23.15	(2.8)	193.0	-172.7	156.0	-135.7	166.0	-145.7
MW-22-80	Alluvial	28-Jan-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	33.59	36.01	(2.5)	80.9	-47.3	69.9	-36.3	79.9	-46.3
MW-23-27	Surficial Fill	16-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	32.77	34.72	(2.3)	28.0	4.8	17.7	15.1	27.7	5.1
MW-23-75	Alluvial	16-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	32.91	34.87	(2.5)	75.7	-42.8	64.7	-31.8	74.7	-41.8
MW-23-123	Alluvial	5-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	32.88	35.05	(2.5)	124.3	-91.4	113.3	-80.4	123.3	-90.4
MW-24-70	Alluvial	3-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	31.42	33.83	(2.4)	71.1	-39.7	60.1	-28.7	70.1	-38.7
MW-24-130	Alluvial	2-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	31.34	33.76	(2.5)	131.1	-99.8	120.1	-88.8	130.1	-98.8
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
PW-3-85	Alluvial	19-Jun-03	Cable Tool	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	25.00	26.80	(1.8)	95.0	-70.0	75.0	-50.0	85.0	-60.0
Proposed Monitoring Wells																	
MW-21-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.00	23.00	(3.0)	41.0	-21.0	30.0	-10.0	40.0	-20.0
MW-22-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	32.00	35.00	(3.0)	52.0	-20.0	41.0	-9.0	51.0	-19.0
MW-23-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.00	36.00	(3.0)	53.0	-20.0	42.0	-9.0	52.0	-19.0
MW-25-L	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	24.00	27.00	(3.0)	65.0	-41.0	54.0	-30.0	64.0	-40.0
MW-26-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	32.00	35.00	(3.0)	50.0	-18.0	39.0	-7.0	49.0	-17.0
MW-27-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.00	34.00	(3.0)	57.0	-26.0	46.0	-15.0	56.0	-25.0
MW-27-L	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.00	34.00	(3.0)	117.0	-86.0	106.0	-75.0	116.0	-85.0
MW-28-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.00	34.00	(3.0)	87.0	-56.0	76.0	-45.0	86.0	-55.0
MW-28-L	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.00	34.00	(3.0)	122.0	-91.0	111.0	-80.0	121.0	-90.0
MW-29-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.00	30.00	(3.0)	47.0	-20.0	36.0	-9.0	46.0	-19.0
MW-30-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	28.00	31.00	(3.0)	48.0	-20.0	37.0	-9.0	47.0	-19.0
MW-31-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.00	30.00	(3.0)	91.0	-64.0	80.0	-53.0	90.0	-63.0
MW-31-L	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.00	30.00	(3.0)	118.0	-91.0	107.0	-80.0	117.0	-90.0
MW-32-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	26.00	29.00	(3.0)	51.0	-25.0	40.0	-14.0	50.0	-24.0
MW-33-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	24.00	27.00	(3.0)	49.0	-25.0	38.0	-14.0	48.0	-24.0
MW-34-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	24.00	27.00	(3.0)	74.0	-50.0	63.0	-39.0	73.0	-49.0
MW-34-L	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	24.00	27.00	(3.0)	110.0	-86.0	99.0	-75.0	109.0	-85.0
MW-35-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.00	36.00	(3.0)	53.0	-20.0	42.0	-9.0	52.0	-19.0
MW-36-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	34.00	37.00	(3.0)	54.0	-20.0	43.0	-9.0	53.0	-19.0
MW-37-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.00	34.00	(3.0)	57.0	-26.0	46.0	-15.0	56.0	-25.0
MW-38-U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.00	34.00	(3.0)	50.0	-19.0	39.0	-8.0	49.0	-18.0
Existing Observation Well																	
OW-7-17	Surficial Fill	23-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	24.20	26.51	(2.3)	17.7	6.5	12.5	11.7	17.5	6.7
OW-8-15	Surficial Fill	12-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	24.56	26.42	(1.9)	15.3	9.3	10.1	14.5	15.1	9.5
OW-8-28	Alluvial	13-Aug-10	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020	10-20	2	23.79	26.38	(2.6)	29.0	-5.2	23.1	0.7	28.1	-4.3
OW-9-25	Surficial Fill	8-Mar-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	33.11	35.38	(2.3)	25.3	7.8	20.0	13.1	25.0	8.1

Table 2-1
Existing and Proposed Shoreline Area Monitoring Wells, Extraction Wells, and Piezometers

Well Number	Water-Bearing Zone	Date Installed	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)	Well Depth[1] (feet bgs)	Well Depth[1] (feet COP)	Top Screen (feet bgs)	Top Screen (feet COP)	Base Screen (feet bgs)	Base Screen (feet COP)
Proposed Observation Well																	
OW-1-F	Surficial Fill	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	35.00	38.00	(3.0)	37.0	-2.0	28.0	7.0	33.0	2.0
OW-2-F	Surficial Fill	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	34.00	37.00	(3.0)	34.0	0.0	27.0	7.0	32.0	2.0
OW-5-F	Surficial Fill	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	32.00	35.00	(3.0)	32.0	0.0	25.0	7.0	30.0	2.0
OW-10-F	Surficial Fill	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	32.00	35.00	(3.0)	22.0	10.0	15.0	17.0	20.0	12.0
Existing Extraction Well																	
PW-3-118	Alluvial	12-Jun-03	Cable Tool	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	25.50	27.00	(1.5)	128.0	-102.5	108.0	-82.5	118.0	-92.5
PW-7-93	Alluvial	22-Feb-10	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	24.19	26.74	(2.6)	95.5	-71.3	73.5	-49.3	93.5	-69.3
PW-8-39	Alluvial	13-Aug-10	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.035	10-20	15	23.22	25.69	(2.5)	50.0	-26.8	24.2	-1.0	39.2	-16.0
PW-8-68	Alluvial	11-Feb-10	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	24.64	27.13	(2.5)	70.0	-45.4	48.0	-23.4	68.0	-43.4
PW-9-92	Alluvial	1-Mar-10	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	33.02	35.78	(2.8)	94.6	-61.6	72.6	-39.6	92.6	-59.6
Proposed Extraction Well																	
PW-1-U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	35.00	38.00	(3.0)	60.0	-25.0	40.0	-5.0	55.0	-20.0
PW-1-L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	35.00	38.00	(3.0)	85.0	-50.0	95.0	-60.0	115.0	-80.0
PW-2-U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	34.00	37.00	(3.0)	59.0	-25.0	39.0	-5.0	54.0	-20.0
PW-2-L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	112.0	-87.8	90.0	-65.8	110.0	-85.8
PW-3-U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	25.00	28.00	(3.0)	50.0	-25.0	30.0	-5.0	45.0	-20.0
PW-4-U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	30.00	33.00	(3.0)	55.0	-25.0	35.0	-5.0	50.0	-20.0
PW-4-L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	123.0	-98.8	101.0	-76.8	121.0	-96.8
PW-5-U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	32.00	35.00	(3.0)	57.0	-25.0	37.0	-5.0	52.0	-20.0
PW-5-L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	119.0	-94.8	97.0	-72.8	117.0	-92.8
PW-6-U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	32.00	35.00	(3.0)	57.0	-25.0	37.0	-5.0	52.0	-20.0
PW-6-L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	108.0	-83.8	86.0	-61.8	106.0	-81.8
PW-10-L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	66.0	-41.8	49.0	-24.8	64.0	-39.8
PW-11-U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	25.00	28.00	(3.0)	50.0	-25.0	30.0	-5.0	45.0	-20.0
PW-12-U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	27.00	30.00	(3.0)	52.0	-25.0	32.0	-5.0	47.0	-20.0
PW-13-U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	32.00	35.00	(3.0)	57.0	-25.0	37.0	-5.0	52.0	-20.0
PW-14-U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	32.00	35.00	(3.0)	57.0	-25.0	37.0	-5.0	52.0	-20.0
Existing Piezometer																	
PZ1-5	Alluvial	17-Mar-05	Manual	Above-grade	Solinst push point		NA	1	9.96	36.07	(26.1)	5.6	4.3	4.5	5.5	5.4	4.6
PZ1-20	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
PZ1-50	Alluvial	23-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.17	37.67	(27.5)	50.4	-40.2	45.2	-35.0	50.2	-40.0
PZ2-5	Alluvial	18-Mar-05	Manual	Above-grade	Solinst push point		NA	1	2.89	37.90	(35.0)	6.7	-3.8	5.5	-2.6	6.4	-3.5
PZ2-20	Alluvial	17-Mar-05	Manual	Above-grade	Solinst push point		NA	1	3.38	37.89	(34.5)	21.7	-18.4	20.6	-17.2	21.5	-18.1
PZ2-43	Alluvial	3-Dec-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	3.76	37.96	(34.2)	43.6	-39.8	38.4	-34.6	43.4	-39.6
PZ2-77	Alluvial	2-Dec-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	3.05	38.65	(35.6)	77.2	-74.2	72.0	-69.0	77.0	-74.0
PZ4-12	Alluvial	4-Dec-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	-8.63	34.67	(43.3)	12.0	-20.6	6.8	-15.4	11.8	-20.4
PZ4-41	Alluvial	24-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	-8.33	33.07	(41.4)	41.4	-49.7	36.2	-44.5	41.2	-49.5
PZ5-5	Alluvial	20-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.70	16.51	(5.5)	5.0	5.7	3.8	6.9	4.8	5.9
PZ5-20	Alluvial	20-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.72	16.24	(5.5)	20.3	-9.6	15.1	-4.4	20.1	-9.4
PZ5-55	Alluvial	20-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.79	16.31	(5.5)	55.3	-44.5	50.1	-39.3	55.1	-44.3
PZ5-85	Alluvial	19-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.79	16.44	(5.4)	85.2	-74.4	80.0	-69.2	85.0	-74.2
Proposed Piezometer																	
PZ6-5	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	5.5	4.5	4.0	6.0	5.0	5.0
PZ6-50	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	50.5	-40.5	45.0	-35.0	50.0	-40.0
PZ6-115	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	115.5	-105.5	110.0	-100.0	115.0	-105.0
PZ6-150	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	150.5	-140.5	145.0	-135.0	150.0	-140.0
PZ7-5	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	5.5	4.5	4.0	6.0	5.0	5.0
PZ7-50	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	50.5	-40.5	45.0	-35.0	50.0	-40.0
PZ7-150	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	150.5	-140.5	145.0	-135.0	150.0	-140.0
PZ8-5	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	5.5	4.5	4.0	6.0	5.0	5.0
PZ8-50	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	50.5	-40.5	45.0	-35.0	50.0	-40.0
PZ9-5	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	9.00	15.00	(6.0)	5.5	3.5	4.0	5.0	5.0	4.0
PZ9-50	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	9.00	15.00	(6.0)	50.5	-41.5	45.0	-36.0	50.0	-41.0
PZ9-75	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	9.00	15.00	(6.0)	74.5	-65.5	69.0	-60.0	74.0	-65.0
PZ9-150	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	9.00	15.00	(6.0)	150.5	-141.5	145.0	-136.0	150.0	-141.0

Notes:

= Proposed well added for Construction Design Report

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

[1] Actual completion depths may differ depending on actual lithology encountered during drilling

[2] Scheduled for abandonment

Table 2-2
Comparison of Groundwater Quality Above (Upper Alluvium) and Below (Deep Alluvium) the Aquitard

Well	Zone	Sample Dates	Benzene µg/L (ppb)		Naphthalene µg/L (ppb)		Total Cyanide mg/L (ppm)		Free Cyanide mg/L (ppm)	
MW-21-12	Surficial Fill	7/19/2007	0.5	U	2.9	U	0.0537		0.0048	
		5/14/2008	0.2	J	1.2		0.05		0.01	J
		9/15/2008	-		-		-		-	
		12/8/2008	0.31	J	0.94		0.09		0.005	J
MW-21-75	Upper Alluvium	7/18/2007	0.5	UJ	0.135	J	0.0648	J	0.0043	J
		5/14/2008	0.045	U	0.081		0.12		0.009	J
		9/15/2008	0.045	U	0.097		0.09		0.012	
		12/8/2008	0.045	U	0.048		0.14		0.005	J
MW-21-115	Upper Alluvium	7/18/2007	0.5	UJ	0.0989	J	0.0123	J	0.003	UJ
		5/15/2008	0.045	U	0.053		0.01		0.003	J
		9/15/2008	0.045	U	0.1		0.02		0.003	U
		12/8/2008	0.045	U	0.042		0.01		0.005	U
MW-21-165	Deep Alluvium	7/18/2007	0.5	UJ	0.0971	J	0.005	UJ	0.003	UJ
		5/14/2008	0.14	J	0.12		0.002	U	0.003	U
		9/15/2008	0.045	U	0.09		0.02	U	0.003	U
		12/8/2008	0.14	J	0.036		0.005	J	0.005	J
MW-16-45	Upper Alluvium	8/26/2004	2880		7500		0.138		-	
		12/22/2004	2680		8140		-		-	
		4/1/2005	2970		6060		-		-	
		6/21/2005	3190		10400		-		-	
		10/3/2005	3710		7820		0.131		-	
		4/3/2006	4210		29400		0.117		0.0013	U
		12/12/2006	5000		11000		0.14		0.005	U
		7/31/2007	4230		64100		0.412		0.003	U
		5/21/2008	4800		4800	J	0.51		0.005	
		9/17/2008	5600		12000		0.67		0.006	J
MW-16-65	Upper Alluvium	8/26/2004	1370		3600		0.402		-	
		8/26/2004	1250		3870		-		-	
		12/22/2004	1290		0.1	U	-		-	
		3/31/2005	1240		4840		-		-	
		6/21/2005	917		5700		-		-	
		10/3/2005	991		2900		0.25		-	
		4/3/2006	1090		3190		0.301		0.0149	
		10/23/2006	930		2500		0.31		0.005	U
		6/28/2007	698		837		0.18	J	0.003	UJ
		5/13/2008	690		2500		0.42		0.009	J
		9/11/2008	680	J	1200		0.28		0.007	J
MW-16-125	Upper Alluvium	9/30/2005	2.95		0.577		0.0775		NS	
		3/30/2006	0.5		0.452		0.0777		0.0016	
		10/16/2006	0.26		0.13		0.13		0.005	U
		6/28/2007	0.5		0.165		0.114	J	0.003	UJ

Table 2-2
Comparison of Groundwater Quality Above (Upper Alluvium) and Below (Deep Alluvium) the Aquitard

Well	Zone	Sample Dates	Benzene µg/L (ppb)		Naphthalene µg/L (ppb)		Total Cyanide mg/L (ppm)		Free Cyanide mg/L (ppm)	
MW-18-30	Surficial Fill	7/31/2007	10100		-		1.65		0.003	
		5/14/2008	8600		1700000		2.22		0.006	J
		9/17/2008	-		-		-		-	
		12/9/2008	-		-		-		-	
MW-18-180	Deep Alluvium	6/28/2007	0.5	U	0.575		0.0242	J	0.003	UJ
		5/13/2008	0.045	U	0.082		0.03		0.003	J
		9/11/2008	0.07	J	0.18		0.04		0.006	J
		12/9/2008	0.045	U	0.044		0.03		0.01	
MW-19-22	Surficial Fill	7/30/2007	6.58		297		0.121		0.003	U
		5/13/2008	1.0		270		0.12		0.004	J
		9/10/2008	3.4		230		0.12		0.007	J
		12/9/2008	4.0		120		0.14		0.013	
MW-19-125	Upper Alluvium	6/27/2007	16.7		2.95		0.0755		0.0087	
		5/14/2008	13		49		0.23		0.007	J
		9/10/2008	2.7		27		0.15		0.004	J
		12/9/2008	0.58		15		0.1	J	0.011	
MW-19-180	Deep Alluvium	6/27/2007	0.5	U	0.0954		0.0172		0.003	U
		5/13/2008	0.17	J	0.11		0.02		0.003	J
		9/10/2008	0.19	J	0.11		0.02		0.005	J
		12/9/2008	0.22	J	0.031		0.02		0.012	
MW-20-120	Upper Alluvium	6/28/2007	75		39.9		0.118		0.003	UJ
		5/15/2008	120		120		0.16		0.007	J
		9/10/2008	55		84		0.14		0.005	J
		12/9/2008	70		51		0.14		0.013	
MW-5-32	Surficial Fill/Alluvium	12/5/1995	0.5	U	11		0.101		-	
		3/19/1996	0.5	U	1		0.11		-	
		3/19/1996	-		0.61		-		-	
		6/20/1996	0.5	U	0.42		0.05		-	
		10/1/1996	0.5	U	10	U	0.14		-	
		2/25/1997	0.5	U	0.16		0.11		-	
		8/27/1997	0.5	U	1.0	U	0.14		-	
		2/17/1998	0.5	U	0.1	U	0.17		-	
		6/2/1998	0.5	U	0.67		0.18		-	
		8/26/1998	0.5	U	3.4		0.23		-	
		11/18/1998	0.5	U	0.1	U	0.25		-	
		2/16/1999	0.5	U	0.1	U	0.13		-	
		5/14/1999	0.5	U	0.95		0.15		-	
		8/24/1999	0.749		0.12		0.18		-	
		10/27/1999	0.5	U	0.1	U	0.19		-	
		3/30/2000	0.5	U	0.1	U	0.02	U	-	
		10/5/2000	0.5	U	0.1	U	-		-	
		3/29/2001	0.5	U	0.13		0.178		-	

Table 2-2
Comparison of Groundwater Quality Above (Upper Alluvium) and Below (Deep Alluvium) the Aquitard

Well	Zone	Sample Dates	Benzene µg/L (ppb)		Naphthalene µg/L (ppb)		Total Cyanide mg/L (ppm)		Free Cyanide mg/L (ppm)	
MW-5-32	Surficial Fill/Alluvium	8/16/2004	0.5	U	0.1	U	0.521		-	
		4/1/2005	0.5	U	0.136		-		-	
		9/27/2005	0.5	U	0.999		0.09		-	
		3/29/2006	0.5	U	0.192	U	0.106		0.0031	
		10/18/2006	0.14	U	0.068	J	0.09		0.005	J
		6/25/2007	0.5	U	4.63		-		-	
		7/30/2007	-		-		0.106		0.003	U
		5/14/2008	0.045	U	0.24		0.11		0.006	J
		9/10/2008	0.34	J	0.34		0.09		0.007	J
MW-5-100	Upper Alluvium	11/18/1998	5000		7100		0.66		-	
		2/17/1999	6650		5010		0.66		-	
		5/14/1999	11400		7440		0.44		-	
		8/25/1999	11800		13300		0.84		-	
		10/28/1999	10300		7450		0.69		-	
		3/30/2000	9550		9800		0.56		-	
		10/6/2000	9180		10100		-		-	
		10/6/2000	9020		9200		-		-	
		3/29/2001	9560		9600		0.142		-	
		4/5/2002	8750		82300		1.8		-	
		4/5/2002	8950		4310		1.54		-	
		3/19/2003	6600		5600		0.56		-	
		8/24/2004	11500		11900		0.816		-	
		4/1/2005	19800		8730		-		-	
		9/21/2005	12300		6530		0.869		-	
		4/4/2006	11300		8390		0.814		0.0283	
		10/27/2006	11000		7100		1.06		0.005	J
		6/25/2007	10100		7320		-		-	
		7/30/2007	-		-		0.747		0.0074	J
		5/14/2008	12000		7800		0.99		0.041	
		9/10/2008	11000		9900		0.91		0.036	
MW-5-175	Deep Alluvium	10/16/2006	0.14	U	0.047		0.04		0.005	U
		6/25/2007	0.5	U	0.114		0.0145	J	0.0022	J
		5/14/2008	0.05	J	0.076		0.02		0.005	J
		9/10/2008	0.045	U	0.075		0.01		0.004	J
WS-14-125	Upper Alluvium	6/12/2007	5430		7580		0.273		0.00563	J
		5/15/2008	6400		7800		0.33		0.008	J
		8/4/2008	4000		NS[1]		0.11		0.014	
		9/25/2008	4500		6800		0.29		0.032	
WS-14-161	Deep Alluvium	6/12/2007	0.09	U	15.7		0.005	U	0.003	UR
		5/15/2008	0.44	J	140		0.002	U	0.003	J
		8/4/2008	0.34		NS[1]		0.01	U	0.01	U
		9/25/2008	0.79		120		0.002	U	0.003	J

Table 2-2
Comparison of Groundwater Quality Above (Upper Alluvium) and Below (Deep Alluvium) the Aquitard

Well	Zone	Sample Dates	Benzene µg/L (ppb)	Naphthalene µg/L (ppb)	Total Cyanide mg/L (ppm)	Free Cyanide mg/L (ppm)
WS-11-125	Upper Alluvium	2/14/2008	799	NS[1]	0.62	0.01 U
		5/15/2008	560	11000	0.61	0.006 J
		8/6/2008	290	NS[1]	0.46	0.031
		9/29/2008	350	11000	0.53	0.003 U
WS-11-161	Deep Alluvium	6/12/2007	8.53	49.9	0.005 U	0.003 UR
		5/15/2008	25	110	0.01 J	0.004 J
		8/6/2008	19.8	NS[1]	0.01 U	0.01 U
		9/29/2008	23	89	0.002 U	0.003 U
WS-12-125	Upper Alluvium	6/12/2007	6.44	0.544	0.452	0.0078 J
		5/21/2008	6.6	0.088 U	0.53	0.007
		8/6/2008	4.58	NS[1]	0.35	0.027
		9/25/2008	6.2	0.056	0.43	0.149
WS-12-161	Deep Alluvium	6/12/2007	0.09 U	0.0952 U	0.006 J	0.003 UR
		5/21/2008	0.07 J	0.021 U	0.008	0.005
		8/5/2008	0.3 U	NS[1]	0.01 U	0.01 U
		9/25/2008	0.06 J	0.025	0.002 U	0.006 J
WS-8-33	Surficial Fill	10/9/2001	107	485	0.02 UJ	-
		12/13/2001	68	287 J	0.854	-
		4/3/2002	89.1	110	0.416	-
		4/3/2002	87.4	101	0.615	-
		7/10/2002	65.9	77.4	0.724	-
		7/10/2002	68.1	77.6	0.726	-
		5/21/2008	76	130 J	0.6	0.006
		9/29/2008	110	170	0.77	0.01
WS-8-59	Upper Alluvium	10/8/2001	14.7	22.7	0.468	-
		10/8/2001	21.4	22.5	0.456	-
		12/12/2001	26.8	10.5	0.725 J	-
		12/12/2001	27	10.8	0.066 J	-
		4/3/2002	13	1.13	1.42	-
		7/10/2002	20.8	0.63	0.459	-
		7/16/2007	7.08	0.0971 U	0.538	0.0061
		5/21/2008	13	0.37 J	0.45	0.004
		9/29/2008	2.7	0.16	0.63	0.003 U

Notes:

U - Not Detected at the detection Limit
J - Estimated value
R - Rejected value
1 - NS = Not Sampled
µg/L = micrograms per liter
mg/L milligrams per liter
ppb = parts per billion
ppm = parts per million

Table 3-1
Groundwater Treatment System Effluent Criteria

Parameter	Monthly Average (µg/L)	Daily Maximum (µg/L)
Benzo(a)anthracene	Calculated limit is 0.0038 µg/L; Compliance will be demonstrated by not exceeding the EPA Method 625 Quantitation Limit of 1 µg/L	Calculated limit is 0.0066 µg/L; Compliance will be demonstrated by not exceeding the EPA Method 625 Quantitation Limit of 1 µg/L
Benzo(a)pyrene	Calculated limit is 0.0038 µg/L; Compliance will be demonstrated by not exceeding the EPA Method 625 Quantitation Limit of 1 µg/L	Calculated limit is 0.0066 µg/L; Compliance will be demonstrated by not exceeding the EPA Method 625 Quantitation Limit of 1 µg/L
Copper[1]	13	23
Cyanide (free)	Calculated limit is 4.9 µg/L; Compliance will be demonstrated by not exceeding the ASTM Method 4282-95 Quantitation Limit of 10 µg/L	Calculated limit is 8.5 µg/L; Compliance will be demonstrated by not exceeding the ASTM Method 4282-95 Quantitation Limit of 10 µg/L
Cyanide (total)	130	230
Dibenzo(a,h)anthracene	Calculated limit is 0.0038 µg/L; Compliance will be demonstrated by not exceeding the EPA Method 625 Quantitation Limit of 1 µg/L	Calculated limit is 0.0066 µg/L; Compliance will be demonstrated by not exceeding the EPA Method 625 Quantitation Limit of 1 µg/L
Indeno(1,2,3-cd)pyrene	Calculated limit is 0.0038 µg/L; Compliance will be demonstrated by not exceeding the EPA Method 625 Quantitation Limit of 1 µg/L	Calculated limit is 0.0066 µg/L; Compliance will be demonstrated by not exceeding the EPA Method 625 Quantitation Limit of 1 µg/L
Iron[1]	950	1600
Lead[1]	Calculated limit is 4.3 µg/L; Compliance will be demonstrated by not exceeding the EPA Method 200.8/SM 3113 Quantitation Limit of 5 µg/L	7.4
Mercury[1]	0.011	0.020
pH	Within the range of 6.5 – 8.5 SU	
Total Arsenic	Operate treatment processes at the highest and best extent practicable treatment[2]	

Notes:
1 = Total Recoverable
2 = The Department has established a quarterly average of 18 µg/L total arsenic as a non-regulatory numeric benchmark to use in assessing whether the applicable treatment technology is providing the highest and best practicable treatment for arsenic in the discharge. An exceedance of this average value shall not in itself constitute a violation of this permit, but the Department will require the facility to submit a report to the Department detailing the conditions that resulted in the elevated value. The Department will use the report, monitoring information and operational records to assist in the determination of whether or not the facility was in compliance with the narrative operational requirements for total arsenic. The permittee must comply with this requirement until it can be determined by the Department that the facility does not have the reasonable potential to exceed the anticipated water quality criteria or the end of the permit term.
3 = This table was provided by the Oregon Department of Environmental Quality and the agency considers these draft, not final criteria.
µg/L = microgram per liter
EPA = U.S. Environmental Protection Agency
SU = standard unit

Table 3-2
Well and Aquifer Test Data

Test	Date	Pumping Rate GPM	Drawdown feet	Specific Capacity GPM/feet	Hydraulic Conductivity feet/day	Hydraulic Conductivity cm/second	Well Efficiency %
Step-Drawdown Tests							
PW-1-80 Step-Drawdown Test[1]							
Step 1	8/25/2005	6	3.27	1.83	NC	NC	NC
Step 2	8/25/2005	13	7.76	1.68	NC	NC	NC
Step 3	8/25/2005	23	14.84	1.55	NC	NC	NC
Step 4	8/25/2005	33	27.26	1.21	NC	NC	NC
PW-3-85 Step-Drawdown Test[2]							
Step 1	7/9/2007	20	8.12	2.46	NC	NC	NC
Step 2	7/9/2007	33.5	15.02	2.23	NC	NC	NC
Step 3	7/9/2007	42	19.88	2.11	NC	NC	3
PW-3-118 Step-Drawdown Test[2]							
Step 1	7/16/2007	30	4.92	6.10	NC	NC	NC
Step 2	7/16/2007	40	5.19	7.71	NC	NC	NC
Step 3	7/16/2007	50	7.37	6.78	NC	NC	69
Constant Rate Tests							
PW-1-80[1][7]	8/30/2005	20	19.72	1.01	3.1	1.09E-03	NC
PW-3-85[2][7]	7/18/2007	40	20.80	1.92	8	2.82E-03	NC
PW-3-118[2][7]	7/18/2007	50	8.24	6.07	190	6.70E-02	NC
PW-7-93[3][8]	4/19/2010	15	2.87	5.23	NC	NC	NC
	4/20/2011	25	5.04	4.96	NC	NC	NC
	4/21/2011	35	7.55	4.64	NC	NC	NC
	4/26/2010	25	5.11	4.89	NC	NC	NC
	5/4/2010	35	8.29	4.22	NC	NC	91
	11/8/2010	25	5.23	4.78	NC	NC	NC
PW-8-39[4][9]	9/9/2010	2	16.69	0.12	NC	NC	NC
	11/8/2010	2	16.37	0.12	0.25	8.82E-05	NC
PW-8-68[3]	4/19/2010	15	1.66	9.04	NC	NC	NC
	4/20/2011	25	2.82	8.87	NC	NC	NC
	4/21/2011	35	4.19	8.35	NC	NC	NC
	4/26/2010	25	2.94	8.50	NC	NC	NC
	5/4/2010	35	4.22	8.29	NC	NC	40
	11/8/2010	25	3.12	8.01	NC	NC	NC
PW-9-92[3]	4/19/2010	15	6.85	2.19	NC	NC	NC
	4/20/2011	25	12.39	2.02	NC	NC	NC
	4/21/2011	35	18.61	1.88	NC	NC	NC
	4/26/2010	25	11.50	2.17	NC	NC	NC
	5/4/2010	35	17.57	1.99	NC	NC	11
	11/8/2010	25	11.58	2.16	NC	NC	NC
Variable Frequency Drive Tests[4]							
PW-7-93	4/5/2011	12[5]	NA	NA	NA	NA	NA
PW-8-68	4/5/2011	50[5]	NA	NA	NA	NA	NA
PW-9-92	4/5/2011	34[5]	NA	NA	NA	NA	NA

Table 3-2
Well and Aquifer Test Data

Test	Date	Pumping Rate GPM	Drawdown feet	Specific Capacity GPM/feet	Hydraulic Conductivity feet/day	Hydraulic Conductivity cm/second	Well Efficiency %
Slug Tests[6]							
MW-1-22	1/13/2011	NA	NA	NA	0.03	1.11E-05	NA
MW-2-32	1/13/2011	NA	NA	NA	0.43	1.51E-04	NA
MW-3-26	1/13/2011	NA	NA	NA	0.02	8.63E-06	NA
MW-19-22	1/13/2011	NA	NA	NA	0.99	3.48E-04	NA
MW-21-12	1/13/2011	NA	NA	NA	0.72	2.55E-04	NA
MW-23-27	1/13/2011	NA	NA	NA	0.09	3.25E-05	NA
OW-7-17	1/14/2011	NA	NA	NA	18.62	6.57E-03	NA
OW-8-15	1/14/2011	NA	NA	NA	0.59	2.08E-04	NA
OW-9-25	1/13/2011	NA	NA	NA	0.66	2.32E-04	NA
MW-1-55	1/13/2011	NA	NA	NA	16.37	5.77E-03	NA
MW-2-61	1/14/2011	NA	NA	NA	58.44	2.06E-02	NA
MW-3-56	1/13/2011	NA	NA	NA	6.71	2.37E-03	NA
MW-4-57	1/13/2011	NA	NA	NA	2.41	8.49E-04	NA
MW-5-32	1/13/2011	NA	NA	NA	0.72	2.52E-04	NA
MW-16-65	1/14/2011	NA	NA	NA	0.32	1.12E-04	NA
MW-24-70	1/13/2011	NA	NA	NA	3.01	1.06E-03	NA
OW-8-28	1/14/2011	NA	NA	NA	0.31	1.11E-04	NA
PZ1-20	1/13/2011	NA	NA	NA	0.28	9.98E-05	NA
PZ2-20	1/13/2011	NA	NA	NA	4.35	1.53E-03	NA
PZ4-12	1/13/2011	NA	NA	NA	4.06	1.43E-03	NA
PZ5-20	1/14/2011	NA	NA	NA	0.02	7.64E-06	NA
PW-1-80	1/20/2011	NA	NA	NA	6.02	2.12E-03	NA
PW-3-85	1/20/2011	NA	NA	NA	16.88	5.95E-03	NA
PW-8-39	1/20/2011	NA	NA	NA	1.10	3.89E-04	NA

Notes: [1]Data from Hahn and Associates, Aquifer Test Evaluation Report, February 2006.
[2]Data from S.S. Papadopulos & Associates, NW Natural Gasco, Pump Test Analysis and MODFLOW Model Summary, October 2007.
[3]Data from Anchor QEA, Segment 2 Capture Zone Field Test Report, March 2011.
[4]Data from Anchor QEA, Field Tests of the Programmable Logic Control and Variable Frequency Drive Well Pumps, Appendix A, May 2011.
[5] Average pumping rate during 72-hour test. Pumping rates varied constantly during test to maintain a constant gradient with the Willamette River.
[6] Data from Anchor QEA, Groundwater Source Control Final Design Report, Appendix C, May 2011.
[7] drawdown calculated by subtracting groundwater elevation at last low tide before pump test began from the groundwater elevation at the first low tide during the pump test.
[8] Wells PW-7-93, PW-8-68, and PW-9-92 achieved steady state water levels after 15 minutes of pumping. Drawdown calculated at this time to minimize tidal and river trend effects.
[9] PW-8-39 did not achieve steady-state water levels during pumping, so final drawdown value before pump shut off used for specific capacity calculations.
NC = Not Calculated
NA = Not Applicable
GPM = Gallons per minute

Table 3-3
Predicted Horizontal DNAPL Travel Distance due to Increased Gradient from Nearshore Groundwater Pumping

Groundwater Gradient Increase in Former Effluent Pond Area[1]	Velocity (feet/day)	Distance traveled (feet) over the following time periods			
		0.5 years	1 year	2 years	3 years
0.0063	0.0030	0.5	1.1	2.2	3.3
0.0141	0.0067	1.2	2.4	4.9	7.3

Notes:
1 - Gradients computed 50 ft and 90 ft upgradient from the location of the upper alluvium extraction well screen. Lower gradients are predicted upgradient from the lower alluvium extraction well.

Table 3-4a
Maximum Possible Sustained Pumping Rates at Seasonal Low Groundwater Elevations
Existing Extraction Wells

Well ID	Two-year Seasonal Range of Groundwater Elevation		Elevation of Pump Inlet	Available Drawdown to Pump Inlet at Seasonal Low Groundwater Elevation	Specific Capacity	Maximum Possible Pumping Rate at Seasonal Low Groundwater Elevation
	Low (Sept 2010)	High (June 2011)				
	feet COP	feet COP	feet COP	feet	GPM/feet drawdown	GPM
PW-3-85	5.12	19.24	-63.2	68.32	1.92[(1)]	131.17
PW-3-118	4.61	19.31	-95.9	100.51	6.07[(2)]	610.10
PW-7-93	4.19	19.18	-46.5	50.69	4.22[(3)]	213.91
PW-8-39	5.06	19.20	-10.3	15.37	0.12[(4)]	1.88
PW-8-68	4.15	20.64	-20.7	24.80	8.29[(3)]	205.59
PW-9-92	4.28	19.25	-37.0	41.28	1.99[(3)]	82.15

Notes: COP = City of Portland Vertical Datum
GPM = gallons per minute
[(1)] Specific Capacity calculated from pump test conducted on 7/18/2007 at a pumping rate of 40 GPM
[(2)] Specific Capacity calculated from pump test conducted on 7/18/2007 at a pumping rate of 50 GPM
[(3)] Specific Capacity calculated from pump test conducted on 5/4/2010 at a pumping rate of 35 GPM
[(4)] Specific Capacity calculated from pump test conducted on 9/9/2010 at a pumping rate of 2 GPM

Table 3-4b
Range of Possible Estimated Sustained Pumping Rates at Seasonal Low Groundwater Elevations
Proposed Upper Alluvium Extraction Wells

Upper Alluvium Extraction Well ID	Estimated Seasonal Low Groundwater Elevation[1]	Elevation of Pump Inlet[2]	Available Drawdown to Pump Inlet at Seasonal Low Groundwater Elevation	Maximum Possible Range of Sustained Pumping Rates at Seasonal Low Groundwater Elevation[3] GPM	
	feet (COP)	feet (COP)	feet	1.0 GPM/feet Specific Capacity	2.0 GPM/feet Specific Capacity
PW-1-U	5.5	-5.0	10.5	10.5	21.0
PW-2-U	5.5	-5.0	10.5	10.5	21.0
PW-3-U	2.5	-5.0	7.5	7.5	15.0
PW-4-U	3.5	-5.0	8.5	8.5	17.0
PW-5-U	4.0	-5.0	9.0	9.0	18.0
PW-6-U	5.0	-5.0	10.0	10.0	20.0
PW-11-U	5.0	-5.0	10.0	10.0	20.0
PW-12-U	3.0	-5.0	8.0	8.0	16.0
PW-13-U	3.5	-5.0	8.5	8.5	17.0
PW-14-U	5.0	-5.0	10.0	10.0	20.0

Notes: COP = City of Portland Vertical Datum
GPM = gallons per minute
[1] Estimated groundwater elevation determined from August 5, 2009 potentiometric surface at proposed location of extraction wells from geologic cross section A-A'
[2] Pump inlet assumed to be at the top of the screen
[3] Specific Capacities for each extraction well assumed to be between 1.0 and 2.0 GPM per foot of drawdown

Table 3-5
Source Control Performance Monitoring Plan

Well ID	Water-Bearing Zone	Data Collection Objectives	Monitoring Water Level Transducer	Controlling Water Level Transducer	Extraction Wells associated with each Control Well	Current Sampling	Source Control Sampling Program		
						Semi-Annual	Tiered[2]	Semi-Annual[1 3]	DNAPL Monitoring[5]
Existing Shoreline Monitoring Wells									
MW-1-22	Surficial Fill	A, F				X		X	
MW-1-55	Alluvial	B, F				X		X	
MW-1-82	Alluvial	C, F				X		X	
MW-2-32	Surficial Fill	A, F				X		X	
MW-2-61	Alluvial	B, F				X		X	
MW-2-104	Alluvial	C, F				X		X	
MW-3-26	Surficial Fill	A, F				X		X	X
MW-3-56	Alluvial	B, F				X		X	X
MW-4-35	Surficial Fill	A, F				X		X	X
MW-4-57	Alluvial	B	X			X		NS[4]	X
MW-4-101	Alluvial	C, F				X		X	X
MW-5-32	Alluvial	B, F	X			X		X	X
MW-5-100	Alluvial	B, F				X		X	X
MW-5-175	Alluvial	C, F	X			X		X	X
MW-16-45	Alluvial	B				NS		NS	X
MW-16-65	Alluvial	B, F				X		X	X
MW-17-79	Alluvial		X			X		NS[4]	
MW-18-30	Surficial Fill	A	X			NS		NS	X
MW-18-125	Alluvial	C, F				X		X	X
MW-18-180	Alluvial	D, F	X			X		X	X
MW-19-22	Surficial Fill	A, F	X			X		X	X
MW-19-125	Alluvial	C, F				X		X	X
MW-19-180	Alluvial	D, F	X			X		X	X
MW-20-120	Alluvial	C, F				X		X	X
MW-21-12	Surficial Fill	A, F				X		X	
MW-21-75	Alluvial	C		X	PW-8-68	X		NS[4]	
MW-21-115	Alluvial	C, F				X		X	
MW-21-165	Alluvial	D, F	X			X		X	
MW-22-80	Alluvial	C		X	PW-10-L	NS		NS[4]	
MW-23-27	Surficial Fill	A, F				NS		X	
MW-23-75	Alluvial	C		X	PW-9-92	NS		NS[4]	
MW-23-123	Alluvial	C, F				NS		X	
MW-24-70	Alluvial	B				NS		NS[4]	X
MW-24-130	Alluvial	C		X	PW-7-93	NS		NS[4]	X
PW-01-80	Alluvial	B				NS		NS	X
PW-3-85	Alluvial	B, F	X					X	X
Monitored Siltronics Wells									
WS-11-161	Alluvial	D, F	X			X		X	X
WS-12-125	Alluvial	D, F	X	X	PW-1-L	X		X	
WS-14-161	Alluvial	D, F	X			X		X	X
WS-21-112	Alluvial	C		X	PW-2-L	X		NS[4]	X
WS-26-86	Alluvial	B, F	X	X	PW-1-U	X		X	

Table 3-5
Source Control Performance Monitoring Plan

Well ID	Water-Bearing Zone	Data Collection Objectives	Monitoring Water Level Transducer	Controlling Water Level Transducer	Extraction Wells associated with each Control Well	Current Sampling	Source Control Sampling Program		
						Semi-Annual	Tiered[2]	Semi-Annual[1 3]	DNAPL Monitoring[5]
Proposed Monitoring Wells									
MW-21-U	Alluvial	B, F	X					X	
MW-22-U	Alluvial	B, F	X					X	
MW-23-U	Alluvial	B, F	X					X	
MW-25-L	Alluvial	C						NS[4]	
MW-26-U	Alluvial	B		X	PW-6-U			NS[4]	X
MW-27-U	Alluvial	B, F	X					X	X
MW-27-L	Alluvial	C		X	PW-6-L			NS[4]	X
MW-28-U	Alluvial	B, F	X					X	X
MW-28-L	Alluvial	C		X	PW-5-L			NS[4]	X
MW-29-U	Alluvial	B		X	PW-13-U			NS[4]	X
MW-30-U	Alluvial	B		X	PW-4-U			NS[4]	X
MW-31-U	Alluvial	B, F	X					X	X
MW-31-L	Alluvial	C		X	PW-4-L			NS[4]	X
MW-32-U	Alluvial	B		X	PW-12-U			NS[4]	X
MW-33-U	Alluvial	B		X	PW-3-U			NS[4]	X
MW-34-U	Alluvial	B, F	X					X	X
MW-34-L	Alluvial	C		X	PW-3-118			NS[4]	X
MW-35-U	Alluvial	B		X	PW-11-U			NS[4]	X
MW-36-U	Alluvial	B		X	PW-2-U			NS[4]	X
MW-37-U	Alluvial	B		X	PW-14-U			NS[4]	X
MW-38-U	Alluvial	B		X	PW-5-U			NS[4]	X
Existing Observation Well									
OW-7-17	Surficial Fill	A, F	X					X	
OW-8-15	Surficial Fill	A, F	X					X	
OW-8-28	Alluvial	B, F						X	
OW-9-25	Surficial Fill	A, F	X					X	
Proposed Observation Wells									
OW-1-F	Surficial Fill	A, F	X					X	
OW-2-F	Surficial Fill	A, F	X					X	X
OW-5-F	Surficial Fill	A, F	X					X	X
OW-10-F	Surficial Fill	A, F	X					X	
Existing Extraction Wells									
PW-3-118	Alluvial	C, F	X				X		X
PW-7-93	Alluvial	C, F	X				X		
PW-8-39	Alluvial	B, F	X				X		
PW-8-68	Alluvial	C, F	X				X		
PW-9-92	Alluvial	C, F					X		
Proposed Extraction Wells									
PW-1-U	Alluvial	B, F	X				X		
PW-1-L	Alluvial	C, F	X				X		
PW-2-U	Alluvial	B, F	X				X		X
PW-2-L	Alluvial	C, F	X				X		X
PW-3-U	Alluvial	B, F	X				X		X
PW-4-U	Alluvial	B, F	X				X		X
PW-4-L	Alluvial	C, F	X				X		X
PW-5-U	Alluvial	B, F	X				X		X
PW-5-L	Alluvial	C, F	X				X		X
PW-6-U	Alluvial	B, F	X				X		X
PW-6-L	Alluvial	C, F	X				X		X
PW-10-L	Alluvial	C, F	X				X		
PW-11-U	Alluvial	B, F	X				X		X
PW-12-U	Alluvial	B, F	X				X		X
PW-13-U	Alluvial	B, F	X				X		X
PW-14-U	Alluvial	B, F	X				X		X

Table 3-5
Source Control Performance Monitoring Plan

Well ID	Water-Bearing Zone	Data Collection Objectives	Monitoring Water Level Transducer	Controlling Water Level Transducer	Extraction Wells associated with each Control Well	Current Sampling	Source Control Sampling Program		
						Semi-Annual	Tiered[2]	Semi-Annual[1 3]	DNAPL Monitoring[5]
Existing Piezometers									
PZ1-5	Surficial Fill	A,E	X			NS		NS	
PZ1-20	Alluvial	B,E	X			NS		NS	
PZ1-50	Alluvial	C,E	X			NS		NS	
PZ2-5	Surficial Fill	A,E	X			NS		NS	
PZ2-20	Alluvial	B,E	X			NS		NS	
PZ2-43	Alluvial	C,E	X			NS		NS	
PZ2-77	Alluvial	C,E	X			NS		NS	
PZ4-12	Alluvial	A,E	X			NS		NS	
PZ4-41	Alluvial	B,E	X			NS		NS	
PZ5-5	Surficial Fill	A,E,F	X			NS		X	
PZ5-20	Alluvial	B,E,F	X			NS		X	
PZ5-55	Alluvial	C,E,F	X			NS		X	
PZ5-85	Alluvial	C,E,F	X			NS		X	
Proposed Piezometers									
PZ6-5	Surficial Fill	A,E,F	X					X	X
PZ6-50	Alluvial	B,E,F	X					X	X
PZ6-115	Alluvial	C,E,F	X					X	X
PZ6-150	Alluvial	D,E,F	X					X	X
PZ7-5	Surficial Fill	A,E,F	X					X	X
PZ7-50	Alluvial	B,E,F	X					X	X
PZ7-150	Alluvial	D,E,F	X					X	X
PZ8-5	Surficial Fill	A,E,F	X					X	
PZ8-50	Alluvial	B,E,F	X					X	
PZ9-5	Surficial Fill	A,E,F	X					X	X
PZ9-50	Alluvial	B,E,F	X					X	X
PZ9-75	Alluvial	C,E,F	X					X	X
PZ9-150	Alluvial	D,E,F	X					X	X

Notes:
NS = Not Sampled

[1] During the first year of operation the two semi-annual sampling events will occur in the first six months.

[2] Tiered Monitoring Program entails monthly sampling for the first year, followed by quarterly sampling for Year 2; semi-annual sampling for Year 3, 4, and 5; and then annual sampling thereafter.

[3] Newly constructed wells , with the exception of control wells, will be sampled for four consecutive quarters, including the semi-annual sampling events

[4] Control wells cannot be sampled without disruption to the pumping of the associated pumping well it controls. Newly installed wells will be initially sampled following well installation and development.

[5] Wells will be gauged for DNAPL daily at startup of Segment 1 pumping for 1 week; weekly for the next 3 weeks; every other week for the remainder of the first quarter; monthly until the completion of 1 year; then following the monitoring program discussed above.

A - used to monitor groundwater elevation and evaluate extent of groundwater capture in the surficial fill

B - used to monitor groundwater elevation and evaluate extent of groundwater capture in the upper alluvium

C - used to monitor groundwater elevation and evaluate extent of groundwater capture in the lower alluvium

D - used to monitor groundwater elevation and evaluate extent of groundwater capture in the lower alluvium below the aquitard

E - shoreline and/or offshore piezometer to monitor groundwater elevation and extent of groundwater capture in nearshore river sediments

F - will be used to monitor changes in groundwater quality parameters and chemistry over time during HC&C system operation

Table 4-1
Permit Information

	Trigger	Jurisdiction	Review Time	Submitted?	Fee (estimate)
Greenway Letter of Determination	Work within Greenway Setback; however, formal permitting is not required for cleanup projects	City of Portland	Minimum of 4 weeks from receipt of complete application	Received determination for borings and access road development (Phase I). Need determination for remaining work (Phase II)	~$7000
1200-C	Disturbance of more than 1 acre of land and potential for stormwater to enter surface waters	State of Oregon, City of Portland	~60 days; 90 days if more than 5 acres are involved, as this triggers public review		$1,510 for year 1, $765 for each additional year permit is active
Removal/Fill Permit or General Authorization for Minimal Disturbance to EFH	Installation or placement of material (outfall pipe) below OHW of Willamette River	Oregon Department of State Lands	60 to 90 days	No	$250
Nationwide Permit #7	Installation of outfall pipe/structure where effluent is (conditionally) authorized under NPDES	Federal; Rivers and Harbors Act Section 10/CWA 404 USACE	90 to 120 days	No	None

Notes:
CWA = Clean Water Act
EFH = Essential Fish Habitat
NPDES = National Pollutant Discharge Elimination System
OHW = ordinary high water
USACE = U.S. Army Corps of Engineers

FIGURES

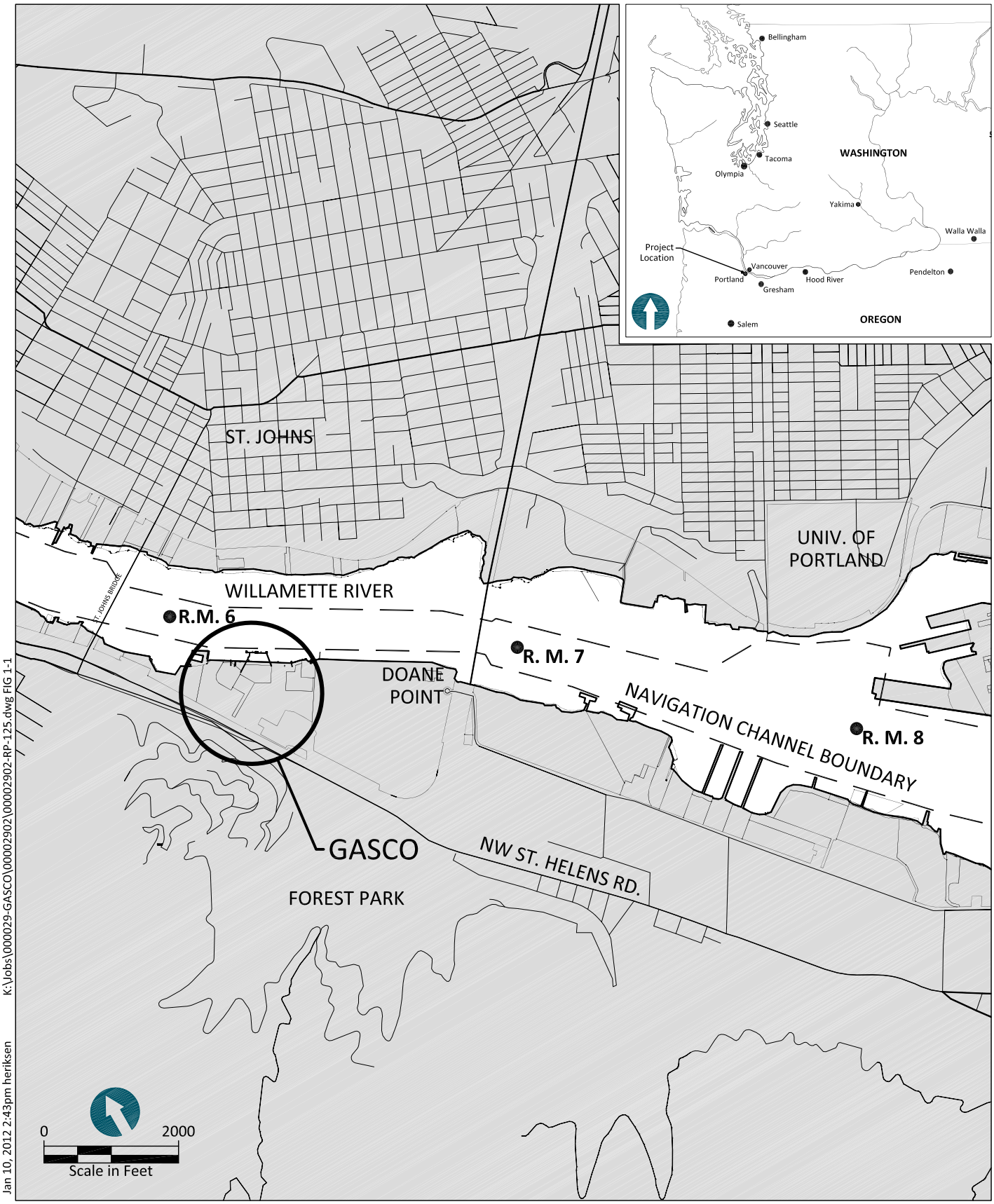

Figure 1-1
Site Vicinity Map
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

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Horizontal Datum: NAD83 HARN Oregon State Plane North International Feet
Vertical Datum of river bathymetry: NAVD88
Vertical Datum of upland topography: City of Portland

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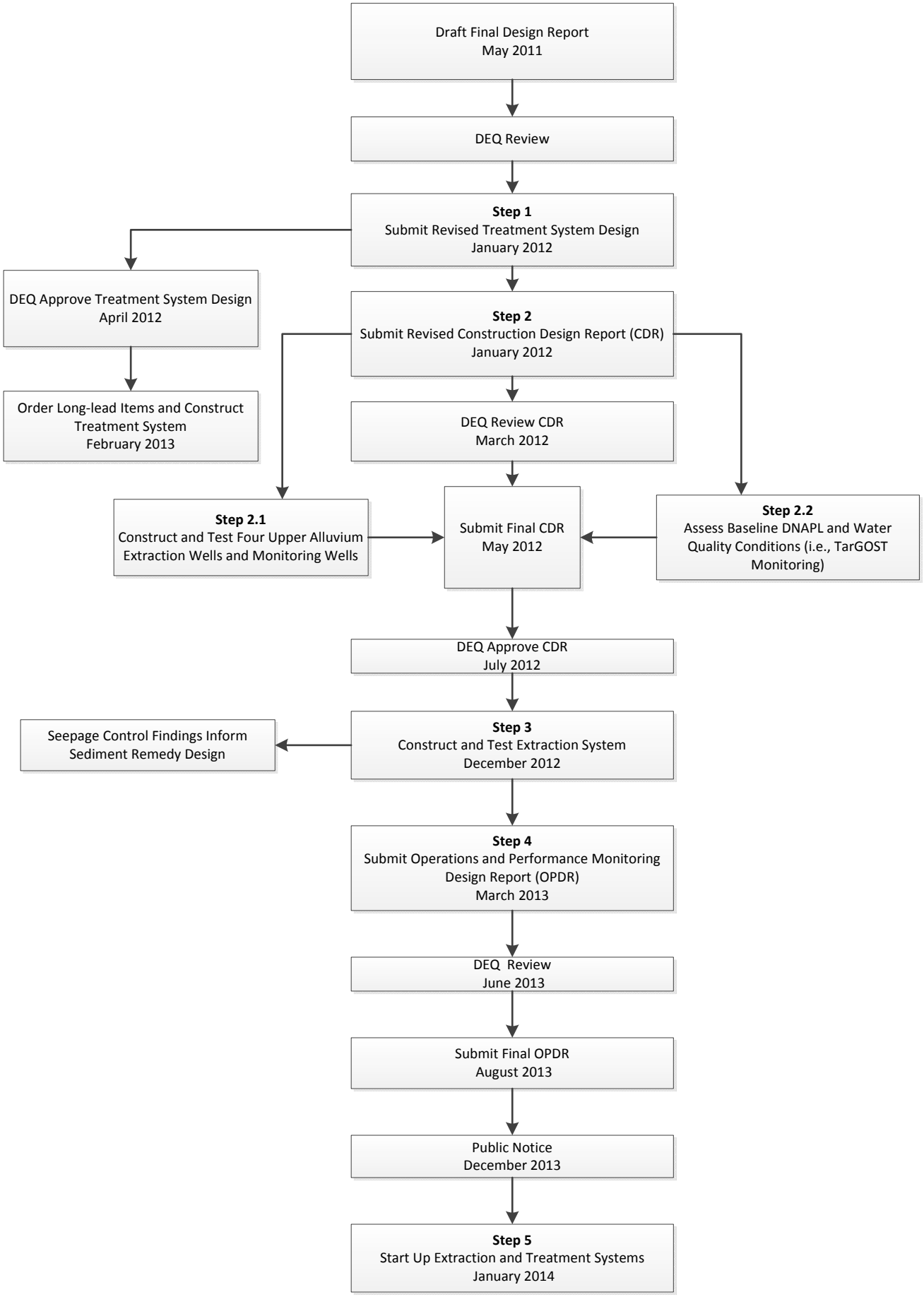
Feet
0 70 140 210 280

Figure 1-2
General Site Map
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

Figure 1-3
Groundwater Source Control Design and Construction Process
NW Natural, Gasco Site



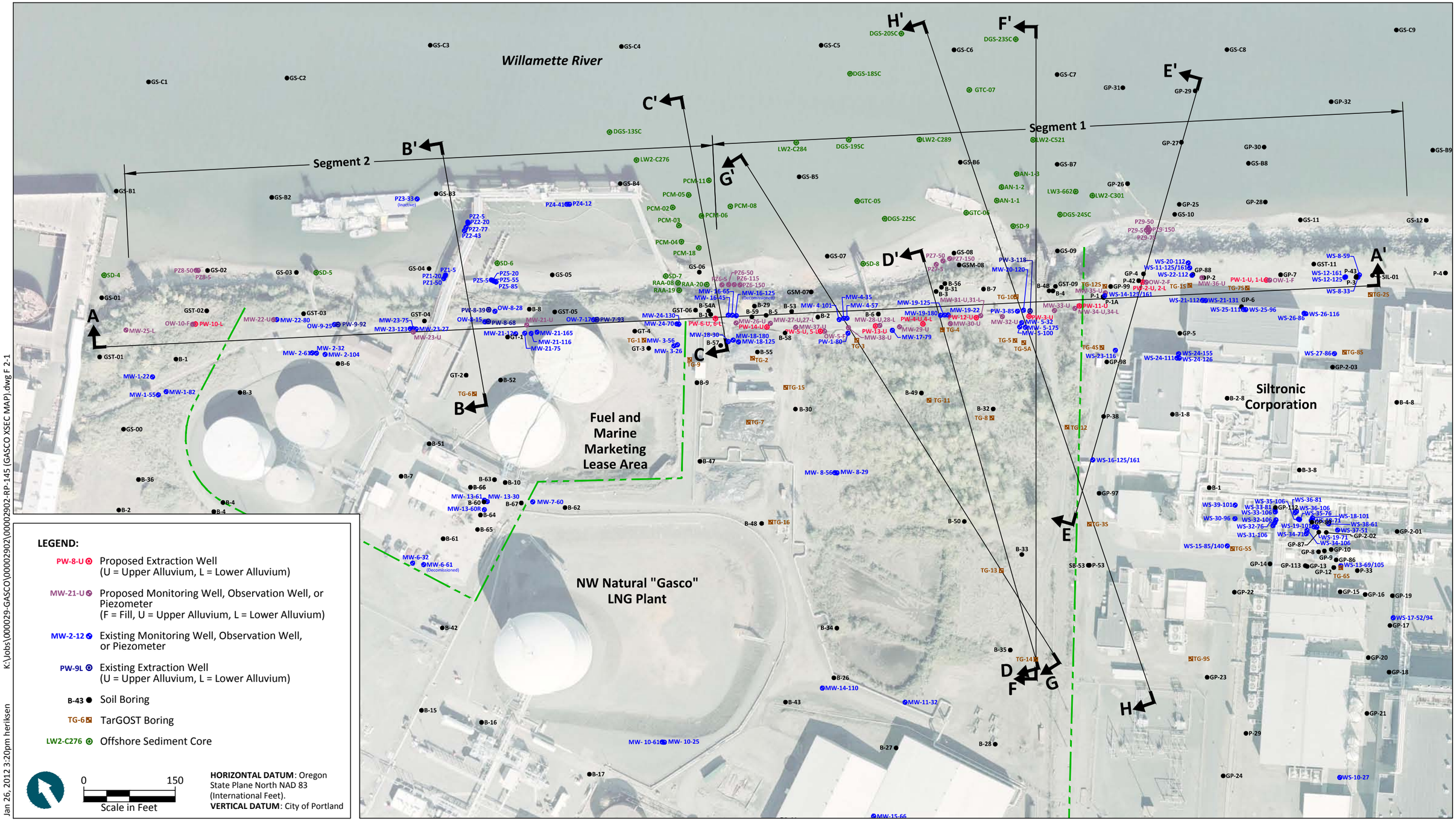


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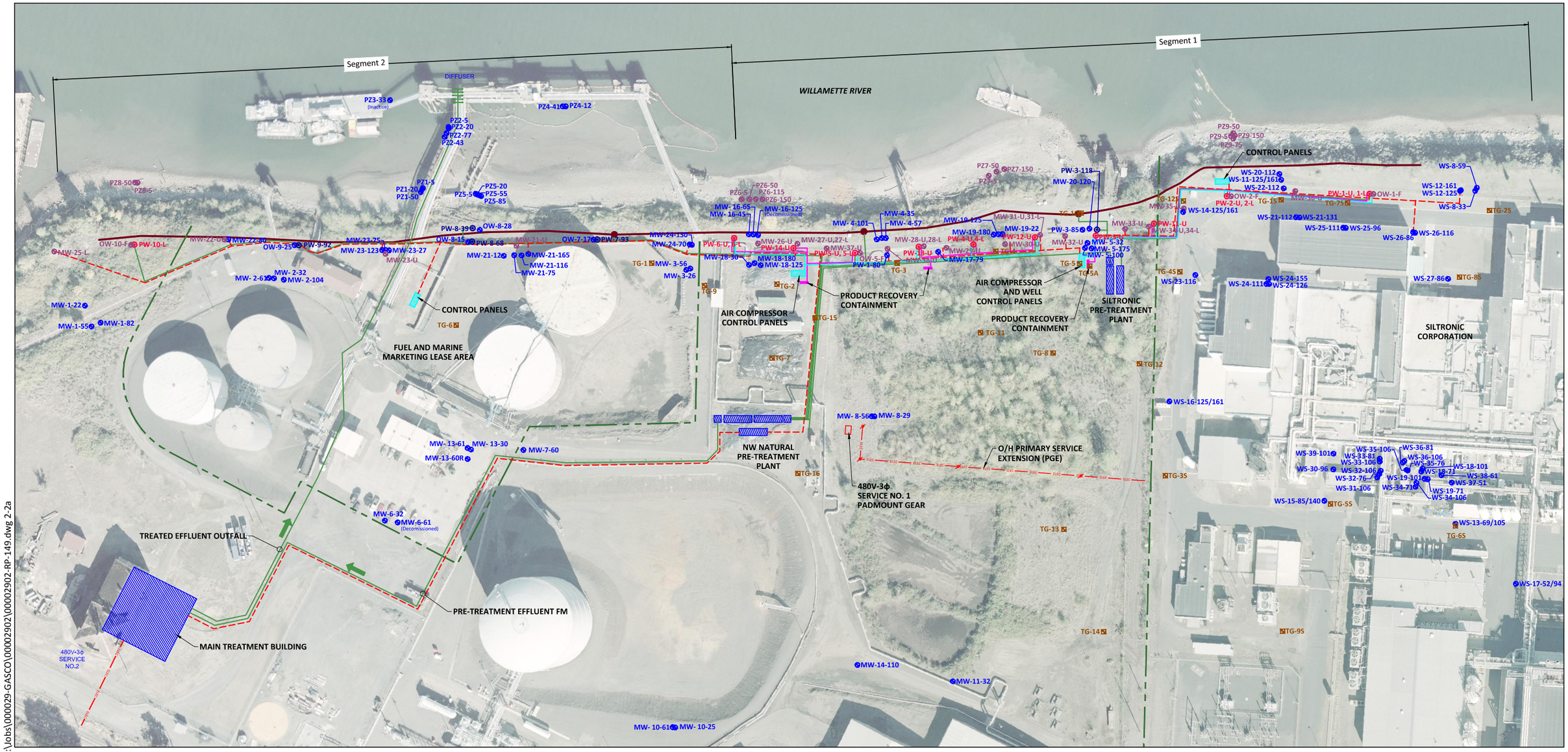
Figure 2-1
Monitoring Well and Cross Section Location Map
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



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LEGEND:

- PW-10L — Proposed Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- MW-21U — Proposed Monitoring Well, Observation Well, or Piezometer (F = Fill, U = Upper Alluvium, L = Lower Alluvium)
- MW-2-32 — Existing Monitoring Well, Observation Well, or Piezometer
- PW-8-39 — Existing Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- TG-6 — TarGOST Boring
- Fill WBZ Trench Alignment with Sump
- Source Control Main Pipeline Route
- Source Control Level Data Route
- Source Control Product Recovery Line
- Source Control Airline

0 140
Scale in Feet

HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland
NOTE: Drawing prepared from CAD file provided by Advanced Remediation Technologies Co, dated January 5, 2012.

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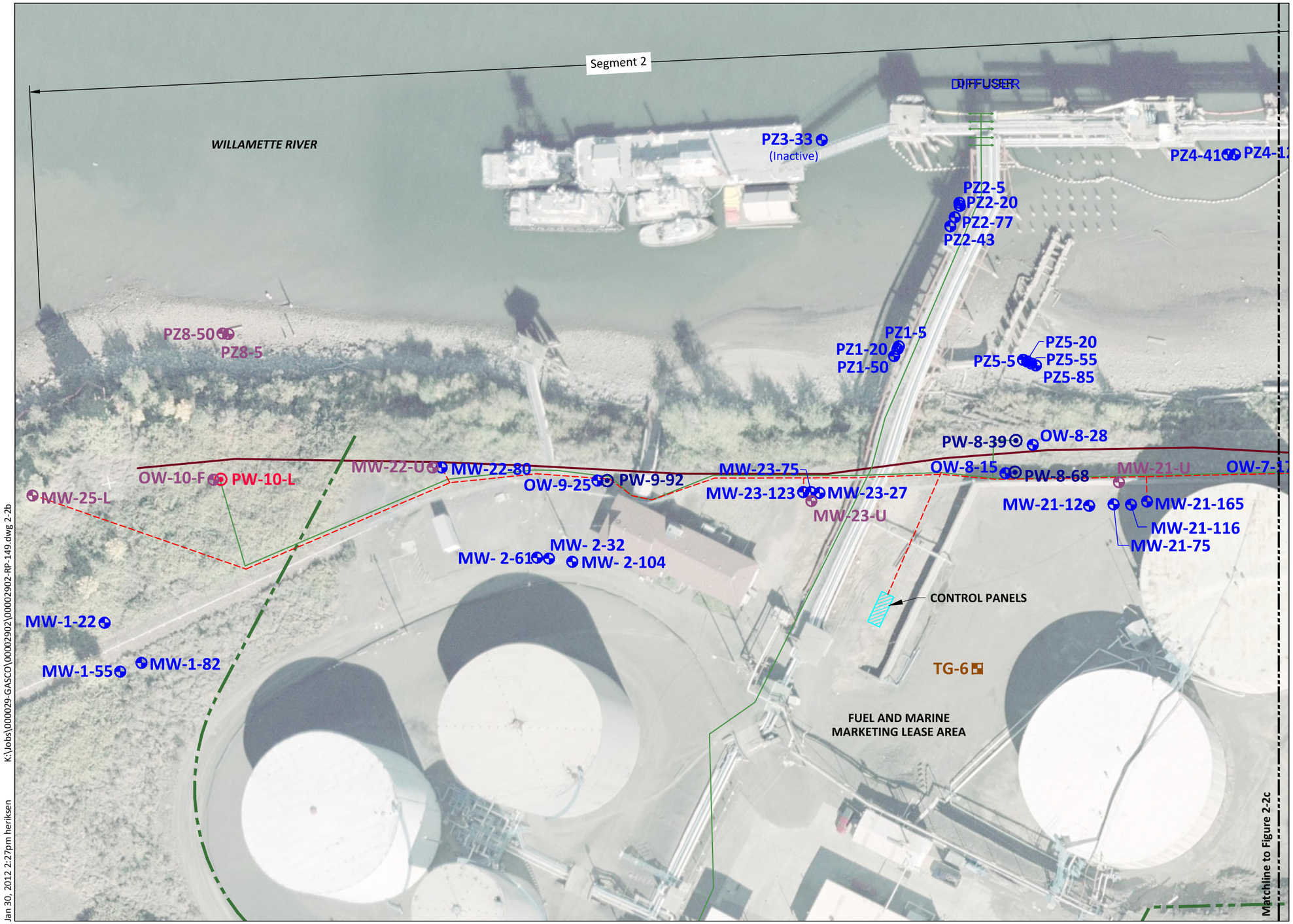
Figure 2-2a
Map of Groundwater Extraction and Treatment System
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

PW-10L	Proposed Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
MW-21U	Proposed Monitoring Well, Observation Well, or Piezometer (F = Fill, U = Upper Alluvium, L = Lower Alluvium)
MW-2-32	Existing Monitoring Well, Observation Well, or Piezometer
PW-8-39	Existing Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
TG-6	TarGOST Boring
	Fill WBZ Trench Alignment with Sump
	Source Control Main Pipeline Route
	Source Control Level Data Route
	Source Control Product Recovery Line
	Source Control Airline

0 60
Scale in Feet

HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland
NOTE: Drawing prepared from CAD file provided by Advanced Remediation Technologies Co, dated January 5, 2012.

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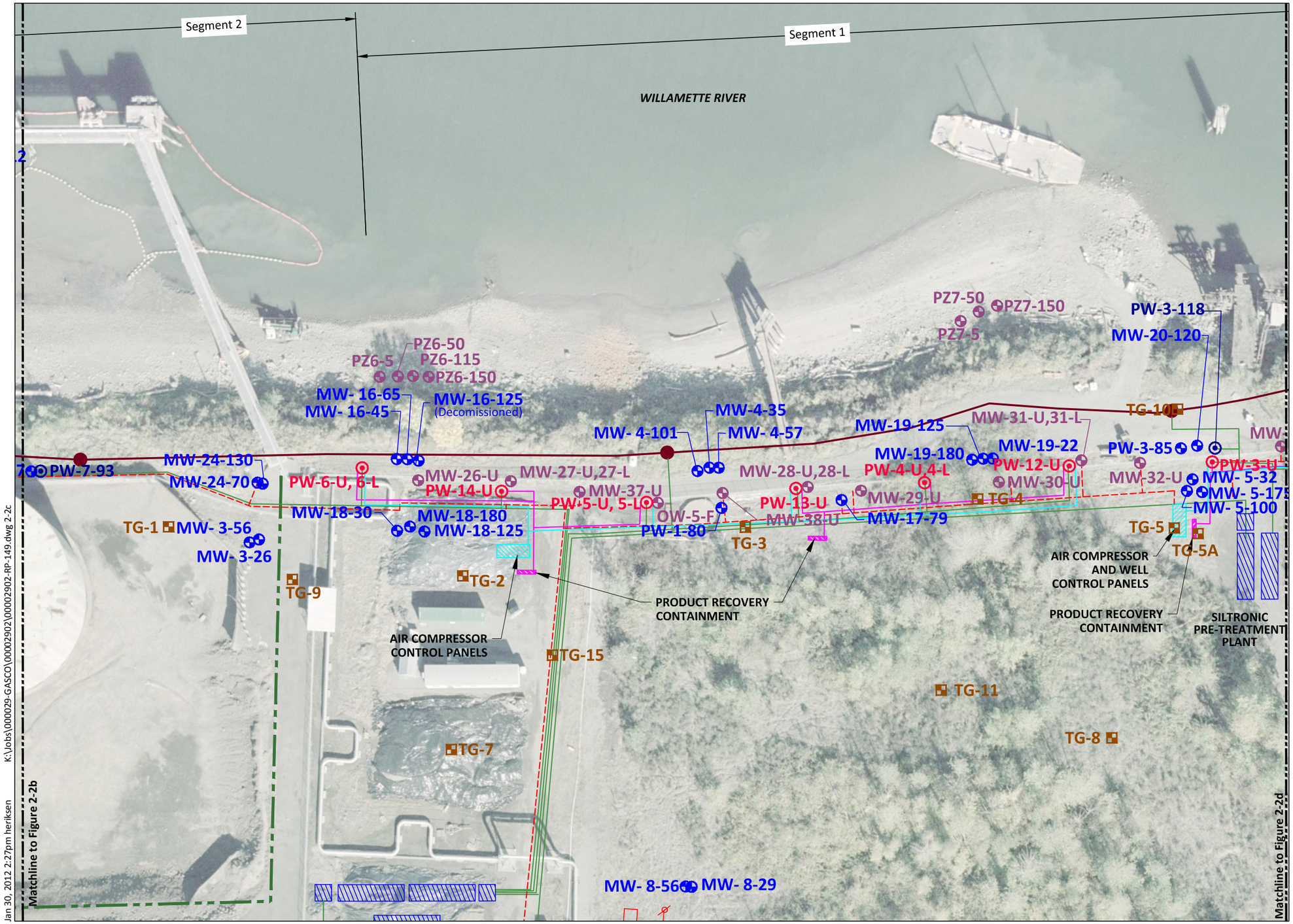
Figure 2-2b
Map of Groundwater Extraction and Treatment System
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- **PW-8U** Proposed Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- **MW-21U** Proposed Monitoring Well, Observation Well, or Piezometer (F = Fill, U = Upper Alluvium, L = Lower Alluvium)
- **MW-2-12** Existing Monitoring Well, Observation Well, or Piezometer
- **PW-9L** Existing Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- **TG-4** TarGOST Boring
- Fill WBZ Trench Alignment with Sump
- Source Control Main Pipeline Route
- Source Control Level Data Route
- Source Control Product Recovery Line
- Source Control Airline

0 60
Scale in Feet

HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland
NOTE: Drawing prepared from CAD file provided by Advanced Remediation Technologies Co, dated January 5, 2012.

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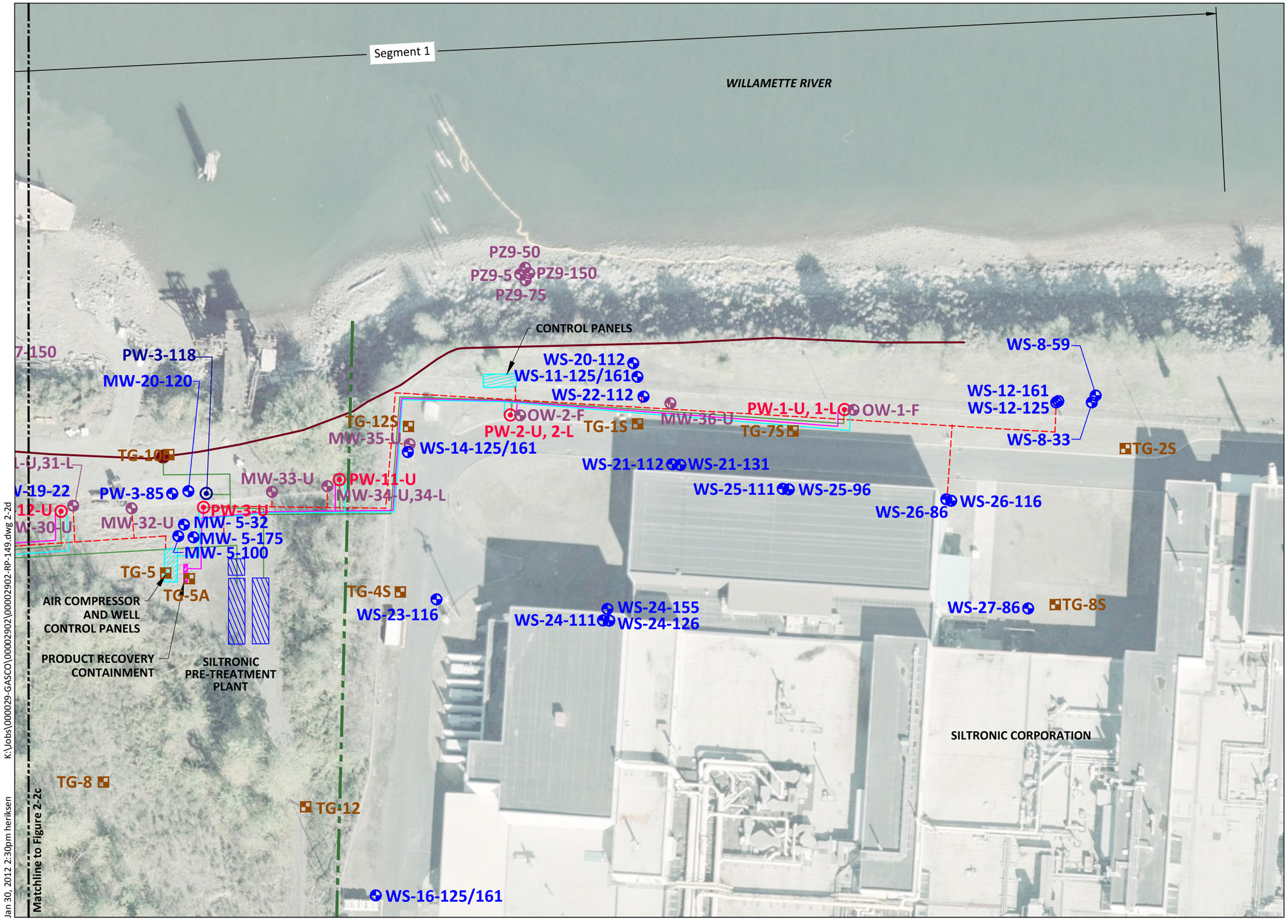
Figure 2-2c
Map of Groundwater Extraction and Treatment System
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

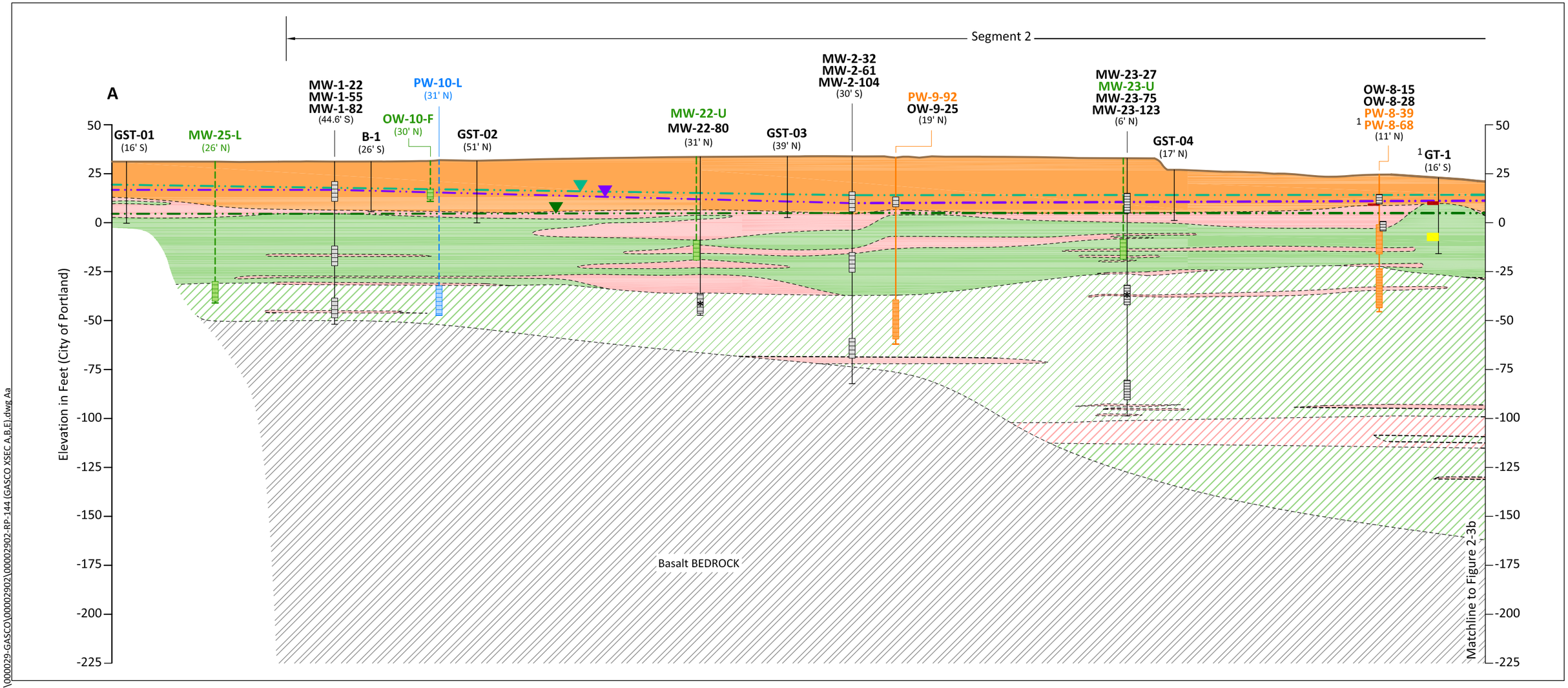
- PW-8U — Proposed Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- MW-21U — Proposed Monitoring Well, Observation Well, or Piezometer (F = Fill, U = Upper Alluvium, L = Lower Alluvium)
- MW-2-12 — Existing Monitoring Well, Observation Well, or Piezometer
- PW-9L — Existing Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- TG-4 — TarGOST Boring
- Fill WBZ Trench Alignment with Sump
- Source Control Main Pipeline Route
- Source Control Level Data Route
- Source Control Product Recovery Line
- Source Control Airline

0 60
Scale in Feet

HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland
NOTE: Drawing prepared from CAD file provided by Advanced Remediation Technologies Co, dated January 5, 2012.

ANCHOR QEA

Figure 2-2d
Map of Groundwater Extraction and Treatment System
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)
- Existing Ground Surface

MW-21-16 — Boring ID
(57' E) — Offset Distance in Feet

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

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen
- * — Control Well

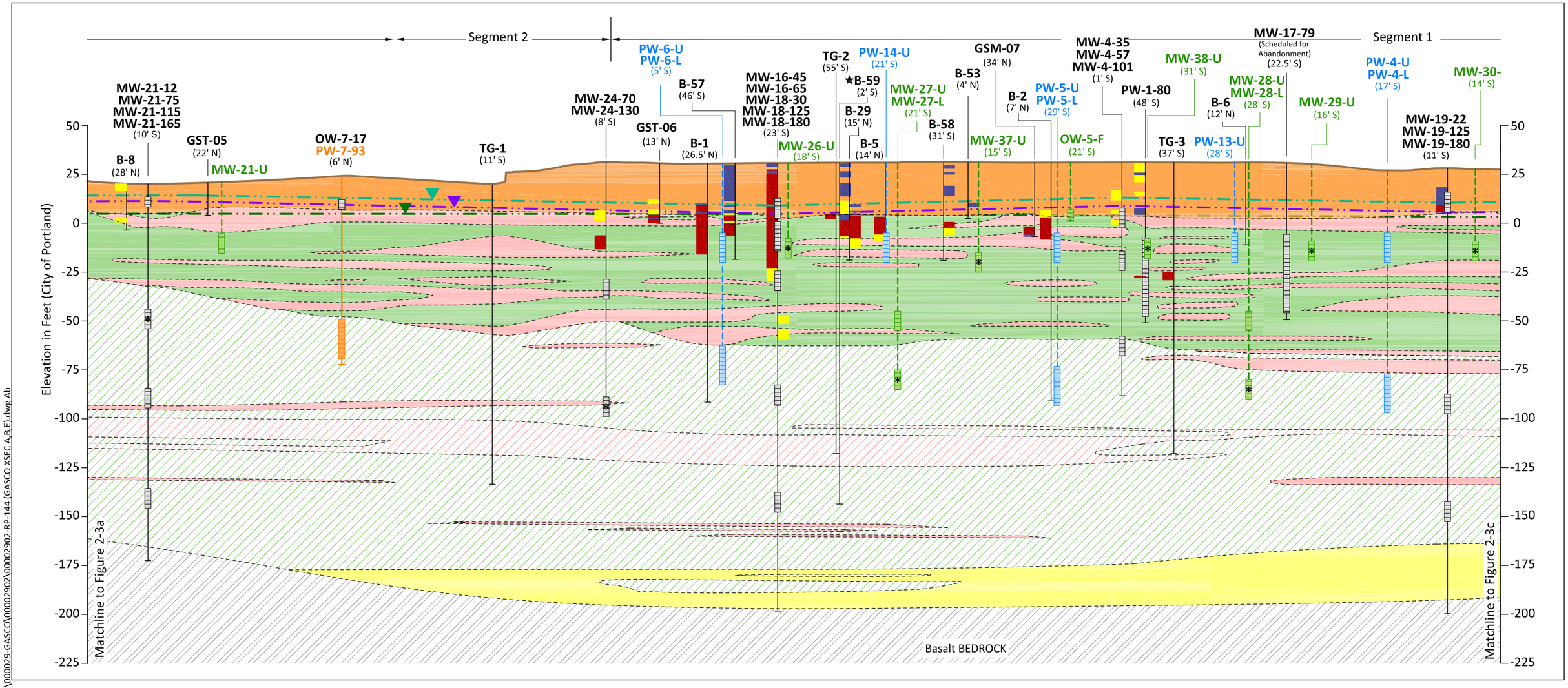
0 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.
[1] Based on visual observations and analytical testing conducted by Hahn and Associates (Remedial Investigation Report, Hahn and Associates, April 2007), the oil and sheen detected in the fill unit does not appear to be MGP-related, but appears to be associated with petroleum products stored in the FAMM storage tanks.

K:\Jobs\000029-GASCO\00002902\00002902-RP-144 (GASCO XSEC A,B,E).dwg Aa
Jan 26, 2012 2:31pm heriksen

ANCHOR QEA

Figure 2-3a
Geologic Cross Section A-A'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



K:\Jobs\000029-GASCO\00002902\00002902-RP-144 (GASCO XSEC A,B,E).dwg Ab

Jan 27, 2012 8:42am heriksen

LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)
- Existing Ground Surface

MW-21-16 — Boring ID
(57' E) — Offset Distance in Feet

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

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen
- * — Control Well

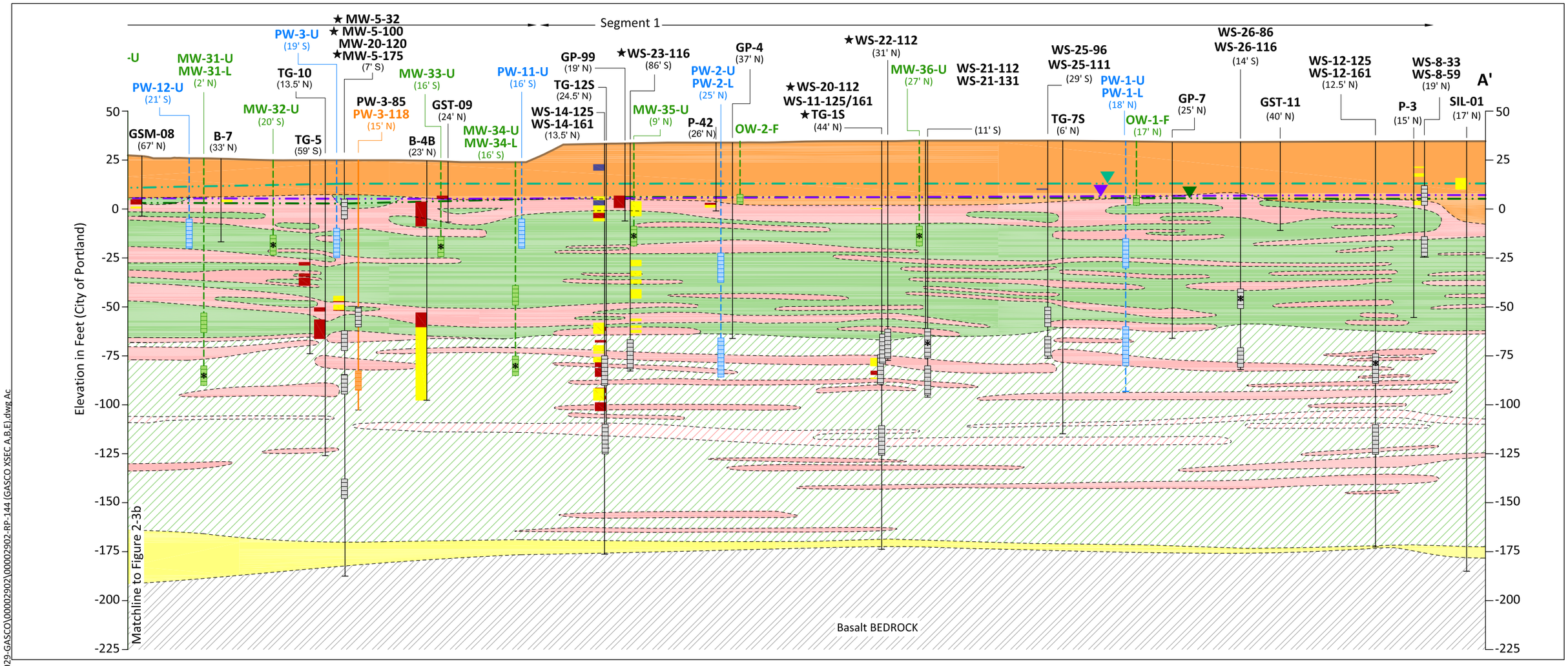
0 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.

★ Not used for geologic interpretation.

ANCHOR QEA

Figure 2-3b
Geologic Cross Section A-A'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)
- Existing Ground Surface

MW-21-16 — Boring ID
(57' E) — Offset Distance in Feet

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

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen
- * — Control Well

0 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.

★ Not used for geologic interpretation.

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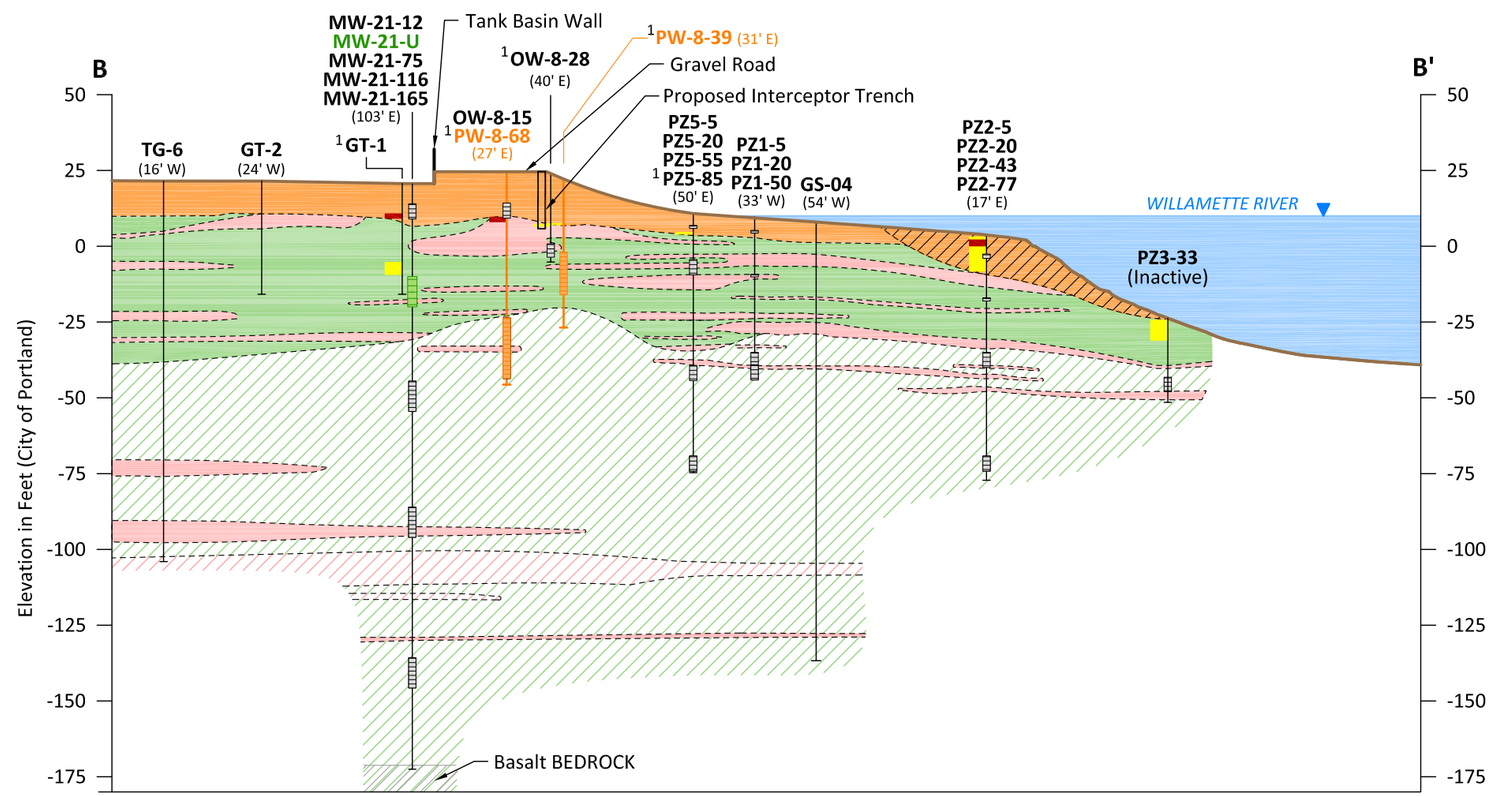
Jan 27, 2012 8:58am heriksen

ANCHOR QEA

Figure 2-3c
Geologic Cross Section A-A'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- SAND and SILT mixed with wood chips and anthropogenic material (wood, metal, cardboard)
- Basalt BEDROCK
- Existing Ground Surface
- Approximate Willamette River Elevation

TG-6 (16' W) — Boring ID — Offset Distance in Feet

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

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

0 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.
[1] Based on visual observations and analytical testing conducted by Hahn and Associates (Remedial Investigation Report, Hahn and Associates, April 2007), the oil and sheen detected in the fill unit does not appear to be MGP-related, but appears to be associated with petroleum products stored in the FAMM storage tanks.

Jan 26, 2012 2:36pm heriksen K:\Jobs\000029-GASCO\00002902\00002902-RP-144 (GASCO XSEC A,B,E).dwg B

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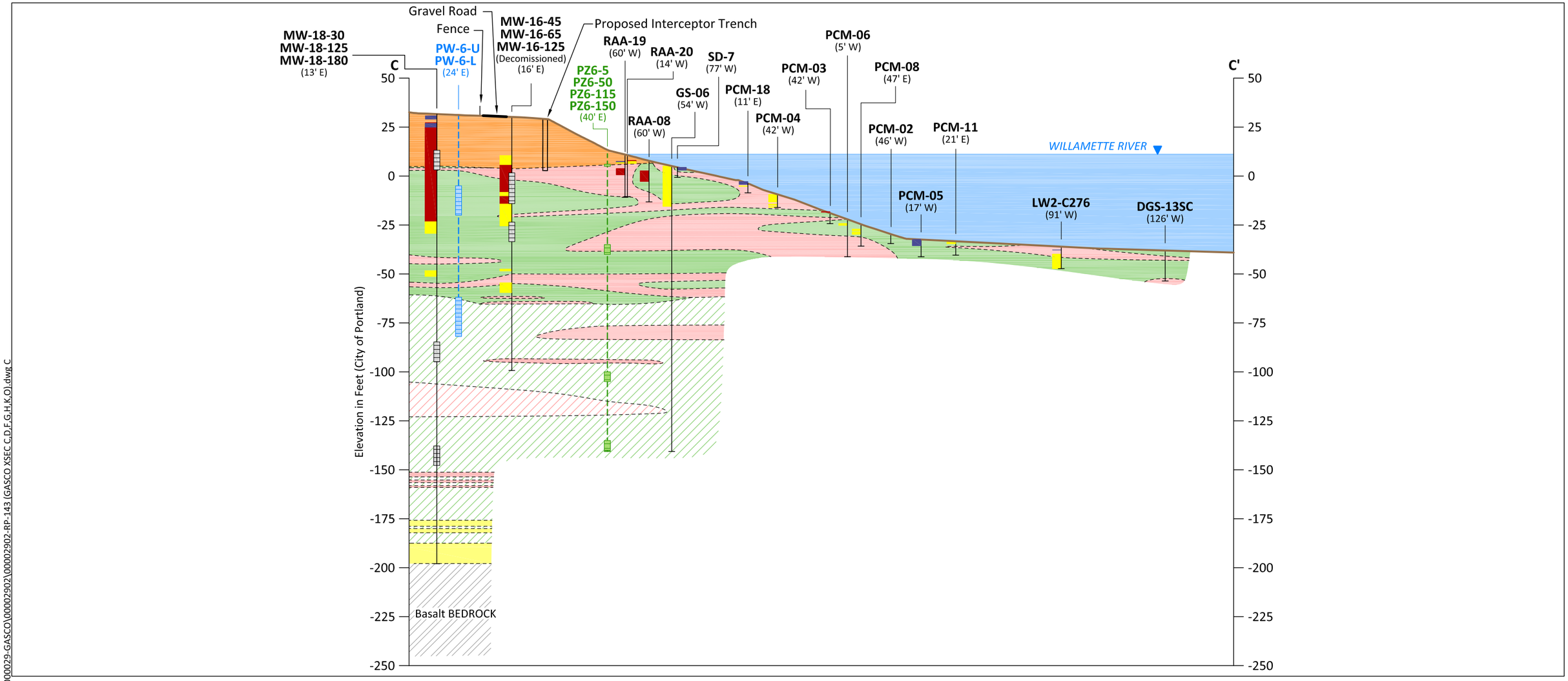
Figure 2-4
Geologic Cross Section B-B'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

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

GS-06 — Boring ID
(54' W) — Offset Distance in Feet

Soil Boring or Sediment Core
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

0 50
Scale in Feet

NOTES:
1. Geologic contacts are inferred between borings.
2. Tar interval in SD-7 is approximately 3 feet higher in elevation than shown on cross section.

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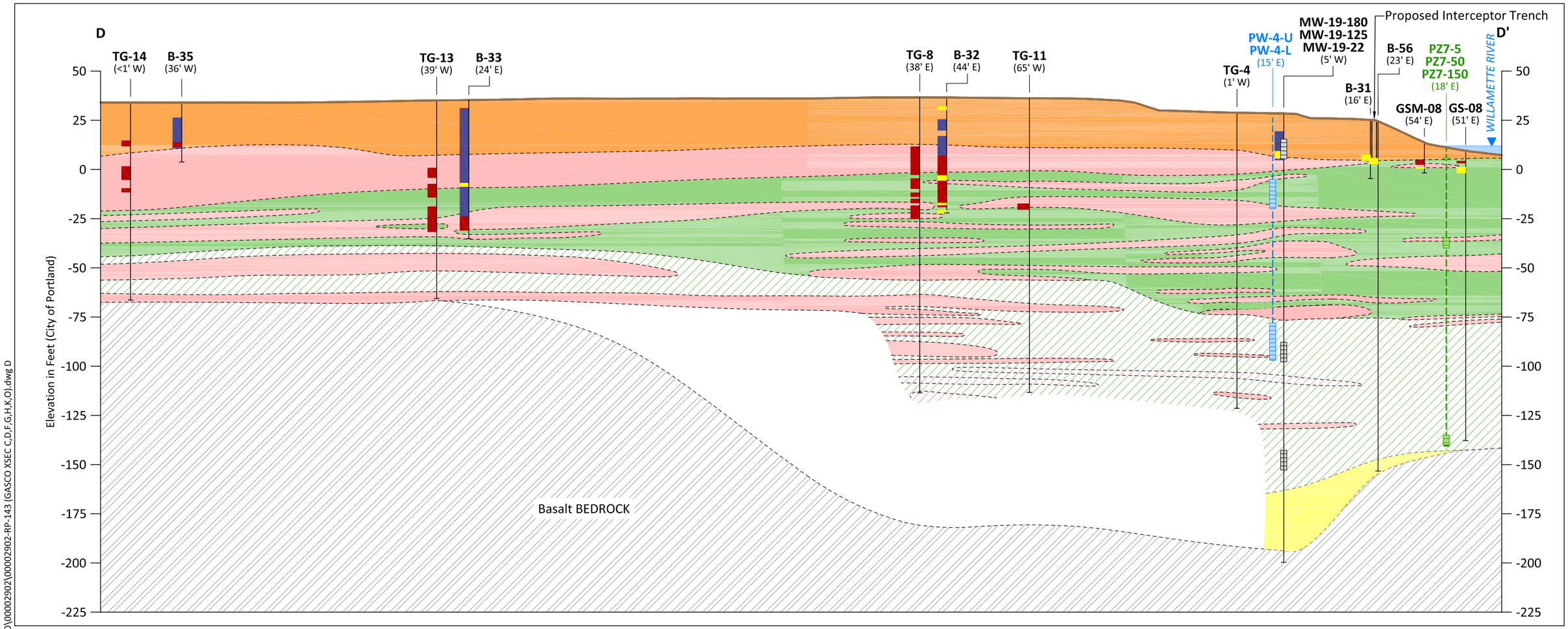
Jan 27, 2012 9:35am heriksen

ANCHOR QEA

Figure 2-5
Geologic Cross Section C-C'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface

TG-8 — Boring ID
(38' E) — Offset Distance in Feet

Soil Boring or Sediment Core
Proposed Well or Piezometer
Proposed Extraction Well
Existing Well or Piezometer

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

0 — 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.

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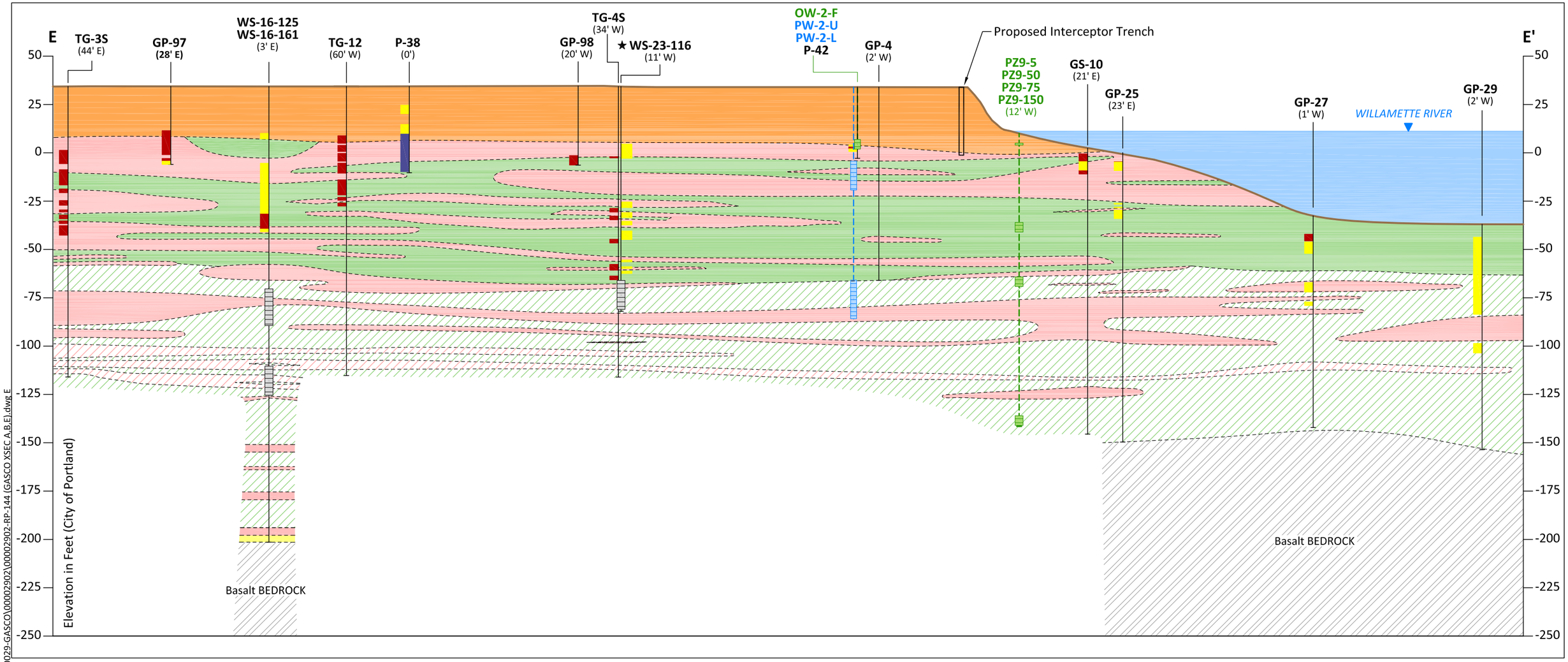
Figure 2-6
Geologic Cross Section D-D'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

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

TG-6 — Boring ID
(16' W) — Offset Distance in Feet

Soil Boring or Sediment Core
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

0 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.

★ Not used for geologic interpretation.

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Jan 27, 2012 9:39am heriksen

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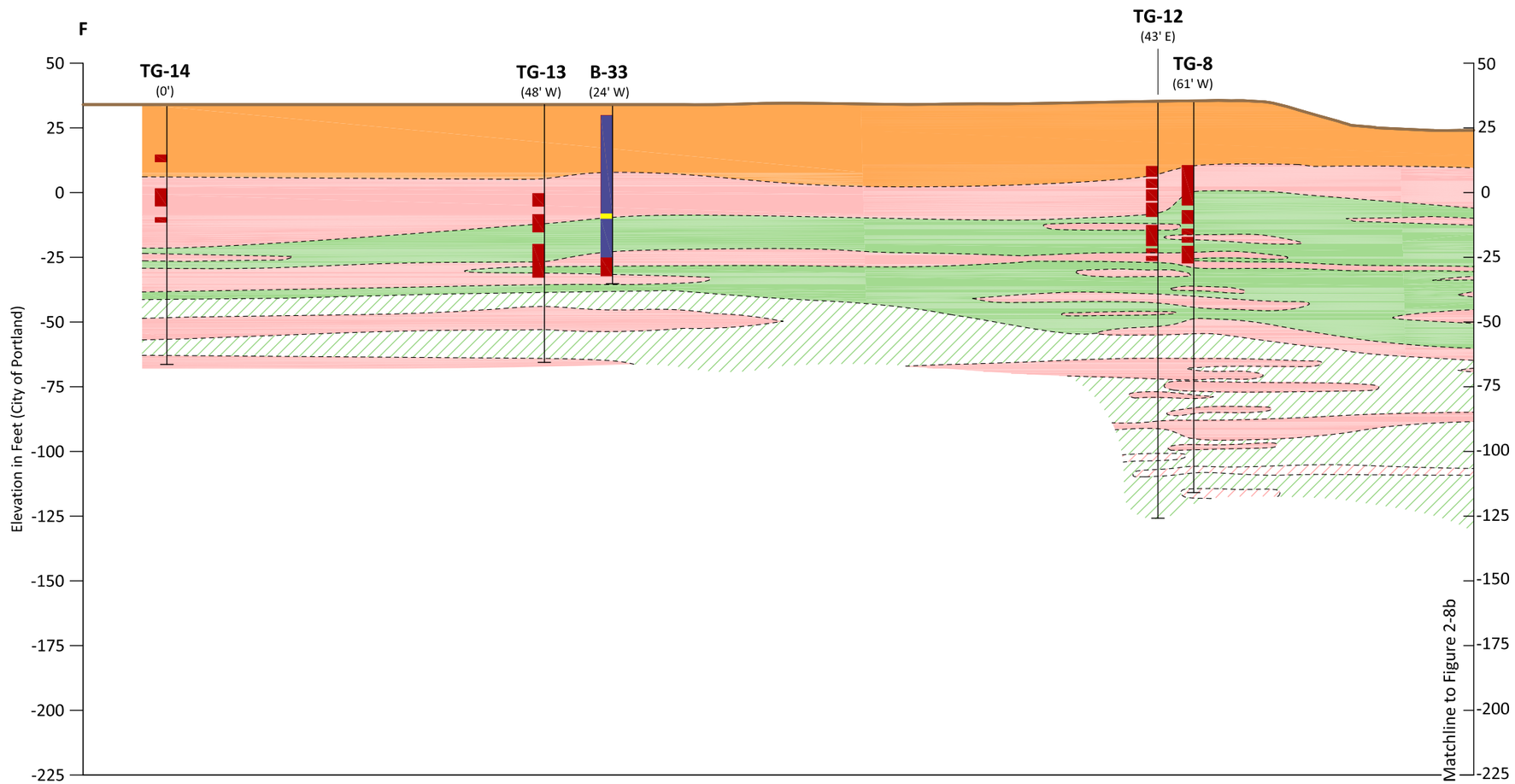
Figure 2-7
Geologic Cross Section E-E'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

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

GS-06 — Boring ID
(54' W) — Offset Distance in Feet

Soil Boring or Sediment Core
Existing Extraction Well
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

0 50
Scale in Feet

NOTES:
1. Geologic contacts are inferred between borings.
2. PW-3-85 was initially intended as an extraction well, but it has been replaced by PW-3U.

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Jan 26, 2012 2:20pm heriksen

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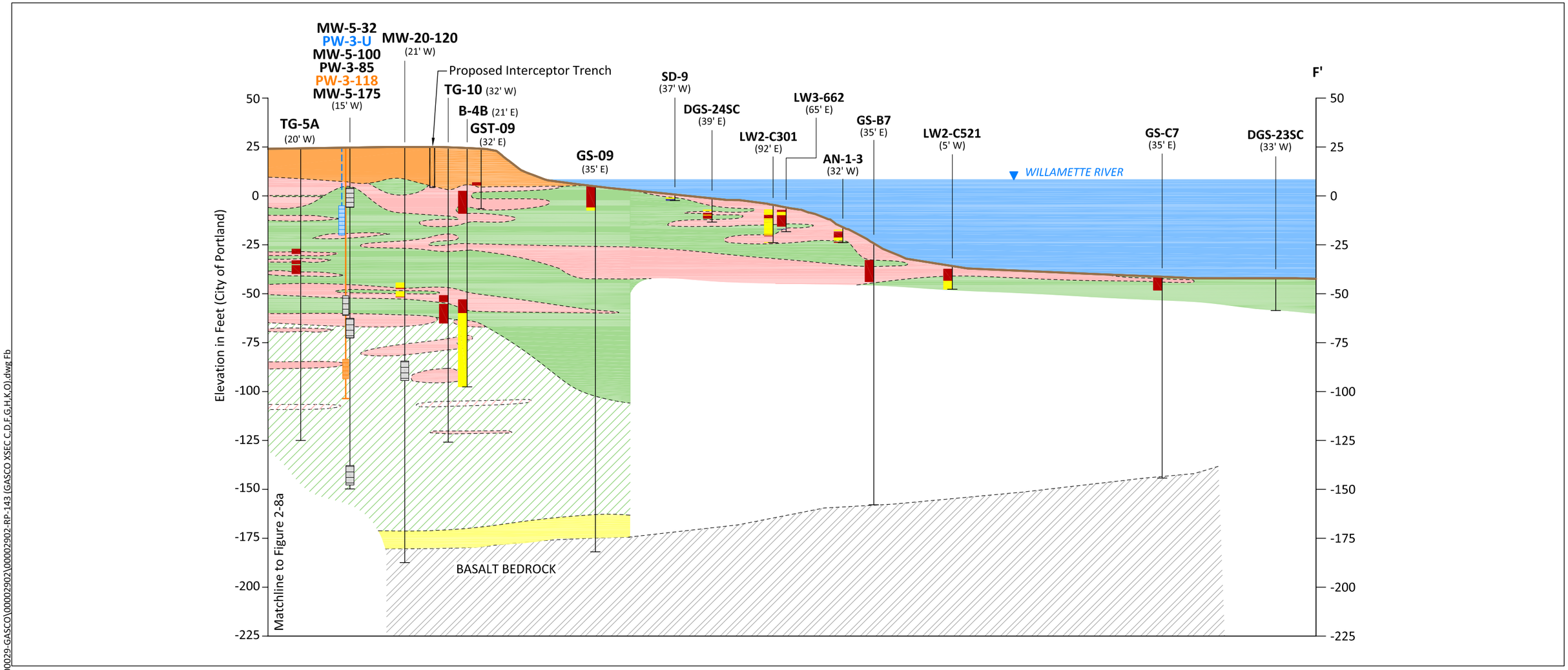
Figure 2-8a
Geologic Cross Section F-F'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

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

GS-06 — Boring ID
(54' W) — Offset Distance in Feet

Soil Boring or Sediment Core
Existing Extraction Well
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

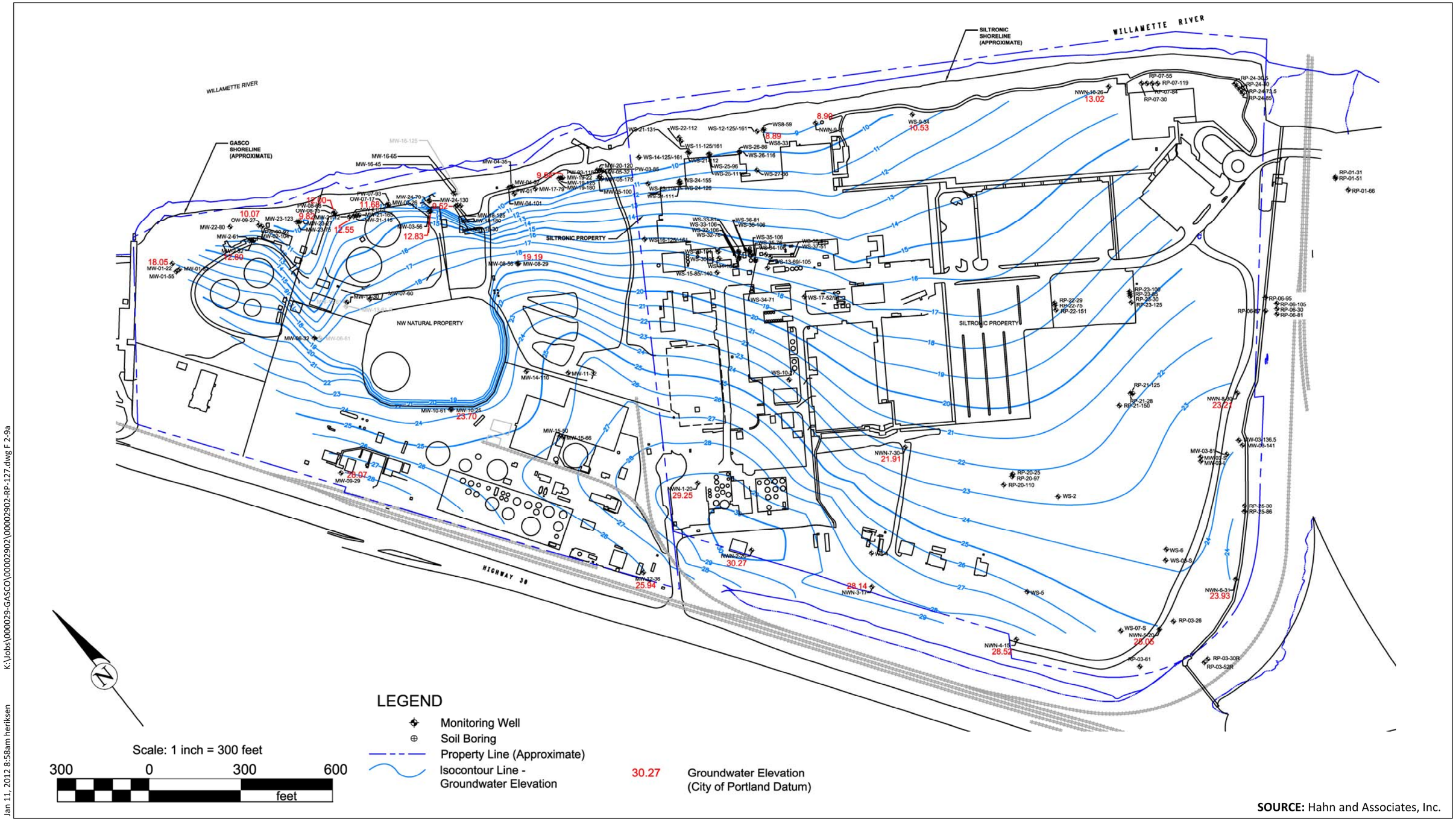
0 50
Scale in Feet

NOTES:
1. Geologic contacts are inferred between borings.
2. PW-3-85 was initially intended as an extraction well, but it has been replaced by PW-3U.

K:\Jobs\000029-GASCO\00002902\00002902-RP-143 (GASCO XSEC C,D,F,G,H,K,O).dwg Fb
Jan 27, 2012 10:25am heriksen

ANCHOR QEA

Figure 2-8b
Geologic Cross Section F-F'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

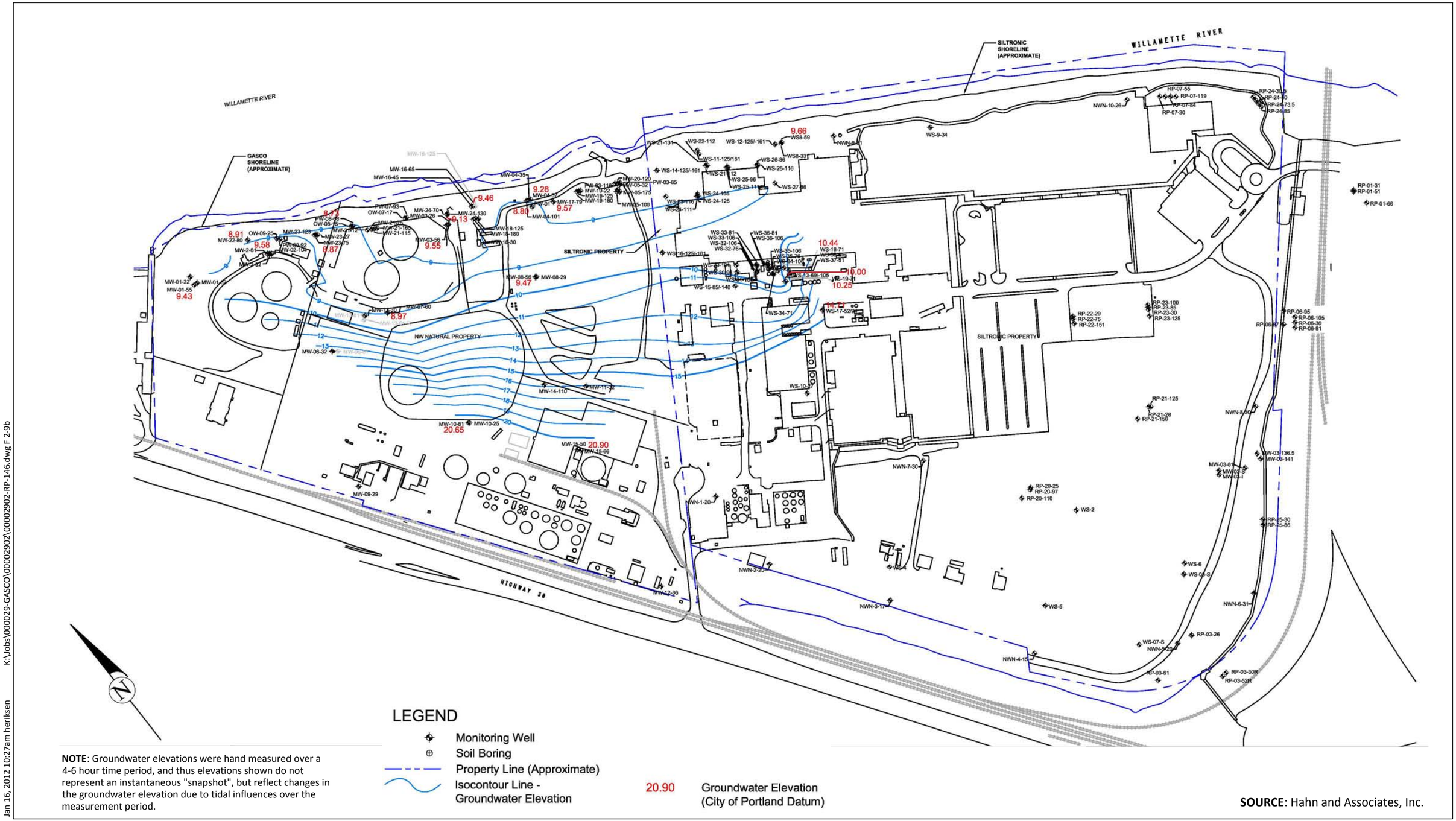


K:\Jobs\000029-GASCO\00002902\00002902-RP-127.dwg F 2-9a

Jan 11, 2012 8:58am heriksen

Figure 2-9a
Groundwater Elevation Map - Surficial Fill WBZ Wells - May 18, 2010
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

ANCHOR QEA



NOTE: Groundwater elevations were hand measured over a 4-6 hour time period, and thus elevations shown do not represent an instantaneous "snapshot", but reflect changes in the groundwater elevation due to tidal influences over the measurement period.

SOURCE: Hahn and Associates, Inc.

K:\Jobs\000029-GASCO\00002902\00002902-RP-146.dwg F 2-9b

Jan 16, 2012 10:27am heriksen

ANCHOR QEA

Figure 2-9b

Groundwater Elevation Map - Alluvial WBZ Wells - May 18, 2010

Revised Groundwater Source Control Construction Design Report

Gasco Groundwater Source Control

LEGEND:

- -100 foot Elevation Contact with Basalt Bedrock
- 15 Line of Equal Deep Aquitard Thickness in feet
- 7 Deep Aquitard Thickness in feet
- NA Boring is not deep enough to encounter Deep Aquitard or Basalt Bedrock encountered before -100 foot elevation
- * No recovery from the -100 to -120 foot elevation interval
- TG-9 Boring Location and Number
- MW-2-12 Existing Monitoring Well or Extraction Well Location and Number
- GS-01 Gasco Phase 1 Offshore Boring Location and Number

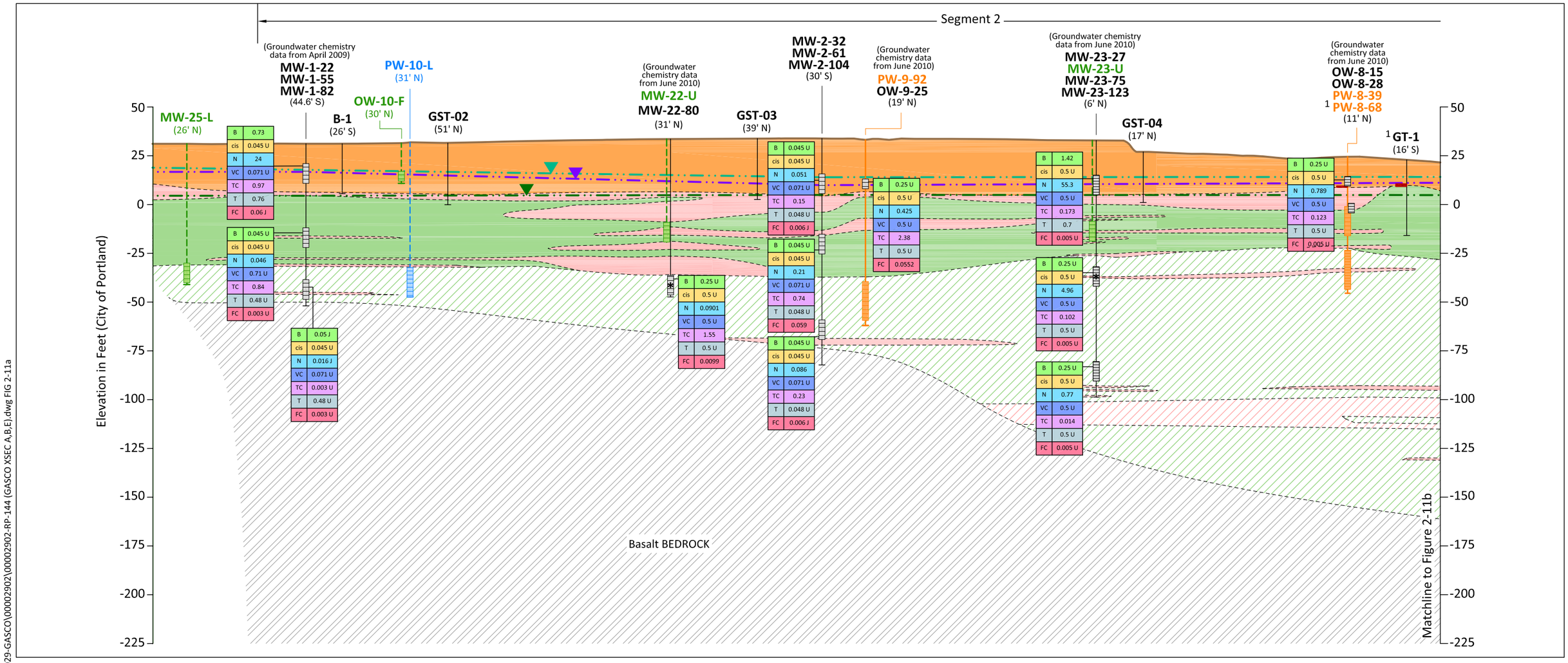
HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland

0 150
Scale in Feet

K:\Jobs\000029-GASCO\00002902\00002902-RP-128.dwg F 2-10
Jan 10, 2012 2:56pm heriksen

ANCHOR QEA

Figure 2-10
Deep Aquitard Isopach Map
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)
- Existing Ground Surface

- B — Benzene in ppb
- cis — cis 1,2-dichloroethene in ppb
- N — Naphthalene in ppb
- VC — Vinyl Chloride in ppb
- TC — Total Cyanide in ppm
- T — Toluene in ppb
- FC — Free Cyanide in ppm
- U — Not Detected at the Detection Limit
- J — Estimated Value
- NS — Not Sampled

MW-21-16 — Boring ID
(57' E) — Offset Distance in Feet
Existing Extraction Well
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer
— Tar Interval
— Oil or Mixed Oil and Tar Interval
— Well Screen
* — Control Well

0 50
Scale in Feet

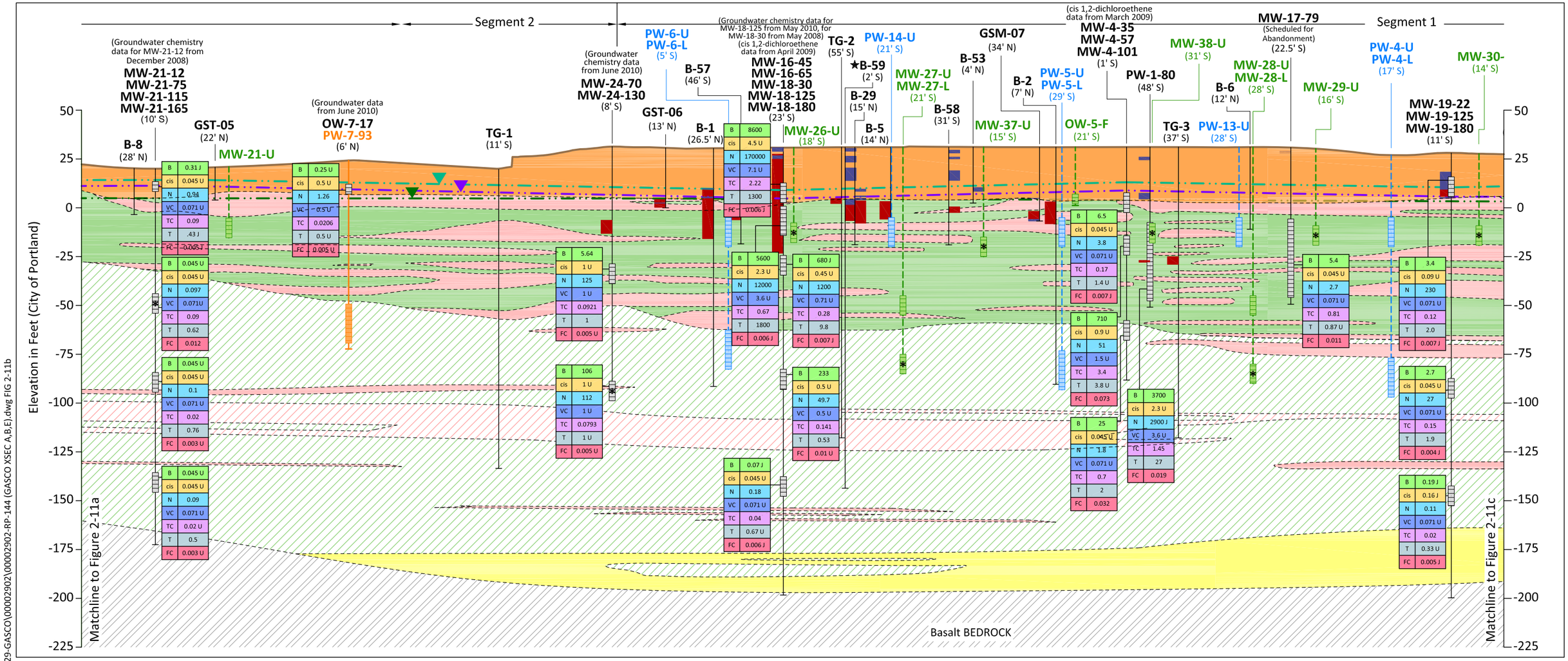
NOTES:

1. Geologic contacts are inferred between borings.
2. Groundwater analytical data from September 2008 except where indicated.
3. cis 1,2-dichloroethene and vinyl chloride data from December 2008.

K:\Jobs\000029-GASCO\00002902\00002902-RP-144 (GASCO XSEC A,B,E).dwg FIG 2-11a
Jan 27, 2012 9:05am heriksen

ANCHOR QEA

Figure 2-11a
Shoreline Groundwater Quality Data, Section A-A'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)
- Existing Ground Surface

- B — Benzene in ppb
- cis — cis 1,2-dichloroethene in ppb
- N — Naphthalene in ppb
- VC — Vinyl Chloride in ppb
- TC — Total Cyanide in ppm
- T — Toluene in ppb
- FC — Free Cyanide in ppm
- U — Not Detected at the Detection Limit
- J — Estimated Value
- NS — Not Sampled

MW-21-16 — Boring ID
(57' E) — Offset Distance in Feet
Tar Interval
Oil or Mixed Oil and Tar Interval
Well Screen
* — Control Well

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

0 50
Scale in Feet

NOTES:

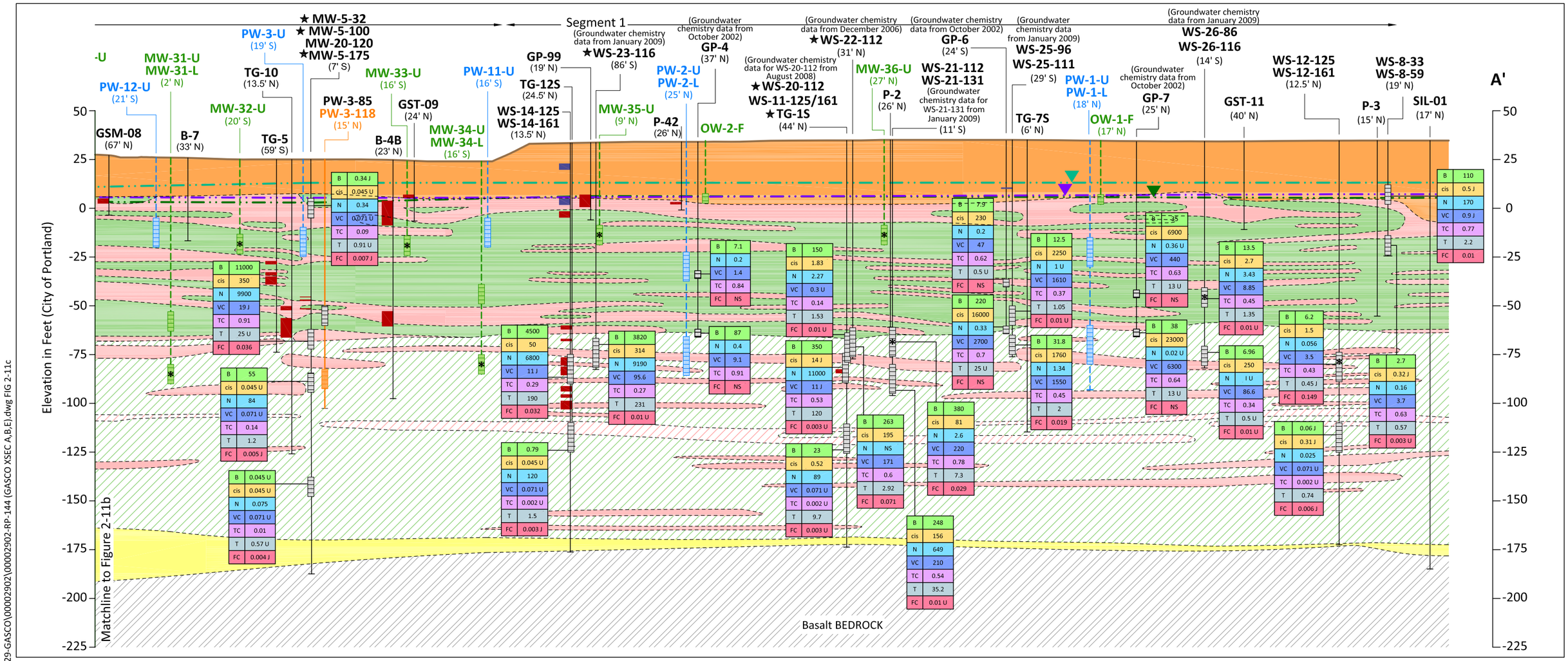
1. Geologic contacts are inferred between borings.
2. Groundwater analytical data from September 2008 except where indicated.

K:\Jobs\000029-GASCO\00002902\00002902-RP-144 (GASCO XSEC A,B,E).dwg FIG 2-11b

Jan 27, 2012 9:06am heriksen

ANCHOR QEA

Figure 2-11b
Shoreline Groundwater Quality Data, Section A-A'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)
- Existing Ground Surface

B Benzene in ppb
cis cis 1,2-dichloroethene in ppb
N Naphthalene in ppb
VC Vinyl Chloride in ppb
TC Total Cyanide in ppm
T Toluene in ppb
FC Free Cyanide in ppm
U Not Detected at the Detection Limit
J Estimated Value
NS Not Sampled

MW-21-16 — Boring ID
(57' E) — Offset Distance in Feet

Existing Extraction Well
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Temporary Well Point

— Tar Interval
— Oil or Mixed Oil and Tar Interval
— Well Screen
* — Control Well

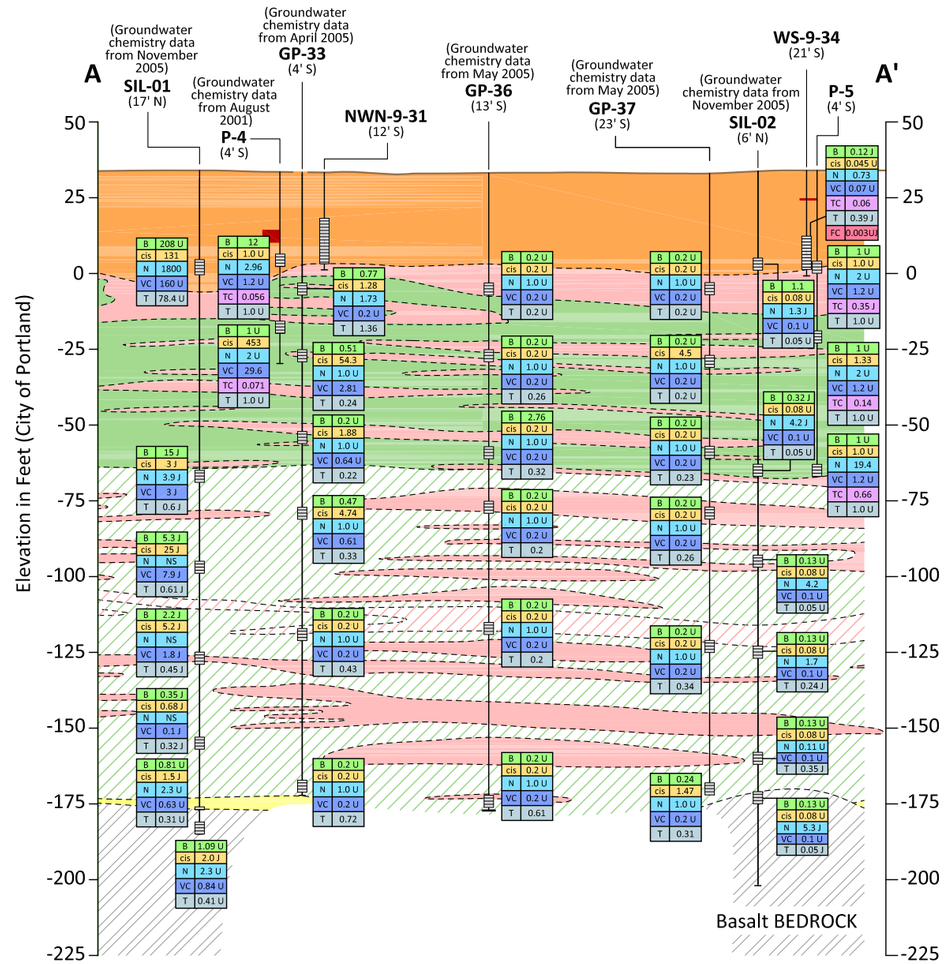
0 50
Scale in Feet

NOTES:
1. Geologic contacts are inferred between borings.
2. Groundwater analytical data from September 2008 except where indicated.
★ Boring not used for lithologic interpretation.

K:\Jobs\000029-GASCO\00002902\00002902-RP-144 (GASCO XSEC A,B,E).dwg FIG 2-11c
Jan 27, 2012 9:06am heriksen

ANCHOR QEA

Figure 2-11c
Shoreline Groundwater Quality Data, Section A-A'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface

- B — Benzene in ppb
- cis — cis 1,2-dichloroethene in ppb
- N — Naphthalene in ppb
- VC — Vinyl Chloride in ppb
- TC — Total Cyanide in ppm
- T — Toluene in ppb
- FC — Free Cyanide in ppm
- U — Not Detected at the Detection Limit
- J — Estimated Value
- NS — Not Sampled

P-47 (22' S)
— Boring ID
— Offset Distance in Feet

Existing Well or Temporary Well Point
— Tar Interval
— Oil or Mixed Oil and Tar Interval
— Well Screen

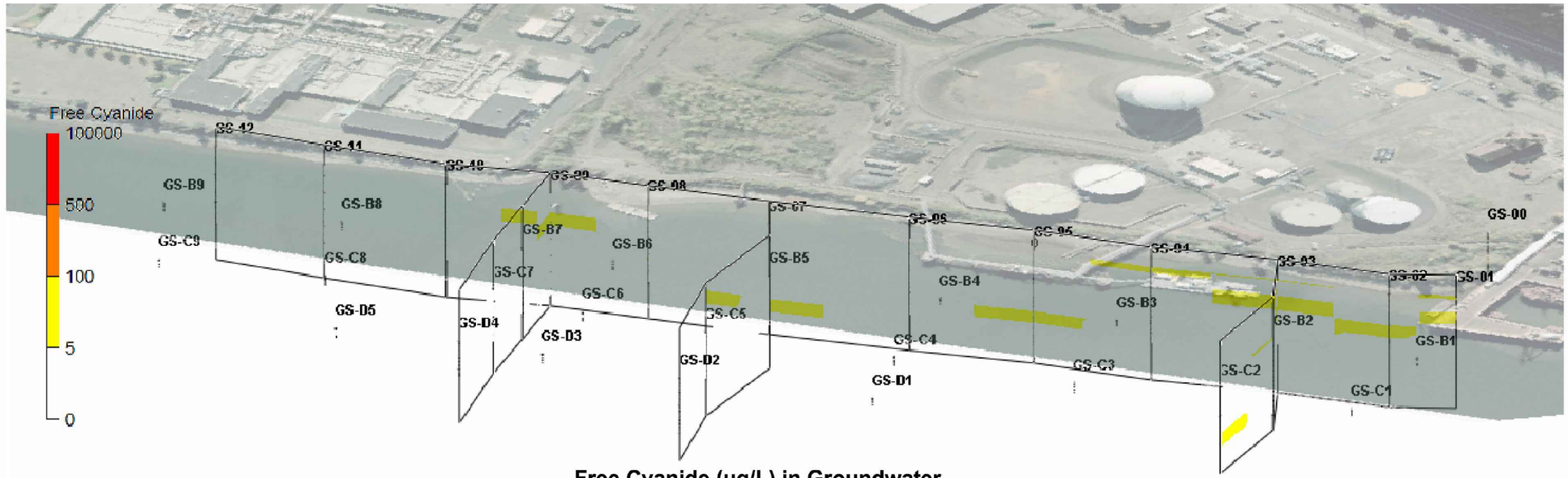
0 50
Scale in Feet

NOTES:
1. Geologic contacts are inferred between borings.
2. Groundwater analytical data from September 2008 except where indicated.

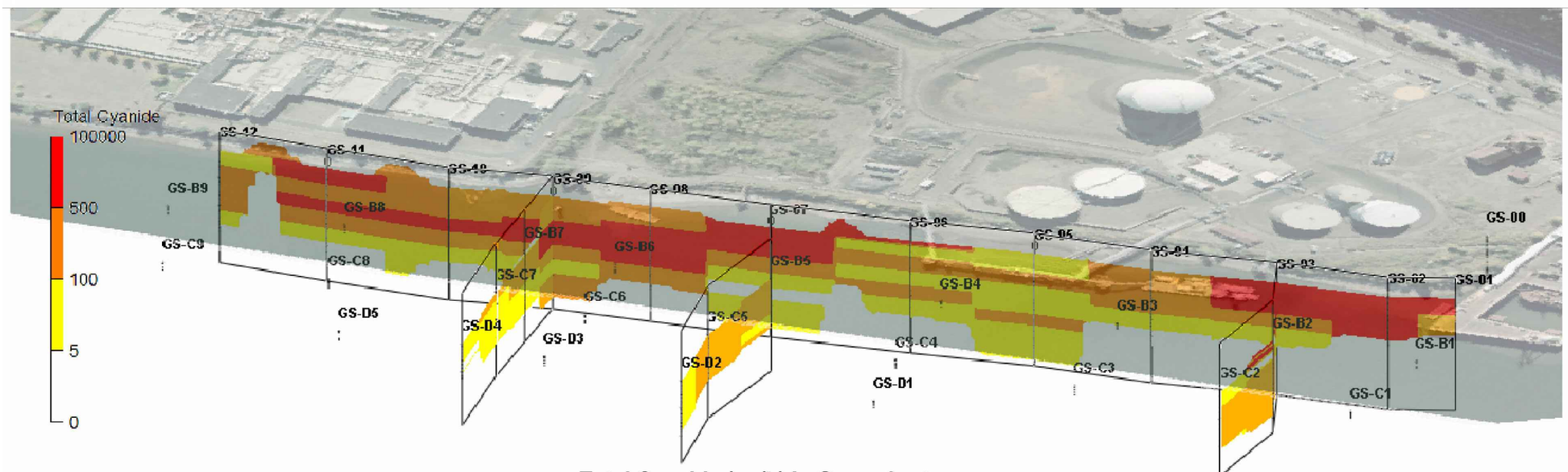
K:\Jobs\000029-GASCO\00002902\00002902-RP-144 (GASCO XSEC A,B,E).dwg FIG 2-11d
Jan 27, 2012 9:07am heriksen

ANCHOR QEA

Figure 2-11d
Shoreline Groundwater Quality Data, Section A-A' Extension
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



Free Cyanide (ug/L) in Groundwater



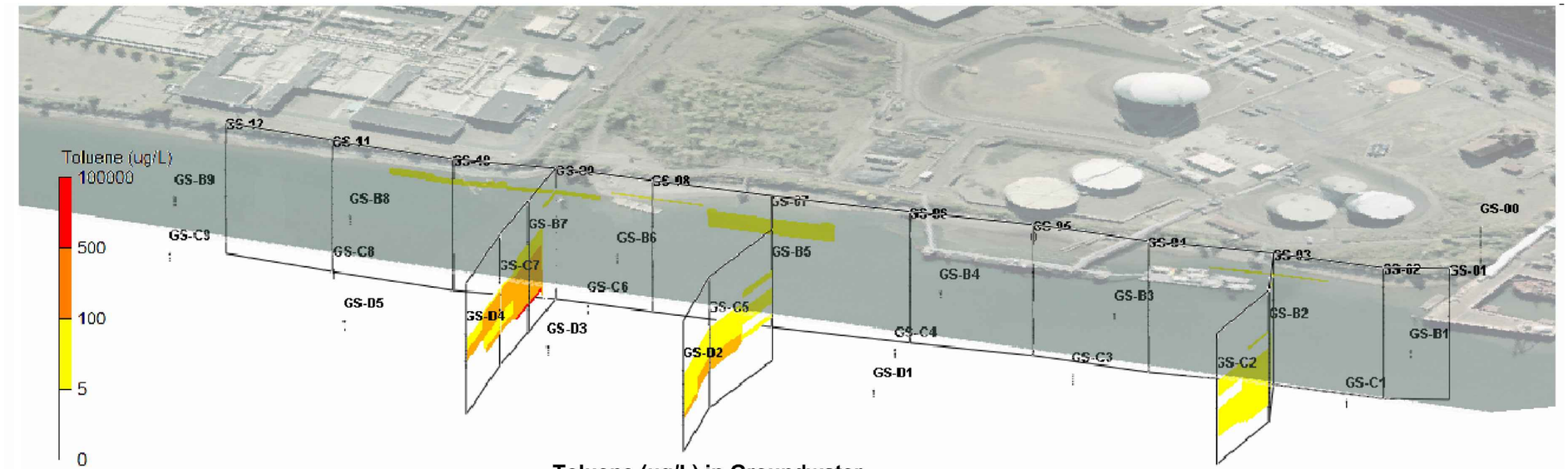
Total Cyanide (ug/L) in Groundwater

NOTE: Locations are approximate and are for visualization purposes only.

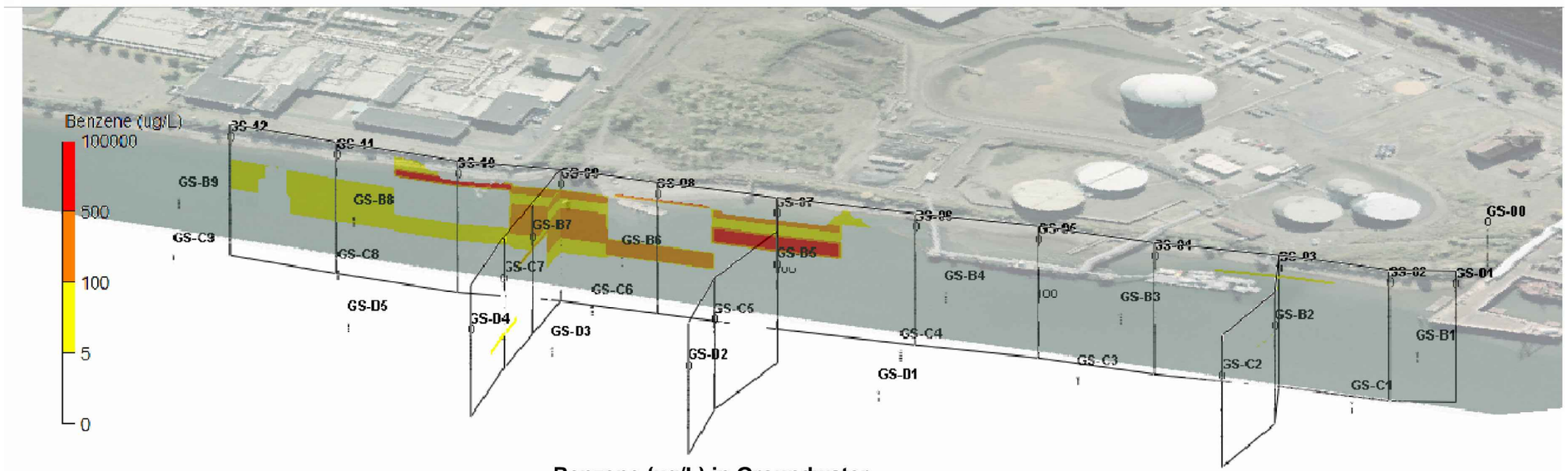
Jan 10, 2012 2:57pm heriksen K:\Jobs\000029-GASCO\0000290\00002902-RP-033.dwg FIG 2-12a

ANCHOR QEA

Figure 2-12a
3D MGP Plume Maps - Free and Total Cyanide
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



Toluene (ug/L) in Groundwater



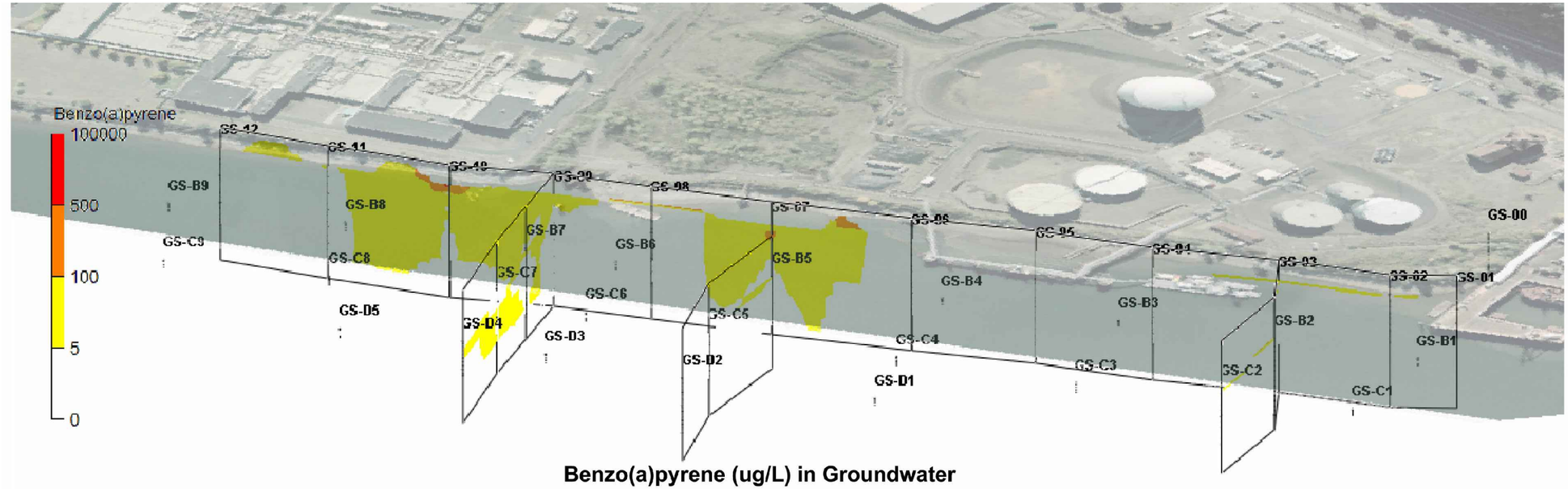
Benzene (ug/L) in Groundwater

NOTE: Locations are approximate and are for visualization purposes only.

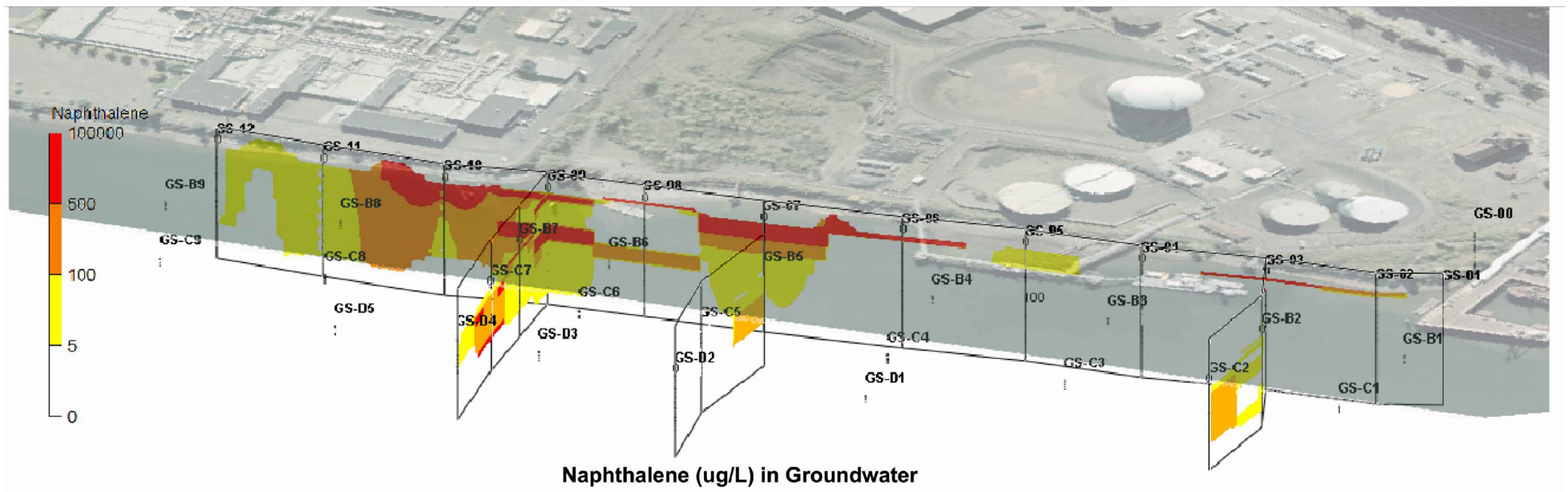
Jan 10, 2012 2:57pm heriksen K:\Jobs\000029-GASCO\00002902\00002902-RP-033.dwg FIG 2-12b

ANCHOR QEA

Figure 2-12b
3D MGP Plume Maps - Toluene and Benzene
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



Benzo(a)pyrene (ug/L) in Groundwater



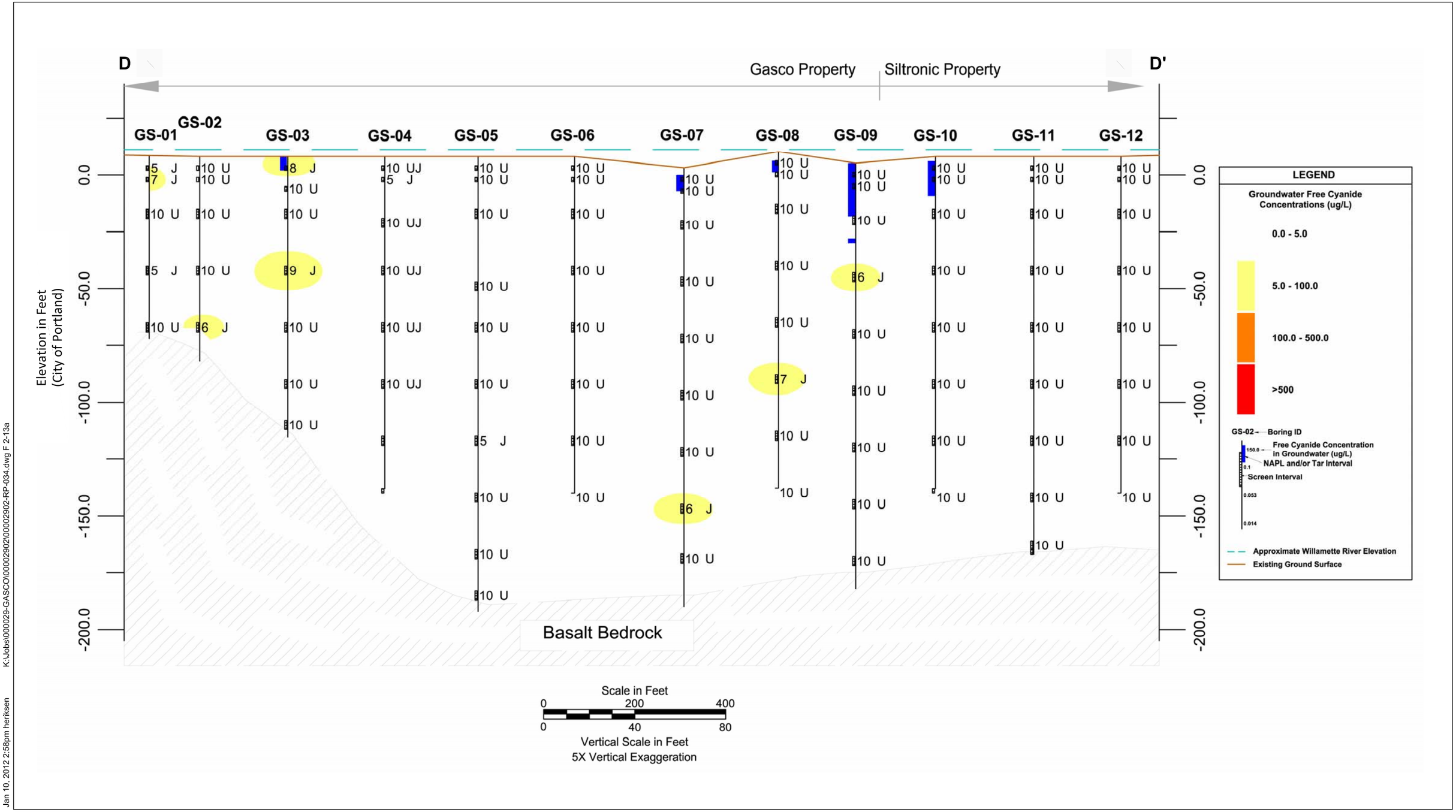
Naphthalene (ug/L) in Groundwater

NOTE: Locations are approximate and are for visualization purposes only.

Jan 10, 2012 2:57pm heriksen K:\Jobs\000029-GASCO\00002902\00002902-RP-033.dwg FIG 2-12c

ANCHOR QEA

Figure 2-12c
3D MGP Plume Maps - Benzo(a)pyrene and Naphthalene
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



K:\Jobs\000029-GASCO\00002902\00002902-RP-034.dwg F 2-13a

Jan 10, 2012 2:58pm heriksen

ANCHOR QEA

Figure 2-13a
Subsurface Profile D-D' - Free Cyanide
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

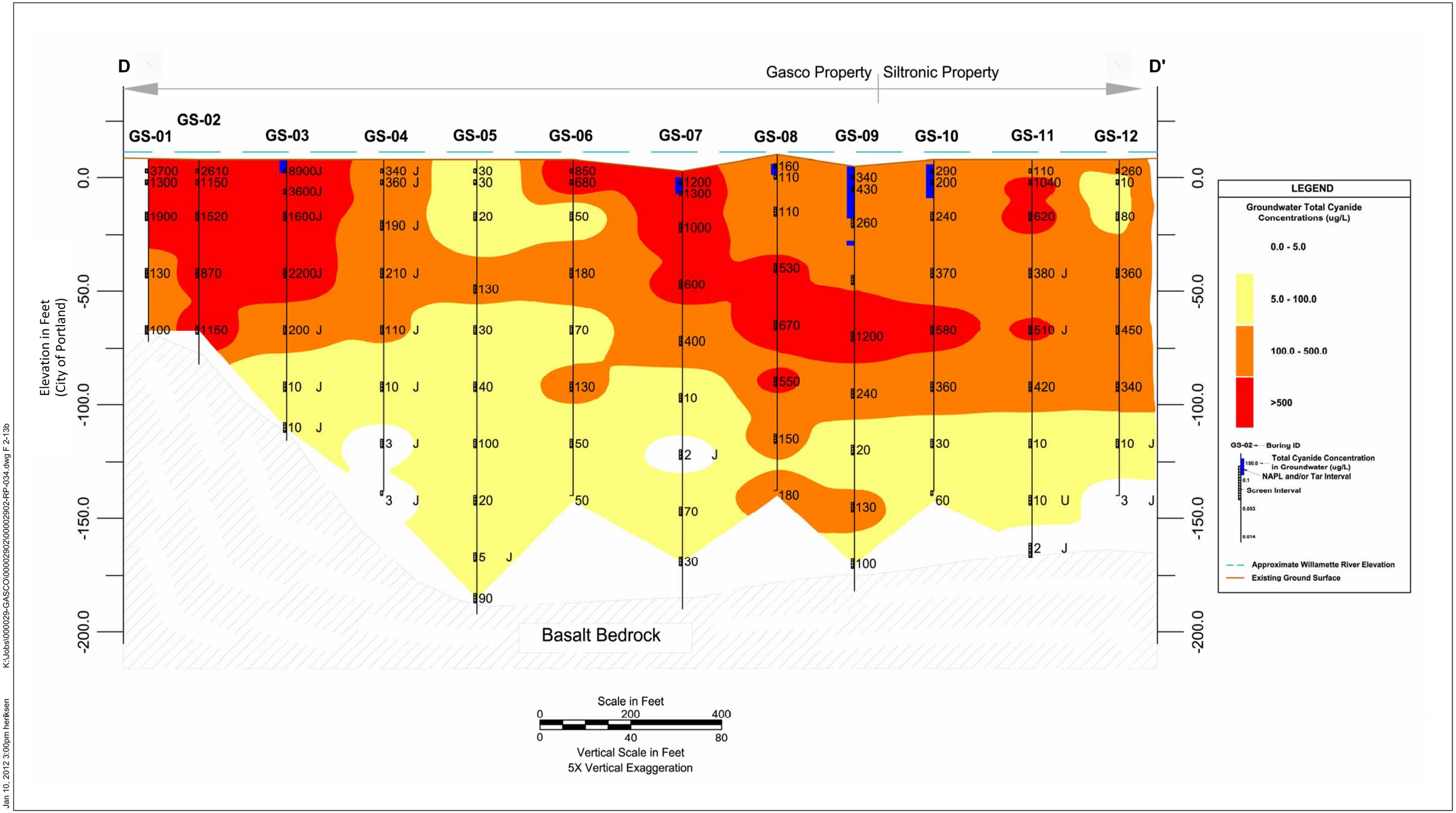
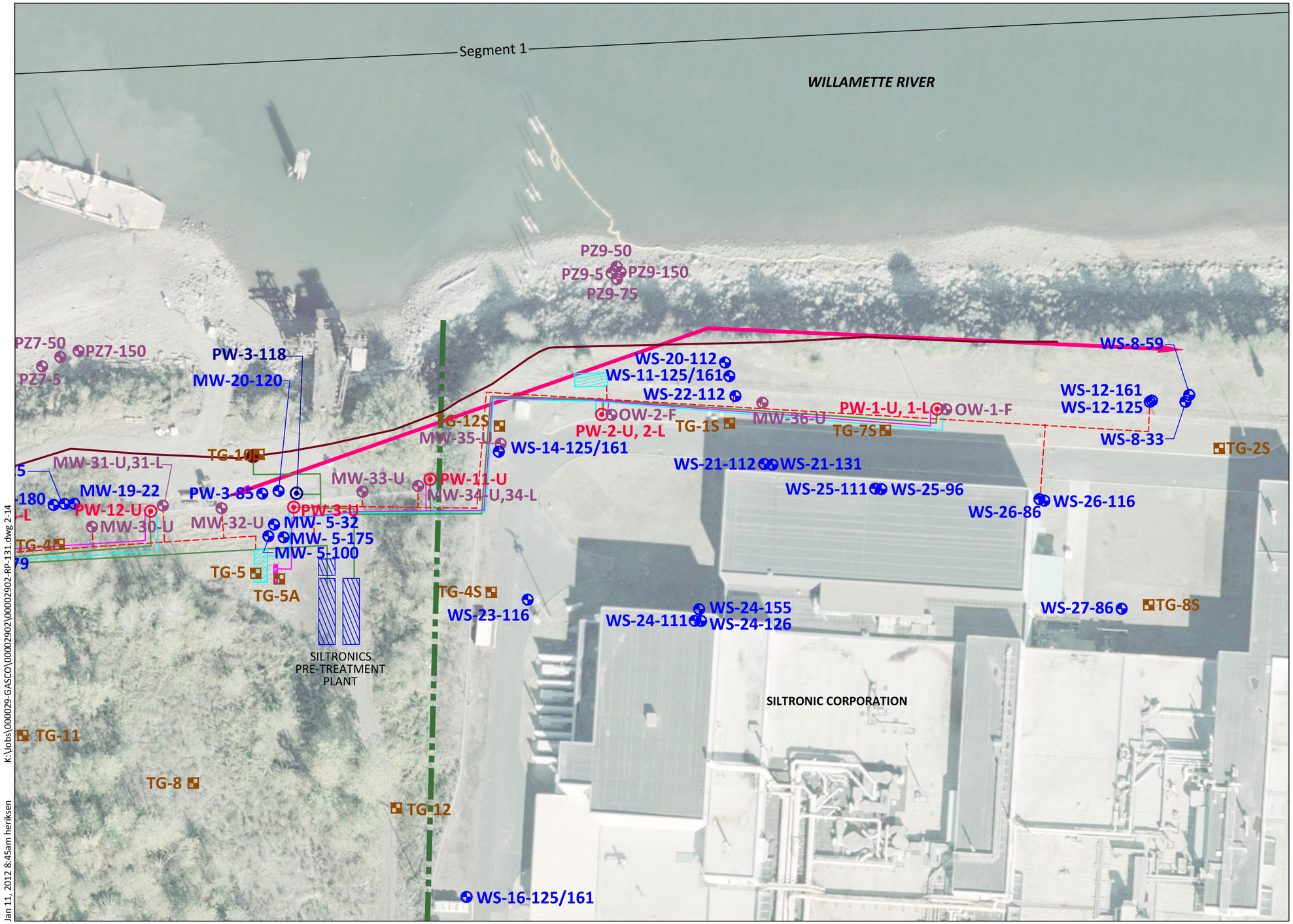


Figure 2-13b
Subsurface Profile D-D' - Total Cyanide
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

ANCHOR QEA



LEGEND:

- PW-8-U — Proposed Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- MW-21-U — Proposed Monitoring Well (F = Fill, U = Upper Alluvium, L = Lower Alluvium)
- MW-2-12 — Existing Monitoring Well, Observation Well, or Piezometer
- PW-3-85 — Existing Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- Fill WBZ Trench Alignment with Sump
- Source Control Main Pipeline Route
- Source Control Level Data Route
- Source Control Product Recovery Line
- Source Control Airline
- Siltronic Plume Extent

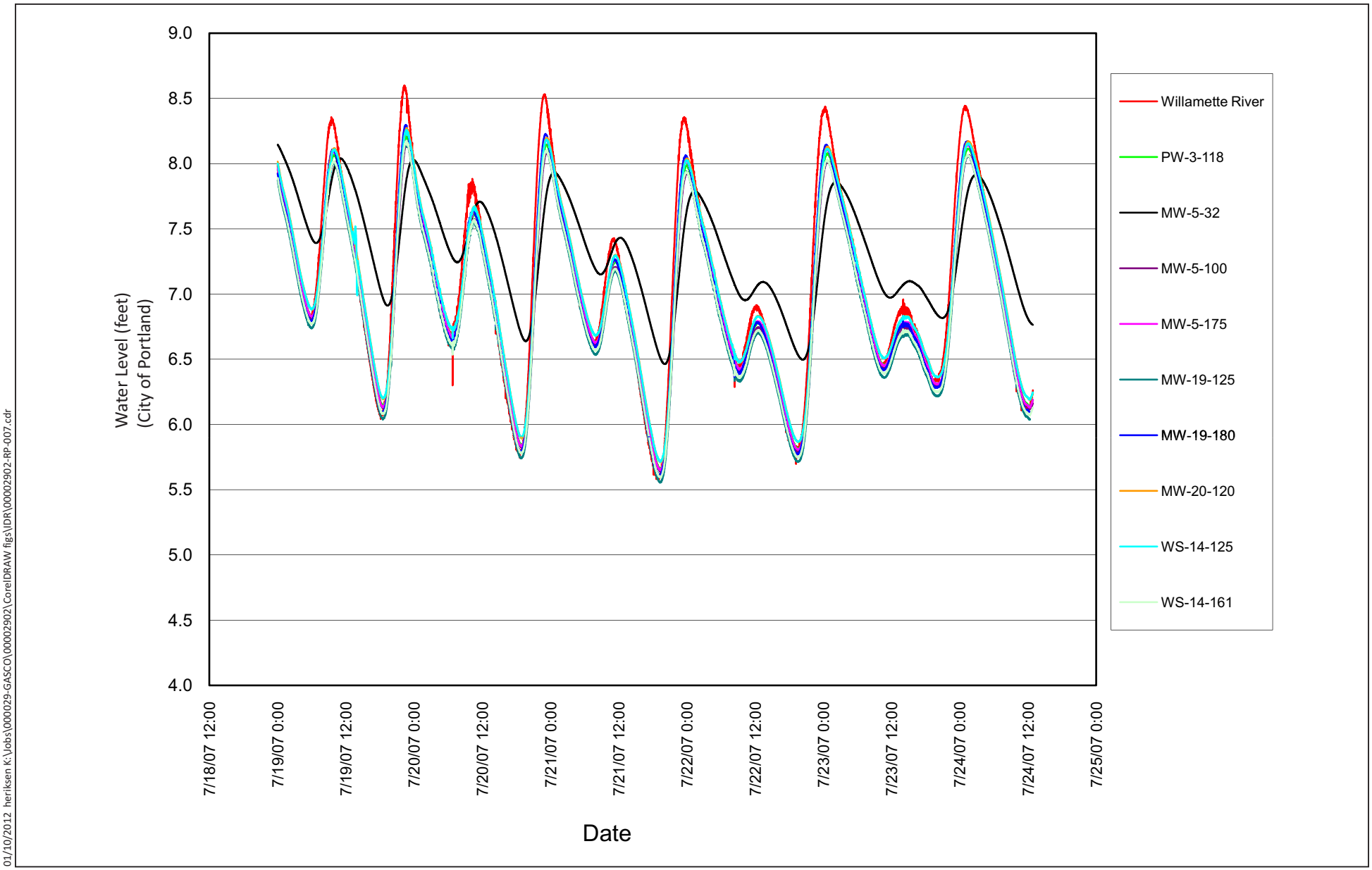
0 60
Scale in Feet

HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland

K:\Jobs\000029-GASCO\0000290\2\00002902-RP-131.dwg 2-14
Jan 11, 2012 8:45am heriksen

ANCHOR QEA

Figure 2-14
Siltronic CVOC Plume Map
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



01/10/2012 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-007.cdr

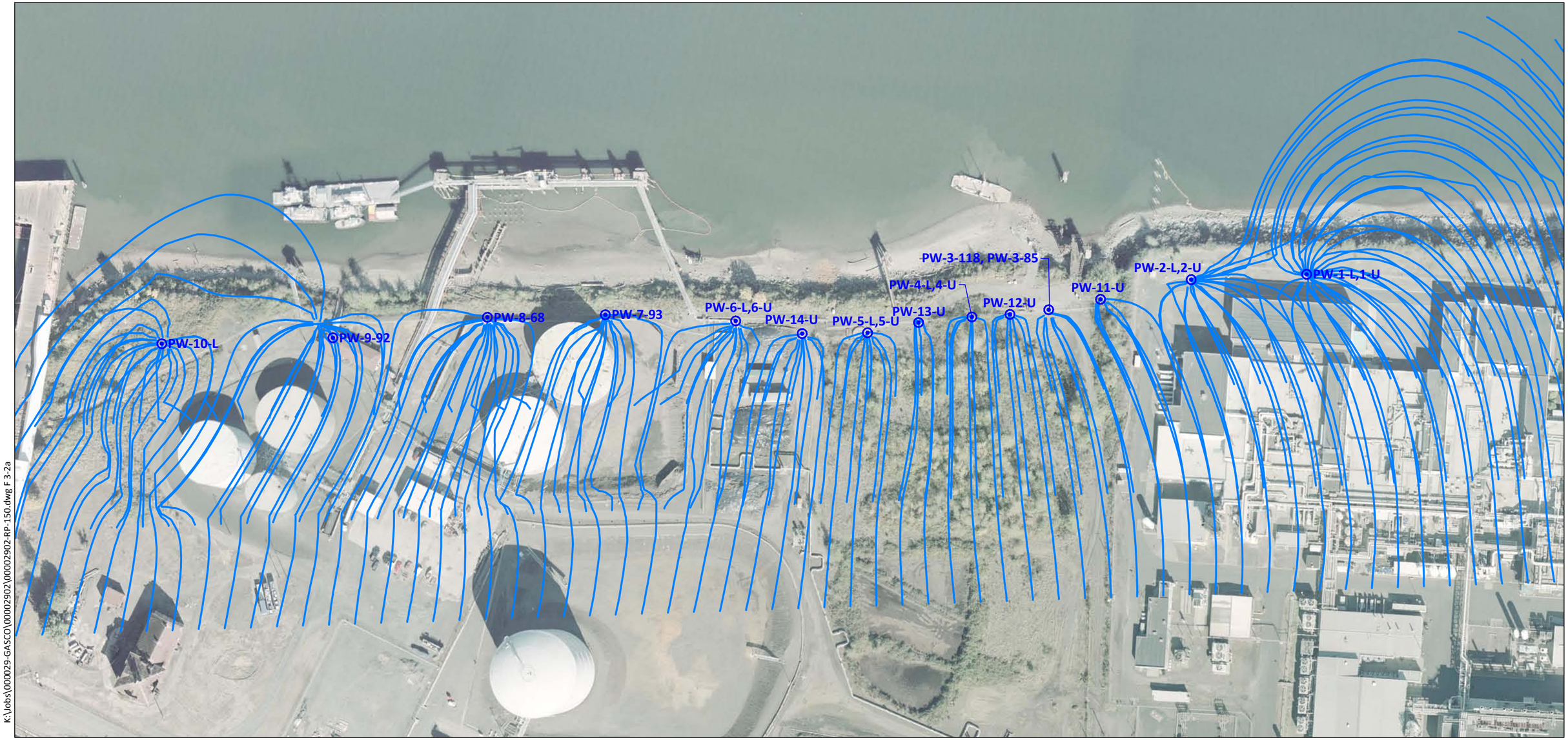
Figure 3-1

River and Groundwater Tidal Fluctuations

Revised Groundwater Source Control Construction Design Report

Gasco Groundwater Source Control

ANCHOR QEA



K:\Jobs\000029-GASCO\00002902\00002902-RP-150.dwg F 3-2a

Jan 16, 2012 1:20pm heriksen

LEGEND:

Pumping Well

Partical Path in Alluvium

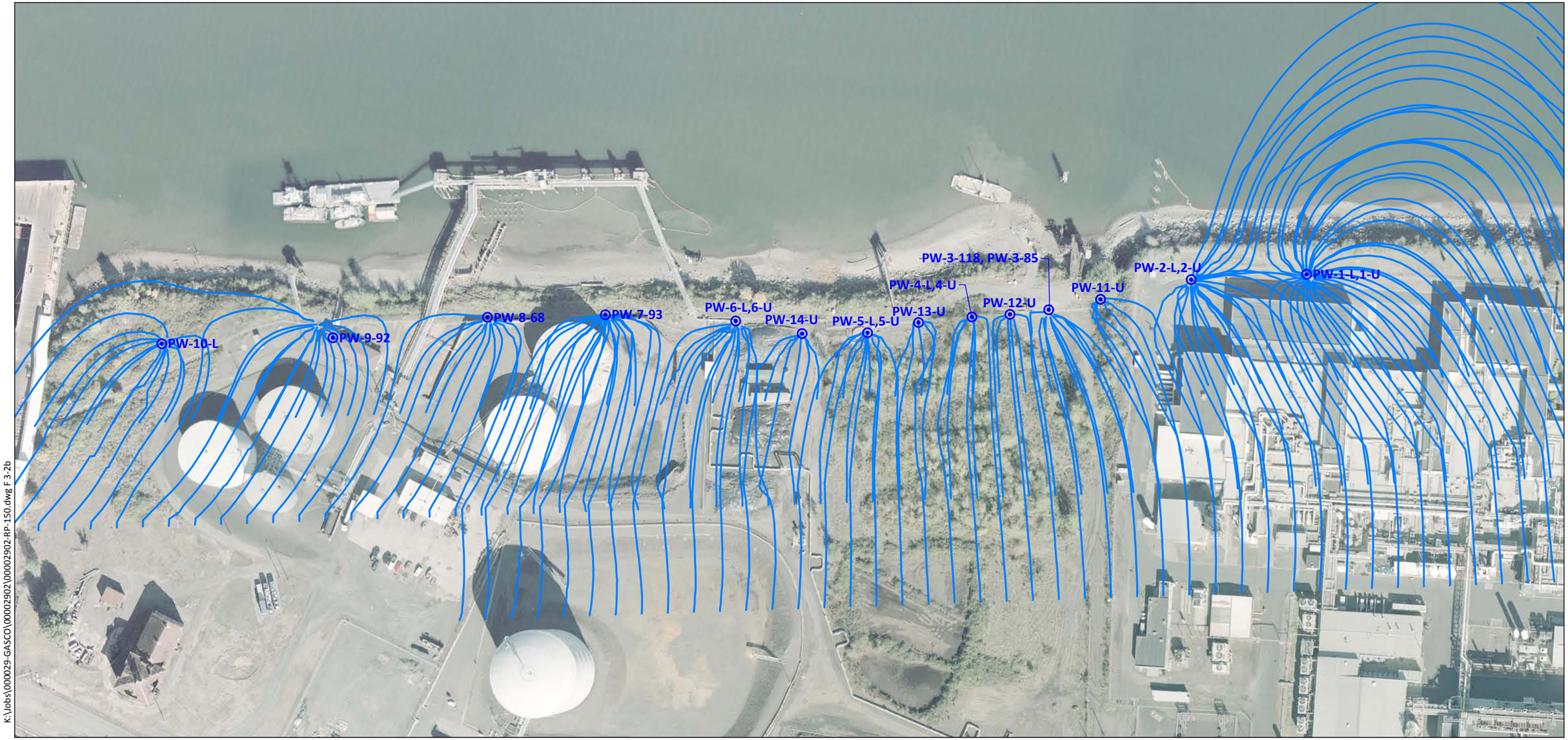
0 150

Scale in Feet

ANCHOR QEA

Figure 3-2a

Particle Track Capture Map for Upper Portion of Upper Alluvium WBZ
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



K:\Jobs\000029-GASCO\00002902\00002902-RP-150.dwg F 3-2b

Jan 16, 2012 1:24pm heriksen

LEGEND:

Pumping Well

Partical Path in Alluvium

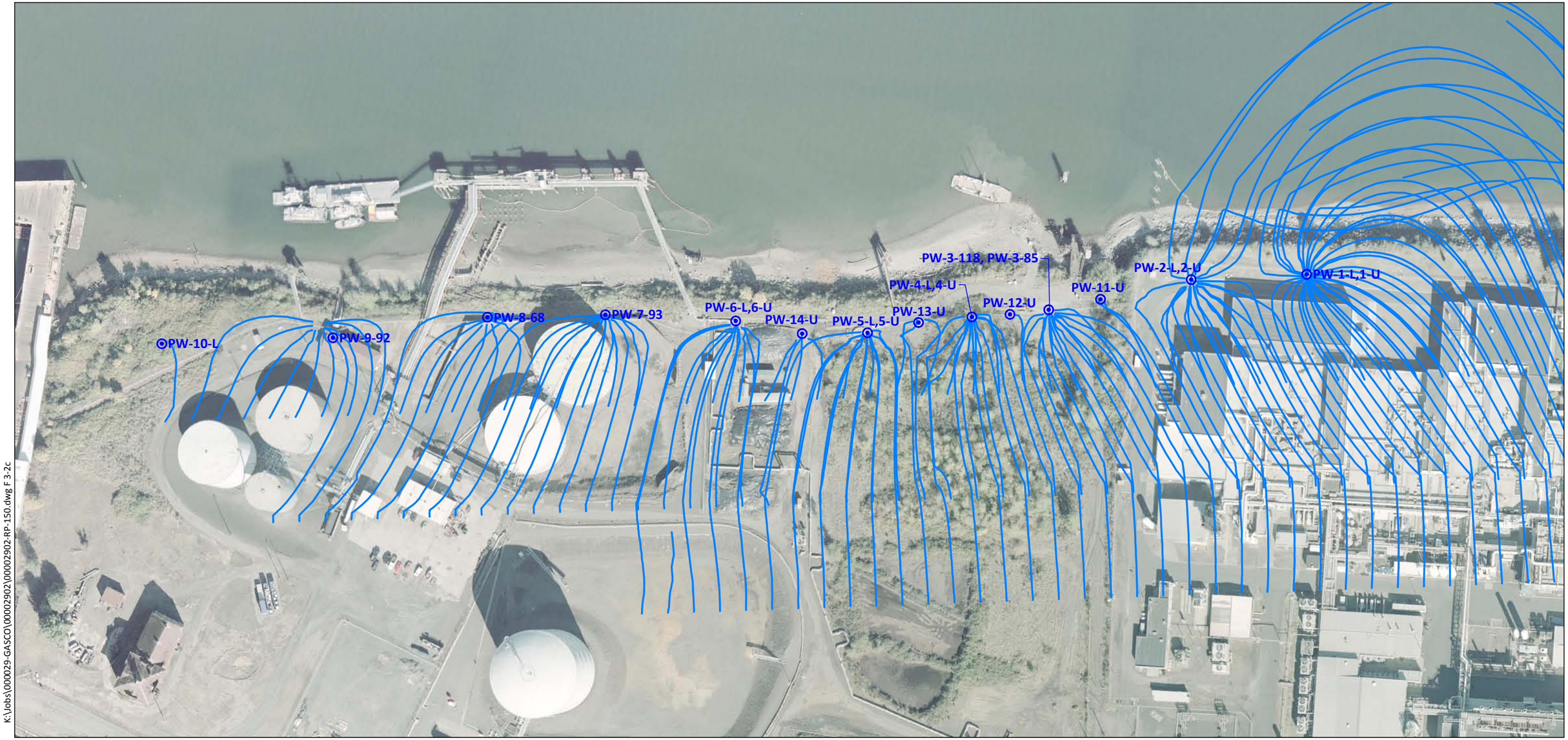
0 150

Scale in Feet

ANCHOR QEA

Figure 3-2b

Particle Track Capture Map for Lower Portion of Upper Alluvium WBZ
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



K:\Jobs\000029-GASCO\00002902\00002902-RP-150.dwg F 3-2c

Jan 17, 2012 11:33am heriksen

LEGEND:

Pumping Well

Partical Path in Alluvium

0 150

Scale in Feet

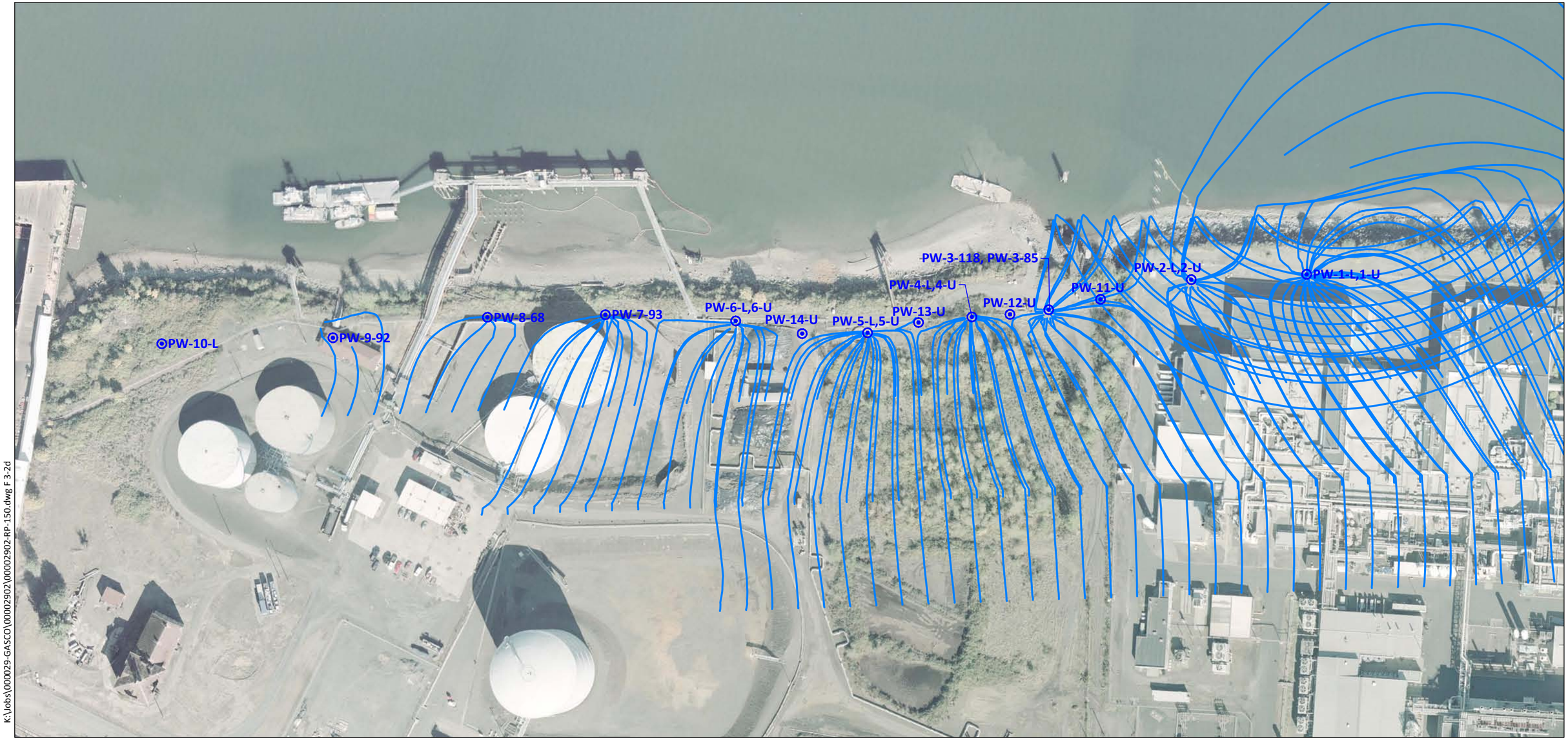
ANCHOR QEA

Figure 3-2c

Particle Track Capture Map for Upper Portion of Lower Alluvium WBZ

Revised Groundwater Source Control Construction Design Report

Gasco Groundwater Source Control



LEGEND:

Pumping Well

Partical Path in Alluvium

0 150

Scale in Feet

K:\Jobs\000029-GASCO\00002902\00002902-RP-150.dwg F 3-2d

Jan 16, 2012 1:21pm heriksen

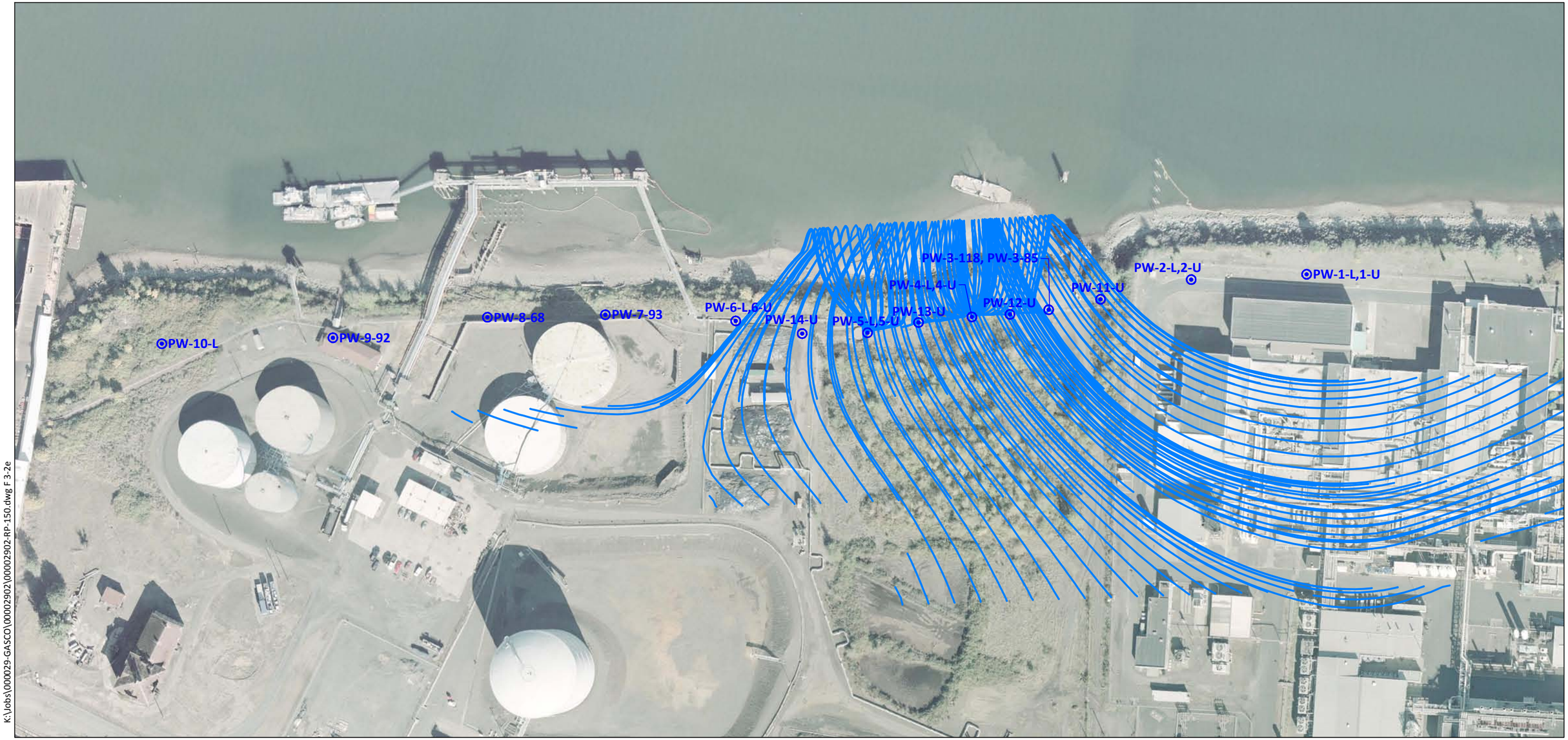
ANCHOR QEA

Figure 3-2d

Particle Track Capture Map for the Top of the Deep Aquitard

Revised Groundwater Source Control Construction Design Report

Gasco Groundwater Source Control



LEGEND:

Pumping Well

Partical Path in Alluvium

0 150

Scale in Feet

K:\Jobs\000029-GASCO\00002902\00002902-RP-150.dwg F 3-2e

Jan 16, 2012 1:21pm heriksen

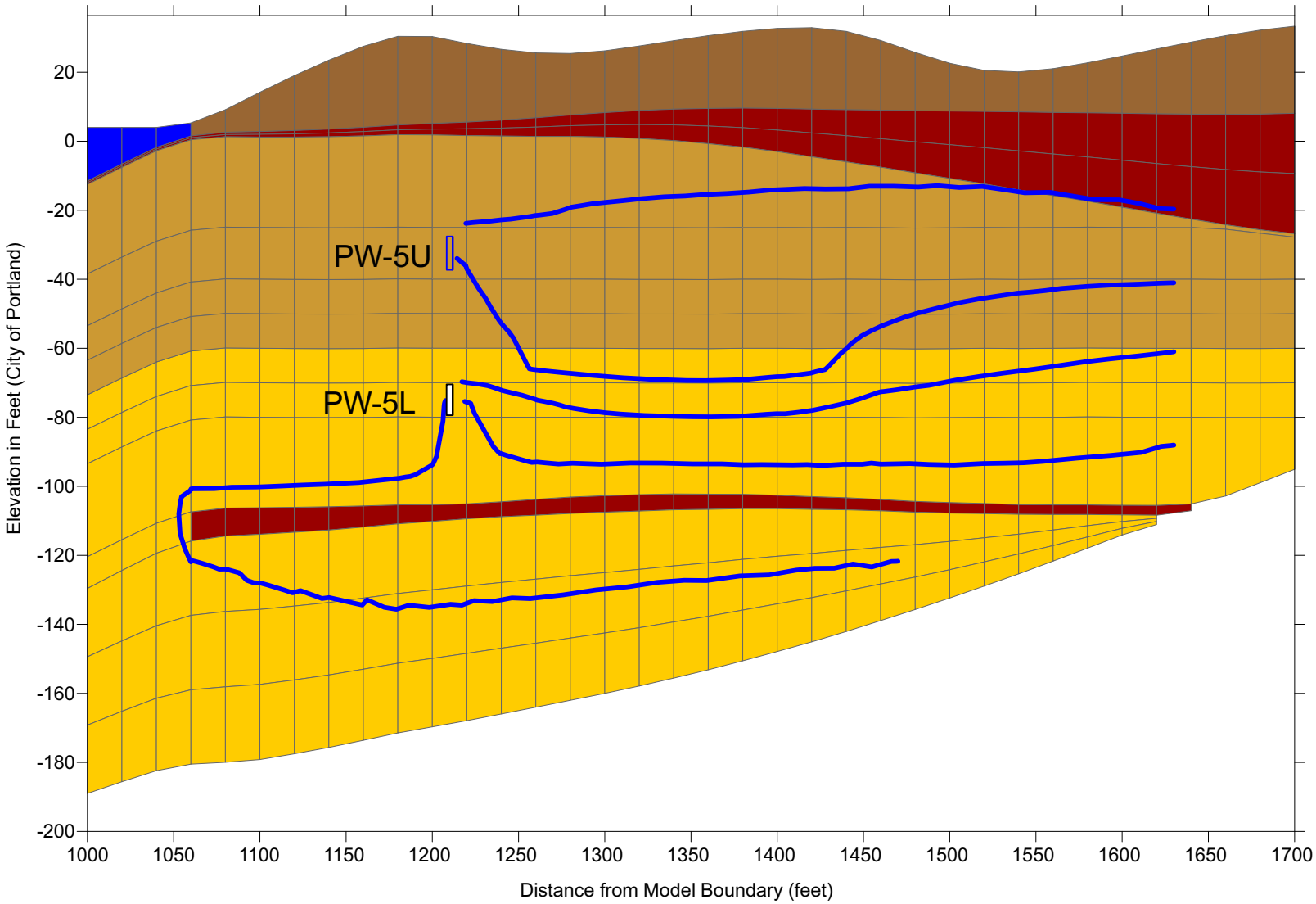
ANCHOR QEA

Figure 3-2e

Particle Track Capture Map for the Bottom of the Deep Alluvium WBZ

Revised Groundwater Source Control Construction Design Report

Gasco Groundwater Source Control



01/16/2012 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-007.cdr

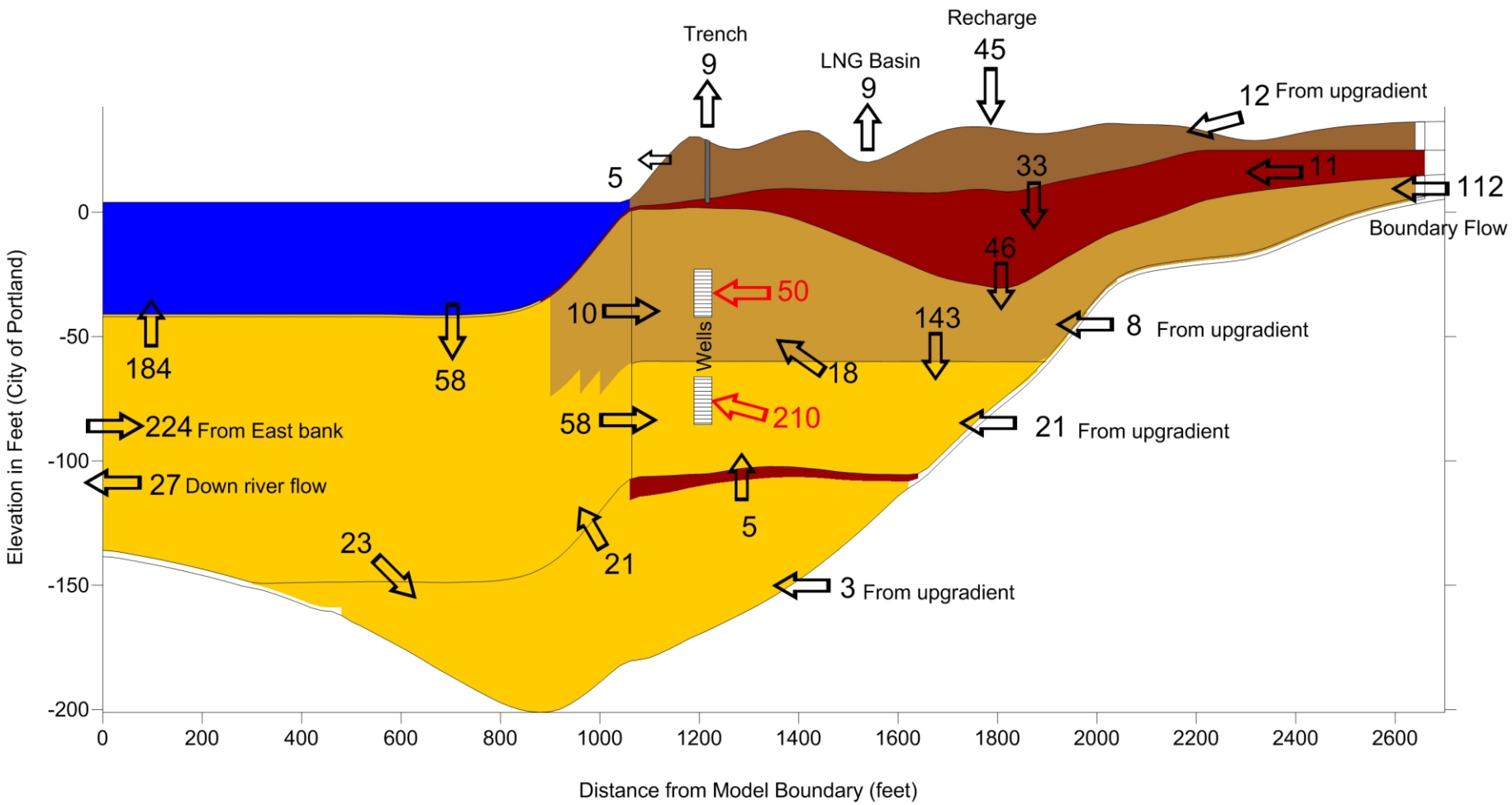
Figure 3-3

Particle Track Map at PW-5 Extraction Wells

Revised Groundwater Source Control Construction Design Report

Gasco Groundwater Source Control

ANCHOR QEA



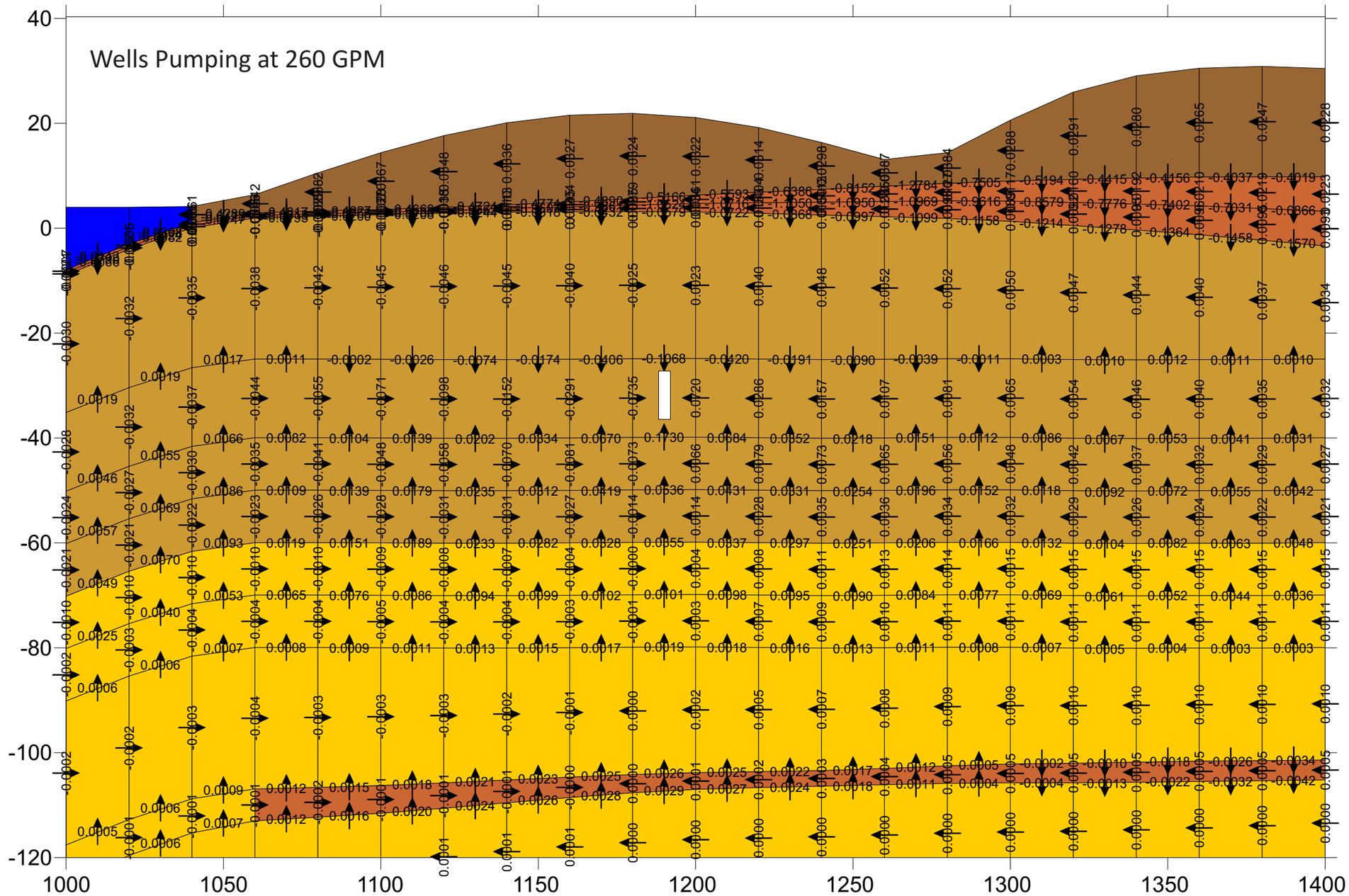
Groundwater flow model mass balance for different model areas. Flows in gallons per minute. Flow to HC&C wells shown in red.

01/16/2012 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-007.cdr

Figure 3-4

Groundwater Flow Budget for the Hydraulic Control and Containment Area
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

ANCHOR QEA

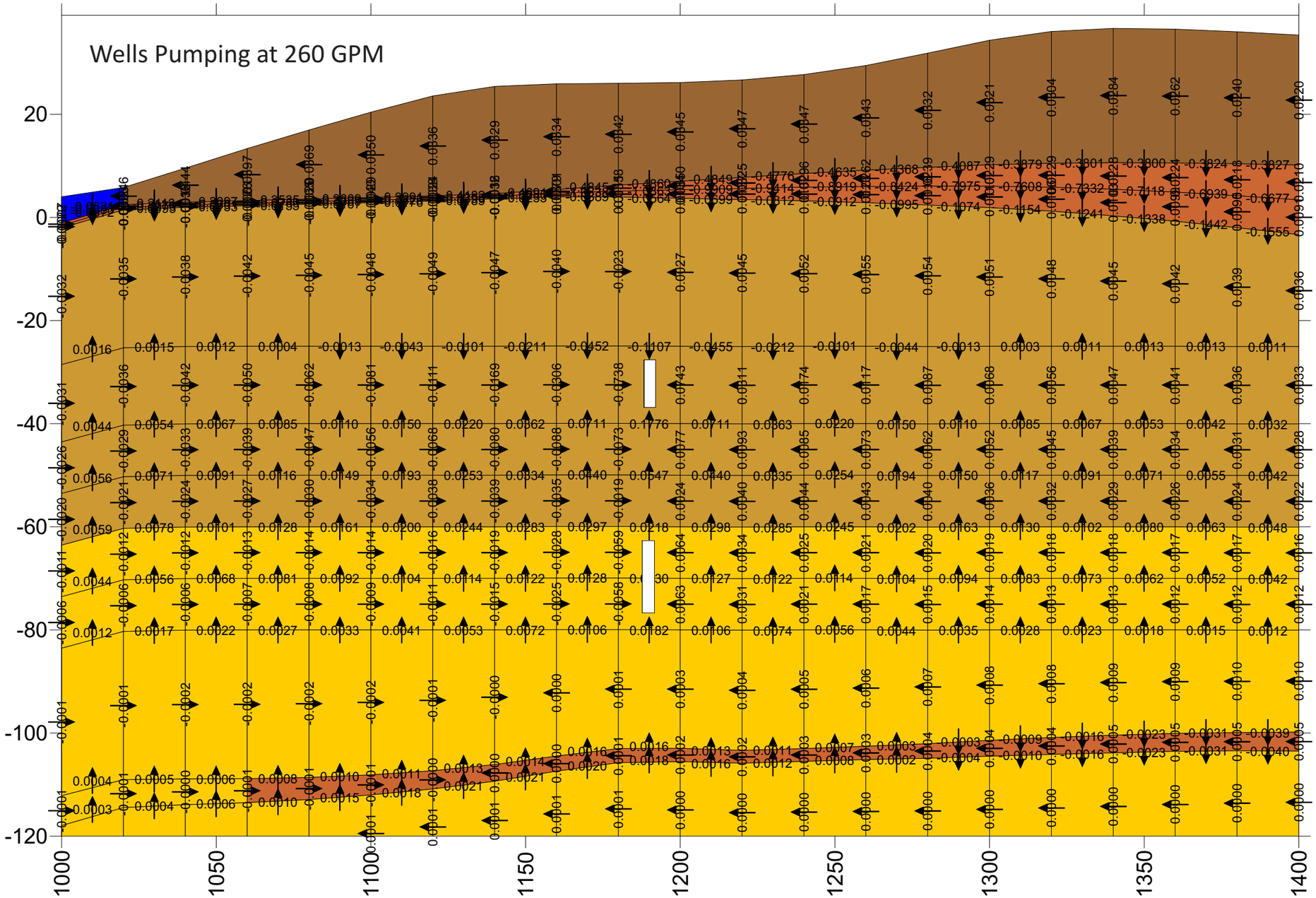


VERTICAL DATUM: City of Portland

01/10/2012 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-002.cdr

ANCHOR QEA

Figure 3-5a
Groundwater Gradient Profile, Upper Alluvium Wells
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

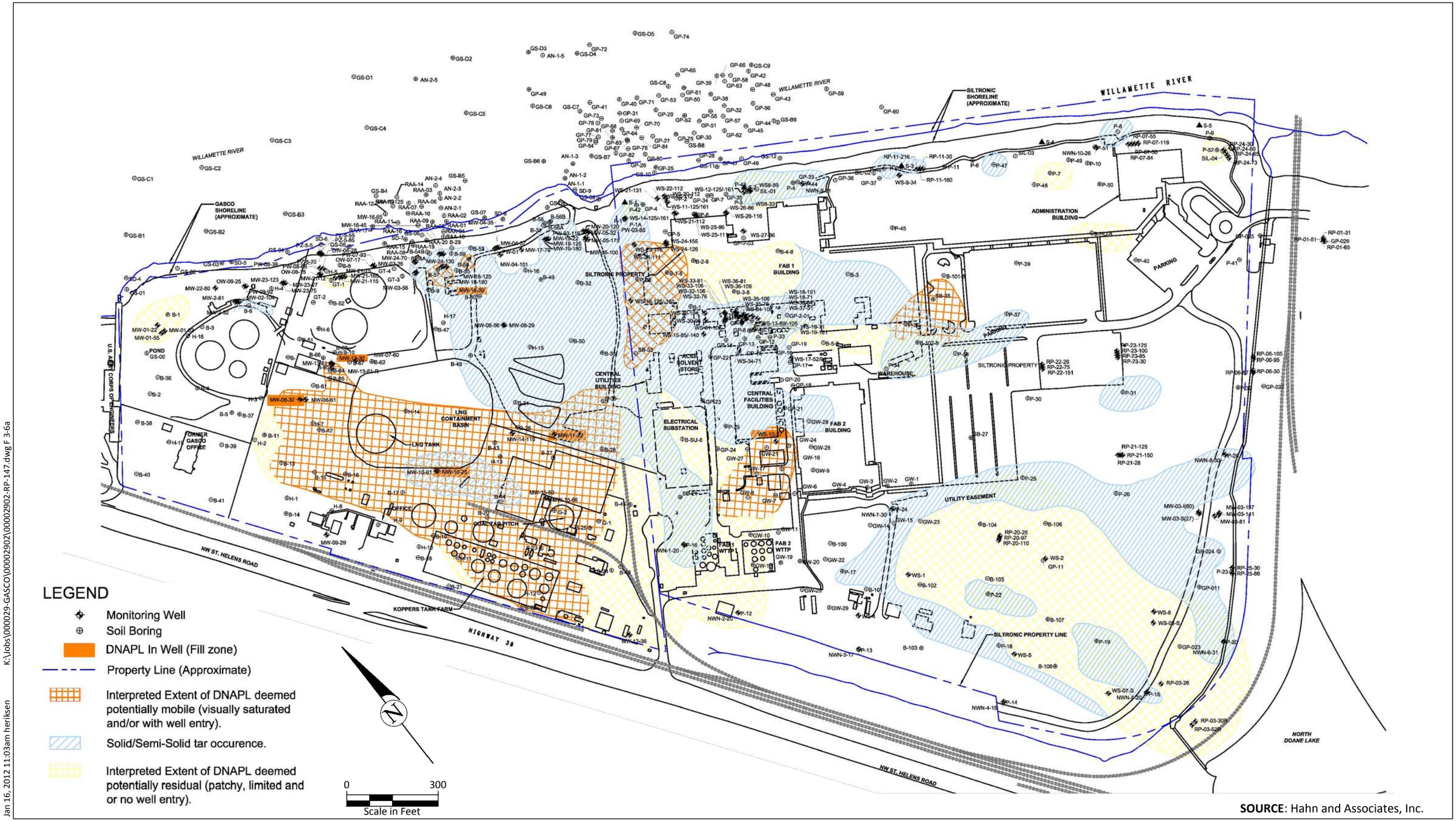


VERTICAL DATUM: City of Portland

01/10/2012 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-002.cdr

ANCHOR QEA

Figure 3-5b
Groundwater Gradient Profile, Upper and Lower Alluvium Wells
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



SOURCE: Hahn and Associates, Inc.

Figure 3-6a
Estimated Distribution of Tar and DNAPL within the Fill Zone
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

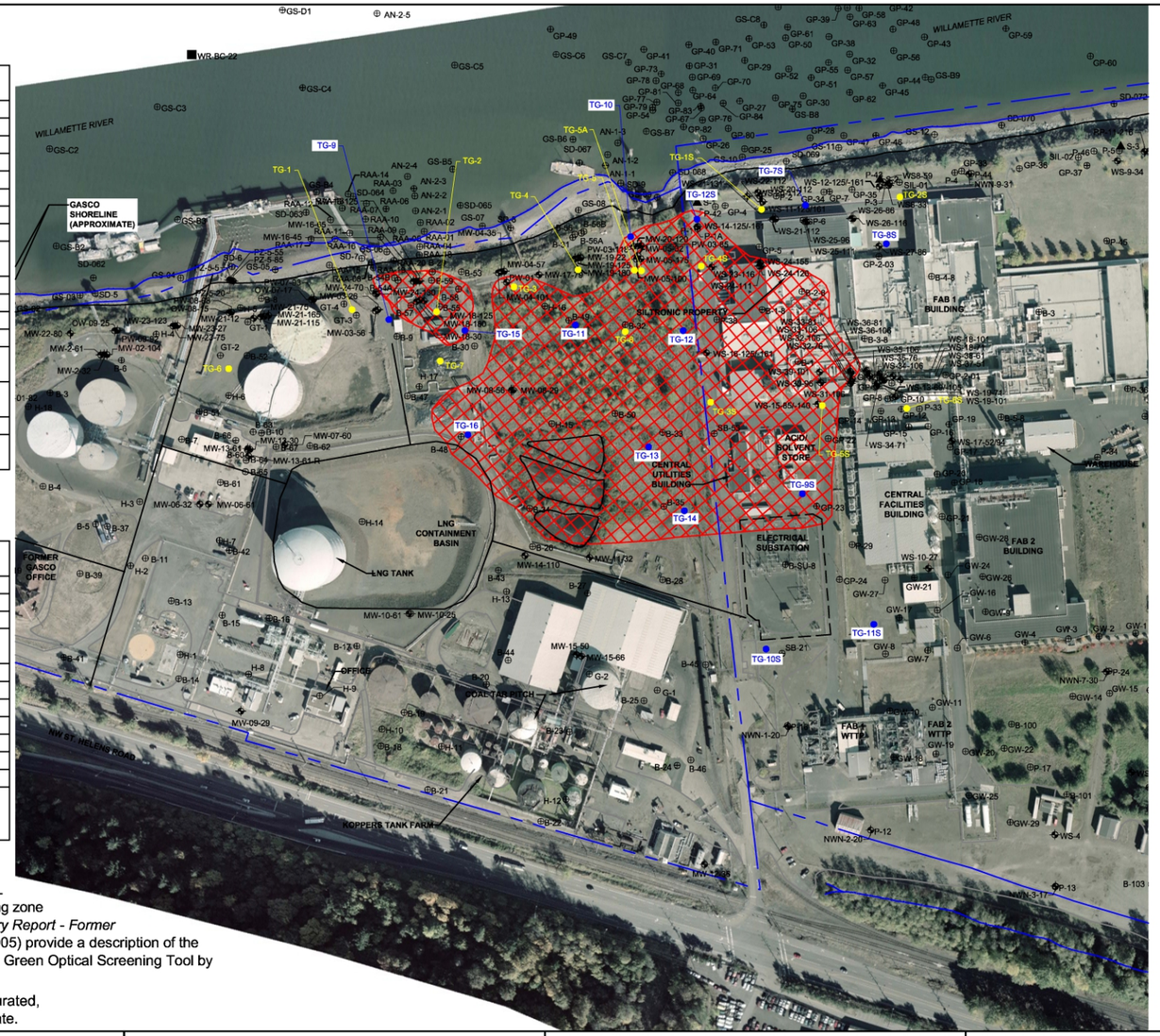
ANCHOR QEA

Table: TarGOST DNAPL Presence
Screening Results - Gasco Property

Boring ID	Boring Depth (ft bgs)	Depths of DNAPL Indication (Alluvial)
TG-1	150.1'	NONE
TG-2	150.3'	28.7'-30.6'
TG-3	150.3'	58.8'-60.6'
TG-4	150.0'	NONE
TG-5	99.1'	51.6'-53.3',57.8'-58.8',59.3'-63.2', 64.8'-65.1'
TG-5A	150.3'	51.3' ?
TG-6	125.5'	NONE
TG-7	150.4'	NONE
TG-8	150.2'	25'-39',41.4'-43.6',44.1'-45.3' 48.7'-48.9',51.5'-52.3',54.9'-61.1'
TG-9	148.2'	27.9'-28.8' (minor-upper silt)
TG-10	150.9'	75.4'-77.4',79.2'-88.2'
TG-11	150.2'	54.5'-56.1',112.3'? (plant/mineral interference?)
TG-12	149.5'	25'-36.8', 40.7'-48.8', 49.6'-49.9', 52.8'-53'
TG-13	101.7' (refusal)	26.5'-35.6' (minor), 35.6'-36.7', 36.7'-43.7' (minor), 43.7'-49.5', 55.3'-68.3'
TG-14	100.5' (refusal)	23'-27.9' (minor), 29.5'-30.8' (minor), 32.3'-32.4' (minor), 33.5'-39.8', 45.7'-46.3'
TG-15	149.4'	143.8'-143.9' (plant/mineral interference?)
TG-16	149.1'	26.5'-27.4', 41'-41.3', 42.5'-46.7', 52.2'-52.5', 57.9', 60.3'-61.2', 78.3'-83.9'

Table: TarGOST DNAPL Presence
Screening Results - Siltronic Property

Boring ID	Boring Depth (ft bgs)	Depths of DNAPL Indication (Alluvial)
TG-1S	151.3'	116.2-118.6'
TG-2S	151'	NONE
TG-3S	150.2'	34'-78' in multiple intervals
TG-4S	150.3'	36.7'-36.9', 62.8'-63.5', 63.8'-65.6', 67.3'-68.6', 79.0'-80.8', 91.8'-93.2', 93.9'-94.5', 98.6'-100'
TG-5S	150.6'	30'-38.6', 40.2'-41.5', 42.9'-44.2'
TG-6S	149.8'	NONE
TG-7S	150.0'	NONE
TG-8S	146.8'	NONE
TG-9S	101.3'	31.2'-48.7', 50.1'-50.5', 73.8'-74.4'
TG-10S	90.5'	NONE
TG-11S	78.5'	30.1'-30.3' (minor-upper silt)
TG-12S	156.0'	33.4'-35', 36.2', 37.2', 94.7'-97.8', 101.3'-101.7', 110.6'-111.6', 113.1'-119.6', 125.5'-127.5', 129.5'-131.4', 132.9'-136.7'



NOTES:
Borings within outlined areas identified the presence of DNAPL at some depth or depth interval within the Alluvial water-bearing zone at depths shallower than 100' bgs. Tables 2 and 3 of *Summary Report - Former MGP Operations and DNAPL Occurrence* (HAI, November 2005) provide a description of the DNAPL presence at each boring. TarGOST ™ = Tar-Specific Green Optical Screening Tool by Dakota Technologies.

Interpreted Extent of DNAPL (visually saturated, well entry, or TarGost ID), May 2011 update.

LEGEND
- Monitoring Well
- Soil Boring
- Property Line (Approximate)
- 2007 TarGost/CPT Boring Locations (TG-Series)
- 2008 TarGost/CPT Boring Locations (TG-Series)

HAHN AND ASSOCIATES, INC.
ENVIRONMENTAL CONSULTANTS
434 NW 6th AVENUE, SUITE 203
PORTLAND, OREGON 97209
503-796-0717

Scale: 1 inch = 250 feet
250 0 250 500
feet

Project No. 2708-5237 REV. MAY 2011

Figure 11
DNAPL Screening with TarGOST 2007 and 2008 Boring Locations Showing Estimated DNAPL within Alluvial - Above 100' BGS

NW Natural and Siltronic Properties
Portland, Oregon

X:\Hahn\Gasco Site 2011\Siltronic Reporting\DNAPL\DNAPL Alluvial Shallow-TarGOST.dwg 5/3/11
01/10/2012 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-005.cdr

SOURCE: Hahn and Associates, Inc.

ANCHOR QEA

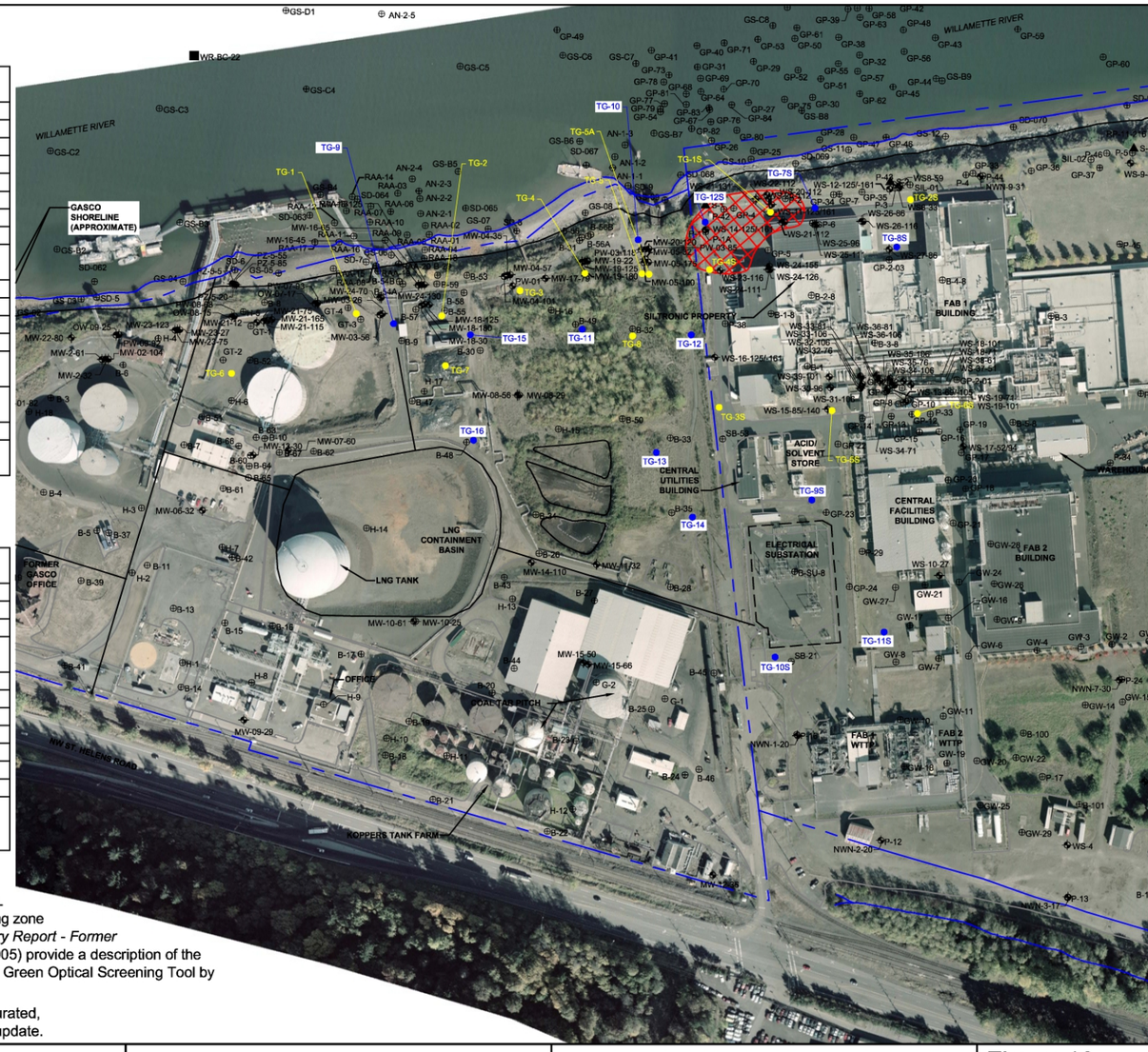
Figure 3-6b
DNAPL Screening with TarGOST 2007 and 2008 Boring Locations Showing Estimated DNAPL within Alluvial - Above 100' BGS
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

Table: TarGOST DNAPL Presence
Screening Results - Gasco Property

Boring ID	Boring Depth (ft bgs)	Depths of DNAPL Indication (Alluvial)
TG-1	150.1'	NONE
TG-2	150.3'	28.7'-30.6'
TG-3	150.3'	58.8'-60.6'
TG-4	150.0'	NONE
TG-5	99.1'	51.6'-53.3',57.8'-58.8',59.3'-63.2', 64.8'-65.1'
TG-5A	150.3'	51.3' ?
TG-6	125.5'	NONE
TG-7	150.4'	NONE
TG-8	150.2'	25'-39',41.4'-43.6',44.1'-45.3' 48.7'-48.9',51.5'-52.3',54.9'-61.1'
TG-9	148.2'	27.9'-28.8' (minor-upper silt)
TG-10	150.9'	75.4'-77.4',79.2'-88.2'
TG-11	150.2'	54.5'-56.1',112.3'? (plant/mineral interference?)
TG-12	149.5'	25'-36.8', 40.7'-48.8', 49.6'-49.9', 52.8'-53'
TG-13	101.7' (refusal)	26.5'-35.6' (minor), 35.6'-36.7', 36.7'-43.7' (minor), 43.7'-49.5', 55.3'-68.3'
TG-14	100.5' (refusal)	23'-27.9' (minor), 29.5'-30.8' (minor), 32.3'-32.4' (minor), 33.5'-39.8', 45.7'-46.3'
TG-15	149.4'	143.8'-143.9' (plant/mineral interference?)
TG-16	149.1'	26.5'-27.4', 41'-41.3', 42.5'-46.7', 52.2'-52.5', 57.9', 60.3'-61.2', 78.3'-83.9'

Table: TarGOST DNAPL Presence
Screening Results - Siltronic Property

Boring ID	Boring Depth (ft bgs)	Depths of DNAPL Indication (Alluvial)
TG-1S	151.3'	116.2-118.6'
TG-2S	151'	NONE
TG-3S	150.2'	34'-78' in multiple intervals
TG-4S	150.3'	36.7'-36.9', 62.8'-63.5', 63.8'-65.6', 67.3'-68.6', 79.0'-80.8', 91.8'-93.2', 93.9'-94.5', 98.6'-100'
TG-5S	150.6'	30'-38.6', 40.2'-41.5', 42.9'-44.2'
TG-6S	149.8'	NONE
TG-7S	150.0'	NONE
TG-8S	146.8'	NONE
TG-9S	101.3'	31.2'-48.7', 50.1'-50.5', 73.8'-74.4'
TG-10S	90.5'	NONE
TG-11S	78.5'	30.1'-30.3' (minor-upper silt)
TG-12S	156.0'	33.4'-35', 36.2', 37.2', 94.7'-97.8', 101.3'-101.7', 110.6'-111.6', 113.1'-119.6', 125.5'-127.5', 129.5'-131.4', 132.9'-136.7'



NOTES:
Borings within outlined areas identified the presence of DNAPL at some depth or depth interval within the Alluvial water-bearing zone at depths shallower than 100' bgs. Tables 2 and 3 of *Summary Report - Former MGP Operations and DNAPL Occurrence* (HAI, November 2005) provide a description of the DNAPL presence at each boring. TarGOST ™ = Tar-Specific Green Optical Screening Tool by Dakota Technologies.

Interpreted Extent of DNAPL (visually saturated, well entry, or TarGost ID), January 2011 update.

LEGEND
- Monitoring Well
- Soil Boring
- Property Line (Approximate)
- 2007 TarGost/CPT Boring Locations (TG-Series)
- 2008 TarGost/CPT Boring Locations (TG-Series)

HAHN AND ASSOCIATES, INC.
ENVIRONMENTAL CONSULTANTS
434 NW 6th AVENUE, SUITE 203
PORTLAND, OREGON 97209
503-796-0717

Scale: 1 inch = 250 feet
250 0 250 500
feet

Project No. 2708-5237 REV. JANUARY 2011

Figure 12
DNAPL Screening with TarGOST 2007 and 2008 Boring Locations Showing Estimated DNAPL within Alluvial - Below 100' BGS

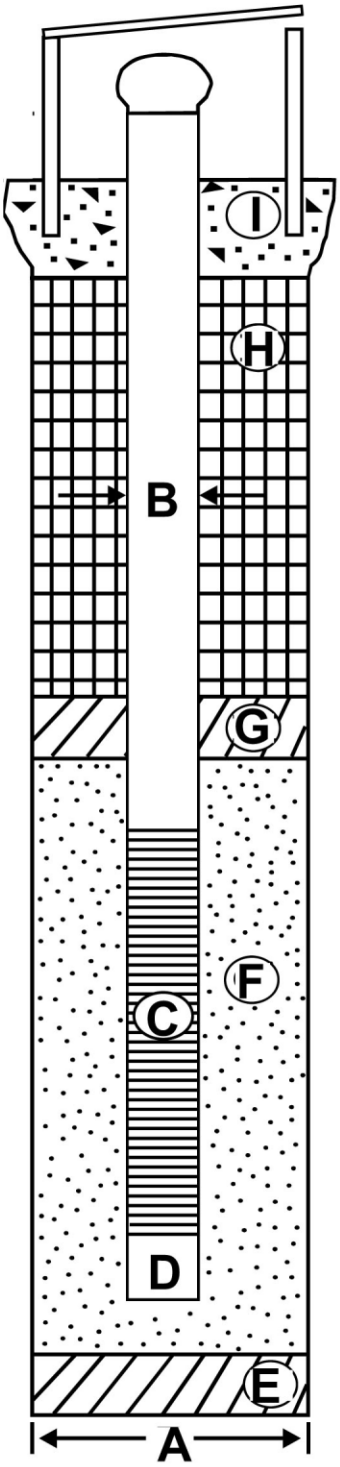
NW Natural and Siltronic Properties
Portland, Oregon

SOURCE: Hahn and Associates, Inc.

X:\Hahn\Gasco Site 2011\Siltronic Reporting\DNAPL\DNAPL Alluvial Deep-TarGOST.dwg 2/24/11 01/10/2012 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-005.cdr

ANCHOR QEA

Figure 3-6c
DNAPL Screening with TarGOST 2007 and 2008 Boring Locations Showing Estimated DNAPL within Alluvial - Below 100' BGS
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



Boring Details

A: 10" diameter casing

Well Construction

B: 6" diameter Steel Riser Pipe

C: 6" diameter Stainless Steel 0.035 slot wire-wrap screen

D: 6" diameter, 5-foot-long steel sump

E:Bentonite Grout / Organoclay if NAPL is present

F: 10x20 Silica Sand Filter Pack

G:Bentonite Chip Filter Pack Seal

H:Bentonite Grout / Organoclay if NAPL is present

I: Cement Grout Surface Seal

01/16/2012 heriksenDRAW figs\IDR\00002902-RP-001.cdr

Figure 3-7
Extraction Well Construction Detail
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

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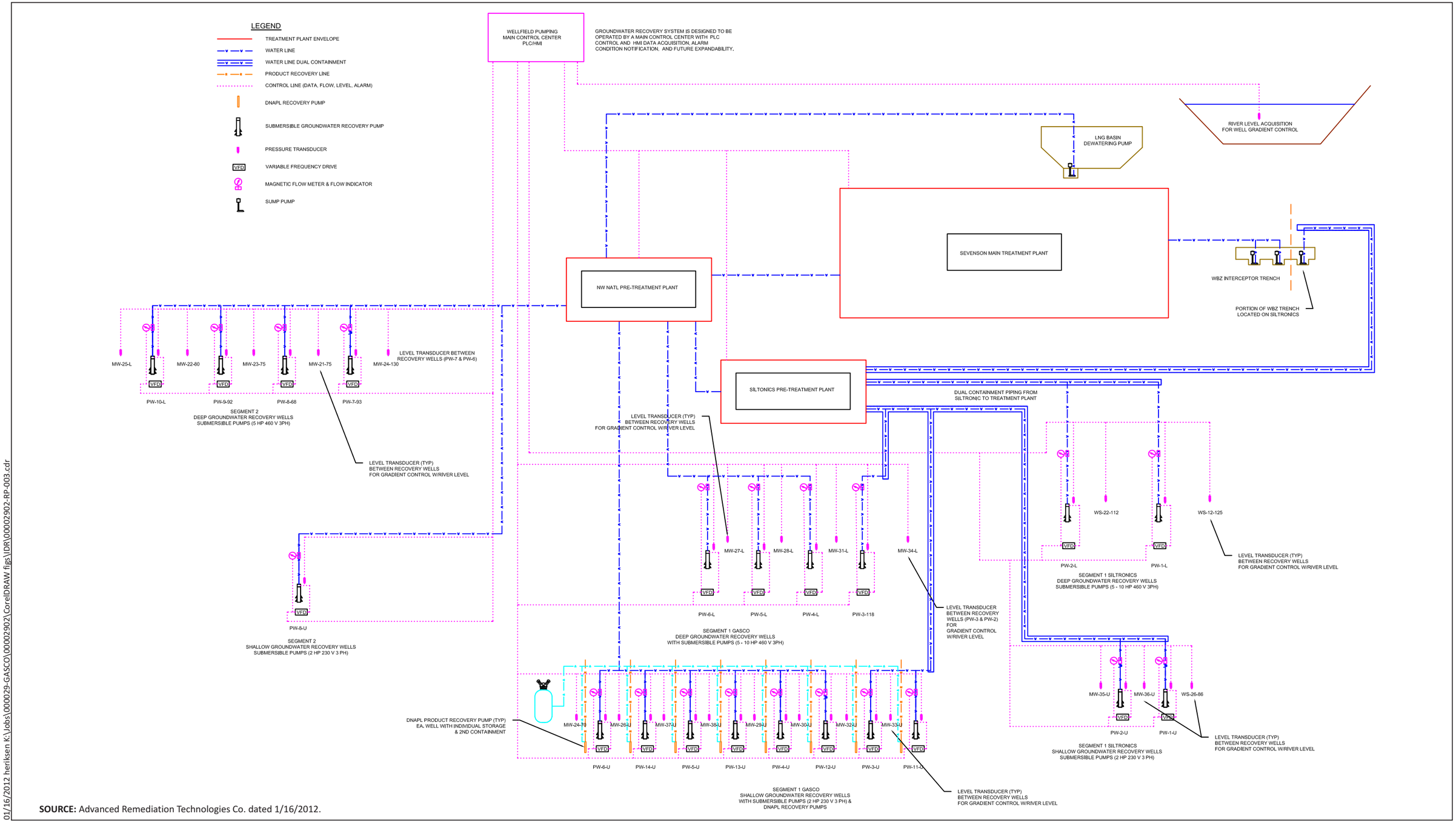

SOURCE: Advanced Remediation Technologies Co. dated 1/16/2012.

01/16/2012 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-003.cdr

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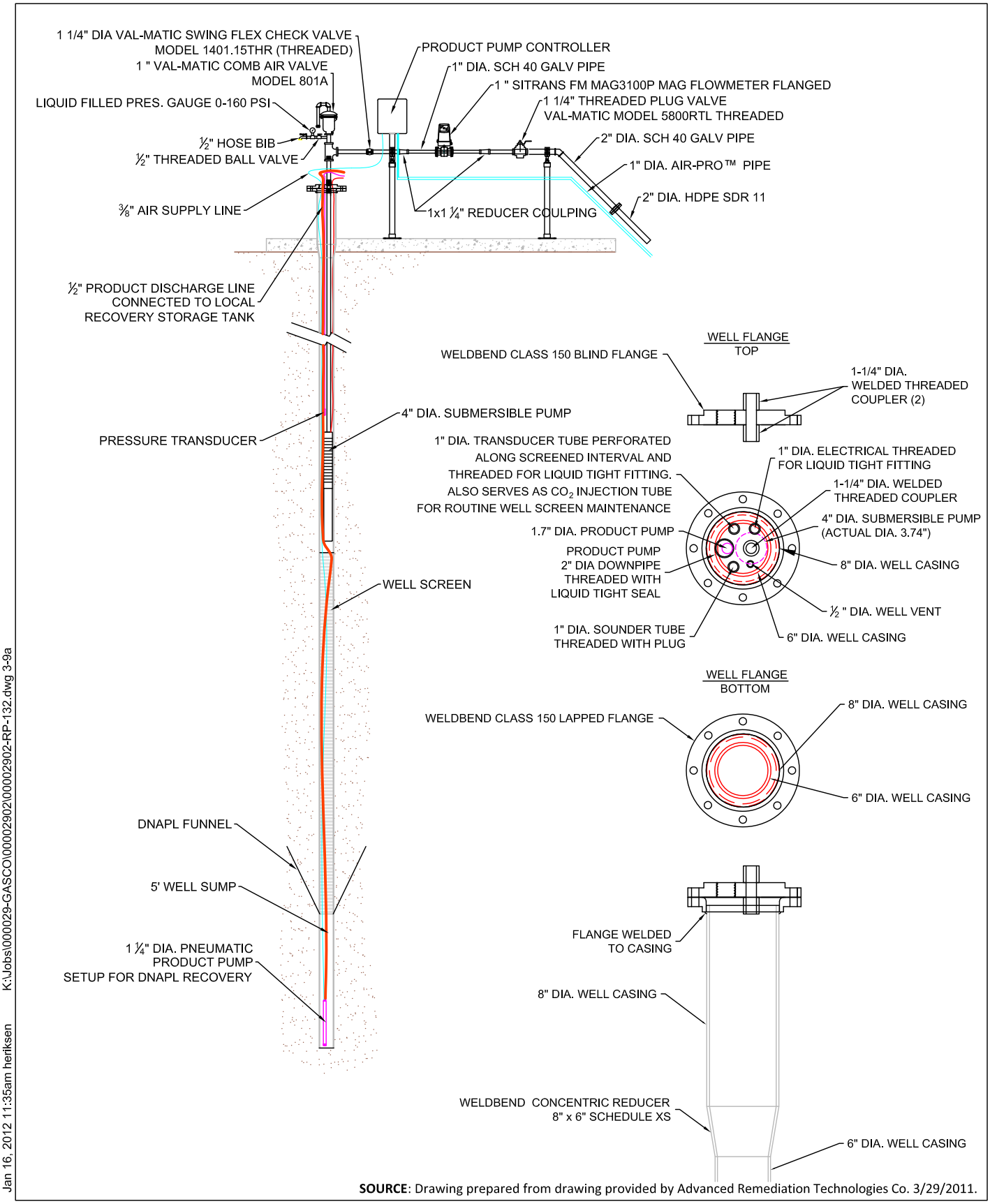
Figure 3-8
Well Field Controls and Piping
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



SOURCE: Drawing prepared from drawing provided by Advanced Remediation Technologies Co. 3/29/2011.

Figure 3-9a

Upper Alluvium Extraction Well with DNAPL Removal System Schematic
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

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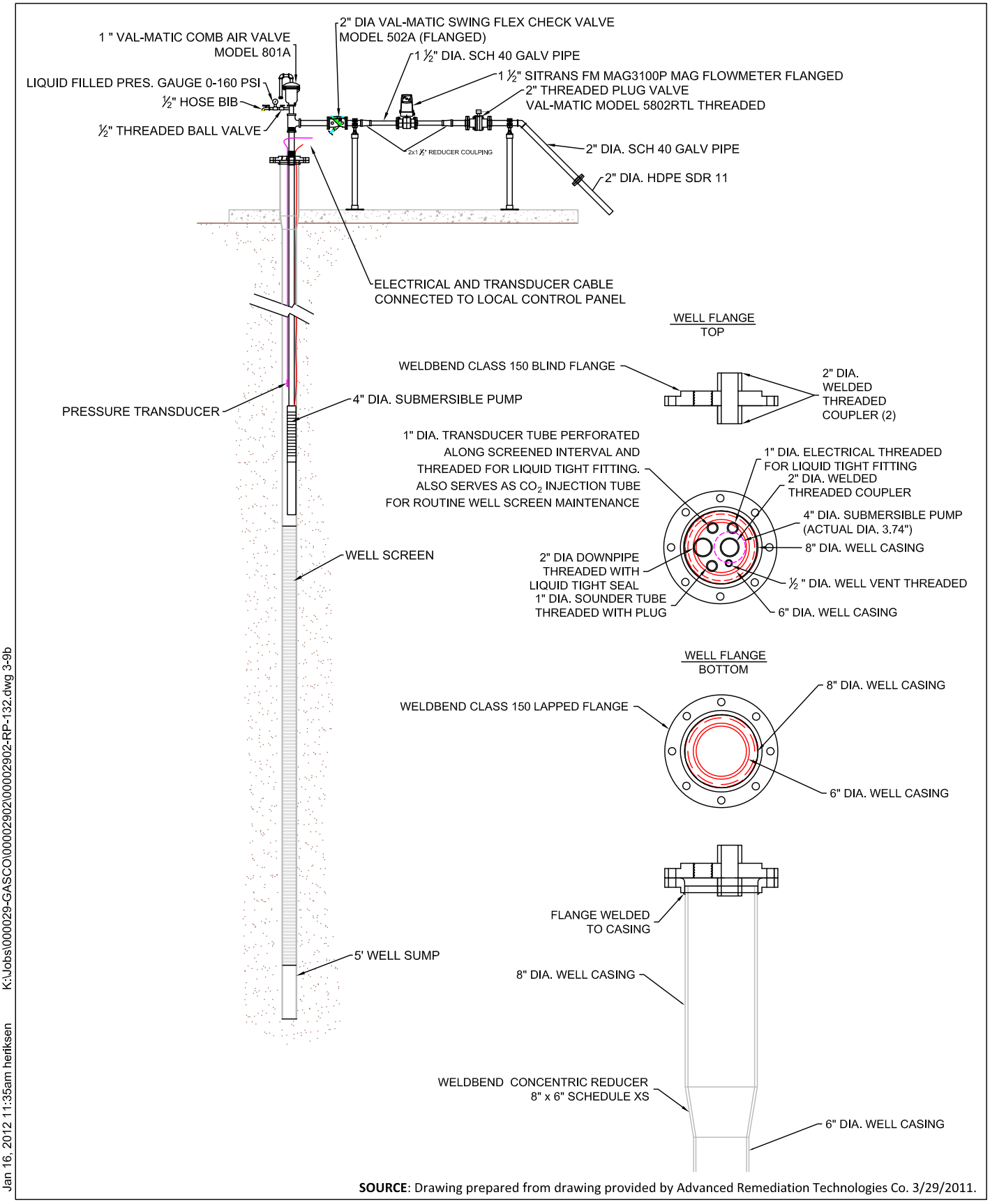
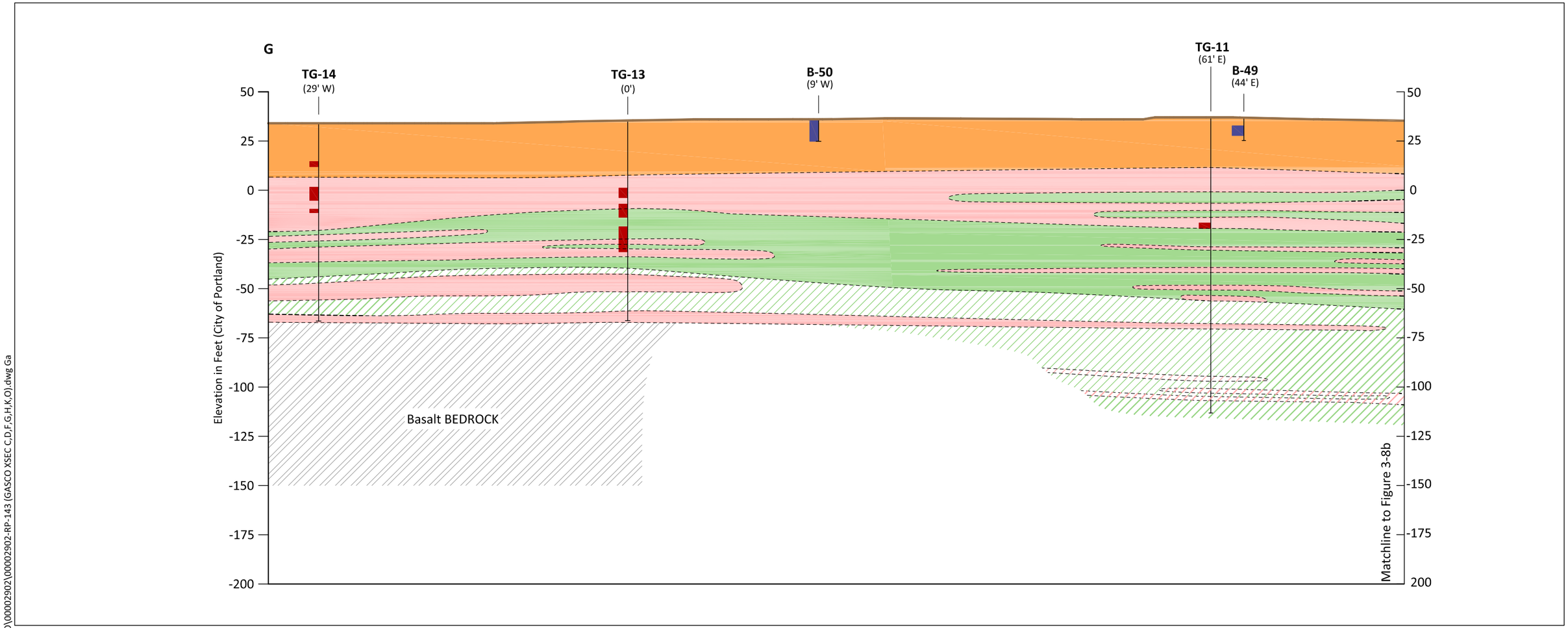


SOURCE: Drawing prepared from drawing provided by Advanced Remediation Technologies Co. 3/29/2011.

Figure 3-9b
Lower Alluvium Extraction Well Schematic
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

ANCHOR QEA



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface

TG-14 — Boring ID
(29' W) — Offset Distance in Feet

Soil Boring or Sediment Core
Proposed Extraction Well
Existing Well or Piezometer

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Well Screen

0 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.

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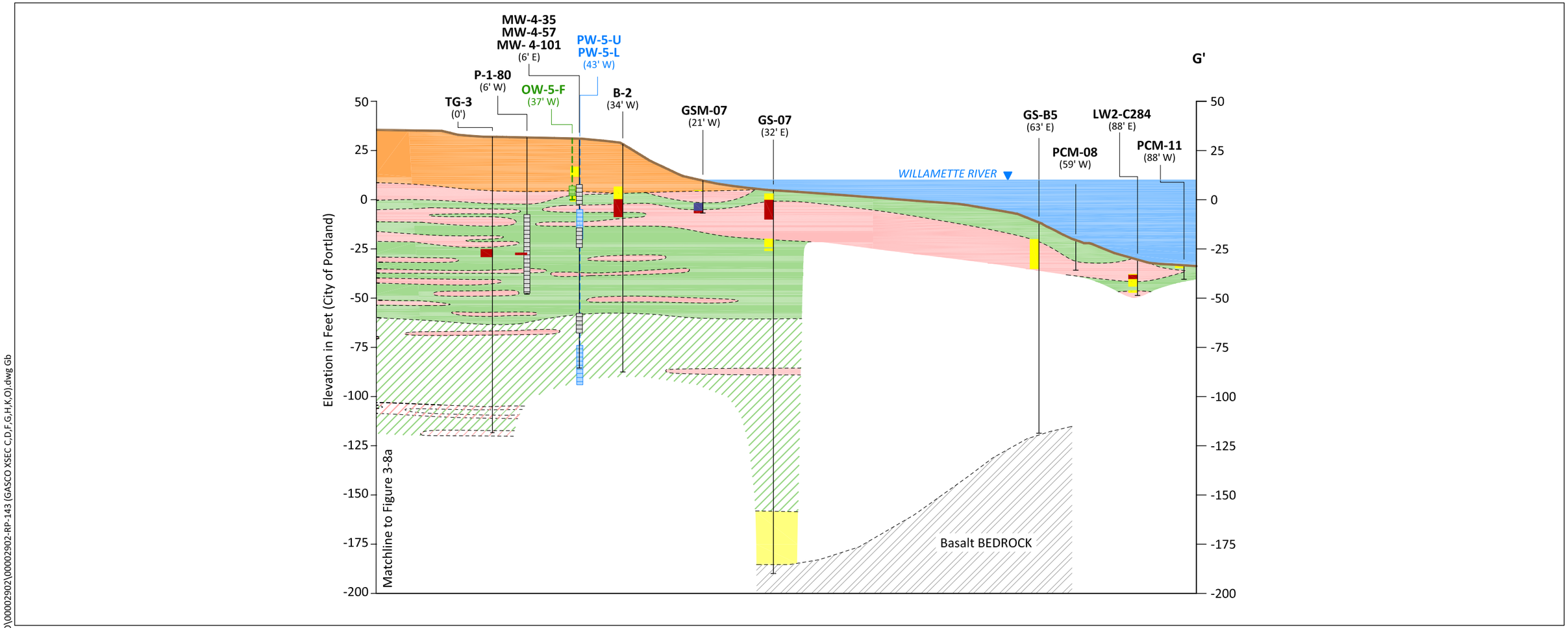
Jan 26, 2012 2:25pm heriksen

ANCHOR QEA

Figure 3-10a
Geologic Cross Section G-G'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface

TG-14 — Boring ID
(29' W) — Offset Distance in Feet

Soil Boring or Sediment Core
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

0 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.

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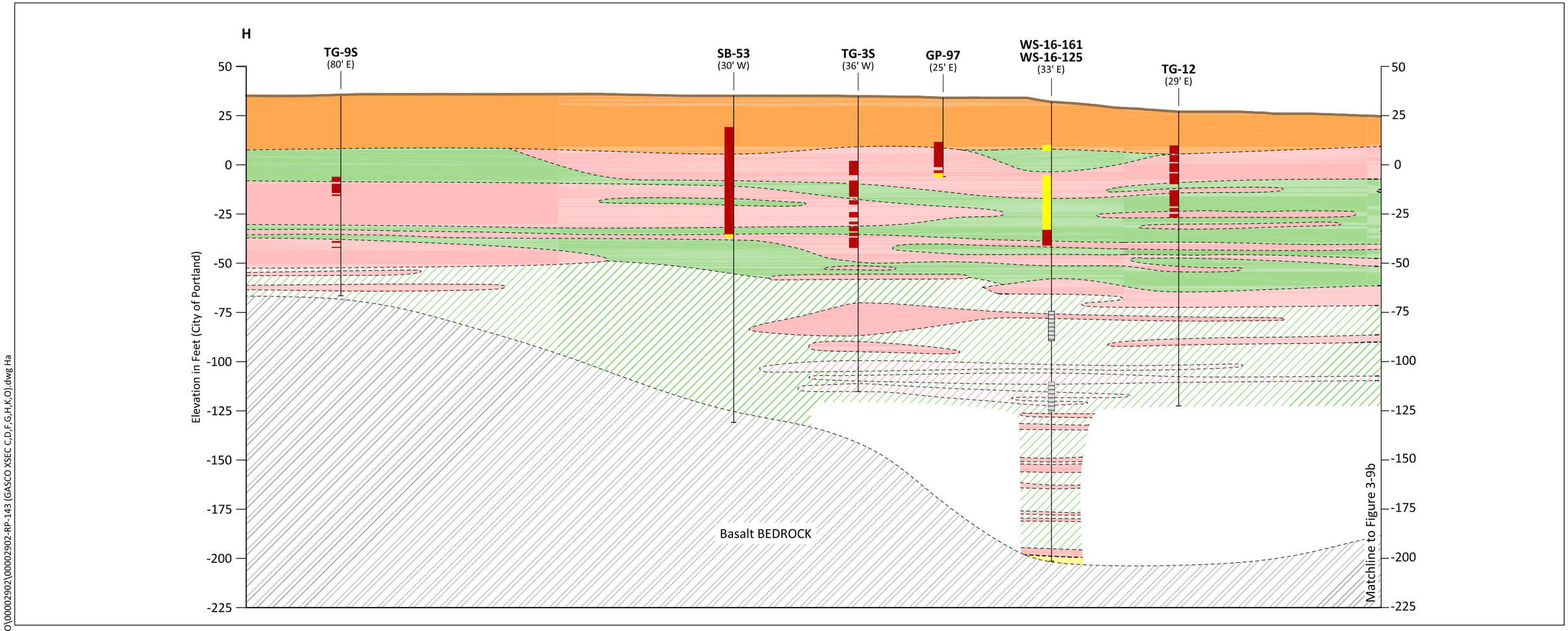
ANCHOR QEA

Figure 3-10b
Geologic Cross Section G-G'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface

TG-12 — Boring ID
(29' E) — Offset Distance in Feet

Soil Boring or Sediment Core
Existing Extraction Well
Proposed Extraction Well
Existing Well or Piezometer

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

0 50
Scale in Feet

NOTES:

1. Geologic contacts are inferred between borings.
2. PW-3-85 was initially intended as an extraction well, but it has been replaced by PW-3U.

* Lithology below 32 feet in depth at MW-5-175 not used for cross section interpretation.

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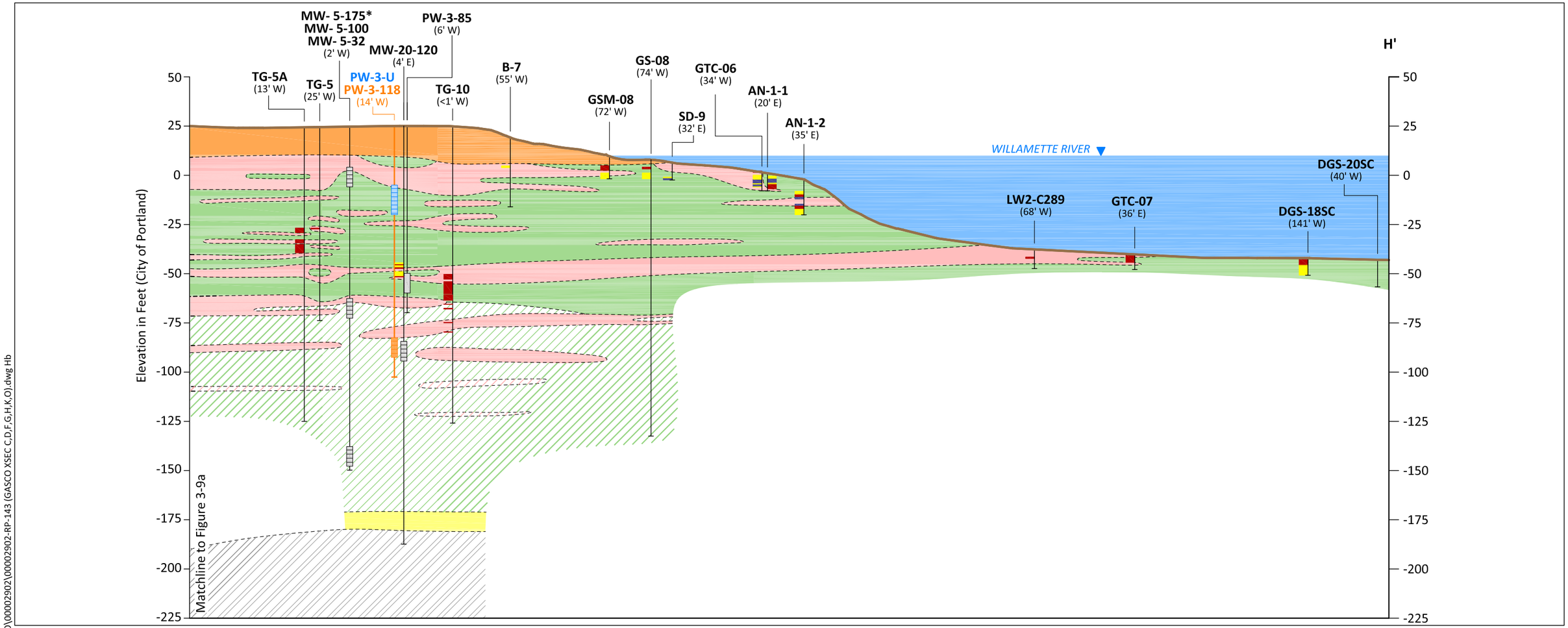
Figure 3-11a
Geologic Cross Section H-H'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- 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
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface

TG-12 — Boring ID
(29' E) — Offset Distance in Feet

Soil Boring or Sediment Core
Existing Extraction Well
Proposed Extraction Well
Existing Well or Piezometer

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

0 50
Scale in Feet

NOTES:

1. Geologic contacts are inferred between borings.
2. PW-3-85 was initially intended as an extraction well, but it has been replaced by PW-3U.

* Lithology below 32 feet in depth at MW-5-175 not used for cross section interpretation.

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ANCHOR QEA

Figure 3-11b
Geologic Cross Section H-H'
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

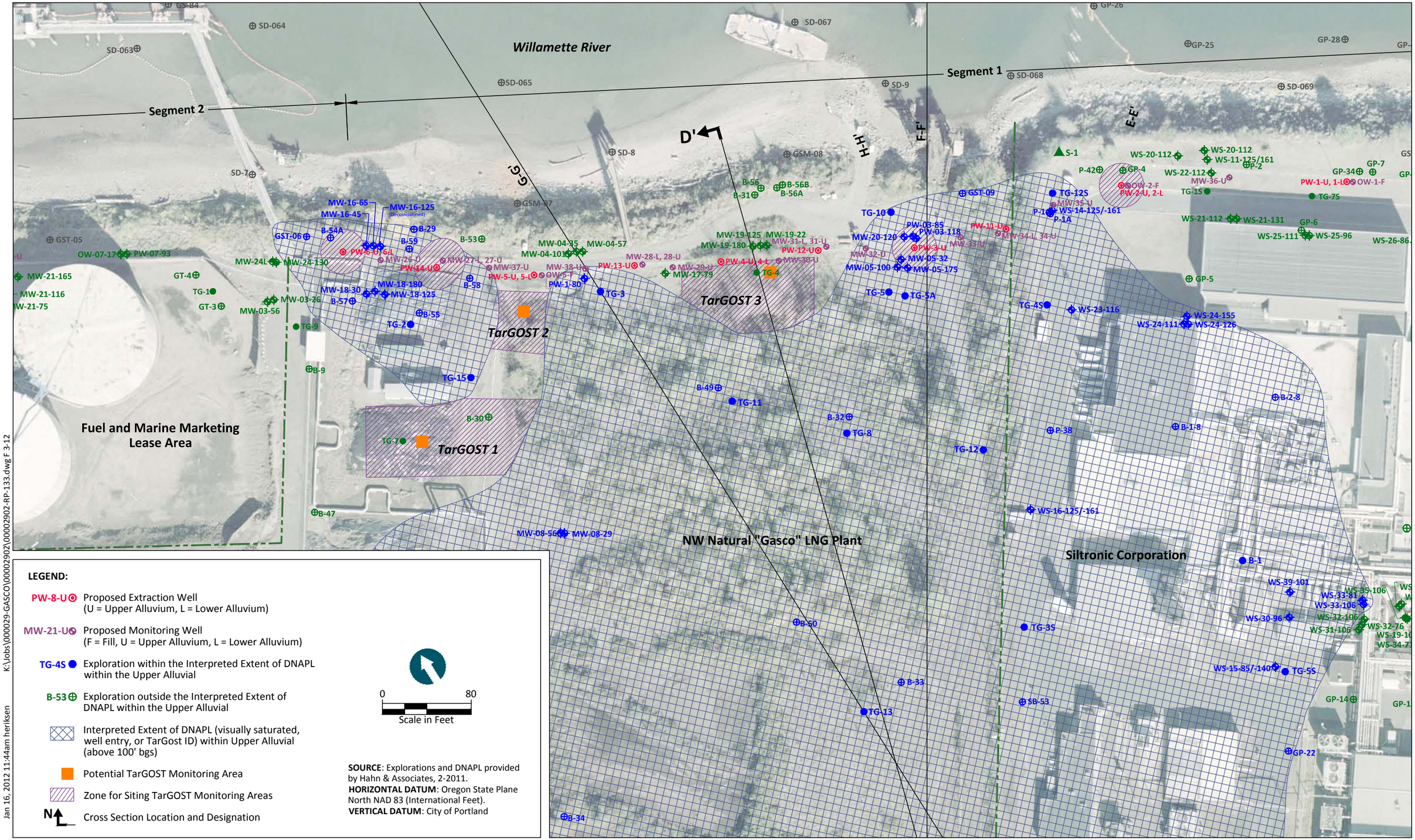

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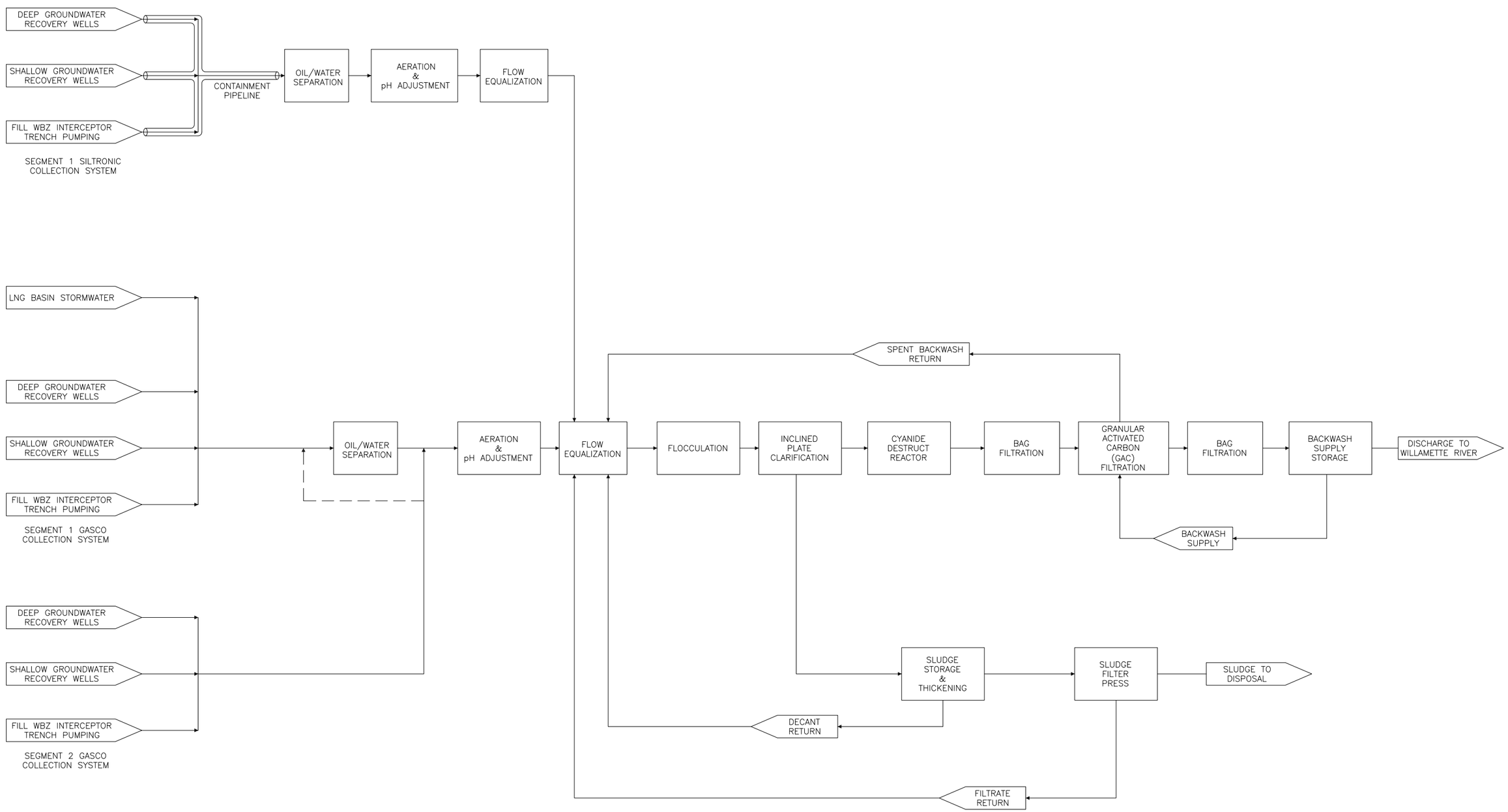
Figure 3-12
TarGOST Screening Locations
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control



SOURCE: ADA, Inc.

01/16/2012 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-006.cdr

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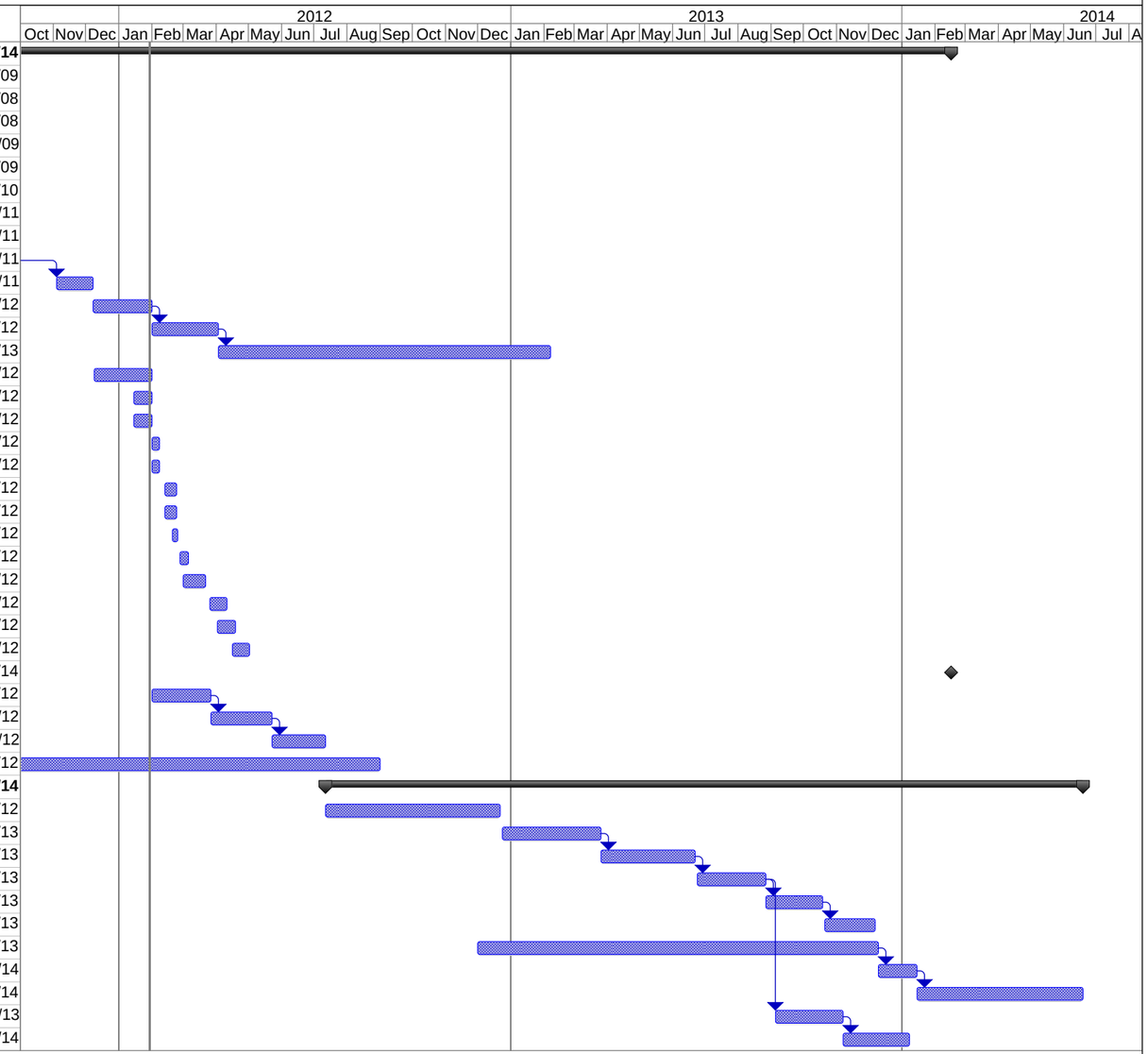
Figure 3-13
Groundwater Treatment System Process Flow Diagram
Revised Groundwater Source Control Construction Design Report
Gasco Groundwater Source Control

Figure 5-1
Gasco Source Control Planning Schedule

ID	Task Name	Duration	Start	Finish
1	**Groundwater/DNAPL Source Control Design**	**1557 days?**	**Wed 4/2/08**	**Sat 2/15/14**
2	Conduct Design Level Studies	210 days	Mon 3/23/09	Thu 12/31/09
3	Prepare Preliminary Design	65 days?	Wed 4/2/08	Mon 6/30/08
4	DEQ/EPA Review Preliminary Design	39 days?	Tue 7/1/08	Fri 8/22/08
5	Prepare Interim Design	323 days	Mon 8/25/08	Fri 11/6/09
6	Treatment Pilot Test	80 days?	Wed 7/1/09	Fri 10/16/09
7	DEQ/EPA Review Interim Design	103 days	Mon 11/9/09	Fri 3/26/10
8	Prepare Draft Final Design Report	50 days?	Tue 3/1/11	Sun 5/8/11
9	Submit Draft Final Design to DEQ	1 day?	Mon 5/9/11	Mon 5/9/11
10	DEQ Review	98 days?	Tue 5/10/11	Thu 9/22/11
11	DEQ Review Design Proposal	24 days?	Fri 11/4/11	Wed 12/7/11
12	Prepare Revised Treatment System Design Report	40 days?	Thu 12/8/11	Tue 1/31/12
13	DEQ Review Revised Treatment System Design Report	44 days?	Wed 2/1/12	Mon 4/2/12
14	Order Treatment System Materials and Construct System	224 days?	Tue 4/3/12	Wed 2/6/13
15	Prepare Construction Design Report	39 days	Fri 12/9/11	Tue 1/31/12
16	Prepare Upper Alluvium Extraction Well Design Work Plan	13 days?	Sun 1/15/12	Tue 1/31/12
17	Prepare Baseline DNAPL and Groundwater Quality Monitoring Work Plan	13 days?	Sun 1/15/12	Tue 1/31/12
18	DEQ Review and Approve Upper Alluvium Extraction Well Work Plan	5 days	Wed 2/1/12	Tue 2/7/12
19	DEQ Review and Approve Baseline DNAPL and Groundwater Quality Monitoring Work Plan	5 days	Wed 2/1/12	Tue 2/7/12
20	Collect Soil Samples for Grain Size Analysis	9 days	Mon 2/13/12	Thu 2/23/12
21	Advance Baseline TarGOST Borings for DNAPL Monitoring	9 days	Mon 2/13/12	Thu 2/23/12
22	Laboratory Analysis of Grain Size Samples	5 days	Mon 2/20/12	Fri 2/24/12
23	Install Upper Alluvium Monitoring Wells	6 days	Mon 2/27/12	Mon 3/5/12
24	Order Well Screen and Filter Pack Sand	15 days	Thu 3/1/12	Wed 3/21/12
25	Install PW-2-U, PW-3-U, PW-5U, and PW-6-U	12 days	Mon 3/26/12	Tue 4/10/12
26	Well Development and Step Tests	13 days	Mon 4/2/12	Wed 4/18/12
27	Input Step Test Results into Model	12 days?	Mon 4/16/12	Tue 5/1/12
28	POTW Discharge Permit Expiration	1 day	Sat 2/15/14	Sat 2/15/14
29	DEQ Review Construction Design Report	39 days	Wed 2/1/12	Mon 3/26/12
30	Revise Construction Design Report	41 days	Tue 3/27/12	Tue 5/22/12
31	DEQ Review and Approve Construction Design Report	36 days	Wed 5/23/12	Wed 7/11/12
32	NPDES Permit Process with Public Comment	409 days?	Mon 2/14/11	Fri 8/31/12
33	**Construction of Groundwater DNAPL Source Controls**	**508 days?**	**Thu 7/12/12**	**Wed 6/18/14**
34	Construct and Test Extraction Well System	119 days	Thu 7/12/12	Fri 12/21/12
35	Prepare Operations and Performance Monitoring Design Report	66 days?	Mon 12/24/12	Mon 3/25/13
36	DEQ Review Operations and Performance Monitoring Design Report	64 days	Tue 3/26/13	Fri 6/21/13
37	Revise Operations and Performance Monitoring Design Report	46 days?	Mon 6/24/13	Mon 8/26/13
38	DEQ Review and Approve Operations and Performance Monitoring Design Report	39 days	Tue 8/27/13	Fri 10/18/13
39	DEQ Short Report	36 days?	Mon 10/21/13	Fri 12/6/13
40	Conduct Baseline DNAPL Monitoring in Wells and Groundwater Quality Monitoring	268 days?	Sat 12/1/12	Mon 12/9/13
41	Startup Extraction and Treatment System	26 days?	Tue 12/10/13	Tue 1/14/14
42	DEQ Source Control Determination to EPA	111 days	Wed 1/15/14	Wed 6/18/14
43	Prepare Work Plan for Evaluation of Fill WBZ Interceptor Trench Construction Alternatives	45 days	Thu 9/5/13	Wed 11/6/13
44	DEQ Review Work Plan for Evaluation of Fill WBZ Interceptor Trench Construction Alternatives	45 days	Thu 11/7/13	Tue 1/7/14



Project: Gasco Source Control Planning Schedule
Date: Mon 1/30/12

Task		Rolled Up Progress		Inactive Task		Manual Summary Rollup		Deadline	
Milestone		Split		Inactive Milestone		Manual Summary			
Summary		Completed Tasks		Inactive Summary		Start-only			
Rolled Up Task		Project Summary		Manual Task		Finish-only			
Rolled Up Milestone		Group By Summary		Duration-only		Progress			

APPENDICES

(on CD)