APPENDIX 2C
Previous Environmental Investigations

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APPENDIX 2C
PREVIOUS ENVIRONMENTAL INVESTIGATIONS

Numerous investigations of upland and sediment conditions associated with the Area of Investigation (AOI) have been conducted since the 1970s. Table 2C-1 provides a summary; further details are discussed below.

Environmental assessments related to the upland portion of the AOI began in the early 1970s during planning and development of Gas Works Park. These investigations, sponsored primarily by the City of Seattle (City), supported planning for park design and development, including demolition and disposal of hazardous materials.

A 1984 United States Environmental Protection Agency (EPA) investigation of Lake Union sediment adjacent to the park (Hileman et al. 1985) found elevated concentrations of polycyclic aromatic hydrocarbons (PAHs), metals and other contaminants. EPA investigations of soil and groundwater (Ecology & Environmental 1984) in the park established that PAHs, metals, and volatile organic compounds (VOCs) were present, in many cases at elevated concentrations. Public health concerns regarding exposure to tar and PAHs in surface soil resulted in temporary closure of the park in April 1984 followed by a public health evaluation that same year (Kalman 1984; Ongerth 1985).

The City reopened the park and, in the interest of public safety, undertook a broader assessment of contamination in park soil and groundwater. Several investigations of soil and groundwater were conducted over the next few years, with oversight by the City and input from the United States Geological Survey (USGS) on the groundwater investigation approach (Tetra Tech 1985a, b, c; 1987a, b). This work helped form an initial conceptual hydrogeologic model for the AOI, which USGS later refined when reevaluating existing data (Sabol et al. 1988).

In 1985, Ecology selectively resampled sediment that EPA had sampled in 1984, partly to address an error[1] in the reporting of analytical data. Focusing on a single location with the highest reported PAH concentration, Ecology also tested the use of a Triad[2] approach in assessing the toxicity of PAHs to benthic invertebrates living in freshwater sediment (Yake et al. 1986).

As part of the City's continuing evaluation of contamination in the park, HDR (1988) conducted a focused field investigation with a threefold purpose:

- Continue monitoring upland groundwater quality, including areas not previously monitored in the park.
- Assess the feasibility of groundwater treatment.
- Determine the feasibility of installing and operating an irrigation system at the park that would limit the contribution of irrigation water to groundwater.

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[1] EPA 1984 sediment data were normalized to dry weight (dw) twice, resulting in values that were higher than actual by a factor of 3 to 7 (Yake et al. 1986).

[2] A Triad approach is based on benthic community structure, sediment chemistry and sediment toxicity to evaluated impacts to surface sediment quality.

This study confirmed that a low-permeability glacial till layer that limits downward migration of groundwater was present below the AOI. Three contaminant plumes in the shallow groundwater above this till layer were also identified: one west of the Play Barn, one south of the Play Barn and one in the northwest corner of the park. It was suspected that the plume south of the Play Barn, which contained light oil and associated benzene, was migrating to Lake Union along the southeastern shoreline. PSE and the City later constructed an air sparging/soil vapor extraction (AS/SVE) groundwater remediation system in this area (see further discussion below and in Section 2).

The City installed an irrigation system following HDR's (1988) recommended design (Graves 2011) that uniformly distributed irrigation water and automatically stopped watering when moisture content immediately below the rooting zone reached a specified threshold. By not generating excess water, the irrigation system would thus have no effect on the movement of contaminated groundwater. HDR (1989) also conducted additional geophysical surveys, treatability studies and modeling in support of the City's management of upland contamination.

In 1992, Ecology collected surface sediment from Lake Union and adjacent areas of the Ship Canal and Lake Washington to document general chemical and biological conditions. Data from the two sampling stations located within the AOI sediment area continued to demonstrate elevated concentrations of PAHs in sediment relative to other areas of Lake Union (Cubbage 1992).

In 1995, EPA completed an expanded investigation of sediment adjacent to the park, using a sampling design similar to that of the 1984 effort (Hileman et al. 1985). Several seep and bank sediment samples were also collected. Corrected data from the 1984 investigation were also provided as part of this study. Results indicated that PAHs continued to be elevated relative to both background levels and effects-based sediment chemical criteria.[3]

In 1997, the City and Puget Sound Energy (PSE) began a focused feasibility study (FS) to address the former light-oil plant and associated benzene plume and contamination associated with the former American Tar Company (ATCO) refinery (Parametrix and Key Environmental 1998) resulting in a cleanup action plan for contaminated upland media. Supporting studies included soil sampling, groundwater monitoring, and fate and transport modeling of contaminants in the western part of the AOI upland (Attachment 2C-1) as well as additional evaluation of the benzene plume in the southeastern part of the AOI upland (RETEC 1998). Detailed descriptions of cleanup actions are provided in Section 2.2 of the remedial investigation (RI).

PSE undertook sediment investigations in North Lake Union to determine the extent of PAHs and metals and to support evaluation of various sediment remedies. In 1999, surface and subsurface sediment was analyzed for a broad suite of contaminants, as well as physical properties. Lake bottom conditions and the potential presence of debris were evaluated using side-scan sonar and video surveys. In this study, PAH contamination within the sediment was greater at depth than at the surface in most areas, and concentrations in both surface and subsurface sediment generally decreased with distance from the upland. Most of the contamination appeared confined to the lake's upper geologic units (lake sediment and glacial outwash) and did not extend into the underlying glacial till. The second phase of study was conducted in 2002. These first two phases of sediment investigation were site-wide studies and provided data to identify the initial area of investigation for sediment for the 2005 Agreed Order. Subsequently, the

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[3] Effect-based sediment criteria are threshold concentrations defining either no effects or low effects to benthic invertebrates (e.g., clams, worms) that live in the sediment.

sediment area was divided approximately in half. In 2004/2005 PSE undertook the investigation of the eastern half (eastern study area or ESA) and the City conducted a series of investigations of the western half (western study area or WSA). This series of studies culminated in two draft RI/FS reports. Data and other evaluations from these RIs have been incorporated into this comprehensive RI (see Table 2C-1 for individual studies).

In addition to the three phases of study conducted by the City and PSE of lake sediment, supplemental studies to provide detailed source characterization, augment the nature and extent of subsurface contamination in the WSA, and evaluate the microscopic make-up of sediment were conducted (Attachments 2D-1 through 2D-6 and 2D-8 in Appendix 2D). Results from these supplemental studies are incorporated in Section 2.1 of the RI.

In a document prepared by RETEC in 2005 called Cleanup Standards Determination (included as Appendix 4C) , PSE and the City proposed a site-specific cleanup level for total PAH (TPAH) and proposed an active remediation. The active remediation area roughly followed the 170 milligrams per kilogram (mg/kg) TPAH contour and encompassed bioassay failures within the AOI.

Upland environmental investigations continued after remediation of upland media. A 2004 study of surface and subsurface soil in the northwest corner of the park found that planned improvements and public access could be constructed in this vicinity without increasing health risks to park users (Parametrix 2004). A similar investigation was conducted in 2005 for soil within the fenced area around the Cracking Towers (Lillie 2005). Then in 2005, the City investigated the western shoreline of the park to evaluate potential pathways by which contaminants could migrate to sediment (see Attachment 2C-2). Work included installation of monitoring wells and aquifer testing that was later used to support groundwater flow model development (Appendix 3F).

Investigations of the northeastern meadow (Floyd|Snider 2008) and eastern shoreline area (ENSR/AECOM 2008) were conducted by the City and PSE in 2007. These studies were designed to provide additional information about subsurface dense nonaqueous phase liquid (DNAPL) to support development of remedies in the eastern portion of the park and to help the City evaluate potential tar exposures within the park.

Floyd|Snider sampled air at locations within Gas Works Park and Harbor Patrol during three quarterly monitoring events in 2007 and 2008 (Appendix 4D, Attachment 4D-2) to evaluate the potential impacts of soil gas on air quality. Results showed that the VOC concentrations were below levels that are protective of park users and park workers.

In 2010, GeoEngineers and Aspect Consulting (GeoEngineers 2010) installed six wells in the park and collected additional hydrogeologic data in support of developing a site-wide, three-dimensional (3D) numerical groundwater flow model. It was this study that resulted in a reinterpretation of the geologic and hydrogeologic conceptual site model (CSM) as discussed in Section 3 of the RI.

A relatively recent environmental study occurred in 2013, when GeoEngineers conducted a supplemental investigation (SI) of upland media to support completion of this site-wide RI/FS. Specific objectives included evaluation of potential source areas, assessment of impacted soil and groundwater to characterize the upland-to-sediment migration pathway, and investigation of nonaqueous phase liquid (NAPL) occurrence and stability. The SI data report is included as Appendix 2A to this RI report.

A series of investigations were subsequently conducted in the Play Area in response to the discovery of elevated arsenic concentrations in groundwater and soil during the 2013 SI. Focused investigations of the Play Area took place in 2014 and 2016 when additional soil and groundwater sampling and analyses were used to delineate the area impacted by arsenic (Appendix 2B-1 and Appendix 2B-3). Data from the 2014 investigation were used in a geochemical fate and transport evaluation of arsenic in the Play Area in 2015 (Appendix 2B-2). Bench scale tests to evaluate the performance of iron-based amendments for arsenic treatment were conducted. Results supported the design and construction of a groundwater injection treatment system. The injection system and groundwater monitoring network were constructed in 2017 and began operation as an Interim Action for groundwater treatment. Three rounds of injections of amendments have taken place since the system was installed (October 2017, June/December 2018 and October 2019). Groundwater samples within and downgradient of the treatment area have been collected and analyzed. The Play Area Interim Action was discontinued following the December 2020 groundwater monitoring event (GeoEngineers 2021). Data from samples collected from wells downgradient of the treatment system in December 2020 are used to characterize groundwater quality in the RI.

REFERENCES

AMEC. 2010. Groundwater Compliance Monitoring Report, Gas Works Park Site, Seattle, Washington.

AMEC. 2012. Soil Investigation at the Proposed Children's Play Area and Lead and Asbestos Survey of the Play Barn Structure.

Analytical Resources, Inc (ARI). 2003a. Laboratory Report RE: Client Project GWPSS/GJRW1-04403-963. ARI Project FJ19.

ARI 2003b. Laboratory Report RE: Client Project: Lake Union Sediment Investigation/N005443, ARI Project: FJ41.

ARI 2003c. Laboratory Report RE: Client Project: Lake Union Sediment Investigation/N005443, ARI Project: FJ42.

Anchor QEA, LLC. 2016. Arsenic Treatability Study Report, Gas Works Park. December 2016

Applied Geotechnology, Inc. 1993. Draft Remedial Investigation/Feasibility Study, Facilities North Site, Seattle, Washington.

Aspect Consulting, LLC. 2012. Hydrogeologic Testing Report, Gas Works Sediment Area (GWSA).

Battelle. 2003. Laboratory Report RE: Lake Union Sediment Chemistry Study Raw Data Submittal to Riddell Williams P.S.

Battelle. 2007. Data Report, Gas Works Park Soils February 2007.

Barnes, RS, and WR Schell. 1973. "Physical Transport of Trace Metals in the Lake Washington Watershed." *Cycling and Control of Metal, Natural Environmental Resources Center* NSF-EPA (PB-216184).

Brooks, RJ. 1972. "Letter to Richard Haag Associates regarding results of soil sample analyses for arsenic." December 11, 1972.

Cole, Dale W, and Peter S Machno. 1971. Myrtle Edwards Park-A Study of the Surface and Subsurface Soil Materials.

City of Seattle. 1973. Personal communication (Letter from Robert Gulino, City of Seattle, to EJ Ferrero of Parks and Recreation, regarding soils investigations for sewer line route). City of Seattle.

Cubbage, J. 1992. A Survey of Contaminants in Sediment in Lake Union and Adjoining Waters (Salmon Bay, Lake Washington Ship Canal, and Portage Bay). Washington State Department of Ecology.

EcoCompliance. 2007-2009. Groundwater Monitoring Reports.

Ecology & Environment, Inc. 1984. Gas Works Park – Summary of Results.

Ecology & Environment, Inc. 2009. Northlake Shipyard Sandblast Grit Study.

ENSR/AECOM. 2008. Gas Works Park Eastern Shoreline Investigation Data Report.

Floyd|Snider. 2007a. First Quarter (Spring) 2007 Air Sampling Results Data Report.

Floyd|Snider. 2007b. Second Quarter (Summer) 2007 Air Sampling Results Data Report.

Floyd|Snider. 2008a. Gas Works Park – NE Corner Investigation Data Report. Prepared for the City of Seattle. April 2008.

Floyd|Snider. 2008b. Memorandum to Pete Rude, City of Seattle, regarding MW-9 Chemistry Analysis Results — Gas Works Park. May 5, 2008.

Floyd|Snider. 2008c. Third Quarter (Winter) 2008 Air Sampling Results Data Report.

Floyd|Snider. 2009. Gas Works Sediment Area - Initial Source Control Screening Investigation of Storm Drains.

Floyd|Snider. 2010a. Gas Works Park – Storm Drain Source Control Evaluation Phase 3 Data Report.

Floyd|Snider. 2010b. Gas Works Sediment Area – Gas Works Park Northeast Corner Source Control Data Report.

Frost, F, J Lee, and M McCallum. 1984. Analysis of Chemical Contaminants in Lake Union and Lake Washington Crayfish. Seattle-King County Health Department.

Garry Struthers Associates, Inc. 1999. Police Harbor Patrol UST Site Assessment Report. Seattle UST Central Group.

GeoEngineers, Inc. 1991. Report of Environmental Sampling, Unimar Yard 1 Dry Dock Facility, Lake Union, Seattle, Washington.

GeoEngineers, Inc. 2002. Report - Limited Geotechnical Engineering Services - Tower Foundation Condition Evaluation.

GeoEngineers, Inc. 2010. Monitoring Well Installation Report, Gas Works Sediment Area, Seattle, Washington.

GeoEngineers, Inc. 2021. Play Area Interim Action Monitoring Report, Gas Works Park Site, Seattle, Washington. August 13, 2021.

Graves, David. 2011. Irrigation Water and Groundwater. Gas Works Sediment Area Ecology Meeting Minutes.

Hart Crowser, Inc. 1992. Sediment Monitoring Program Results, Lake Union Drydock Company, Seattle, Washington.

Hart Crowser, Inc. 2014. Construction Completion Report, Sandblast Grit Removal, Interim Remedial Action, Northlake Shipyard Site.

Hansen, L, T Georgianna, D Houck, and J Frodge. 1994. Lake Union Data Compilation and Review.

HDR. 1988a. Focused Field Investigation and Irrigation Feasibility Study, Gas Works Park, Seattle, Washington.

HDR. 1988b. Environmental Testing for Gas Works Park Play Barn, Investigation Report.

HDR. 1989. Groundwater Contaminant Migration Control System Conceptual Design Report.

Hileman, J, J Anderson and J Yearsley. 1985. Lake Union Sediment Investigation: Seattle, Washington, March 20-21, 1984. U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

Jack, R. 2009. "King County database results for Lake Union sediments." August-October 2009.

Kalman, David. 1984. “Gas Works Park Surface Soil Contamination Survey.” June 18, 1984.

Lillie, John LG, LHG. 2005. “Letter of Findings - Cracking Tower Sampling.” July 25, 2005.

Manchester Environmental Laboratory. 2011a. Hydrogeological Investigation Gas Works Park, Case Narrative.

Manchester Environmental Laboratory. 2011b. Kite Hill and Transformer Pad, Case Narrative.

META. 2001. Environmental Laboratory Report, Gas Works Park and Lake Union Sediment.

North Creek Analytical. 1997. Appendix J Data from Tar Investigation and Removal [In]Parametrix and Key Environmental Draft Gasworks Park Environmental Cleanup Focused Feasibility Study Report, Volumes 1 and 2.

Ongerth, JE. 1985. “Draft Evaluation of Health Risk for Public Use of Gas Works Park.” Department of Environmental Health, University of Washington, The Gas Works Parks Risk Evaluation Panel, appointed by Charles Royer, Mayor, Seattle, Washington. April 4, 1985.

Parametrix, Inc. 1999. Gas Works Park Environmental Cleanup, Cleanup Action Plan and SEPA Checklist, Volume 4 (Volume 4 of FFS) Includes ThermoRetec 1999 Memorandum to the Department of Ecology Re: Extremely Hazardous Waste.

Parametrix, Inc. 2004. Soil Testing Results - Proposed Northwest Corner Improvements Project, Gas Works Park, Seattle, Washington.

Parametrix, Inc., and Key Environmental. 1998. Draft Gas Works Park Environmental Cleanup, Focused Feasibility Study Report Volumes 1 and 2.

Puget Sound Air Pollution Control Agency (PSAPCA). 1984. Gas Works Park Air Toxics Study.

RETEC. 1998. Technical Memorandum – Evaluation of Air Sparging as a Potential Interim Remedial Action at Gas Works Park.

RETEC. 2001-2007. Quarterly Groundwater Monitoring Reports Submitted to Ecology in Compliance with the 1999 Consent Decree.

RETEC. 2002b. North Lake Union Sediment Investigation Report.

RETEC. 2004a. Gas Works Park Sediment Area Bioassay Report.

RETEC. 2004b. Gas Works Park Sediment Area Chemical Data Package.

RETEC. 2004c. Gas Works Park Sediment Area Radioisotope Sediment Profile Report.

RETEC. 2004d. Radioisotope Sediment Profile Report, Gas Works Park Sediment Area, Seattle, Washington.

Sabol, MA, GL Turney and GN Ryals. 1988. Evaluation of Available Data on the Geohydrology, Soil Chemistry, and Ground-Water Chemistry of Gas Works Park and Surrounding Region, Seattle, Washington. Prepared in cooperation with the WA Department of Ecology.

Science Applications International Corporation (SAIC). 2006. Site Environmental Report, Former Chevron Bulk Terminal #100-1327, 1602 North Northlake Way, Seattle, Washington.

Seattle Structural. 2011. Preliminary Environmental Review and Disposal Recommendations, Seattle Police Harbor Patrol Bulkhead Repair.

Tetra Tech. 1985a. Field Operations Plan, Gas Works Park Groundwater Investigation.

Tetra Tech. 1985b. Gas Works Park Supplemental Soils Testing Phase I Surface Soils Analysis.

Tetra Tech. 1985c. Sampling and Analysis Plan, Gas Works Park Supplemental Soils Testing.

Tetra Tech. 1987a. Gas Works Park Groundwater Investigation and Site Evaluation.

Tetra Tech. 1987b. Supplemental Data Report, Gas Works Park, Groundwater Investigation and Site Evaluation.

Tetra Tech 2006. Gas Works Park Bathymetry Survey Report. October 2006.

Tomlinson, RD, RJ Jr Morrice, ECS Duffield, and RI Matsuda. 1977. A Baseline Study of the Water Quality, Sediments, and Biota of Lake Union, Municipality of Metropolitan Seattle.

Trial, WT. 1988. Lake Union: 1987 Crayfish PCB Study. Parametrix, Inc.

Turney, GL, and DF Goerlitz. 1989. Groundwater Contamination at an Inactive Coal and Oil Gasification Plant Site, Gas Works Park, Seattle, Washington. Prepared in cooperation with the City of Seattle, Department of Parks and Recreation.

Washington Department of Ecology (Ecology). 2003a. Sediment Quality Information System (SEDQUAL).

U.S. Environmental Protection Agency (EPA). 1995. Expanded Site Inspection Report, Washington Natural Gas - Seattle Plant, (WAD 980639280), Seattle, Washington.

Yake, B, D Norton and M Stinson. 1986. Application of the Triad Approach to Freshwater Sediment Assessment: An initial Investigation of the Sediment Quality near Gas Works Park, Lake Union. Washington State Department of Ecology, Water Quality Investigations Section.

Table 2C-1

Upland and Sediment Investigations

Gas Works Park Site

Seattle, Washington

Year	Survey Name	Database Name[a]	Investigation Description	Location of Investigation	Type of Exploration	Type of Sample	In the RI Database?	Reference
1971	Not named	--	Borings were completed site-wide to explore subsurface conditions at the park.	Upland	boring	Surface soil, suburface soil	N	Cole and Machno 1971
1972	Not named	--	Soil grab samples were collected in the vicinity of the Kelly filters and analyzed for arsenic.	Upland	grab	Surface soil	N	Brooks 1972
1973	Not named	--	Test pits were dug site-wide in support of park design and construction.	Upland	test pit	Surface soil, suburface soil	N	City of Seattle 1973
1973	Not named	--	Borings and test pits were completed along a proposed sewer line in support of park design and construction.	Upland	boring, test pit	Surface soil, suburface soil	N	City of Seattle 1973
1977	Not named	--	Sediments, water and biota samples collected across Lake Union for a baseline study. Sediment and surface water sampling stations were selected for testing based on lake bathymetry and circulation patterns. Stations also provided characteristics of Lake Union's major inlet and outlet sources.	Lake Union	grab, core, biological	Surface water, subsurface sediment, benthic infauna	N	Tomlinson et al. 1977; Barnes and Schell 1973
1981–1986	King County Lake Monitoring Study	LUUMON86	Sediment grab samples were collected across Lake Union for a Lake Union sediment monitoring study by King County. Subsequent related monitoring surveys include LUUMON95, LUUCSO97 and LUUCSO00. Data accessed from SEDQUAL (now EIM).	Lake Union	grab	Surface sediment	Y	Ecology 2003a
1984	1984 EPA Sediment Investigation	EPA-84	EPA collected sediment grab samples in Lake Union adjacent to Gas Works Park. Original data were incorrectly reported; PAH data were later reevaluated in the 1995 EPA sediments study (EPA 1995). The corrected results are used in the RI data set.	Lake Union	grab	Surface sediment	Y	Hileman et al. 1985
1984	1984 Soil Characterization	EPA-84	EPA collected soil samples as a follow-up to their 1984 sediments study. Soil grab samples were collected in the northeast corner, Play Barn and Prow. Borings were completed site-wide; surface (0 to 6 inches) and subsurface (0 to 3 feet) soil samples were collected for analysis.	Upland	grab, boring	Surface soil, suburface soil	Y	Ecology & Environment 1984
1984	1984 Risk Evaluation	UofW-84	The University of Washington collected soil grab samples (uppermost inch) for a health risk evaluation for park users.	Upland	grab	Surface soil	Y	Ongerth 1985
1984	Not named	--	Air and soil gas samples were collected for an air toxicity study focused on Gas Works Park. Air samples were evaluated for off-site release of VOCs and soil gas samples were evaluated for PAHs.	Upland	charcoal tube	Air, soil gas	N	PSAPCA 1984; Ongerth 1985
1984	1984 King County Human Health Risk Evaluation	--	King County collected crayfish tissue samples for human health and ecological risk evaluations.	Lake Union	biological	Crayfish tissue	N[b]	Frost and McCallum 1984; Hansen et al. 1994
1985	1985 Soil Characterization	Tetra-85	Tetra Tech collected soil grab samples (upper 2 inches) for a surface soil study. A subset of those samples was analyzed for PAHs and some for cyanide. Several tar samples were also collected; however, these samples are not in the RI data set.	Upland	grab	Surface soil	Y	TetraTech 1985c
1985	1985 Lake-wide Sediment Investigation	GWPLKUN	Ecology collected a grab sediment sample (0 to 2 cm) to determine the quality of Lake Union sediments using a weight-of-evidence approach, and to replicate EPA's 1984 most-contaminated station. The sample was a composite sediment sample collected near the west end of the former barge loading dock. The composite was analyzed for toxicity and chemistry; benthic infaunal analysis was also conducted.	Lake Union	grab, biological	Surface sediment, bioassays	Y	Yake et al. 1986
1986	Not named	SLUPLT86	Grab sediment samples were collected in south Lake Union for a sediment pilot project. Benthic infaunal abundance and bioassay samples were also collected. Data accessed from SEDQUAL (now EIM); original references are City of Seattle, Ecology and Solomon.	Lake Union	grab	SS, BI	Y	Ecology 2003a
1986-1987	1987 Hydrogeology Evaluation	Tetra-87	Tetra Tech and others conducted a study to evaluate groundwater quality at the park and potential discharge of contaminants to Lake Union. Included monitoring well installation, borehole sampling, groundwater sampling, subsurface stratigraphy investigation, soil gas sampling, groundwater elevation measurement and hydraulic transmissivity testing. Groundwater samples were collected and analyzed for PAHs, BETX and arsenic.	Upland	boring, monitoring well	Suburface soil, groundwater, soil gas	Y	TetraTech 1987a,b; Turney and Goerlitz 1989
1987	1987 PCB Risk Evaluation	--	The City collected crayfish tissue samples for human health and ecological risk evaluations; focused primarily on PCBs.	Lake Union	biological	Crayfish tissue	N[b]	Trial 1988 Hansen et al. 1994
1988	Not named	--	Air, soil and asbestos samples collected from the Play Barn area for protection of workers prior to renovation. Soil samples were collected from thin "dirt" accumulation on top of concrete basement floor.	Upland	charcoal tube, grab	Air, subsurface sediment, subsurface soil	N	HDR 1988b

Year	Survey Name	Database Name[a]	Investigation Description	Location of Investigation	Type of Exploration	Type of Sample	In the RI Database?	Reference
1988	1988 Monitoring	HDR-88	HDR conducted a focused field study to continue ongoing monitoring of the park and assess plans for an irrigation system. Groundwater samples were collected from temporary monitoring wells. A permanent monitoring well (MW-17) was installed. Surface soil samples were collected near the berm northeast of Kite Hill.	Upland	grab, piezometer, monitoring well	Surface soil, groundwater	Y	HDR 1988a
1989	1989 GW CSM	HDR-89	HDR installed permanent monitoring wells for a groundwater migration conceptual design report. Groundwater was sampled for BETX and PAHs. A geophysics study in the former tar refinery area was also completed.	Upland	monitoring well	Groundwater	Y	HDR 1989
1989	Not named	SCLITE89	EcoChem collected sediment grab samples in southeast Lake Union for a sediment quality study. A subset of samples was collected along the eastern shoreline of the lake. Data accessed from SEDQUAL (now EIM).	Lake Union	grab	Surface sediment	Y	Ecology 2003a
1990	1990 Lake-wide Sediment Investigation	LKUNION	Ecology collected sediment grab and biological samples across Lake Union for a survey of contaminants throughout the lake and adjoining waters. Data accessed from SEDQUAL (now EIM).	Lake Union	grab, biological	Surface sediment, bioassays	Y	Ecology 2003a
1990	1990 Lake-wide Sediment Investigation	SLUPRK90	Ecology collected sediment grab samples in southwest Lake Union for a South Lake Union Park sediment study. Data accessed from SEDQUAL (now EIM); original source is Hart Crowser.	Lake Union	grab	Surface sediment	Y	Ecology 2003a
1991	1991 King County Human Health Risk Evaluation	--	King County collected crayfish and fish tissue samples for human health and ecological risk evaluations for the University regulator pre-CSO separation monitoring study. Subsequent related risk evaluation surveys were conducted in 1997 and 1999. Data accessed from SEDQUAL (now EIM).	Lake Union	biological	Crayfish tissue, fish tissue	N[b]	Ecology 2003a
1991	Not named	--	Landolt and others collected fish tissue samples across Lake Union for histopathology study. Data accessed from SEDQUAL (now EIM).	Lake Union	biological	Fish tissue	N[b]	Ecology 2003a
1991	1991 Northlake Shipyard Investigation	UNIMAR2-CORES; UNIMAR2-GRABS; UNIMAR2	GeoEngineers collected sediment grab and core samples for an investigation focused on the UNIMAR facility; a subset of the explorations occurred just within the AOI. Grab samples were tested for arsenic, other metals, PAHs and additional analytes; core samples were tested for metals only.	Lake Union	grab, core, biological	Surface sediment, subsurface sediment, bioassays	Y	GeoEngineers 1991
1992	Not named	LKUNDRDK	Ecology and others collected sediment shallow samples (0 to 2 cm) and biological in east Lake Union to determine representative concentrations of chemicals in the lake. Samples were analyzed for metals and organic chemicals. A subset of the samples was analyzed using bioassays and benthic macroinvertebrate abundance and diversity.	Lake Union	grab, biological	Surface sediment, bioassays	Y	Cubbage 1992; Hart Crowser 1992
1993	Not named	--	Subsurface explorations, soil and groundwater sampling, and groundwater elevation monitoring were completed for a METRO RI/FS report. All samples were collected outside the AOI.	Upland	boring, monitoring well	Suburface soil, groundwater	N	Applied Geotechnology 1993
1994	Not named	NOAPMC94	Sediment grab samples were collected in east Lake Union for a survey focused on Pacific Marine Center. Data accessed from SEDQUAL (now EIM); original source is National Oceanic and Atmospheric Administration (NOAA).	Lake Union	grab	Surface sediment	Y	Ecology 2003a
1994	Not named	SEACOM94	Sediment grab and biological samples were collected in southwest Lake Union for a sediment monitoring study. Data accessed from SEDQUAL (now EIM); original source is Ecology.	Lake Union	grab, biological	Surface sediment, bioassays	Y	Ecology 2003a
1995	1995 EPA Sediment Investigation	EPA-95; EPAGAS95	EPA collected sediment grab and water samples across Lake Union with an emphasis on the sediments adjacent to Gas Works Park; investigation was a follow-up to the 1984 EPA investigation (Hileman et al. 1985). Surface water data were not included in the RI data set	Lake Union	grab	Surface sediment, surface water	Y	EPA 1995
1995-2000	King County Lake Monitoring Study	LUUMON95	King County collected sediment grab samples in Lake Union as part of a multi-year monitoring program. Data accessed from EIM.	Lake Union	grab	Surface sediment	Y	Ecology 2003a
1996	Not named	DUNATO96	Sediment grab samples were collected in northeast Lake Union for a survey focused on Dunato's Marine Service & Supply. Data accessed from SEDQUAL (now EIM); original source is ATC Environmental.	Lake Union	grab	Surface sediment	Y	Ecology 2003a
1996-1997	King County University Regulator Studies	LUUCSO97	King County collected sediment grab samples in northeast Lake Union for a University regulator post-CSO separation monitoring study. Data accessed from SEDQUAL (now EIM).	Lake Union	grab	Surface sediment	Y	Ecology 2003a
1997	King-County Post-Separation Risk Evaluation	--	King County collected crayfish and fish tissue samples for human health and ecological risk evaluations for the University regulator pre-CSO separation monitoring study. Data accessed from SEDQUAL (now EIM); original source is King County.	Lake Union	biological	Crayfish tissue, fish tissue	N[b]	Ecology 2003a
1997-1998	1998 Fate and Transport Evaluation	EPRI-98; RETEC Product	RETEC collected boring, monitoring well and piezometer sampling for an assessment of the fate and transport of soil and groundwater. Focus was Harbor Patrol plus western portion of Gas Works Park and central shoreline area within the park. The investigation also included measuring groundwater flow gradients, and evaluating the nature and extent of NAPL occurrences. The study also characterized DNAPL and estimated leaching potential for PAHs. Fate and transport modeling was used to predict downgradient attenuation of dissolved PAHs as part of the conceptual site model.	Upland	boring, piezometer, monitoring well	Suburface soil, groundwater, NAPL	Y	Appendix 2C (Attachment 2C-1)

Year	Survey Name	Database Name[a]	Investigation Description	Location of Investigation	Type of Exploration	Type of Sample	In the RI Database?	Reference
1997-1998	1998 FFS	Param-98; Parametrix/Key_98; RETEC-Product	Parametrix and others collected samples for a focused feasibility study across Gas Works Park. Groundwater samples were collected from existing monitoring wells; wells with detectable NAPL thickness were excluded. Test pits were completed site-wide. An assessment of upwelling tar sources was conducted including removal and disposal of several drums of tar. An assessment of the fenced Cracking Towers area was conducted, including visual inspection of potential sources. Tar samples from test pits and a tank (sample identified as "GWP Tank") were collected for characterization.	Upland	monitoring well, test pit, grab	Groundwater, suburface soil, tar	Y	Parametrix and Key 1998; Parametrix, Inc 1999; North Creek Analytical 1997
1997-1998	1998_AVS-SVE	RETEC-97,98; Parametrix/Key_98	Parametrix and RETEC sampled the southeastern area soil and groundwater to evaluate the feasibility of an air sparging system. Geoprobe borings were advanced and soil and groundwater samples were collected.	Upland	boring, monitoring well	Suburface soil, groundwater, NAPL	Y	Parametrix and Key 1998; Parametrix, Inc 1999; RETEC 1998
1999	1999 UST Decommissioning	HarborPatrol_UST_ 1999	Gary Struthers and Associates collected confirmation soil samples from a 2,000-gallon diesel fuel UST decommissioning at Harbor Patrol.	Upland	test pit	Suburface soil	Y	Gary Struthers Associates 1999
1999	King-County Post-Separation Risk Evaluation	--	King County collected fish tissue samples for human health and ecological risk evaluations for the University regulator pre-CSO separation monitoring study. Data accessed from SEDQUAL (now EIM).	Lake Union	biological	Fish tissue	N[b]	Ecology 2003a
1999	1999 RETEC Phase 1 Investigation	RETEC99-Cores; RETEC99-Grabs	RETEC collected sediment grab (0 to 10 cm) and core samples a Phase 1 sediment study to provide preliminary chemical data regarding surface and subsurface sediment quality in the AOI. Core sediment samples, which were collected nearshore, were used to determine vertical extent and magnitude of COCs in nearshore. Grab sediment samples offshore were used to determine horizontal extent and magnitude of COCs in sediments beyond the nearshore coring areas. Chemical analysis focused on PAHs and metals. Samples delineated the lateral extent of surface sediment impacts. Sediment cores collected were used to identify subsurface sediment material types and the vertical extent of sediment impacts in most areas. Physical surveys including an underwater diver-assisted towed video survey and a side-scan sonar survey were incorporated into this study to help delineate bathymetry, substrate and debris.	Lake Union	grab, core, physical survey	Surface sediment, subsurface sediment	Y	RETEC 2002b
1999	Phase 1 Split Sample Analysis	RETEC99-Cores; RETEC99-Grabs	META analyzed split grab and core samples from RETEC's Phase 1 study for supplemental characterization.	Lake Union	grab, core	Surface sediment, subsurface sediment	Y	RETEC 2002b META 2001
2000	King County Lake Monitoring Study	LUUCS000	King County collected sediment grab and biological samples in northeast Lake Union for the University regulator post-CSO separation monitoring study. Data accessed from SEDQUAL (now EIM).	Lake Union	grab, biological	Surface sediment, bioassays	Y	Ecology 2003a
2000-2010	2000-2010 Quarterly GW Sampling	AMEC_2010	AMEC conducted quarterly (2000 to 2007) and annual (2008 to 2010) groundwater sampling in accordance with a 2000 groundwater compliance monitoring plan. A subset of the existing monitoring wells was selected as the monitoring network, including some Harbor Patrol wells, a few wells directly north and west on Kite Hill and observational wells by the AS/SVE near the eastern shoreline.	Upland	monitoring well	Groundwater	Y	RETEC 2001-2007; EcoCompliance 2007-2009; AMEC 2010
2001	Not named	KC_LKUN01	Additional surface sediment samples across Lake Union were discovered from studies conducted by King County. Data were provided by R. Jack through electronic communication.	Lake Union	grab	Surface sediment	Y	Jack 2009
2002	2002 Cracking Tower Geotechnical Investigation	--	GeoEngineers drilled a pair of borings within the fenced Cracking Towers area for a geotechnical evaluation of their foundations. The evaluation was strictly geotechnical and did not include analytical sampling or field screening.	Upland	boring	suburface soil	Y	GeoEngineers 2002
2002	2002 Agency Sediment Investigation	TAMU02	Texas A&M University and Ecology collected biological and split surface sediment samples in March and July 2002 across the AOI. Sediment results from March are in the RI data set and bioassay results from July are used in the RI.	Lake Union	grab, biological	Surface sediment, bioassays	Y	Ecology 2003b
2002	Not named	--	The City conducted a side-scan sonar survey and a detailed multibeam bathymetric survey to help delineate bathymetry and debris offshore.	Lake Union	physical survey	--	--	City of Seattle 2002; Parametrix 2002
2002	2002 RETEC Phase 2 Investigation	RETEC02-Cores; RETEC02-Grabs	RETEC collected sediment grab (0 to 10 cm) and core and biological samples for a Phase 2 sediment study to fill chemical data gaps identified from the Phase 1 sampling. Sediment samples were also used assess sediment quality for benthic organisms, evaluate sedimentation rates and collect geotechnical data. Radioisotope cores were collected and analyzed. The spatial extent of biological effects was determined from the analysis of chemical and biological data at co-located stations. A nearshore bathymetry survey was performed as part of this study to help delineate bathymetry and debris.	Lake Union	grab, core, biological, physical survey	Surface sediment, subsurface sediment, bioassays	Y	RETEC 2004a, b, c, d
2002-2003	Phase 2 Split Sample Analysis	RETEC02-Cores; RETEC02-Grabs; RETEC-Product	Battelle and others analyzed split sediment, NAPL and tar samples from RETEC's Phase 2 study for supplemental characterization. The study included various grab and core sediment samples; DNAPL samples from MW-09, MW-5 and DW-5; and a tar sample near former MGP structures. NAPL from MW-09 and a pair of surface sediment samples were used for additional supplemental characterization evaluation.[c]	Lake Union	grab, core, monitoring well	Surface sediment, subsurface sediment, NAPL, Tar	Y[c]	Battelle 2003; ARI 2003a, b, c

Year	Survey Name	Database Name[a]	Investigation Description	Location of Investigation	Type of Exploration	Type of Sample	In the RI Database?	Reference
2004	2004 NW Park Investigation	PARA-NW_2004	Parametrix collected surface and subsurface soil samples in the northwest corner of Gas Works Park for an investigation evaluating the removal of physical barriers which would then allow public access to that area.	Upland	grab, test pit	Surface soil, suburface soil	Y	Parametrix 2004
2004	WSA Sediment Investigation	FSnider_05	Floyd|Snider collected core samples from western slope sediments. Samples were also used in forensics analysis.	Lake Union	Core	Subsurface sediment	Y	Appendix 2D (Attachment 2D-4)
2004-2005	2004-2005 RETEC Phase 3 Investigation	NLU04; RIFSE	RETEC collected sediment grab (0 to 10 cm) and core samples for the Phase 3 sediment investigation, completing the eastern sediment RI/FS. The study was conducted to refine the horizontal and vertical extent of chemical concentrations in the eastern sediment area and further investigate potential contaminant sources, sediment physical properties and transport pathways to facilitate development of remedial alternatives to address impacted sediment. The investigation also evaluated porewater, geotechnical and physical properties, bathymetry, soft sediment extent, seeps and DNAPL, debris extent, currents and wave forces, and supplemental organic carbon and PAH partitioning to assess bioavailability.	Lake Union	grab, core, physical survey	Surface sediment, subsurface sediment, porewater	Y	Appendix 2C (Attachment 2C-3), Appendix 2D (Attachments 2D-4, 2D-7 and 2D-8), 3A, 3C, 3D, 3H, 3I and 3J
2005	2005 Cracking Tower Soil Investigation	Corvus2005	Corvus collected subsurface soil samples (6 to 18 inches) within the fenced Cracking Towers area for a soil quality study.	Upland	test pit	Subsurface soil	Y	Lillie 2005
2005	2005 RETEC Biological Evaluation	NLUBio05; GWSA05	RETEC collected surface sediment for chemical and bioassay testing to address bioassay data gaps and to establish cleanup levels.	Lake Union	grab, core, biological	Surface sediment, subsurface sediment, bioassays, porewater	Y	Appendix 5C
2005	2005 Western Area RI/FS	Fsnider_05	Floyd|Snider collected sediment grab (0 to 10 cm) and core samples for the western sediments RI/FS. Sampling was focused on surface sediment evaluation. Analysis was focused on BETX, PAHs, other SVOCs and arsenic. The investigation also included geotechnical testing and NAPL characterization.	Lake Union	grab, core	Surface sediment, subsurface sediment	Y	Appendix 2C (Attachment 2C-2); Appendix 2D (Attachment 2D-4); Appendices 3C, 3D, and 3J
2006	2006 Metro Site Preliminary Investigation	SAIC_2007	SAIC completed a pair of borings, P-10 and P-12, within the upland AOI as part of a limited environmental investigation at the METRO site to determine if soil in the vicinity of monitoring well MW-22 (METRO) was acting as a source of hydrocarbons. Subsurface soil samples from only P-10 were submitted for analytical testing.	Upland	boring	Suburface soil	Y	SAIC 2006
2006	2006 Western Shoreline Investigation	Fsnider_06	Floyd|Snider advanced soil borings and installed monitoring wells along the western shoreline of the upland AOI to delineate the presence and assess the mobility of DNAPL in the subsurface. Soil samples were collected and analyzed for petrophysical properties, and slug tests were performed to determine hydrogeologic properties.	Upland	boring	Suburface soil	Y	Appendix 2C (Attachment 2C-2)
2006	WSA Sediment Investigation and WSA Shoreline Investigation	--	Floyd|Snider documented DNAPL collected from a Harbor Patrol well and sediment from the Western Study Area as part of the 2004 core sampling and 2005 RI/FS sampling for forensic chemical and geotechnical properties.	Upland and Lake Union	Monitoring well, grab, core	NAPL, surface and subsurface sediment	N	Appendix 2C (Attachment 2C-2) and Appendix 2D (Attachment 2D-4)
2006	2006 Bathymetric Survey	--	TetraTech performed a multibeam bathymetry survey in September 2006 to help delineate bathymetry and debris. Results incorporated into AOI bathymetry map (RI Figure 3-2).	Lake Union	physical survey	--	--	TetraTech 2006
2007	2007 NE Soil-Gas Survey	--	Floyd|Snider conducted a soil gas survey in the northeast corner of the upland AOI to identify locations where aromatics measured in the subsurface soil may be associated with the presence of shallow subsurface tar and/or DNAPL. A real-time instrument, the Aromatic-Specific Laser Ionization Detector (ARSLID) manufactured by Dakota Technologies, and a gas vapor probe kit were used for the survey.	Upland	ARSLID with GVP	Soil gas	N[b]	Floyd|Snider 2008a
2007	2007 NE Park Investigation	NE Corner-GWSA	Cooperative investigations of the northeastern meadow and eastern shoreline area were conducted by the ENSR/AECOM and Floyd|Snider. Soil borings were advanced to collect subsurface soil samples.Chemical tests were conducted on selected samples for SVOCs, VOCs, total petroleum hydrocarbons and synthetic precipitate leaching protocol (for SVOCs). UV light photography was also completed on a subset of the cores.	Upland	boring	Suburface soil	Y	Floyd|Snider 2008a; ENSR/AECOM 2008
2007	2007 Supplemental Source Characterization	BattelleFeb07; FSNIDER-Product	Battelle analyzed a subsurface soil sample and several tar and NAPL samples for supplemental characterization.	Upland	boring, grab, monitoring well	Subsurface soil, tar, NAPL	Y	Battelle 2007
2007	2007 Supplemental Source Characterization	FloydSniderMW9_ 2007	Floyd|Snider collected a NAPL sample from monitoring well MW-9 for supplemental characterization.	Upland	monitoring well	NAPL	Y	Floyd|Snider 2008b

Year	Survey Name	Database Name[a]	Investigation Description	Location of Investigation	Type of Exploration	Type of Sample	In the RI Database?	Reference
2007-2008	2007-2008 Quarterly Air Quality Monitoring	--	Floyd|Snider evaluated air quality using three quarterly monitoring events conducted from spring 2007 to winter 2008. Air samples were collected from locations within Gas Works Park (Cracking Towers, Prow Upwind, Weather Station Location, East Shore, and Play Barn Basement) and the Harbor Patrol facility.	Upland	thermal desorption tubes	Air	N[b]	Floyd|Snider 2007a,b, 2008c
2008	Not named	KC_2008ww	A surface sediment sample from Lake Union was discovered from studies conducted by King County. Data were provided by R. Jack through electronic communication.	Lake Union	grab	Surface sediment	Y	Jack 2009
2008	2008 Catch Basin Sampling	Phase 1 StW CS Inv; F|S09	Catch basins were screened (including chemical testing of solids) for Floyd|Snider's Phase 1 source control evaluation. The study included video inspection of portions of accessible storm drains.	Upland	grab	Catch basin solids	Y	Floyd|Snider 2009
2009	2009 Northlake Shipyard Investigation	NLSY09	Ecology & Environment collected sediment core samples for a Northlake Shipyard sandblast grit investigation. Its purpose was to delineate the extent of and define the characteristics of sandblast grit-impacted sediments. The study was conducted to support a removal action of the sandblast grit. Sampling evaluated the vertical and horizontal extent and the chemical and geotechnical characteristics of grit-impacted sediments. Additional bathymetric data were also collected.	Lake Union	core	Subsurface sediment	Y	Ecology & Environment 2009
2009 - 2010	2008 Catch Basin Sampling	NE Corner 2009; P3 Storm Drain December 2010	Storm drain solids captured in filter fabrics from selected catch basins and surrounding soil were collected for Floyd|Snider's Phase 3 source control evaluation. Surface soil samples were also collected from the Waterway 19 storm drain ditch.	Upland	grab	Surface soil, catch basin solids, filter fabric	Y	Floyd|Snider 2010a, b
2010	2010 3-D Model Sampling	--	GeoEngineers and Aspect conducted a hydrogeologic investigation in support of a site-wide, three-dimensional numerical groundwater flow model. The investigation included surveying groundwater levels from existing monitoring wells, advancing soil borings to provide stratigraphic information, completing monitoring wells and performing slug and pump tests. No chemical analysis were conducted.	Upland	boring	Subsurface soil	Y	GeoEngineers 2010 Aspect et al. 2012
2010	2010 Agency Split Samples	HydroInvest 2010	Ecology obtained split soil samples from the 2010 hydrogeologic investigation (GeoEngineers 2010). The samples were analyzed for metals and SVOCs.	Upland	boring	Subsurface soil	Y	Manchester Environmental Laboratory 2011a
2011	2011 Agency Evaluation of Kite Hill	ECYKiteHill 2011	Ecology collected surface (0 to 3 inches) soil samples across Kite Hill for analysis of PAHs and SVOCs.	Upland	grab	Surface soil	Y	Manchester Environmental Laboratory 2011b
2011	2011 Sink Hole Sampling	HarborPatrol 2011	Seattle Structural collected subsurface soil samples from a boring and a grab sample from a sinkhole for analysis of environmental chemicals of concern as part of a bulkhead structural review and assessment at Harbor Patrol.	Upland	grab, boring	Surface soil, subsurface soil	Y	Seattle Structural 2011
2012	2012 Play Area Investigation	AMEC2012_Playbarn	AMEC conducted soil sampling as a preliminary investigation for a proposed children's Play Area near the Play Barn structures.	Upland	auger	Surface soil	Y	AMEC 2012
2013	2013 Supplemental Investigation	2013_SI; 2013_SI_2	GeoEngineers conducted a site-wide supplemental investigation in the upland. Components of the investigation included geophysical survey, existing monitoring well survey, TarGOST® laser-induced fluorescence testing, environmental soil investigation, geotechnical investigation of Kite Hill, monitoring well installation, baseline groundwater monitoring (spring), NAPL testing, slug testing, UV light photography, NAPL physical properties evaluation and an additional round of groundwater monitoring (fall).	Upland	boring, monitoring well	Surface soil, subsurface soil, groundwater, NAPL	Y	Appendix 2A
2014	2014 Northlake Shipyard Post-Dredging Confirmational Sampling	2014_HC	Hart Crowser collected post-dredging surface sediment at Northlake Shipyard to document post-dredging sediment conditions.	Lake Union	grab	Surface sediment	N	Hart Crowser 2014
2014	2014 Play Area Investigation	2014_Play Area	GeoEngineers sampled soil and groundwater as part of a Play Area supplemental investigation in the upland. Components of the investigation included environmental soil investigation, XRF data, grab groundwater sampling, and monitoring well sampling.	Upland	boring, monitoring well	Subsurface soil, groundwater	Y	Appendix 2B (Attachment 2B-1)
2015	Not named	SPU_CatchB	SPU collected a composite sample from the Harbor Patrol catch basins	Upland	grab	Catch basin solids	Y	Appendix 6B
2015	2015 Arsenic Treatment Bench Scale Testing	2015_Treatability Study	Anchor conducted a bench-scale study of various injection agents for groundwater. Groundwater analyzed for arsenic, including speciation	Upland	grab	Groundwater	N	Anchor 2016; Appendix 2B (Attachment 2B-2)
2016	2016 Play Area Investigation	2016_Play Area	GeoEngineers collected additional groundwater samples to define arsenic extent in Play Area. Also collected soil XRF and conventional data	Upland	boring	Groundwater, subsurface soil	Y	Appendix 2B-3

Year	Survey Name	Database Name[a]	Investigation Description	Location of Investigation	Type of Exploration	Type of Sample	In the RI Database?	Reference
2017-2019	Play Area Pre- and Post-Treatment Sampling	--	GeoEngineers collected a series of groundwater samples for arsenic analysis from the Play Area prior to three rounds of injection (baseline), two weeks following each injection (short-term), and one month following each injection (performance). Speciation was conducted as part of the first and second baseline events.	Upland	grab	Groundwater	N	GeoEngineers. 2021
2020	Play Area Confirmation Sampling	2020_CONF	GeoEngineers collected groundwater samples 13 months following the last performance monitoring event to confirm the effectiveness of groundwater treatment.	Upland	grab	Groundwater	Y	GeoEngineers. 2021
2017	2017 Catch Basin Sampling	SEA_18	SPU continued catch basin sampling as part of source control evaluation. Samples collected in 2017, processed in 2018.	Upland	grab	Catch basin solids	Y	Appendix 6B

Notes:

[a] Database name cross-references to RI data tables provided in Appendix 5B.

[b] Risk assessment and air data used in the RI Report but not stored in the EQUIS database.

c Tar samples from the carburated water gas unit (SS-4) and northeast corner tar mound (SS 5) were also analyzed; however, tar results were not included in the RI data set because there is good data coverage in those areas, and these tar samples were collected from the ground surface and are not considered representative of underlying/surrounding soil. Data not included in the RI data set are discussed in Appendix 5A (Data Management).

N = no

Y = yes

NAPL = nonaqueous phase liquid; also light NAPL or LNAPL and dense NAPL or DNAPL

SPLP = synthetic precipitation leaching procedure

SPU = Seattle Public Utilities

See text for full acronym list.

Attachment 2C-1

Electric Power Research Institute (EPRI). 1998.
Distribution of Tar and Polycyclic Aromatic Hydrocarbons in the Subsurface at a Former MGP Site

RETEC

Fate and Transport Assessment of Polycyclic Aromatic Hydrocarbons from Tar

Gas Works Park MGP Site

Final Report, September 1998

PREPRINT

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1 Introduction

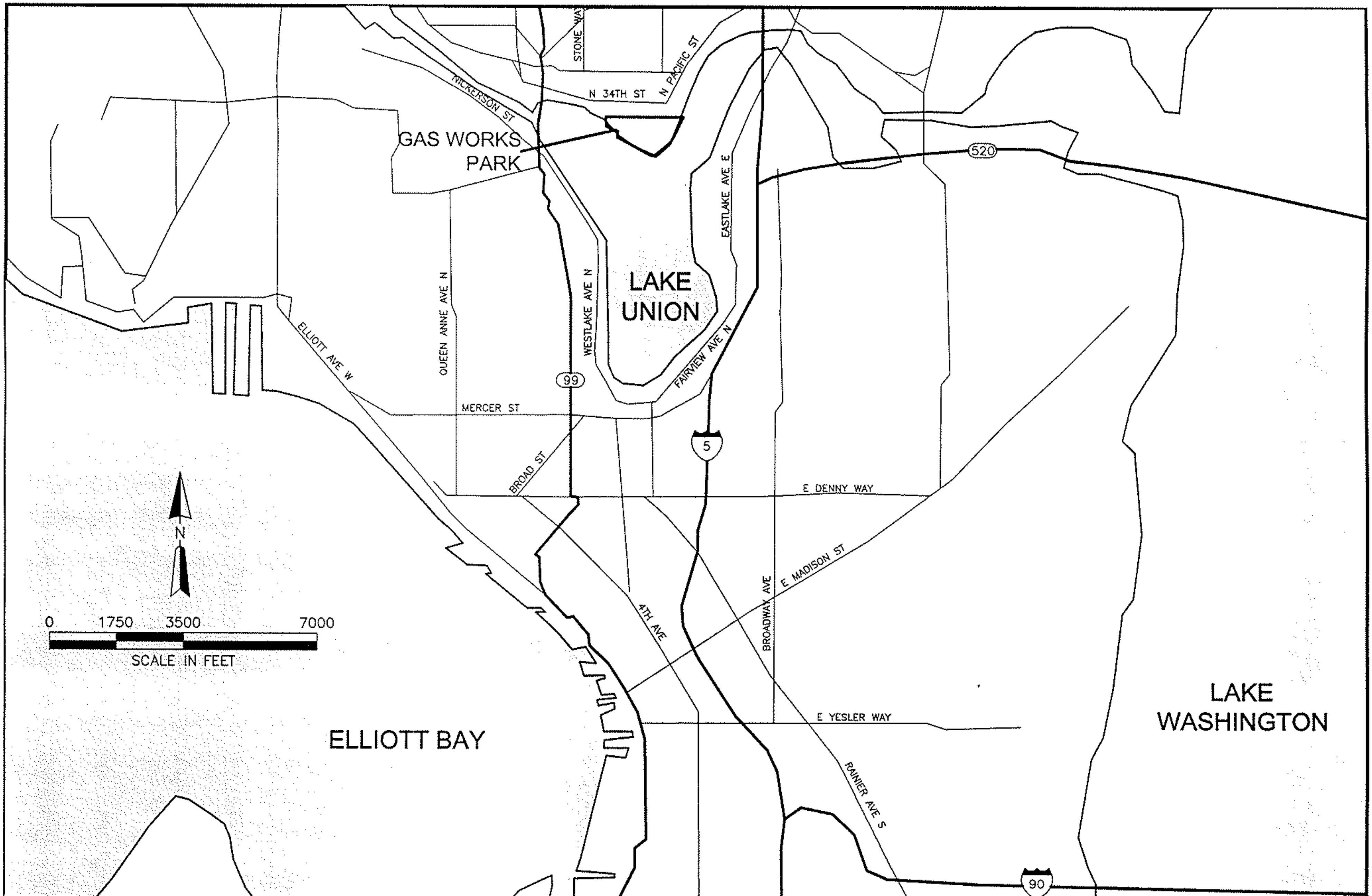
Polycyclic aromatic hydrocarbons (PAHs) are commonly found in the soil and groundwater beneath former manufactured gas plant (MGP) sites. Fate and transport of PAHs are a common consideration when addressing potential risks to receptors from exposure to PAHs at MGP sites. This report summarizes the results of an investigation and assessment of tar and PAH fate and transport in the western part of Gas Works Park. Gas Works Park is currently a public park situated on the north shore of Lake Union in Seattle, Washington (Figure 1-1). Portions of the park were used for gas manufacturing, tar refining, and storing other petroleum products. Tar, PAHs, and monocyclic aromatic hydrocarbons (MAHs) are present in subsurface soils and groundwater.

The field investigation work and PAH transport assessment that are summarized in this report were completed as a Tailored Collaboration (TC) project supported by Electric Power Research Institute (EPRI) and Puget Sound Energy (PSE). The results of this work will be used, if needed, to identify and evaluate remedial measures for Gas Works Park. Information collected as a part of this work may be applied to other MGP sites.

1.1 Site Description and Background

Gas Works Park is located at the north end of Lake Union in Seattle, Washington (Figures 1-1 and 1-2). An MGP operated on the east side of the 20-acre park for about 50 years. A coal gasification plant was operated from 1906 to 1937. The plant was converted to an oil gasification facility in 1937 which closed in 1956. A small tar company started operations in 1907 on the northwestern part of the park. The tar company purchased and processed MGP tars as well as feed stocks from other sources. These materials were refined using steam distillation to produce various grades of tar and pitch. After conversion from coal gasification to oil gasification in 1937, MGP tar was no longer a major source of raw material for the tar refinery.

To convert the site to a park, some of the MGP structures were demolished and the site was recontoured. Between 1973 and 1976, a significant amount of debris and contaminated soil were buried on site and rubble and soil containing carbon black and oil were removed. To develop the park, a soil cover consisting of sawdust, dewatered sludge, and imported fill was placed. The westernmost portion of the property was converted to a police facility (the Harbor Patrol). The site was opened as a public park in 1976 and is currently owned and maintained by the City of Seattle Department of Parks and Recreation. Heavily



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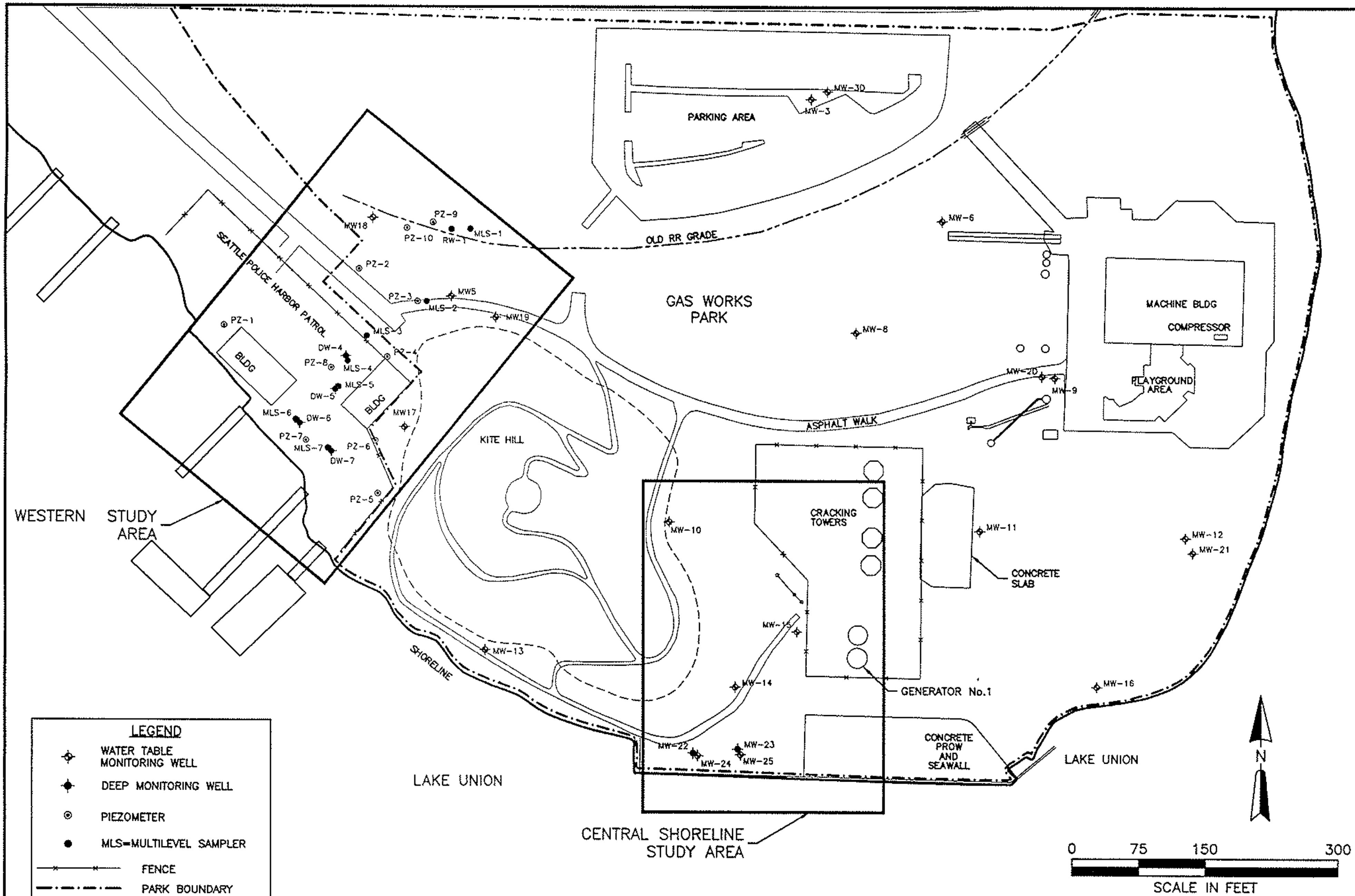
GAS WORKS PARK 5-3434-300				SITE LOCATION MAP	
CURRENT DATE	9/17/98	CADD FILE	3434S041	DRAWING NO.	FIGURE 1-1



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GAS WORKS PARK 5-3434-300				STUDY AREA LOCATIONS	
CURRENT DATE	9/4/98	CADD FILE	3434S053	DRAWING NO.	FIGURE 1-2

impacted soils (e.g., tar seeps) are periodically removed to prevent public exposure. Gas Works Park provides shoreline access and includes a play barn, sand box and concession facilities for the public's enjoyment. Several of the former MGP structures have been left intact as center pieces and a reminder of the site's history.

1.2 Objectives

This project for Gas Works Park focused on the fate and transport of dissolved-phase PAHs from a tar source in the subsurface. As scoped, the project included a combination of field studies, laboratory analysis, and computer modeling.

Specific objectives were to:

- Evaluate hydrogeologic conditions and the associated groundwater flow rates;
- Determine the distribution of tar as a dense nonaqueous-phase liquid (DNAPL) and evaluate factors controlling its migration;
- Characterize DNAPL and estimate release/leaching potentials for PAHs;
- Determine the distribution of PAHs relative to DNAPL-impacted soils; and
- Predict the fate and transport of dissolved PAHs downgradient of source areas.

The work concentrated primarily on the western portion of Gas Works Park and the adjacent Harbor Patrol facility. Previous investigations indicated this area had elevated concentrations of dissolved PAHs in groundwater. The work also addressed an area in the central portion of the site immediately east of Kite Hill to provide information on the variability in PAH concentrations along the shoreline. Study areas within the park are shown on Figure 1-2.

1.3 Report Organization

This report contains the evaluation of the effects of site conditions on the exposure point, the mudline. The methods used in the investigation are summarized in Section 2 and results are presented in Section 3. The fate and transport modeling approach and results are presented in Section 4. In Section 5, the results are incorporated into the site conceptual model. A summary and conclusions of the investigation are contained in Section 6.

2 Approach and Methods

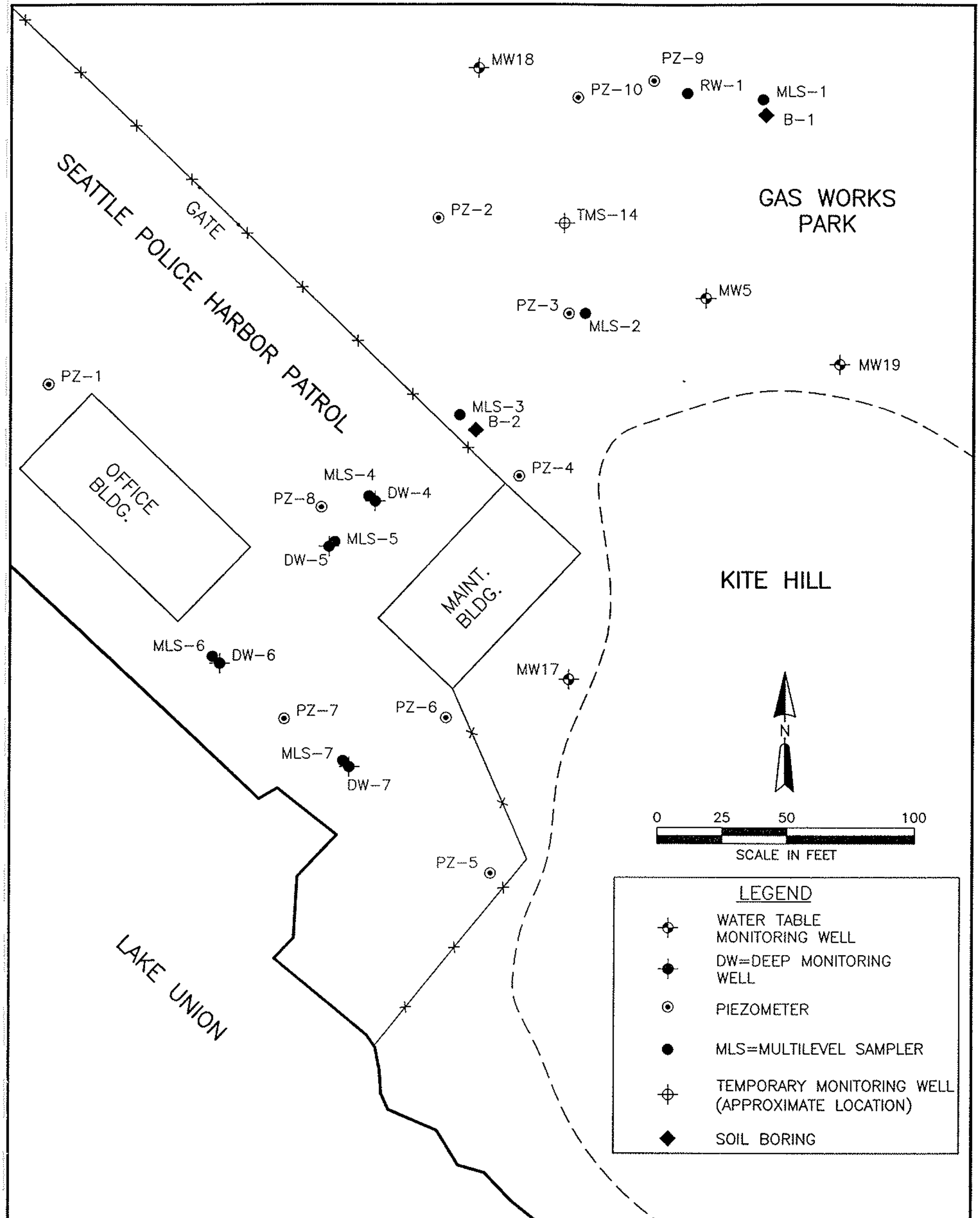
Prior to initiating field studies, existing site data were reviewed to identify a likely location for the study. Field studies were then phased to effectively characterize the site as follows:

- An initial investigation of stratigraphy, groundwater flow direction and groundwater quality was completed through piezometer installation, water level measurement, and preliminary chemical analysis of samples.
- A detailed assessment of groundwater quality was completed using installation and sampling of an area-wide monitoring network including multilevel samplers, followed by additional sampling of shoreline wells. This portion of the study provided information on the distribution of dissolved PAHs in the aquifer.
- A pump test was completed to estimate aquifer properties.
- Laboratory studies were completed to define the release/leaching characteristics of PAHs from residual tar in soils.

The data collected from the 31 soil borings, piezometers and monitoring wells installed as part of the investigation were summarized, and the fate and transport of PAHs were modeled using MYGRT software (Tetra Tech, Inc., 1989). The potential for PAH exposure at Lake Union was evaluated by comparing the estimated PAH concentrations at the receptor point (the mudline) to possible Washington State cleanup criteria.

2.1 Site Selection and Characteristics

Subsurface investigations were performed in the 1980s by Tetra Tech, HDR Engineering, and the United States Geological Survey (see Appendix A for a list of reports). These investigations identified two main plume areas: one located in the northwest part and the second in the southeast part of the site (HDR, 1989). Naphthalene was present at the highest concentrations in the northwestern area plume located in the vicinity of the former tar refining facility. The 92,000 $\mu g/L$ concentration of naphthalene in temporary well TMS-14 located in the northwestern area (see Figure 2-1) indicated the presence of NAPL in the area. The northwest area was selected for the natural attenuation study because of the high PAH concentrations. The central shoreline area was also selected for this study based on moderate naphthalene concentrations in upgradient wells and the



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GAS WORKS PARK

5-3434-300

WESTERN STUDY AREA MAP

CURRENT DATE 7/2/98 | CADD FILE 3434S035 | DRAWING NO. FIGURE 2-1 need for additional data to characterize shoreline conditions in this area. Locations of the western and central shoreline study areas are shown on Figure 1-2. The detailed layout of the western and central shoreline study areas is shown on Figures 2-1 and 2-2.

Previous work has defined the general site stratigraphy. Soil beneath the site is subdivided into the four stratigraphic units as illustrated on Figure 2-3.

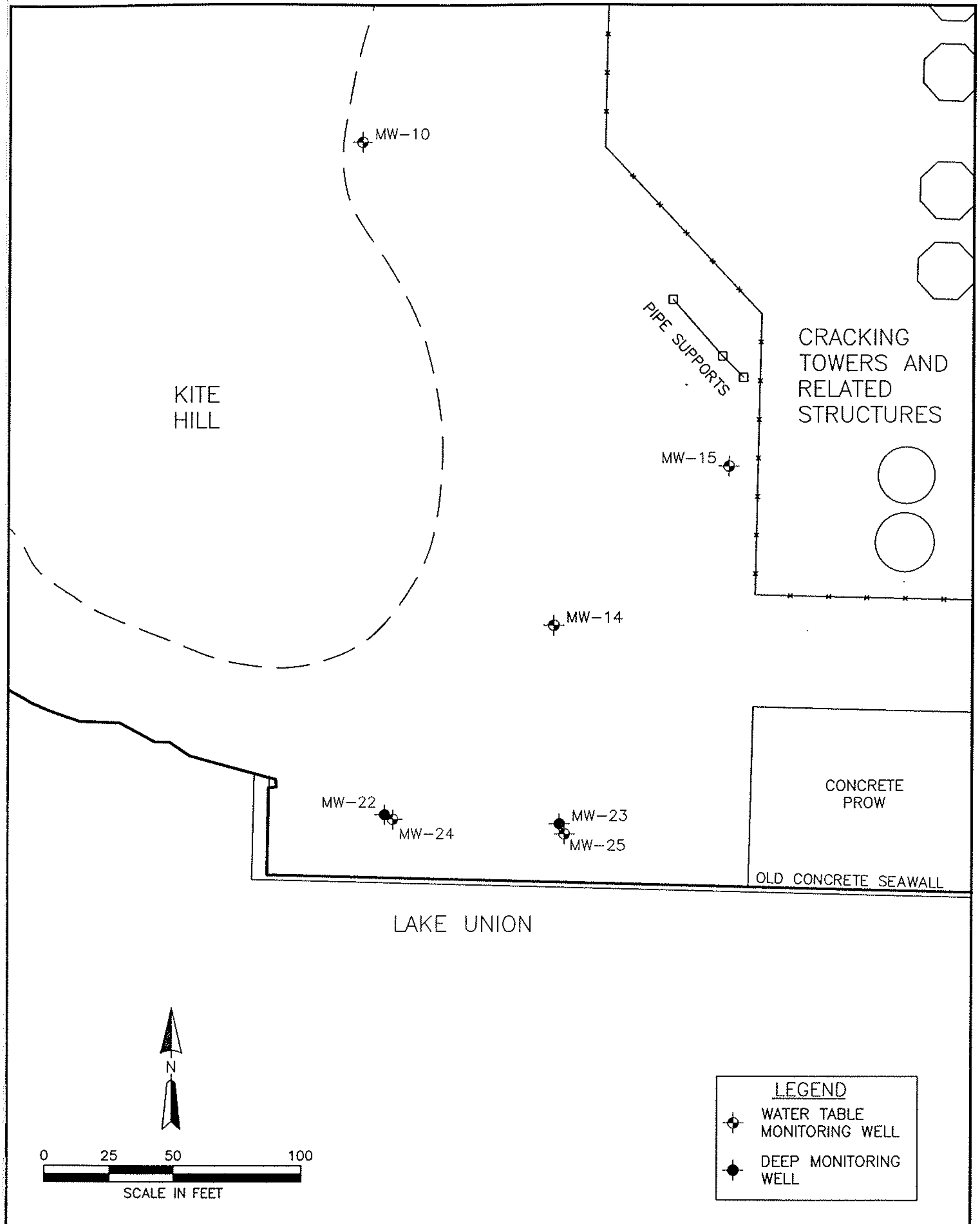
Unconfined shallow groundwater occurs within the Gas Works Deposit and underlying drift material. The Vashon Till is relatively impermeable and acts as the floor of the shallow groundwater system in the park. Groundwater flow is radial and generally southward towards Lake Union. Slight local variations in flow directions may be associated with the topography of the till. Horizontal gradients at the Park generally range from 0.008 to 0.03 feet per foot. The gradient flattens and likely reverses for a short period of time in the immediate vicinity of the shoreline in late winter and spring when the lake level rises.

2.2 Phase I Piezometer Investigation

The objective of the first phase of work was to define the site stratigraphy, groundwater flow direction and contaminant distribution. This information provided the basis for optimal design of the sampling network for the second phase of the investigation. The Phase I investigation included: 1) piezometer installation and an associated evaluation of soil stratigraphy, 2) groundwater quality screening, and 3) water level measurements to establish the groundwater flow field.

2.2.1 Piezometer Installation and Soil Sampling

Eight piezometers (PZ-1 through PZ-8) were installed in December 1997 using a truck-mounted hydraulic hammer and direct-push (soil probe) equipment. Piezometer locations are shown on Figure 2-1. Soils were sampled with a small-diameter split-spoon sampler as the probe rod was advanced. The piezometers were then installed in the hollow rod at the desired depth. Piezometers were constructed with 1-inch diameter PVC screen and casing. The casing was held in place while the rod was withdrawn from the hole. As the drilling rod was withdrawn, the annulus was backfilled with clean silica sand to approximately 2 feet above the top of the screen. The remainder of the annulus was backfilled with bentonite chips. A flush-mount well monument was cemented in place to protect each piezometer. Construction details for piezometers are summarized on Table 2-1; boring logs are provided in Appendix B. Equipment was decontaminated between sampling locations.



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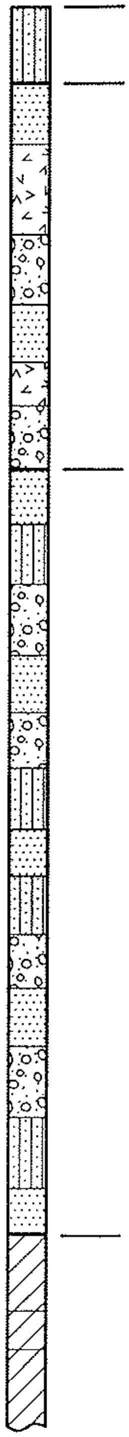
GAS WORKS PARK 5-3434-300				CENTRAL SHORELINE STUDY AREA MAP	
CURRENT DATE	9/2/98	CADD FILE	3434S034	DRAWING NO.	FIGURE 2-2



• **Surface Fill (F).** Clean fill brought to Gas Works Park as a surface cover. This unit was reported as typically 1 to 5 feet thick and composed of topsoil, vegetation, sand and gravel. In this study area, the surface fill is generally 2 feet thick.

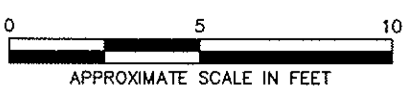
• **Gas Works Park Deposit (GWP).** Material remaining from operation and demolition of the former Manufactured Gas Plant. This unit is generally gray to black silty and/or gravelly sand mixed with wood, cinders, ash, brick, and occasional oil or tar residue. This unit was reported as present throughout most of the park area and is generally less than 10 feet thick. In the study area, it ranged in thickness from 4 to 18 feet.

• **Stratified Drift (SD).** Recessional Vashon deposits primarily composed of interbedded fine to coarse sand with some silt and gravel. This unit was reported to be absent from some areas of the park, but is present in the study area where the thickness ranged from 7 to 26 feet. Beds within this unit generally can not be correlated between wells.

• **Vashon Till (VT).** Glacially compacted conglomerate of clay, silt, sand, gravel, and cobbles thought to underlay the entire park. With the exception of Kite Hill, the surface of the till generally follows the ground surface.

LEGEND

- SANDY OR SILTY DEBRIS
- SILTY SAND TO SILT
- SAND TO SILTY SAND
- TILL (CLAYEY SILTY SAND)
- SAND TO GRAVELLY SAND



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GAS WORKS PARK 5-3434-500	GENERALIZED STRATIGRAPHIC COLUMN
CURRENT DATE 7/24/98 CADD FILE 3434S043	DRAWING NO. FIGURE 2-3

Table 2-1 Well Completion and Boring Information

Well ID	Northing	Easting	Ground Surface Elevation (ft. NAVD88)	Top of Well Casing Elevation (ft. NAVD88)	Boring Depth		Sample Interval ID Number	Screen Interval				Sand Pack	
								Top		Bottom		Top	
					Depth (ft. bgs)	Elevation (ft. NAVD88)		Depth (ft. bgs)	Elevation (ft. NAVD88)	Depth (ft. bgs)	Elevation (ft. NAVD88)	Depth (ft. bgs)	Elevation (ft. NAVD88)
MLS-1	239314.00	1269886.17	33.50	33.13	22.30	11.20	3	12.30	21.20	13.30	20.20	NA	NA
							2	16.80	16.70	17.80	15.70	NA	NA
							1	21.30	12.20	22.30	11.20	NA	NA
MLS-2	239231.43	1269818.25	30.97	30.63	24.00	6.97	3	14.00	16.97	15.00	15.97	NA	NA
							2	18.50	12.47	19.50	11.47	NA	NA
							1	23.00	7.97	24.00	6.97	NA	NA
MLS-3	239192.08	1269769.51	30.35	29.95	27.30	3.05	5	8.30	22.05	9.30	21.05	NA	NA
							4	12.80	17.55	13.50	16.85	NA	NA
							3	17.30	13.05	18.30	12.05	NA	NA
							2	21.80	8.55	22.80	7.55	NA	NA
							1	26.30	4.05	27.30	3.05	NA	NA
MLS-4	239160.46	1269734.02	22.09	21.74	24.00	-1.91	5	5.00	17.09	6.00	16.09	NA	NA
							4	9.50	12.59	10.50	11.59	NA	NA
							3	14.00	8.09	15.00	7.09	NA	NA
							2	18.50	3.59	19.50	2.59	NA	NA
							1	23.00	-0.91	24.00	-1.91	NA	NA
DW-4	239158.45	1269736.49	22.10	21.76	37.00	-14.90		32.00	-9.90	37.00	-14.90	29.00	-6.90
MLS-5	239142.62	1269720.66	21.81	21.58	25.00	-3.19	5	6.00	15.81	7.00	14.81	NA	NA
							4	10.50	11.31	11.50	10.31	NA	NA
							3	15.00	6.81	16.00	5.81	NA	NA
							2	19.50	2.31	20.50	1.31	NA	NA
							1	24.00	-2.19	25.00	-3.19	NA	NA
DW-5	239140.73	1269718.48	21.92	21.59	29.00	-7.08		24.00	-2.08	29.00	-7.08	21.00	0.92
MLS-6	239097.55	1269673.08	21.39	21.07	25.00	-3.61	5	6.00	15.39	7.00	14.39	NA	NA
							4	10.50	10.89	11.50	9.89	NA	NA
							3	15.00	6.39	16.00	5.39	NA	NA
							2	19.50	1.89	20.50	0.89	NA	NA
							1	24.00	-2.61	25.00	-3.61	NA	NA
DW-6	239094.90	1269675.85	21.39	21.04	42.00	-20.61		37.00	-15.61	42.00	-20.61	34.00	-12.61

Table 2-1 Well Completion and Boring Information (Continued)

Well ID	Northing	Easting	Ground Surface Elevation (ft. NAVD88)	Top of Well Casing Elevation (ft. NAVD88)	Boring Depth		Sample Interval ID Number	Screen Interval				Sand Pack	
								Top		Bottom		Top	
					Depth (ft. bgs)	Elevation (ft. NAVD88)		Depth (ft. bgs)	Elevation (ft. NAVD88)	Depth (ft. bgs)	Elevation (ft. NAVD88)	Depth (ft. bgs)	Elevation (ft. NAVD88)
MLS-7	239056.92	1269724.13	21.69	21.40	25.00	-3.31	5	6.00	15.69	7.00	14.69	NA	NA
							4	10.50	11.19	11.50	10.19	NA	NA
							3	15.00	6.69	16.00	5.69	NA	NA
							2	19.50	2.19	20.50	1.19	NA	NA
							1	24.00	-2.31	25.00	-3.31	NA	NA
DW-7	239054.45	1269726.57	21.80	21.46	42.50	-20.70		37.50	-15.70	42.50	-20.70	34.50	-12.70
MW-22	238720.50	1270122.50	20.70	20.40	34.00	-13.30		24.00	-3.30	34.00	-13.30	21.00	-0.30
MW-23	238717.10	1270190.67	19.96	19.51	32.50	-12.54		22.00	-2.04	32.00	-12.04	19.00	0.96
MW-24	238718.65	1270125.73	20.67	20.34	15.00	5.67		5.00	15.67	15.00	5.67	3.00	17.67
MW-25	238713.06	1270192.66	19.72	19.39	15.00	4.72		5.00	14.72	15.00	4.72	3.00	16.72
B-1	239314.00	1269888.17	33.50	—	25.50	8.00		—	—	—	—	—	—
B-2	239192.08	1269771.51	30.35	—	29.00	1.35		—	—	—	—	—	—
PZ-1	239203.82	1269609.08	22.00	21.55	13.00	9.00		3.00	19.00	13.00	9.00	2.00	20.00
PZ-2	239268.33	1269760.87	31.15	30.95	20.00	11.15		5.00	26.15	20.00	11.15	4.00	27.15
PZ-3	239231.41	1269811.84	31.03	30.83	25.00	6.03		5.00	26.03	20.00	11.03	4.00	27.03
PZ-4	239168.25	1269792.76	30.48	30.30	30.00	0.48		10.00	20.48	30.00	0.48	8.00	22.48
PZ-5	239012.95	1269782.06	24.49	24.28	18.00	6.49		3.00	21.49	18.00	6.49	2.00	22.49
PZ-6	239073.70	1269764.55	23.91	23.55	20.00	3.91		5.00	18.91	20.00	3.91	4.00	19.91
PZ-7	239073.28	1269701.21	21.28	21.12	20.00	1.28		5.00	16.28	20.00	1.28	4.00	17.28
PZ-8	239156.10	1269715.46	21.92	21.73	20.00	1.92		5.00	16.92	20.00	1.92	4.00	17.92
PZ-9	239321.31	1269844.61	33.51	33.09	22.50	11.01		12.50	21.01	22.50	11.01	9.50	24.01
PZ-10	239314.80	1269815.08	33.72	32.83	22.50	11.22		12.50	21.22	22.50	11.22	8.50	25.22
RW-1	239316.46	1269857.64	33.66	33.31	22.50	11.16		12.50	21.16	22.50	11.16	9.50	24.16

NOTES:

Sand Pack interval extends from the total boring depth to the listed top of sand pack. Bentonite seal excents from the top of sand pack to a depth of 0.5 to 2 feet below ground surface

DW - Deep well

MLS - Multilevel sampler

MW - Monitoring well

NA - Not applicable; no sand pack was installed.

PZ - Piezometer

RW - Pumping well

2.2.2 Groundwater Quality Screening

Samples for groundwater quality evaluation were obtained from piezometers PZ-3, PZ-4 and PZ-7 on December 29, 1997. The sampling protocol included water purging, measuring water quality parameters (pH, temperature, conductivity, turbidity) until stabilization, and then collecting the groundwater samples for chemical analysis. Both purging and sampling were accomplished by pumping at a low flow rate with a peristaltic pump. New pump tubing was used at each sampling location to prevent cross contamination. Piezometers were not developed prior to sampling and, therefore, the measured PAH concentrations are qualitative and were used only for screening purposes.. Unfiltered groundwater samples were collected in 1-liter amber bottles The samples were placed in a cooler on ice and transported to Analytical Resources, Inc. (ARI), of Seattle, Washington. Chain-of-custody procedures were followed. ARI analyzed the samples for PAHs by EPA Method 8270.

2.2.3 Piezometer Gauging

Water level data were gathered from piezometers and nearby existing wells. Where the wells were of sufficient diameter, the presence of LNAPL was measured using an interface probe. Where the diameter was insufficient, the water level meter was inspected for the presence of LNAPL after contacting the water table. The presence of DNAPL was evaluated using cotton string. A weighted, dry cotton string was lowered to the base of the well and then withdrawn. DNAPL appears as black staining on the string and its thickness can be estimated by the length of stained string. Water levels were measured with a decontaminated groundwater level indicator to the nearest 0.01 foot. Water levels were measured on six occasions during December 1997, January 1998, and February 1998.

2.3 Groundwater Quality Assessment

Based on the results of the piezometer work, a monitoring network was designed to define the distribution of dissolved PAH concentrations in the western study area. Vertical and lateral variations were addressed in a transect running from the source area to the shoreline in the direction of groundwater flow. Well locations are shown on Figures 2-1 and 2-2. The monitoring network consists of six multilevel sampling wells (MLS) installed along the transect (MLS-1 through MLS-6) and one MLS installed perpendicular to the transect, near the shoreline (MLS-7). MLS-6 and MLS-7 were installed in the vicinity of the shoreline in the western area to assess variation along the shoreline. Where the total depth of the aquifer exceeded the maximum sampling depth of the MLS well, an adjacent deep well (DW) was installed at the base of the aquifer. To further quantify variation in dissolved PAH concentration along the shoreline, two pairs of wells MW-22/MW-24 and MW-23/MW-25 were installed near the shoreline in the central shoreline area.

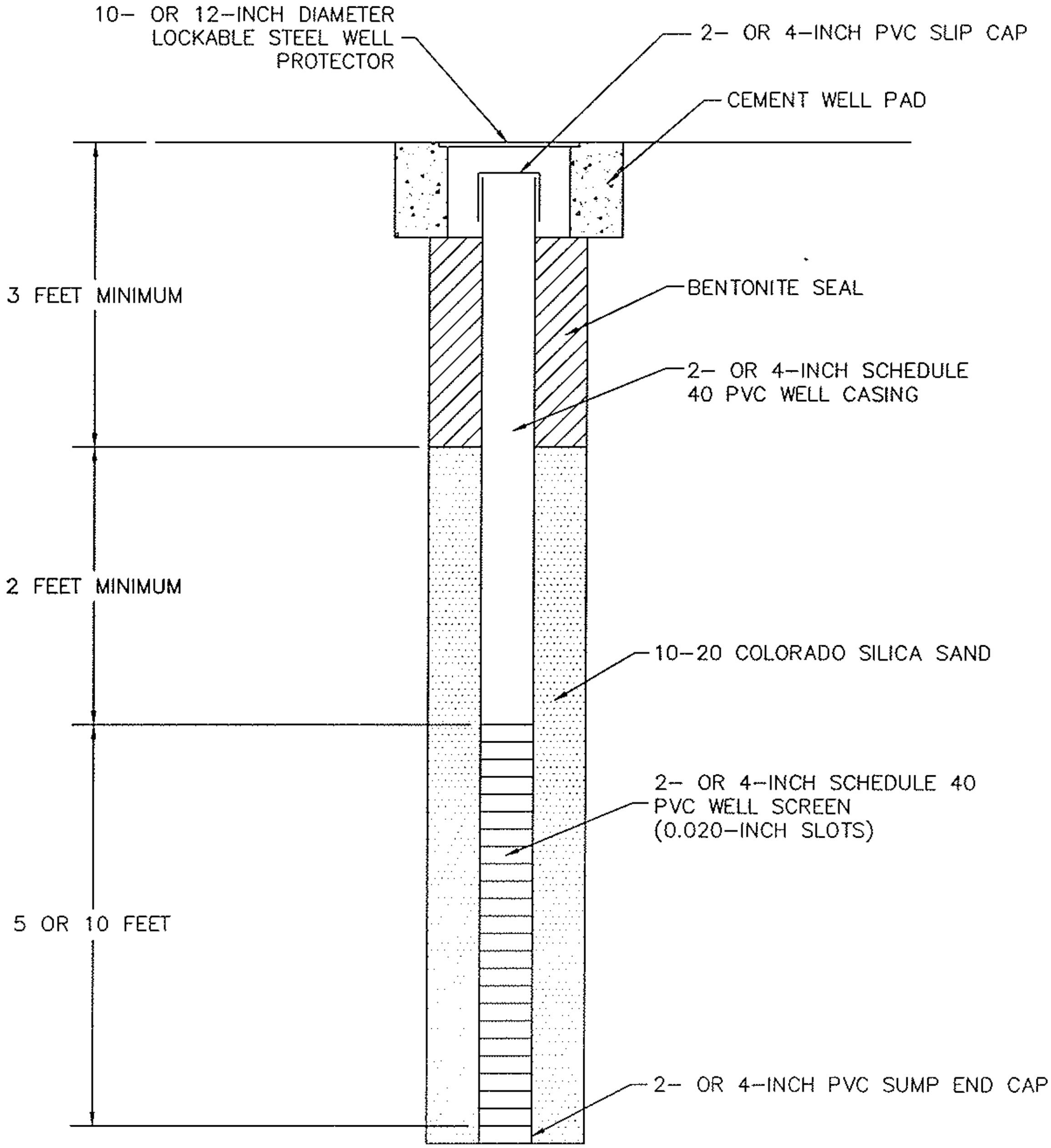
Soil stratigraphy and contaminant distribution in soils at the MLS/DW locations in the western shoreline area and at the well pair locations in the central shoreline were defined by soil sampling during installation of the deep well. At locations where a deep well was not installed, a boring was drilled to define soil stratigraphy. Soil samples were submitted for leachability testing and three tar samples were submitted for characterization. Groundwater samples were collected after well installation. Additional sampling of shoreline wells was completed approximately 2 months later to confirm the original sampling results.

2.3.1 Monitoring Well and Boring Installation

In February 1998, soil borings were advanced to the top of the till using hollow-stem auger drilling techniques. Soil samples were collected every 2.5 feet from ground surface to the bottom of the boring. Samples for geologic logging and analytical testing were taken from clean stainless-steel split-spoon samplers driven ahead of the lead hollow-stem auger flight via a standard penetration test.

The recovered soil was used for geologic logging and screened in the field for organic vapors. A portion of the sample was jarred for possible analytical testing. Soil characteristics and field evidence of contamination (odor, sheen, staining, NAPL) were noted on the boring log. The presence of organic compounds was evaluated by isolating recovered soil in a sealed plastic bag and allowing it to equilibrate. The concentration of volatile organic compounds within the headspace of the bag was screened using a precalibrated photoionization detector (PID). The PID headspace reading was recorded on the boring log. Soil samples collected from borings B-2, DW-5 and DW-7 were submitted for leachability tests as described below. PZ-9 and PZ-10 were installed for the pump test as described in Section 2.4.1.

Wells were constructed in accordance with the Washington State Department of Ecology *Minimum Standards for Construction and Maintenance of Wells*, Chapter 173-160 Washington Administrative Code (WAC). Typical well construction details are shown on Figure 2-4. All wells were constructed using 2-inch-diameter, Schedule 40 PVC casing and screen with 0.010-inch slots. Five-foot screen lengths were used in wells DW-4 through DW-7. Ten-foot screens were used in wells MW-22, MW-23, MW-24, and MW-25. Well construction details are summarized on Table 2-1. The annulus was packed with clean silica sand across the screened interval and extending a minimum of 2 feet above the top of the screen. Before installing the overlying seal, a surge block was raised and



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GAS WORKS PARK 5-3434-300				TYPICAL WELL CONSTRUCTION DETAILS	
CURRENT DATE	5/29/98	CADD FILE	3434D01S	DRAWING NO.	FIGURE 2-4

lowered across the screened interval to settle the sand in the filter pack. Bentonite chips were installed in the annulus above the filter pack to seal the boring and prevent vertical migration of groundwater. The wells were completed with flush-mount monuments firmly cemented in place.

Monitoring wells were developed by overpumping with a Brainerd-Kilman pump from February 6 through 10. This method provided surging action to agitate the filter pack and remove fines. If wells were pumped dry, then the well was allowed to recover prior to resuming water removal. Wells were developed until recovered water was relatively clear and free of suspended particulate matter.

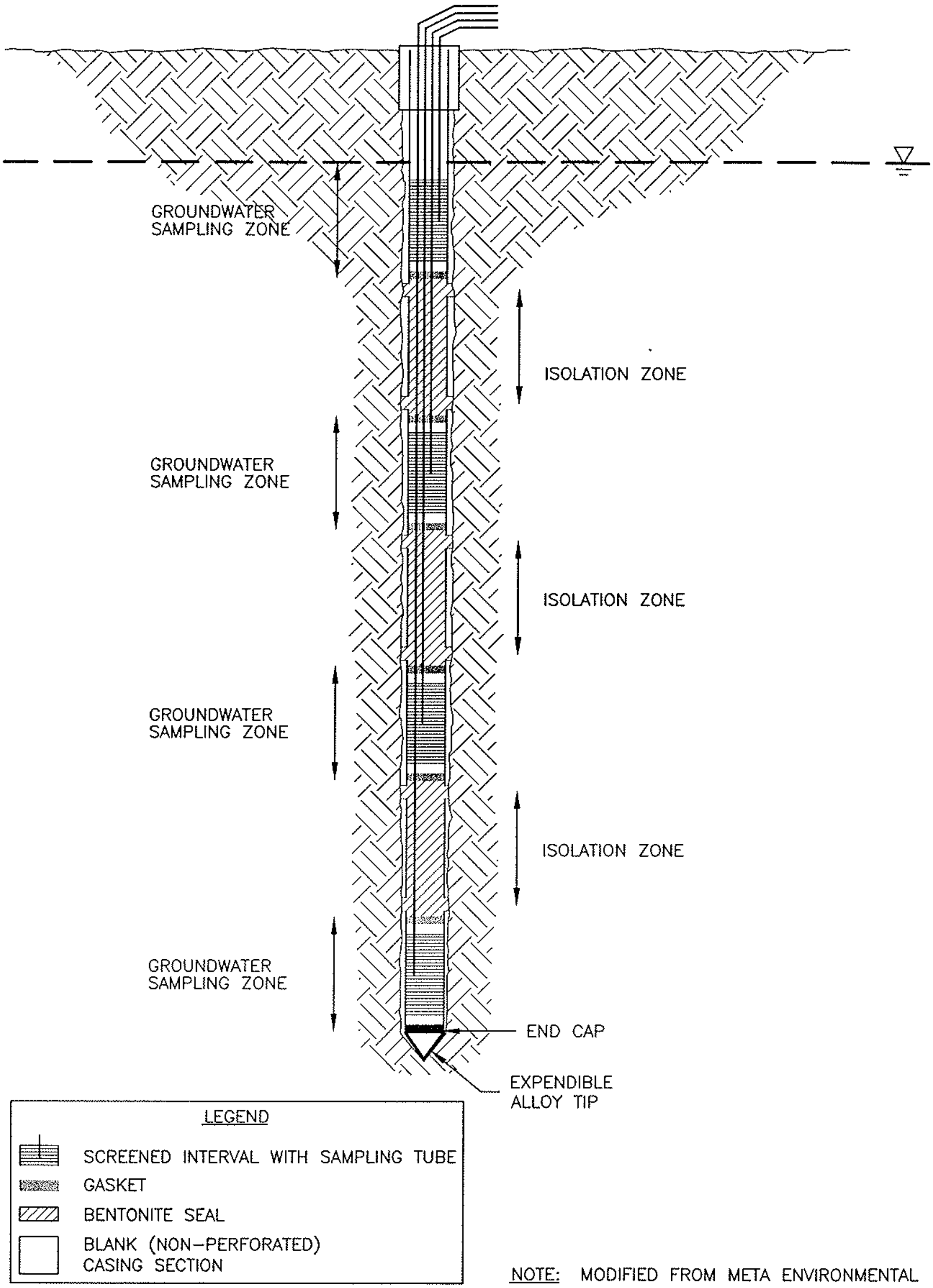
2.3.2 Multilevel Sampling Well Installation

Multilevel sampling (MLS) wells were used in this study to quantify the vertical and lateral distribution of PAHs in groundwater along a flow path. MLS wells were installed using direct-push equipment. A hollow steel rod with a disposable solid tip was pushed into the ground to the desired depth. The MLS well was then lowered into the rod and the rod was withdrawn from the hole. The outside diameter of the rod is 0.75 inch larger than the outside diameter of the well, minimizing the annulus and preventing cross contamination between screened intervals as described below.

The MLS wells were constructed using 2-inch-diameter PVC casing pipe and screen. The MLS consist of three to five 1-foot screened sections separated by 3.5-foot PVC spacers. The typical MLS well configuration details are shown in Figure 2-5 and construction details are summarized in Table 2-1. A stretch of polyethylene sample tubing runs from each screen interval to the ground surface through the interior of the well casing. The PVC spacers are packed with bentonite to provide a seal between the screened sections. These blank casing sections are slotted near the top and bottom of the section. When the MLS is installed below the water table, bentonite swells out of the slots and seals against the borehole wall. Horizontal gaskets at the top and bottom of each spacer section prevents bentonite from swelling into the screen section. A lockable flush-mount steel well monument was installed to protect the MLS.

2.3.3 Groundwater Sampling

Groundwater samples were collected from deep wells (DWs), MLSs, and existing wells in 1997 and 1998 according to the schedule in Table 2-2. Prior to sampling, water levels in monitoring wells were measured as described above. Monitoring wells and MLS wells were then sampled using low-flow sampling techniques. All wells were purged and sampled using an electric peristaltic pump and ⅜-inch outside diameter Tygon tubing. The inlet of the Tygon tubing was



NOTE: MODIFIED FROM META ENVIRONMENTAL

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GAS WORKS PARK 5-3434-300				MULTILEVEL SAMPLER CONFIGURATION	
CURRENT DATE	9/15/98	CADD FILE	3434S022	DRAWING NO.	FIGURE 2-5

Table 2-2 Groundwater Sampling Schedule

Well Location	Date Sampled		
	Dec-97	Feb-98	Apr-98
DW-4		✓	
DW-5		✓	
DW-6		✓	✓
DW-7		✓	✓
MLS-1-1		✓	
MLS-1-2		✓	
MLS-1-3		✓	
MLS-2-1		✓	
MLS-2-2		✓	
MLS-2-3		✓	
MLS-3-1		✓	
MLS-3-2		✓	
MLS-3-3		✓	
MLS-4-2		✓	
MLS-4-3		✓	
MLS-4-4		✓	
MLS-4-5		✓	
MLS-5-1		✓	
MLS-5-2		✓	
MLS-5-3		✓	
MLS-5-4		✓	
MLS-5-5		✓	
MLS-6-1		✓	✓
MLS-6-2		✓	✓
MLS-6-3		✓	
MLS-6-4		✓	✓
MLS-6-5		✓	✓
MLS-7-1		✓	✓
MLS-7-2		✓	✓
MLS-7-3		✓	✓
MLS-7-4		✓	✓
MLS-7-5		✓	✓
MW-13			✓
MW-14		✓	
MW-22		✓	✓
MW-23		✓	✓
MW-24		✓	✓
MW-25		✓	✓
PZ-3	✓		
PZ-4	✓		
PZ-7	✓		

lowered into the well and positioned in the middle of the screened portion of the well. Each well was purged at a flow rate of less than 0.30 liters per minute until field parameter values stabilized to within 10 percent of the previous measurement. The purge water was monitored for temperature, pH, conductivity, reduction/oxidation (redox) potential, dissolved oxygen and turbidity. All parameters except turbidity were measured using an in-line flow cell. Turbidity was measured with a nephelometer. The meters were calibrated at the beginning of each field day. The tabulated groundwater purge data are presented in Appendix C, Table C-1.

New pieces of Tygon tubing were used for purging and sampling each well. Laboratory-provided 1-liter amber bottles were filled with unfiltered groundwater directly from the tubing. After sample collection, sample containers were placed in a cooler with ice. The samples were then delivered to the laboratory for analysis following chain-of-custody procedures.

The MLS wells were purged and sampled using similar low-flow sampling methods. All screened sections of an individual MLS were pumped at the same time using a multichannel peristaltic pump connected to the sampling tubes from each screened section. A total of 1,000 milliliters of water was purged from each screened section and water quality parameters were recorded every 500 milliliters, or approximately after each screened section volume.

2.3.4 Soil and Product Testing

Six soil samples were used for leachability testing in the laboratory by Purdue University in Lafayette, Indiana. Methods are described in detail in Appendix D.

Three DNAPL samples (from wells MLS-4-1, DW-4, and MW-5) were collected from wells and multilevel samplers in the western study area. Each sample was quantitatively diluted in methylene chloride following a modification of EPA Method 3580A and analyzed for MAH and PAH by a modification of EPA method 8100. The EPA Method 8100 modification utilized capillary column gas chromatography with flame ionization detection (GC/FID) operated so that MAHs, including benzene, and PAHs could be determined in a singe run. The DNAPL samples from wells DW-4 and MW-5 were analyzed for total carbon, total hydrogen, and total oxygen. In addition to chemical analyses, several physical properties including kinematic viscosity, density, Karl Fisher water content, and average molecular weight, were determined for the samples. DNAPL analyses were completed by META Environmental, Inc., of Watertown, Massachusetts.

2.4 Pump Test Methods

A 50-hour pump test was performed to refine previous hydraulic conductivity estimates for the site. The pump test was performed in the northern portion of the western study area. The following factors were considered in selecting the locations of the pumping and observation wells:

- **Distance from Lake Union.** The test was completed away from the constant head boundary effects of Lake Union.
- **Aquifer Properties.** The test was completed in an area where the aquifer was primarily composed of the drift.
- **NAPL.** The test was completed north in an area with limited amount of NAPL in the aquifer. NAPL in the aquifer can reduce hydraulic conductivity or effective permeability of water.
- **Water Quality.** The test was completed in an area where the treatment needs for produced fluids would be minimized.

Pump test activities included installation of a pumping well and two piezometers, and conducting a step test, pump test, and recovery test.

2.4.1 Well and Piezometer Construction

Pumping well (RW-1) and two additional piezometers (PZ-9 and PZ-10) were installed on March 20, 1998, to perform the pump test. Wells were installed and constructed using the hollow-stem auger methods described previously. However, the pumping well, RW-1, was constructed with 4-inch-diameter casing. The screen length in the pumping well and piezometers was 10 feet.

Piezometers PZ-9 and PZ-10 were developed using the Brainerd-Kilman pump as described previously. Development of RW-1 was more rigorous and included surging, bailing, and pumping. First, a surge block was raised and lowered into the well beginning with short strokes above the screen and slowly increasing in speed, length, and depth. A dart-valve bailer was then used to remove sediment from the well prior to pumping. This type of bailer also provided some surging effects in the well. After bailing, a submersible pump was placed in the well and the pumping rate was slowly increased to draw water down close to the level of the pump. To test well yield, the depth to water was measured before beginning pumping and again every 5 minutes during pumping until equilibrium was reached (depth to water constant for 10 minutes). The pumping rate was then slowly increased in 0.25- to 0.5-gallon per minute (gpm) increments and the new equilibrium depth was recorded. The well was then surged, bailed, and pumped. The measurement program during pumping was continued to gauge the improvement from each surging, bailing, and pumping cycle. If the well was pumped dry, the pump was stopped and the well was allowed to recover. Development continued until measurements indicated that surging and bailing was providing no additional benefit to the well yield.

2.4.2 Step Drawdown Test

A step drawdown test was conducted to assess the aquifer response and to select the pumping rate for the long-term, constant-discharge pump test. The test was conducted by pumping the aquifer at a given rate until the water level in the pumping well had stabilized. After the water level stabilized, the discharge rate was increased and the water level was again allowed to stabilize. Three discharge rates (0.2, 0.3 and 0.45 gpm) were used for the step drawdown test. The final pumping cycle was terminated when the water level in the well dropped below the top of the pump, thereby preventing further water level measurements. Approximately 25 gallons of water were removed during the test. After completion of the final pumping cycle, the pump was turned off and the water levels were allowed to recover overnight before initiation of the constant-discharge pumping test. During the step drawdown test, water levels in RW-1 and PZ-9 were measured manually.

2.4.3 Pump Test

The constant-discharge pump test began on April 8, 1998, at 0900 hours and was completed on April 10, 1998 at 1130 hours. The pumping rate was maintained at approximately 0.25 gpm for the duration of the test. Approximately 750 gallons of water were pumped during the test. The data logger was programmed to collect readings at the sampling intervals listed in Appendix E, Table E-1. Periodically, groundwater levels in the wells with transducers and selected wells nearby were measured manually to verify transducer data and determine the extent of drawdown. The wells closer to the pumping well were gauged more frequently than those farther away. Pertinent well construction information for wells and piezometers monitored during the pump test is presented in Table 2-3. Monitoring well gauging frequency during the pump test is listed in Appendix E, Table E-1.

Table 2-3 Recovery and Monitoring Well Construction Data

Well No.	Measuring Point Elevation (feet NAVD88)	Well Depth (feet bgs)	Well Construction	Screen Interval (feet bgs)	Distance from Pumping Well (feet)
RW-1	33.31	22.5	4-inch PVC	12.5–22.5	—
PZ-9	33.09	22.5	2-inch PVC	12.5–22.5	14
PZ-10	32.83	22.5	2-inch PVC	12.5–22.5	42.5
MW-18	33.47	NA	2-inch PVC	NA	82
PZ-3	31.03	20.0	1-inch PVC	5.0–20.0	96.5
PZ-2	30.95	20.0	1-inch PVC	5.0–20.0	108
MW-19	33.43	NA	2-inch PVC	NA	120.5
PZ-4	30.30	30.0	1-inch PVC	10.0–30.0	162
MW-17	29.32	16.5	2-inch PVC	6.5–16.5	232
MW-8	33.09	18.0	2-inch PVC	8.0–18.0	1,110

NOTE:
NA - No boring log available.

The transducer measurements and the manual measurements for wells RW-1, PZ-9, and PZ-10 were plotted on semi-log paper during the test to view the drawdown trends.

Flow rates were measured during the test to ensure that the pumping rate remained constant. The flow rate was checked every hour during the pump test both by noting the volume recorded by the totalizer in one minute and by holding a graduated cylinder at the discharge outlet for one minute. If the flow rate varied from 0.25 gpm, the valve was adjusted until the flow rate returned to 0.25 gpm.

2.4.4 Recovery Test

A recovery test was conducted immediately following the constant-discharge pump test. When the pump was turned off, wells RW-1, PZ-9, PZ-10, and PZ-2 were monitored with pressure transducers and the data logger until the water levels had recovered from pumping. The data logger was programmed to record readings at the intervals listed in Appendix E, Table E-1. Water levels in the remaining monitoring wells were measured manually. Groundwater recovered to 90 percent of the initial water levels within 35 minutes. The recovery test was completed on April 10, 1998, at 1820 hours.

2.4.5 Drawdown Data Corrections

To determine if the water level measurements were influenced by regional water level changes, well MW-8, located 1,110 feet from the pumping well, was monitored to establish trends in background water levels. Over the course of the pumping test the water table elevation measured in MW-8 rose from 26.27 to 26.47 feet NAVD88 (Appendix E, Figure E-7). The pumping test data compiled from observation wells PZ-9 and PZ-10 was corrected by the following equation before being analyzed:

$$\textit{corrected drawdown} = \textit{measured drawdown} + \Delta h_t$$

where

$$\Delta h_t = \|\textit{initial water level in } MW\text{-}8 - \textit{water level in } MW\text{-}8 \textit{ at time } t\|$$

This equation allows for a changing drawdown correction factor to remove the variable background influence on the aquifer throughout the pump test.

The drawdown at PZ-9 was large enough and the duration of the recovery short enough that external influences were negligible and data corrections were unnecessary. Recovery data from well PZ-10 was not used because drawdown in this well was minimal and therefore was susceptible to minor background influences within the aquifer.

2.4.6 Data Analysis Methods

Drawdown data from the pumping and monitoring wells were analyzed to calculate the transmissivity and storativity of the aquifer. The transmissivity was then used to calculate the aquifer's hydraulic conductivity. Because of the uncertainty in the behavior of the aquifer and the ambiguity in the drawdown plots, the following analytical solutions, both for unconfined and semiconfined conditions, were utilized to analyze the data:

- Theis (1935) - unconfined
- Cooper-Jacob (1946) - unconfined
- Neuman (1974) - unconfined
- Hantush-Jacob (1955) - semiconfined
- Hantush (1960) - semiconfined
- Moench (1985) - semiconfined

The graphical analyses of the time-drawdown data for these methods was performed using AQTESOLV™. These plots are included in Appendix E. In addition to the AQTESOLV™ (Duffield, 1996) analyses, the Jacob distance-drawdown graphical solution was also applied as a check on the AQTESOLV™

results. Appendix E also lists the input parameters and complete data sets for the tests.

The analyses were completed on drawdown data from the pumping well (RW-1) and monitoring wells PZ- 9 and PZ-10. After running each well's data set through all of the solutions, the resulting curves were visually compared and the best matches were selected.

Recovery data were analyzed graphically to provide additional information on aquifer characteristics by plotting drawdown versus time since pumping stopped divided by the duration of the pump test. The recovery data from monitoring well PZ-9 were analyzed by the same analytical solutions used for the drawdown data.

3 Results

This section summarizes results of the data collection efforts. Well and piezometer installation, water level measurements, the pump test, and groundwater sampling and analysis provided information on soil characteristics, groundwater flow and the water quality in the aquifer.

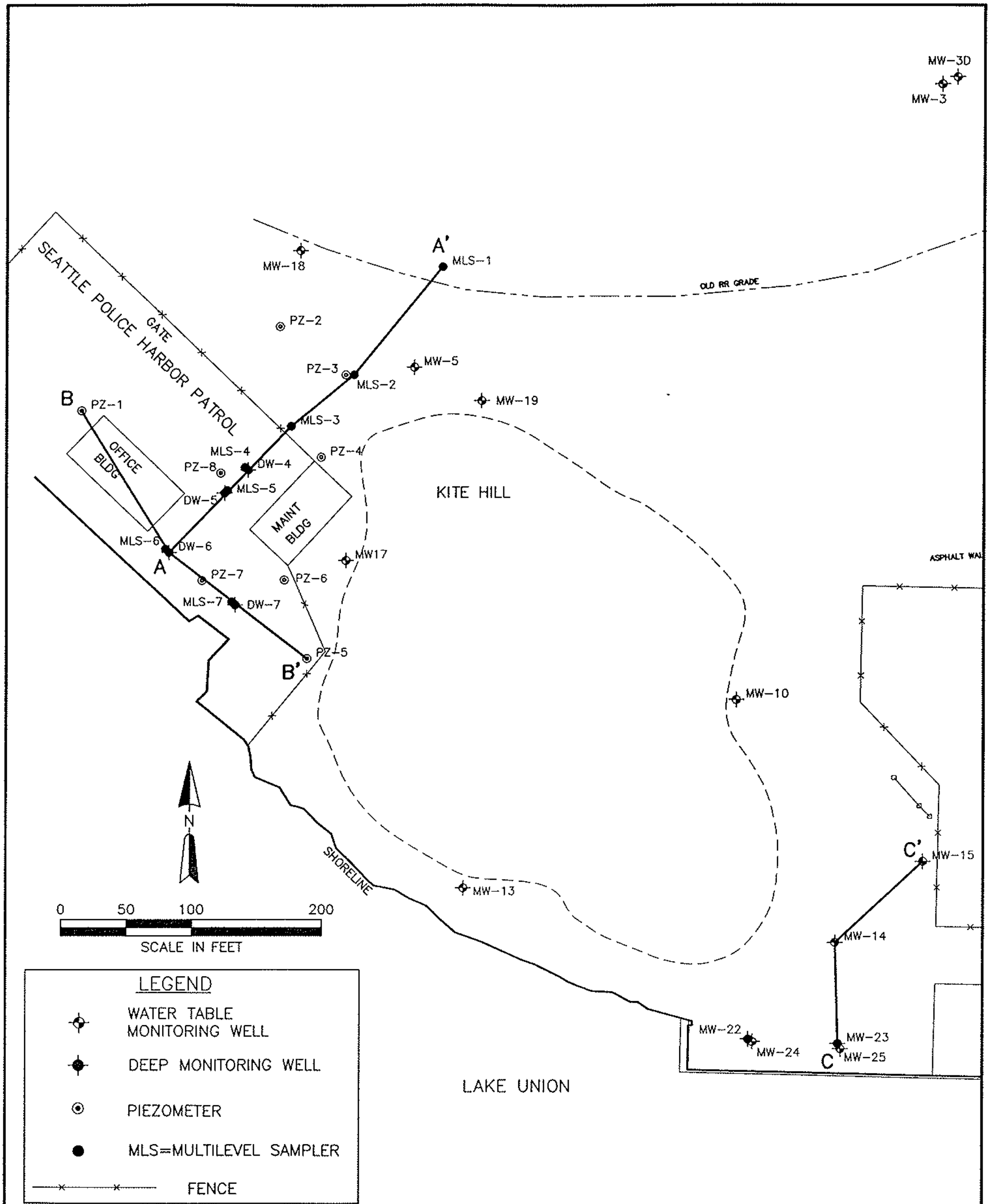
3.1 Soil Stratigraphy

Sampling during well and piezometer installation confirmed that stratigraphic units in the western and central shoreline areas were similar to those previously defined at the site (see Figure 2-3). Cross section locations are shown on Figure 3-1. The cross sections, on Figures 3-2, 3-3, and 3-4, illustrate the distribution and thickness of the lithologies encountered during this study.

The fill at the park can generally be divided into two units. The surficial fill was placed as a cap during park construction and generally consists of fine- to medium-grained sand with gravel. The surficial fill was approximately 2 feet thick in the western shoreline area. The underlying fill, referred to as the Gas Works Park (GWP) deposit is composed of soil and debris deposited during operation and demolition of the MGP. The GWP is very heterogeneous. In general, it consists primarily of grey to black silt, sand, and gravel with occasional clay beds and abundant ash, cinders, wood, and brick fragments. In the study area, this unit ranged in thickness from 4 to 18 feet and was thickest in the shoreline borings.

Underlying the GWP is the native Stratified Drift unit. This unit consists of reworked glacial material deposited by swift moving braided streams at the terminus of the retreating ice sheet. The Stratified Drift is complexly interbedded and is composed primarily of sand with 5 to 50 percent silt. Thin silt and clay beds are common, as are sandy gravel zones up to 3 feet thick. The beds are laterally discontinuous and generally cannot be correlated between borings. In the central study areas, the Stratified Drift ranged from less than 5 feet thick in upgradient well MW-15 to over 25 feet thick in the shoreline borings. In the upland portion of the western study area the drift has an approximate thickness of 14 feet, which increases to 23 feet at the shoreline. The maximum observed thickness of Stratified Drift is 26 feet at soil boring DW-4.

The lowermost unit encountered during the investigation was the Vashon Till, a glacially compacted conglomerate of clay, silt, sand and gravel. The dense nature and relatively low permeability of this unit make it an effective aquitard for the



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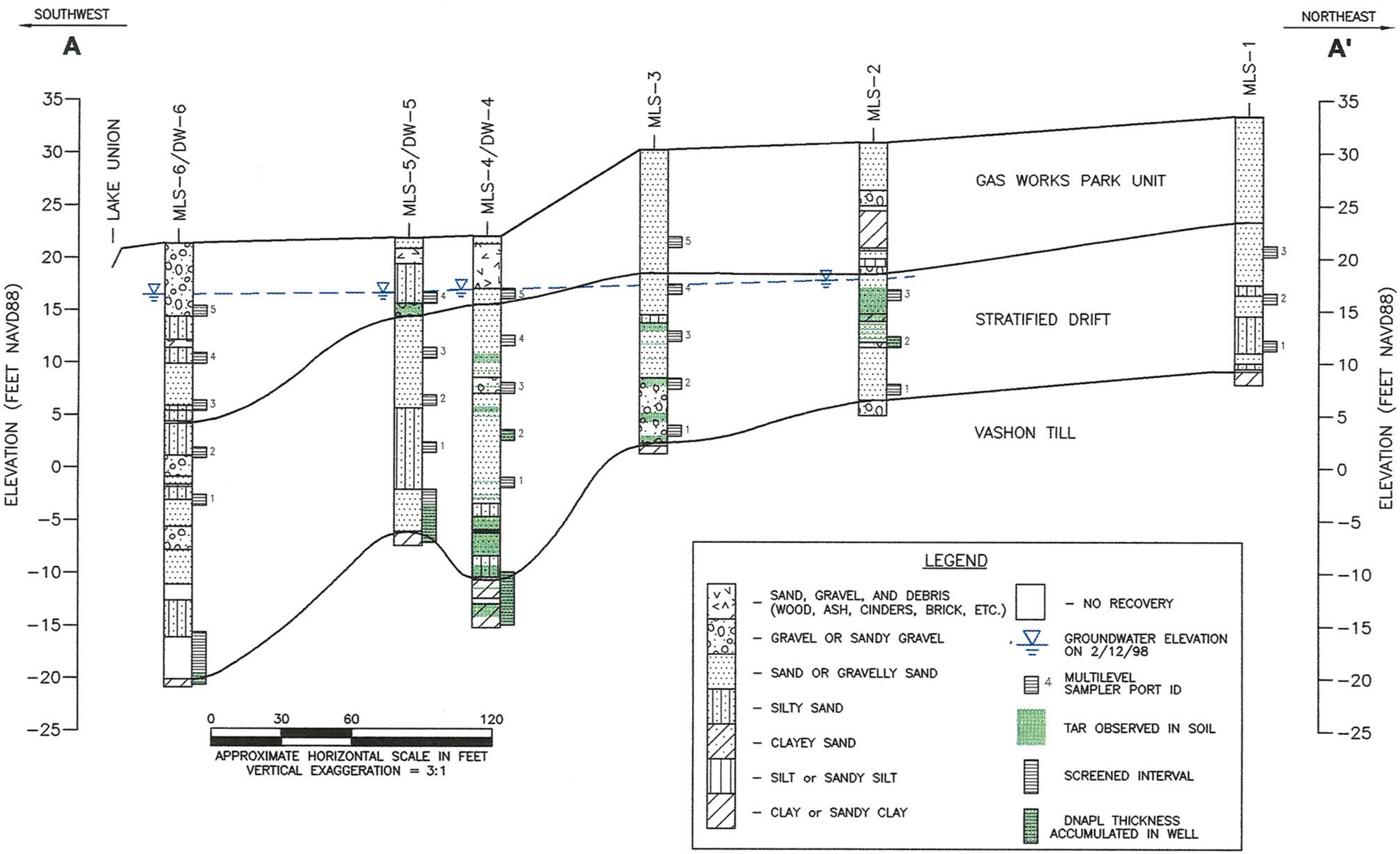
GAS WORKS PARK 3-2306-000				CROSS-SECTION LOCATION MAP	
CURRENT DATE	9/2/98	CADD FILE	3434S050	DRAWING NO.	FIGURE 3-1



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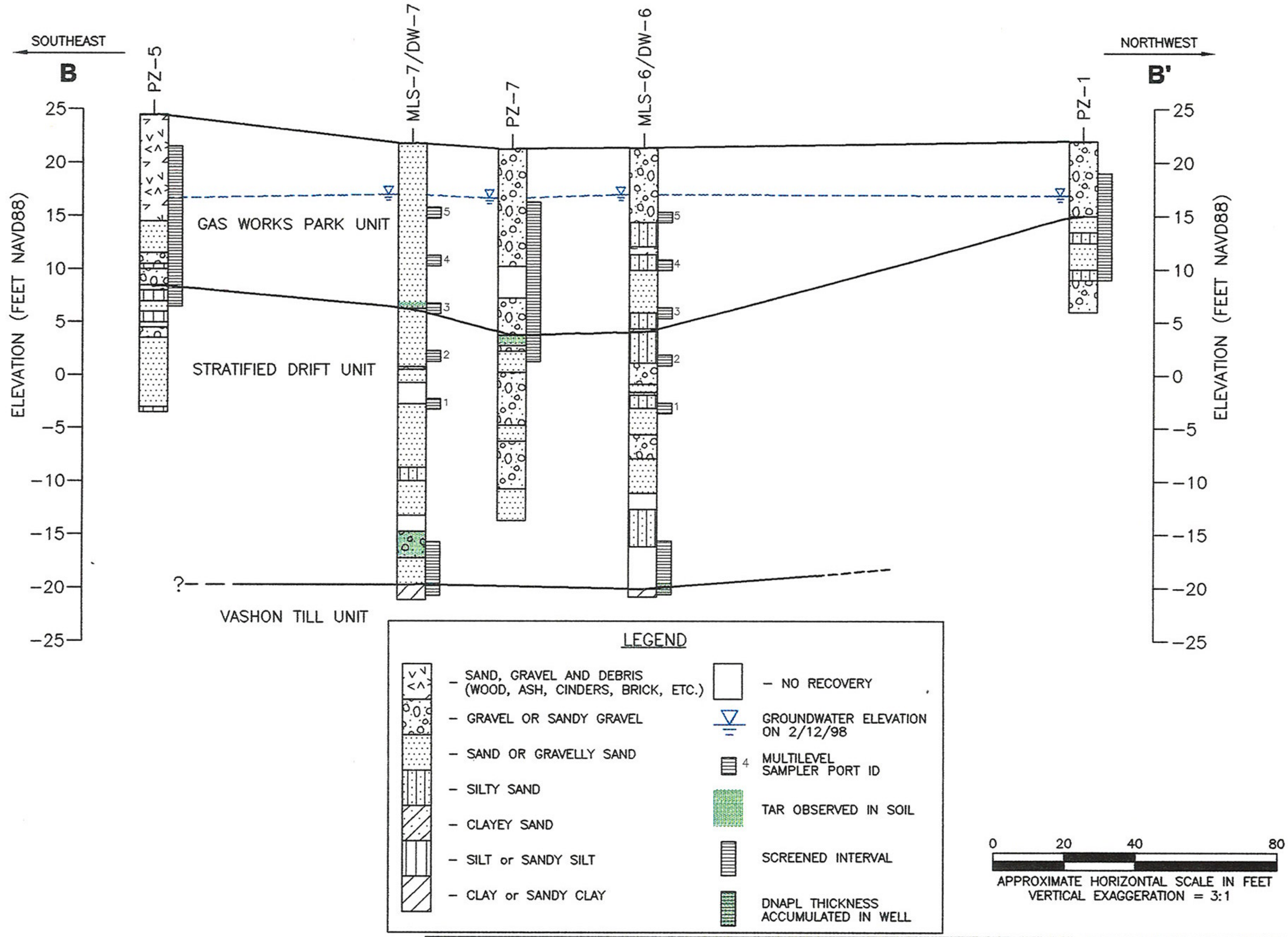
REMEDIATION TECHNOLOGIES INC

GAS WORKS PARK 5-3434-300	GEOLOGIC CROSS-SECTION A-A'
CURRENT DATE 9/3/98 CADD FILE 3434G01B	DRAWING NO. FIGURE 3-2



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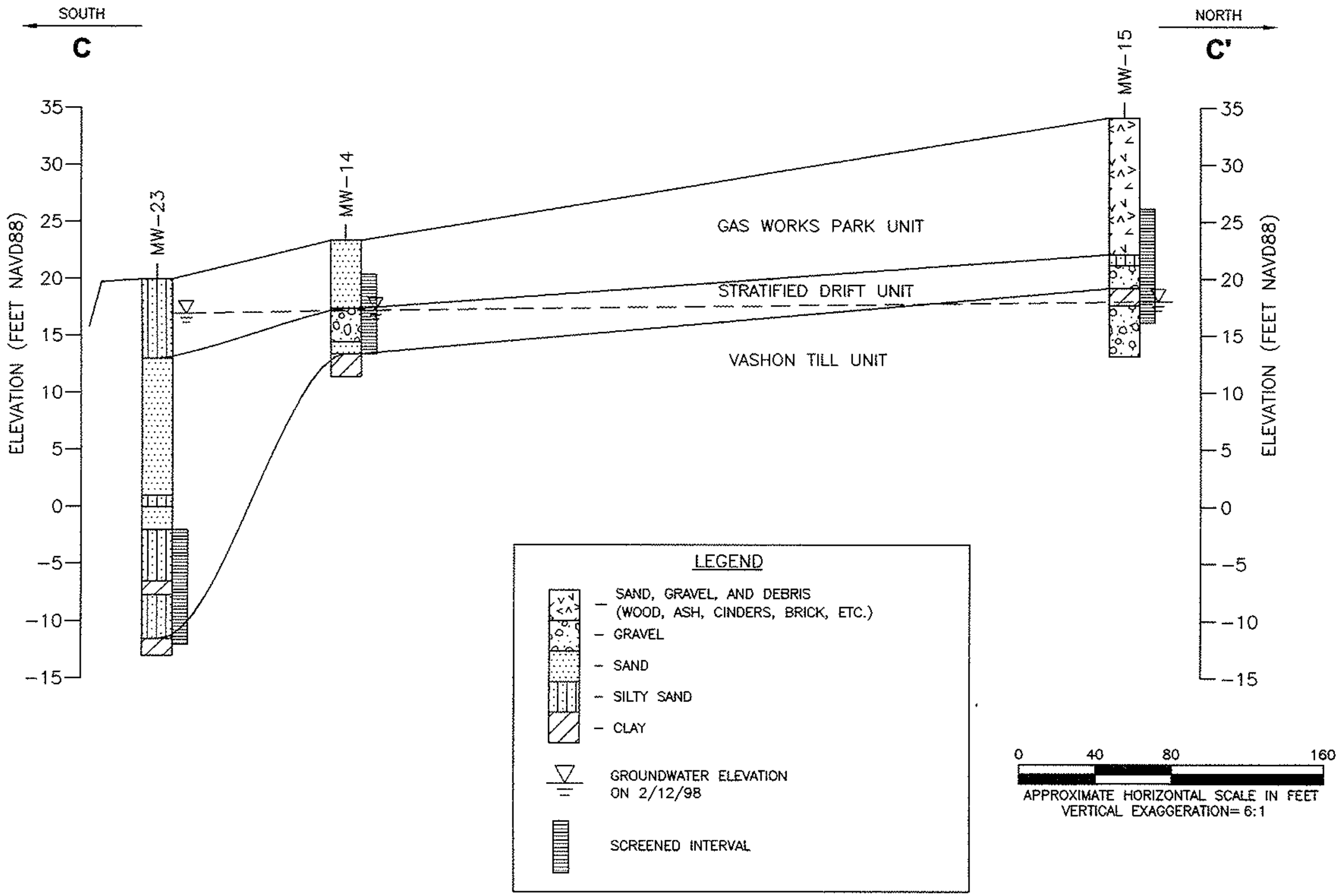
GAS WORKS PARK

5-3434-300

GEOLOGIC CROSS-SECTION B-B'

CURRENT DATE	9/3/98	CADD FILE	3434G02B	DRAWING NO.	FIGURE 3-3



RETEC
REMEDIATION TECHNOLOGIES INC

GAS WORKS PARK 5-3434-300				GEOLOGIC CROSS-SECTION C-C'	
CURRENT DATE	9/2/98	CADD FILE	3434G003	DRAWING NO.	FIGURE 3-4

overlying water table aquifer. The upper contact of the till was found at a minimum depth of 10 feet bgs in the upland portion of the western study area, and deepened to a maximum depth of 42 feet bgs in the western area shoreline wells. A contour map showing the topography of the top of the till is presented as Figure 3-5. A localized depression on the top of the till was noted in the vicinity of DW-4. This depression has a relief of approximately 4 feet on the downdip (shoreline) side.

3.2 Groundwater Occurrence and Flow Direction

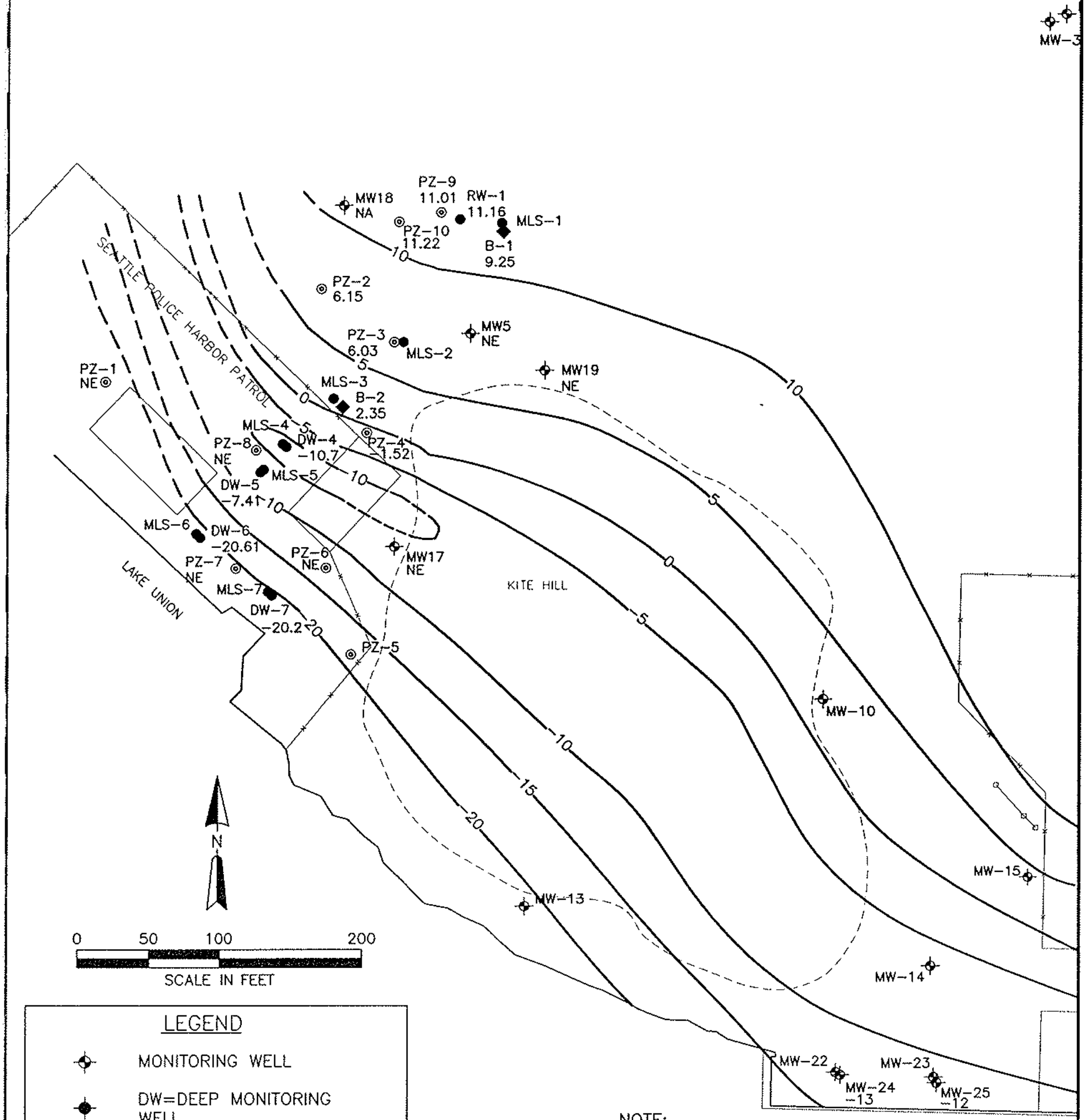
Groundwater at the site occurs primarily under unconfined, water table conditions, with the base of the water table aquifer at the top of the Vashon Till. The presence of thin fine-grained layers may result in localized semiconfined conditions. The water table is primarily within the Stratified Drift. To the south where the top of the Stratified Drift dips and GWP unit thickens, the water table is within the GWP unit. The aquifer is thought to be recharged by uplands flow and infiltration of precipitation through exposed soils in the park and surrounding properties.

Table 3-1 presents the gauging data from December 1997 to May 1998 for wells located in the study areas, and Figure 3-6 is a typical groundwater flow map for the western and central study areas. Additional groundwater contour maps based on the data collected during this project are included in Appendix F. Data from piezometer PZ-4 was not used in this study. Measurements in PZ-4 were anomalous and showed rapid changes related to precipitation suggesting problems with well construction.

The water table in the western study area occurs from 10 to 18 feet bgs upgradient of the Harbor Patrol facility, and from 3 to 8 feet bgs under the capped surface of the property. The depth to water variations in this western study area are primarily associated with changes in surface topography. The flow direction is consistently southwesterly towards Lake Union.

Groundwater in the central study area ranged in depth from 5 to 6 feet bgs in the upgradient wells to 1 to 4 feet bgs in the shoreline wells. The flow direction is south towards Lake Union.

The horizontal flow gradient for the western study area was calculated from water table elevation data generated during eight gauging rounds completed from December 1997 through May 1998. In the western study area, the gradient varied from the upland unpaved area to the shoreline paved area. The groundwater gradient varied from 0.0016 to 0.0042 feet per foot beneath the



LEGEND

- MONITORING WELL
- DW=DEEP MONITORING WELL
- PIEZOMETER
- MLS=MULTILEVEL SAMPLER
- SOIL BORING
- —5— TOP OF VASHON TILL (FEET NAVD88)

NOTE:

1. NE: TILL NOT ENCOUNTERED
2. NA: BORING DATA NOT AVAILABLE
3. PZ-5 DATA NOT INCLUDED IN CONTOUR
4. CONTOURS EXTENDED NORTHWESTWARD BASED ON 1993 AGI REPORT FOR THE METRO FACILITY (AGI, 1993), SOUTHEASTWARD BASED ON USGS WORK (TURNEY AND GOERLITZ, 1989)

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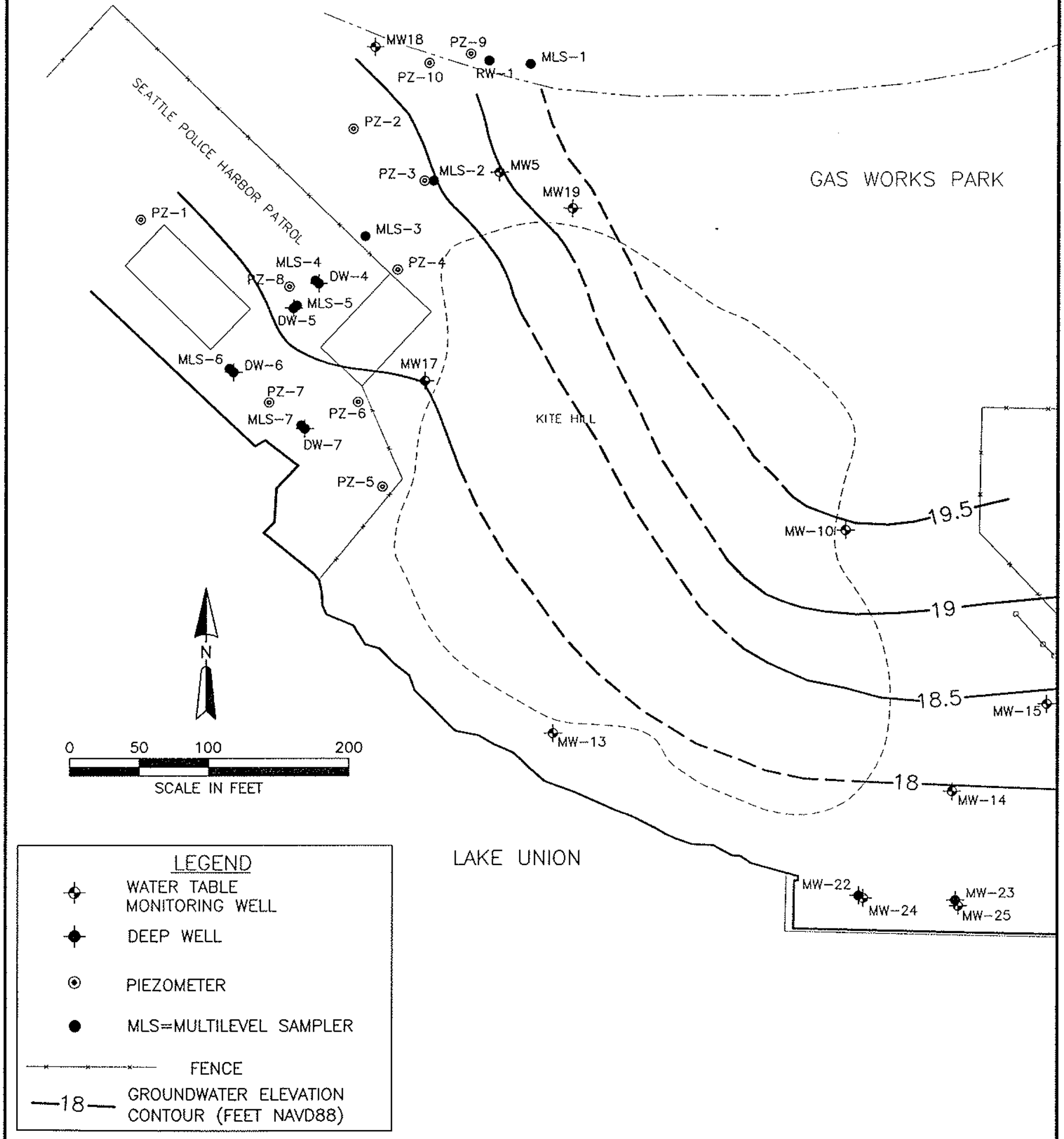
GAS WORKS PARK 5-3434-300				WESTERN STUDY AREA VASHON TILL ELEVATION CONTOUR MAP	
CURRENT DATE	9/2/98	CADD FILE	3434S042	DRAWING NO.	FIGURE 3-5

Table 3-1 Gauging Data

Well ID	Top of Casing Elevation (ft NAVD88)	12/09/97 DTW (ft)	12/09/97 Elevation (ft)	12/18/97 DTW (ft)	12/18/97 Elevation (ft)	12/23/97 DTW (ft)	12/23/97 Elevation (ft)	12/29/97 DTW (ft)	12/29/97 Elevation (ft)	01/05/98 DTW (ft)	01/05/98 Elevation (ft)	02/12/98 DTW (ft)	02/12/98 Elevation (ft)	02/18/98 DTW (ft)	02/18/98 Elevation (ft)	03/31/98 DTW (ft)	03/31/98 Elevation (ft)	05/19/98 DTW (ft)	05/19/98 Elevation (ft)
DW-4	21.76											4.5	17.26	4.51	17.25	4.13	17.63	3.95	17.81
DW-5	21.59											4.54	17.05	4.5	17.09	3.75	17.84	3.37	18.22
DW-6	21.04											4.01	17.03	3.99	17.05	3.08	17.96	2.78	18.26
DW-7	21.46											4.42	17.04	4.38	17.08	3.47	17.99	3.15	18.31
MW-7	32.43											8.53	23.9	8.57	23.86	9.09	23.34	10.58	21.85
MW-10	28.32											9.07	19.25	9.05	19.27	8.83	19.49	9.25	19.07
MW-13	28.54											11.72	16.82	11.63	16.91	10.62	17.92	10.35	18.19
MW-14	22.99											5.94	17.05	5.88	17.11	5.01	17.98	4.70	18.29
MW-15	33.84											16.14	17.7	16.1	17.74	15.41	18.43	15.36	18.48
MW-17	29.32	12.69	16.63	12.59	16.73	12.59	16.73	12.62	16.70	12.43	16.89	12.21	17.11	12.17	17.15	11.32	18.00	11.04	18.28
MW-18	33.47	NM	NM	15.86	17.61	15.89	17.58	16.02	17.45	15.78	17.69	15.42	18.05	15.38	18.09	14.76	18.71	14.77	18.70
MW-19	33.43	15.40	18.03	15.18	18.25	15.18	18.25	15.27	18.16	15.16	18.27	14.23	19.20	14.26	19.17	14.03	19.40	14.39	19.04
MW-22	20.40											3.55	16.85	3.46	16.94	2.52	17.88	2.16	18.24
MW-23	19.51											2.60	16.91	2.58	16.93	1.66	17.85	1.26	18.25
MW-24	20.34											3.46	16.88	3.37	16.97	2.46	17.88	2.08	18.26
MW-25	19.39											2.50	16.89	2.41	16.98	1.48	17.91	1.14	18.25
PZ-1	21.55	5.00	16.55	4.98	16.57	4.99	16.56	4.99	16.56	4.71	16.84	4.57	16.98	4.58	16.97	3.65	17.90	3.29	18.26
PZ-2	30.95	14.01	16.94	13.85	17.10	13.90	17.05	13.95	17.00	13.71	17.24	13.46	17.49	13.47	17.48	12.79	18.16	12.66	18.29
PZ-3	30.83	13.74	17.09	13.45	17.38	13.57	17.26	13.63	17.20	13.17	17.66	13.01	17.82	13.10	17.73	12.46	18.37	12.49	18.34
PZ-4	30.30	13.22	17.08	12.33	17.97	13.02	17.28	13.17	17.13	12.43	17.87	10.35	19.95	10.78	19.52	11.59	18.71	11.80	18.50
PZ-5	24.28	7.78	16.50	7.76	16.52	7.76	16.52	7.73	16.55	7.51	16.77	7.39	16.89	NM	NM	6.39	17.89	6.05	18.23
PZ-6	23.55	7.05	16.50	7.01	16.54	7.03	16.52	7.02	16.53	6.75	16.80	6.66	16.89	6.62	16.93	5.65	17.90	5.30	18.25
PZ-7	21.12	4.62	16.50	4.61	16.51	4.63	16.49	4.60	16.52	4.37	16.75	4.23	16.89	4.18	16.94	3.25	17.87	2.91	18.21
PZ-8	21.73	5.02	16.71	4.95	16.78	4.97	16.76	4.99	16.74	4.73	17.00	4.55	17.18	4.60	17.13	3.68	18.05	3.40	18.33
PZ-9	33.09																	13.54	19.55
PZ-10	32.83																	13.81	19.02
RW-1	33.31																	13.75	19.56
Lake Union			16.63		16.63		16.63		16.63		16.83		16.93		17.00		18.01		18.38

NOTES:
NM - Not measured



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GAS WORKS PARK 3-2306-000				WATER TABLE CONTOUR MAP 3/31/98	
CURRENT DATE	7/28/98	CADD FILE	3434S044	DRAWING NO.	FIGURE 3-6

Harbor Patrol facility near the shore of Lake Union. Across the upgradient portion of the study area the gradient varied from 0.007 to 0.019 feet per foot. The gradient varied in the upgradient unpaved area in response to precipitation. The calculated horizontal gradients for each gauging round in the western study area are presented in Table 3-2.

The horizontal gradient measured in the central shoreline area was 0.002 feet per foot during three gauging rounds completed in February, March, and May 1998. The relatively low gradients in the shoreline areas may, in part, be due to rising lake levels during the period (see Table 3-1).

Figure 3-7 compares the recorded rainfall data measured at the National Oceanographic and Atmospheric Administration (NOAA) station on the eastern shore of Lake Union and gradients in the upland part of the western study area. In the western study area, the highest upland horizontal gradients occurred in February 1998, approximately 2 weeks after the wettest period of the study (January 12 through 27, 1998). By March 31, the upland horizontal gradient had decreased to levels consistent with those measured earlier in the winter. During this time, the gradient in the shoreline portion of the western study area and in the central shoreline study area remained relatively constant.

A comparison of water table elevation data collected from the deep wells (which are screened across the lower 5 feet of the Stratified Drift) and shallow piezometers screened across the water table provide information on vertical gradients in the western shoreline area. Data from shoreline well pairs indicate a slight upward vertical gradient exists within the aquifer consistent with regional flow patterns and discharge to the lake from lower stratigraphic intervals (Turney and Goerlitz, 1989). Groundwater elevations in deep wells near PZ-7 are 0.08 to 0.15 feet higher than elevations in PZ-7. Data from PZ-8 and nearby deep wells are more variable. The majority of the data in the vicinity of PZ-8 indicate a downward gradient. The variability in this area may be due to precipitation. Vertical gradient data are presented on Table 3-3.

3.3 Groundwater Analytical Results

3.3.1 Groundwater Quality Screening PAH Results

During Phase I of the investigation, PAH concentrations in groundwater in piezometers PZ-3, PZ-4, and PZ-7 were obtained using EPA Method 8270. Analytical results are summarized in Appendix G.

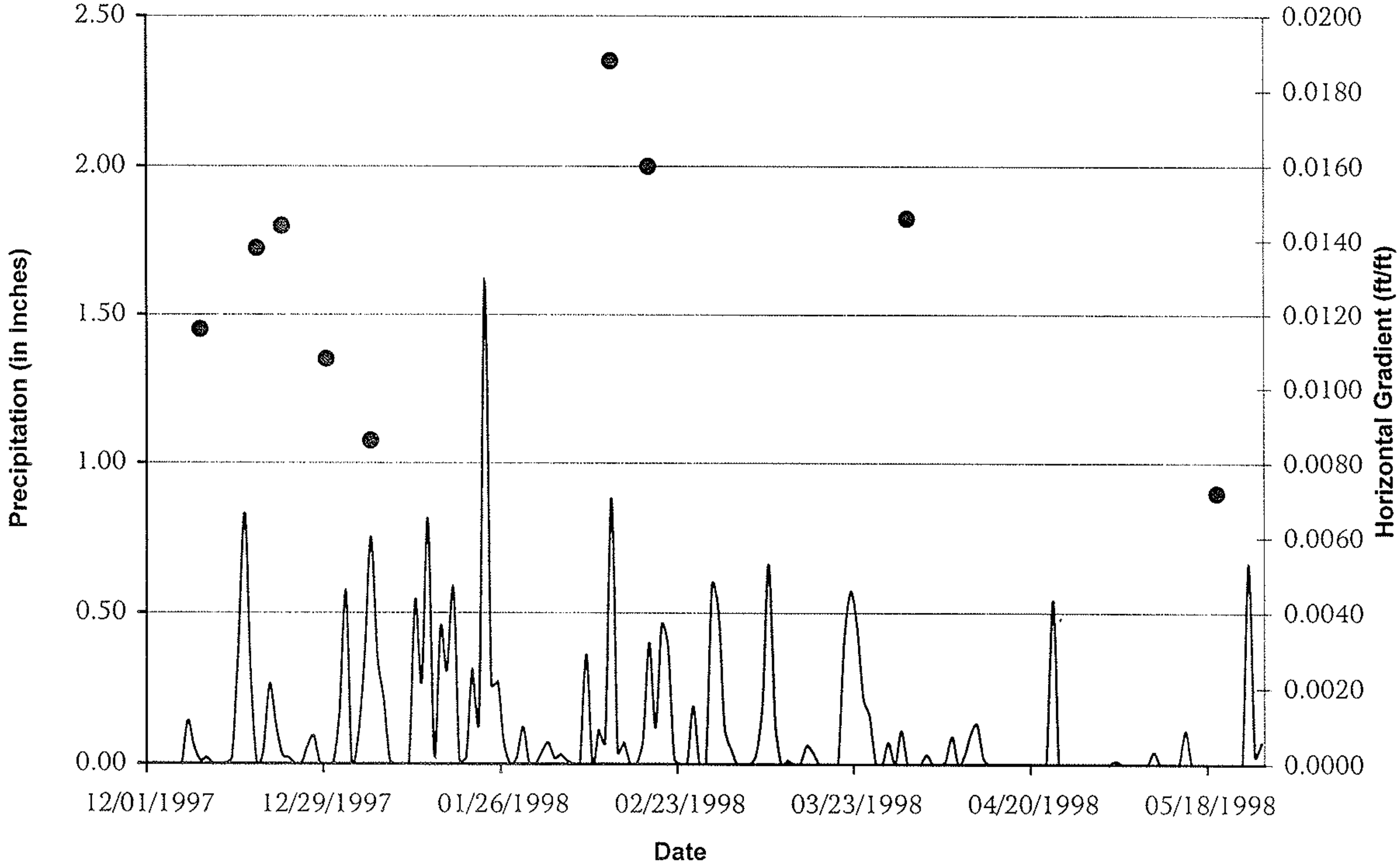
Table 3-2 Horizontal Gradients in Western Study Area

Date	Horizontal Gradient (ft/ft)	
	Upland Area	Harbor Patrol Area
12/09/1997	0.0116	0.0028
12/18/1997	0.0138	0.0040
12/23/1997	0.0144	0.0042
12/29/1997	0.0108	0.0033
01/05/1998	0.0086	0.0033
02/12/1998	0.0188	0.0030
02/18/1998	0.0160	0.0042
03/31/1998	0.0146	0.0031
05/19/1998	0.0072	0.0016

NOTE:

Values shown in feet per foot.

Figure 3-7 Comparison of Precipitation and Horizontal Gradients in Gas Works Park



NOTES:

1. Precipitation data from National Oceanographic and Atmospheric Administration station on Lake Union.
2. Horizontal gradient data from the upland portion of the western study area.

Table 3-3 Vertical Gradients in Western Study Area

Date	Well Pairs			
	DW-4/PZ-8	DW-5/PZ-8	DW-6/PZ-7	DW-7/PZ-7
02/12/1998	-0.0037	0.0093	-0.0052	-0.0056
02/18/1998	-0.0055	0.0029	-0.0041	-0.0052
03/31/1998	0.0192	0.0150	-0.0033	-0.0044
05/19/1998	0.0238	0.0079	-0.0019	-0.0037

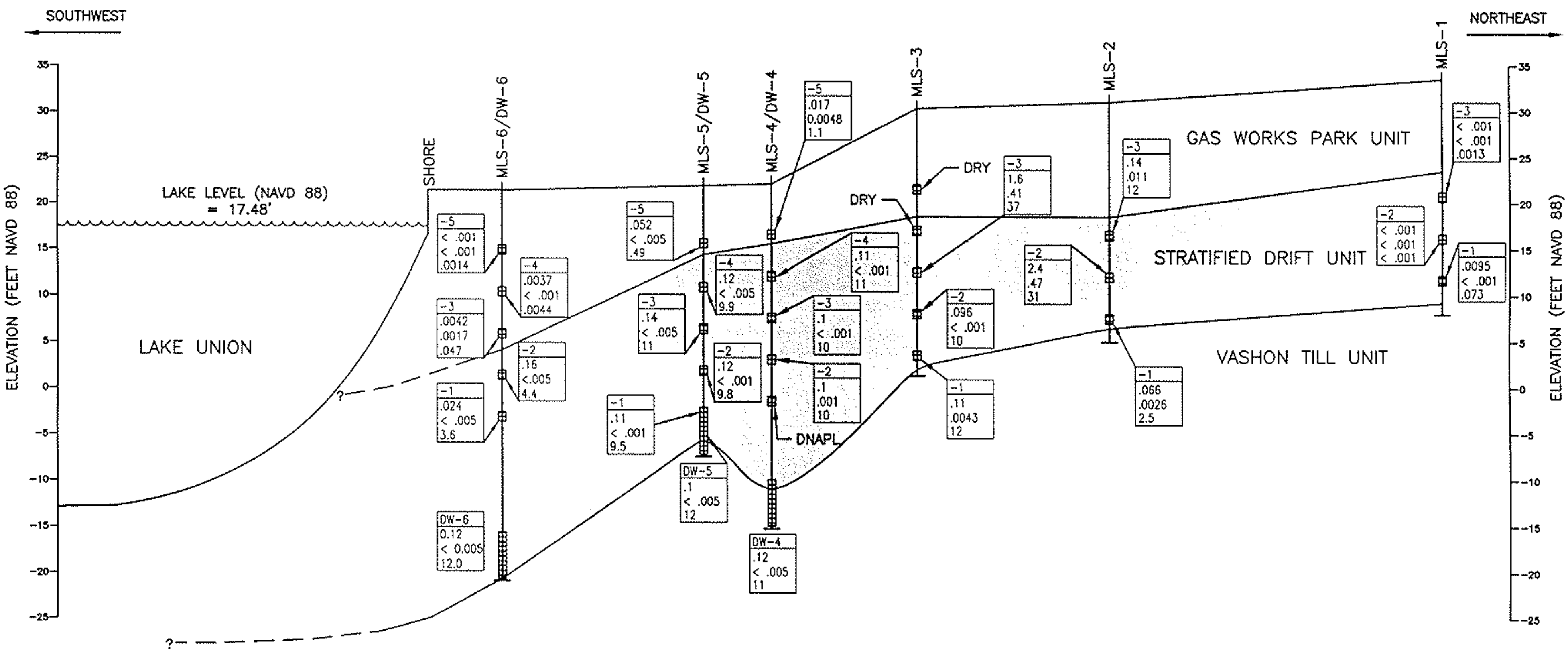
NOTE:
Values shown in feet per foot. Negative numbers indicate an upward gradient.

Elevated concentrations in PZ-3 are thought to be indicative of groundwater with small droplets or emulsified DNAPL. DNAPL was purged from this piezometer approximately 1 week prior to sampling. A measurable amount of DNAPL did not reaccumulate in the piezometer prior to sampling. The total PAH concentration in PZ-3 was 65 mg/L. Naphthalene was over half of the total PAH, at a concentration of 34 mg/L. The total PAH concentration in piezometers PZ-4 and PZ-7 were 5 and 8 mg/L, respectively. Again, the naphthalene concentration was half or more of the total PAH concentration; naphthalene concentrations in PZ-4 and PZ-7 were 2.5 and 6.9 mg/L, respectively. PZ-4 and PZ-7 are both located downgradient of PZ-3.

3.3.2 Results of the Detailed PAH Assessment

During the detailed groundwater assessment, attempts were made to collect groundwater samples from all MLS well sampling ports and deep wells. PAH concentrations measured in groundwater samples are presented in Appendix G and shown on Figures 3-8 and 3-9. Sampling locations MLS-3-5 and MLS-3-4 were dry and samples could not be obtained. MLS-4-1 contained NAPL which was sent off for characterization. PAH were present at very low concentrations or below detection levels in MLS-1 indicating that this area is upgradient of the source area.

PAH concentrations in the Gas Works Park unit groundwater differed from those measured in the underlying Stratified Drift. The upper two sampling locations within the Stratified Drift at MLS-2, and all sampling locations within the Stratified Drift at MLS-3, MLS-4/DW-4, and MLS-5/DW-5 had naphthalene concentrations of 10 mg/L or higher. As indicated by the leachability test results, this concentration of naphthalene is consistent with what can be expected to leach from the DNAPL at the site. Concentrations in MLS-2-2 and MLS-3-3 exceed 12 mg/L. At the sampling locations closest to the shoreline (MLS-6/DW-6), naphthalene concentrations in the Stratified Drift area were generally lower, suggesting attenuation of the dissolved PAH groundwater plume during transport from the DNAPL source (see Figure 3-8). For example, naphthalene concentrations in the deepest MLS-6 port was 3.6 mg/L. This concentration is lower than the equilibrium concentration expected when DNAPL is present. DW-6, the deepest sampling location located on the top of the till, did contain 12 mg/L of naphthalene, however, suggesting that product is present in close vicinity of the well. MLS-7/DW-7 is located approximately 65 feet southeastward of MLS-6/DW-6 at a similar distance from the shoreline. Naphthalene concentrations exceeding 11 mg/L in groundwater at MLS-7/DW-7 are indicative of presence of DNAPL.



LEGEND

-1	– MLS SAMPLE PORT NUMBER
Acenaphthene Benzo(a)pyrene Naphthalene	CONCENTRATION IN mg/L
(symbol)	– SCREENED INTERVAL
(shaded box)	– GENERAL TAR-IMPACTED AREA BASED ON DNAPL ACCUMULATION IN WELLS AND GROUNDWATER CONCENTRATIONS

NOTES:
- LAKE BOTTOM ELEVATION = –18.52' NAVD 88 @ 180' FROM SHORE (NOAA CHART #18447)
- LAKE BOTTOM ELEVATION = –21.89' NAVD 88 @ 197' FROM SHORE (USGS/NOAA SEATTLE NORTH MAP)

0 25 50 100
APPROXIMATE HORIZONTAL SCALE IN FEET
VERTICAL EXAGGERATION = 3:1

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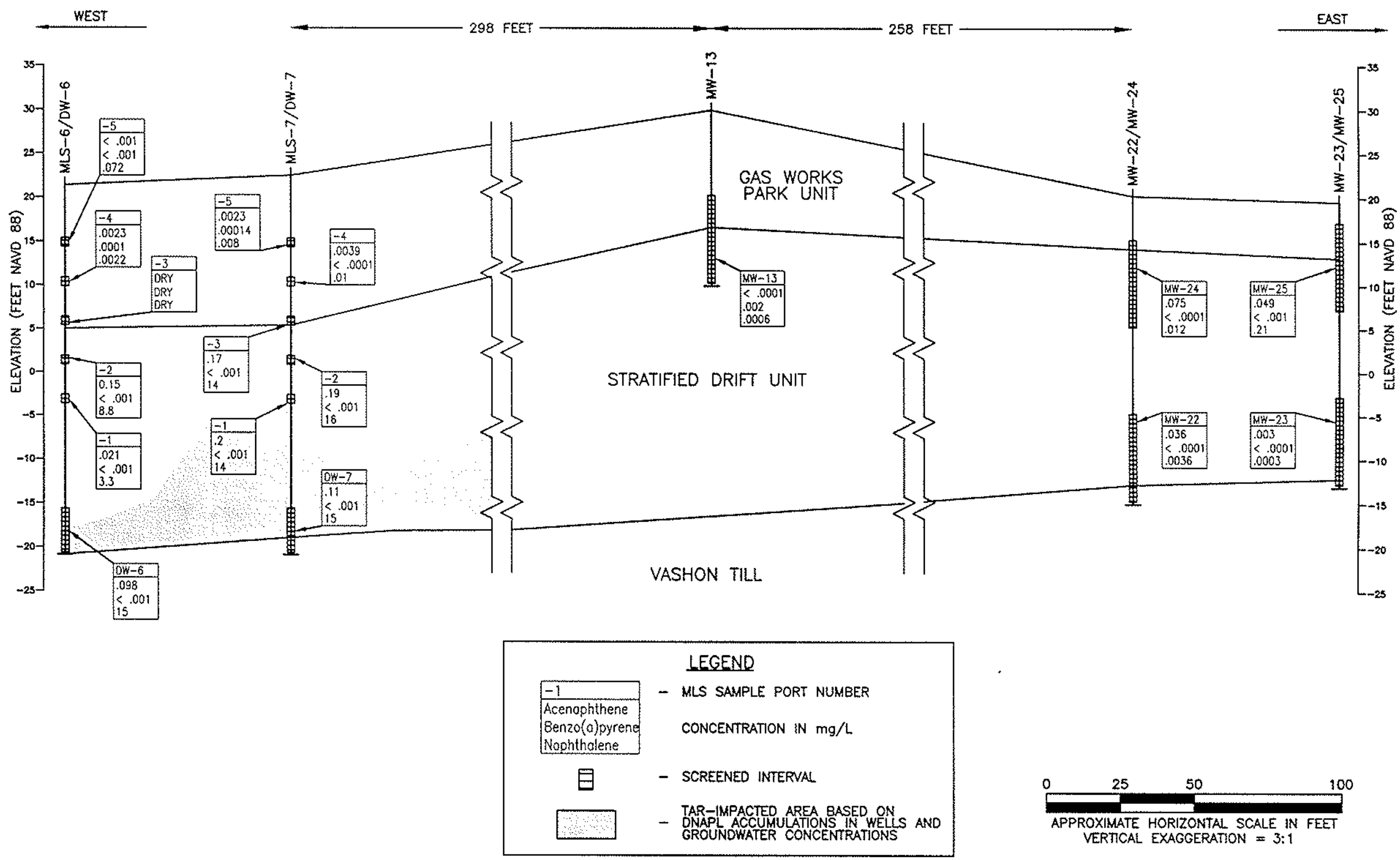
GAS WORKS PARK 5-3434-300				WESTERN STUDY AREA SELECTED PAH CONCENTRATIONS (mg/L) 2/17/98	
CURRENT DATE	9/3/98	CADD FILE	3434G019	DRAWING NO.	FIGURE 3-8



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GAS WORKS PARK

5-3434-300

CURRENT DATE 9/3/98 | CADD FILE 3434G020

SHORELINE AREA
PAH CONCENTRATIONS (mg/L)
4/15/98

DRAWING NO. FIGURE 3-9

Carcinogenic PAHs were detected in groundwater where naphthalene concentrations indicate that DNAPL is present. In sampling ports and wells which do not intercept DNAPL zones, carcinogenic PAHs were commonly not detected or detected at concentrations below 3 μg/L. A second round of sampling was completed using very low-flow sampling techniques. Carcinogenic PAH concentrations were generally below detection and did not confirm the concentrations detected during the first sampling event. Sampling results, combined with leachability data described in Section 3.5 indicate that carcinogenic PAHs are not dissolved in groundwater. Low-level concentrations are thought to be associated with suspended solids in groundwater samples.

Within the Gas Works Park unit, groundwater PAH concentrations were lower than the underlying Stratified Drift. Naphthalene concentrations ranged from 0.001 to 1.1 mg/L with concentrations decreasing towards the shoreline. Despite staining and limited evidence of NAPL, the groundwater concentrations in the Gas Works Park Deposit were relatively low. Lower PAH concentrations compared to the Stratified Drift may reflect the greater amount of DNAPL in this lower unit, dilution as a result of infiltration, and/or a higher degree of weathering in the Gas Works Park Deposit.

3.3.3 Dissolved Oxygen and Reduction/Oxidation

Dissolved oxygen (DO) and reduction/oxidation (redox) potential were measured in the western and the central shoreline study areas. As shown in Table 3-4, DO levels were less than 2.6 mg/L with the exception of well MLS-1, in which a DO concentration of 4.5 mg/L was observed. Except for MLS-1, very little change in DO concentration was noted with depth. In the western study area, DO measurements were 1.8 or above in the three upgradient MLS locations (MLS-1, MLS-2, MLS-3) and are 1.8 or less in the downgradient MLS locations (MLS-4 through MLS-7). DO concentrations of less than 2.0 mg/L are generally indicative of oxygen-limited environments.

Redox measurements ranged from approximately -130 to 11 mV. These redox values are indicative of an anaerobic environment. Conditions were generally more reduced in tar-impacted areas.

3.4 NAPL Distribution, Composition and Leachability

3.4.1 NAPL Distribution

Presence or absence of NAPL is indicated by observations of soil samples during drilling and subsequent accumulation of NAPL in wells. Sheen, stain, and visible

Table 3-4 Reduction/Oxidation Potential and Dissolved Oxygen Field Measurements

Well	Sample Port No.	Redox Potential (mV)	Dissolved Oxygen (mg/L)
PZ-3		0	1.70
PZ-4		0	1.65
PZ-7		-1	1.85
MW-13		-19	2.3
MW-14		-66	0.60
MW-22		-41	0.45
MW-23		-42	0.75
MW-24		-58	0.40
MW-25		-52	0.40
MLS-1	3	-4	4.50
	2	-129	1.80
	1	-108	2.10
MLS-2	3	NM	NM
	2	NM	NM
	1	-108	2.10
MLS-3	5	NM	NM
	4	NM	NM
	3	-102	2.60
	2	-96	2.10
	1	-89	2.35
MLS-4	5	-98	1.60
	4	-66	1.80
	3	-64	1.60
	2	-78	1.70
	1	NM	NM
DW-4		-60	0.95
MLS-5	5	-67	1.25
	4	-69	1.10
	3	-65	1.20
	2	-61	1.20
	1	-76	1.20
DW-5		11	0.40
MLS-6	5	-17	1.50
	4	-56	1.30
	3	NM	NM
	2	-41	1.50
	1	-62	1.10
DW-6		-85	0.45
MLS-7	5	-95	1.10
	4	-78	1.35
	3	-59	1.20
	2	-48	1.05
	1	-57	1.75
DW-7		-39	0.95

NOTES:

NM - Not measured

Data collected February 1998, except for PZ-3, PZ-4 and PZ-7 sampled December 1997, and well MW-13 sampled April 1998.

NAPL were found in the soil samples along with some odor. An oily residue (i.e., residual DNAPL) was observed at the base of the GWP stratum in borings DW-5, PZ-6, and DW-7 (Figures 3-2 and 3-3). In addition, the GWP often exhibited sporadic hydrocarbon odor, staining, or a light to heavy sheen. The Stratified Drift stratum showed the highest amounts of NAPL, staining, and sheen in the western study area. The greatest evidence of NAPL was often observed in coarse-grained sands and gravels which overlie finer-grained material. Impacts in the Stratified Drift are generally found at greater depth towards the shoreline. The highest amount of DNAPL in the Stratified Drift in the western study area is found between wells DW-4/MLS-4 and MW-5, located approximately 100 to 200 feet inland from the Lake Union shoreline. The NAPL, staining, and sheen found within this area diminishes to a light sheen and then a hydrocarbon odor both upgradient from this area and downgradient towards the shoreline.

LNAPL was not found in any of the wells in the western or central shoreline study areas. DNAPL has not accumulated in wells in the central shoreline area (MW-22, MW-23, MW-24, and MW-25). However, DNAPL has accumulated in five of the wells in the western study area.

In December 1997, approximately 12 inches of DNAPL was found in piezometer PZ-3, less than a week after its installation. This DNAPL was pumped out prior to sampling of the piezometer. PZ-3 was gauged on a regular basis through April of 1998 without finding any new DNAPL since the initial gauging and development.

On May 19, 1998, monitoring wells and piezometers in the western study area were tested for DNAPL. DNAPL was present in the new wells DW-4, DW-5, DW-6 and the old well MW-5. The measured DNAPL thicknesses were as follows:

Well No.	DNAPL Thickness (inches)
MW-5	4
DW-4	66
DW-5	41
DW-6	12

Droplets of product were noted during groundwater sampling in several of the deep MLS screens (MLS-2-2, MLS-2-3, MLS-3-1, and MLS-3-3). The liquid recovered from MLS-4-1 was primarily DNAPL. These results indicate that DNAPL has migrated to lower portions of the Stratified Drift and accumulated at the top of the Vashon Till. Accumulations are thickest (the DNAPL has pooled) in the depression on the till in the vicinity of DW-4.

3.4.2 DNAPL Composition

Three DNAPL samples collected from MLS-4-1, DW-4, and MW-5 were characterized. The tabulated results for the target compounds are provided in Table 3-5 and the tabulated physical property and additional chemical data are provided in Table 3-6. The CG/FID chromatograms are contained in Appendix H. An examination of the GC/FID chromatograms and the chemical concentration data shows that all the samples are tar, as indicated by the presence of MAHs and PAHs in the pattern and relative abundances typical of tar, and the relative abundance of naphthalene. There are no indications of substances other than tar; the samples are essentially pure tar, as indicated by the very high percentages of carbon and hydrogen, the very low water content, and the high concentrations of total MAHs and PAHs.

The chromatograms of the three tar samples are almost identical when adjusted for scale. However, there are some notable differences between the MW-5 and the other two samples. MAHs, naphthalene and acenaphthylene concentrations are lower in MW-5 and the ratio of MAHs to PAHs is lower for MW-5 than DW-4 and MLS-4-1. For example, the amount of MAHs in the MW-5 sample is about 41 percent of the amount in DW-4. The DW-4 and MLS-4-1 samples have similar MAH and PAH concentrations and a similar MAH to PAH ratio as shown in Table 3-7.

It should also be noted that the MW-5 sample has a slightly higher average molecular weight and significantly higher viscosity relative to the DW-4 and MLS-4-1 samples. These differences are postulated to be a result of chemical weathering of the tar in the subsurface. MW-5 represents the farthest upgradient DNAPL accumulation. The upgradient edge of the tar-impacted area may be exposed to a higher degree of weathering (e.g., higher dissolved oxygen concentrations). DW-4 and MLS-4-1 are located near the center of the pooled DNAPL and may not have been subjected to as much weathering as tar near the upgradient edge of the DNAPL body. The chemical weathering of tar commonly causes it to loose lower molecular weight compounds by dissolution, volatilization, and biodegradation. Chemical weathering results in tars which have higher average molecular weights, higher viscosities, and lower MAH to PAH ratios as is the case in the MW-5 sample.

The chemical differences among the samples are illustrated further by line graphs of the normalized concentrations of MAHs and PAHs (Figures 3-10 and 3-11, respectively). It is clear that samples DW-4 and MLS-4-1 are nearly identical in

Table 3-5 DNAPL Characterization Results

Sample Location	MLS-4-1	MW-5	DW-4
MAHs:			
Benzene	1,760	563	2,440
Toluene	5,540	2,040	6,490
Ethylbenzene	3,090	1,530	3,130
m/p-Xylene	5,020	3,520	5,880
Styrene	1,600	177	2,630
o-Xylene	2,140	1,620	2,520
1,2,4-Trimethylbenzene	4,780	3,320	5,460
Total MAHs:	19,100	9,450	23,100
PAHs:			
Naphthalene	117,000 E	84,400 D	131,000 D
2-Methylnaphthalene	47,100 E	38,900 D	49,400 D
1-Methylnaphthalene	25,900	23,700 D	27,400 D
Acenaphthalene	6,910	2,330	7,310
Acenaphthene	9,930	10,600	10,900
Dibenzofuran	7,480	3,690	6,000
Fluorene	11,300	8,680	10,900
Phenanthrene	27,500 E	25,700 D	31,900 D
Anthracene	7,490	6,460	7,840
Fluoranthene	9,710	7,560	10,400
Pyrene	10,100	9,840	11,600
Benz(a)anthracene	4,250	3,090	4,320
Chrysene	3,820	3,290	3,890
Benzo(b)fluoranthene	1,720	1,260	1,690
Benzo(k)fluoranthene	2,270	1,720	2,350
Benzo(a)pyrene	3,330	2,690	3,480
Indeno(1,2,3-cd)pyrene	1,490	1,180	1,610
Dibenz(a,h)anthracene	384	293	378
Benzo(g,h,i)perylene	1,490	1,230	1,570
Total PAHs:	292,000	233,000	318,000

NOTES:

All concentrations in mg/kg

E - Estimated value, above calibration range

D - Values from a diluted sample extract

Table 3-6 Physical Properties of NAPL Samples from the Gas Works Park Site

Field ID	Lab ID	Viscosity [1] (cSt)	Molecular Weight [2]	Density [3]	Elemental Analysis (%)			Water [4] (%)
					C	H	O	
MLS-4-1	EL980224-01	NA	217	1.08	NA	NA	NA	NA
MW-5	RE980604-01	83.4	253	1.08	84.4	7.43	4.76	0.20
DW-4	RE980604-02	18.1	221	1.08	90.5	6.89	0.94	0.13

NOTES:

[1] kinematic viscosity at 40 °C
[2] single point vapor phase osmometry
[3] at 22 °C
[4] Karl Fisher method
NA - not analyzed

Table 3-7 Comparison of DNAPL Analytical Results

(mg/kg)	DW-4	MLS-4-1	DW-5
MAHs	23,100	19,100	9,450
PAHs	318,000	292,000	233,000
MAHs/PAHs	0.0726	0.0654	0.0406
PAHs/PAHs/ in DW-4	1.0	0.918	0.733
MAHs/MAHs in DW-4	1.0	0.827	0.409

composition and relative abundances while sample DW-5 contains consistently lower amounts of MAHs, naphthalene and acenaphthylene. In contrast, all three samples contain approximately the same relative amounts of the other PAHs, supporting weathering processes as the cause of the chemical and physical differences between sample DW-5 and the other two samples.

3.4.3 Leachability Test Results

Laboratory tests were conducted to obtain insights into the release or leaching characteristics of PAHs from the contaminated soils containing low to heavy amounts of tar or tar-like substances. This work was carried out by Purdue University researchers who have completed similar work for EPRI (1992, 1996). The total composition data as well as the equilibrium aqueous phase concentrations are shown in Table 3-8 for 13 PAHs studied in the laboratory.

Figure 3-10

Normalized Concentration of MAHs in NAPL Samples from Gas Works Park

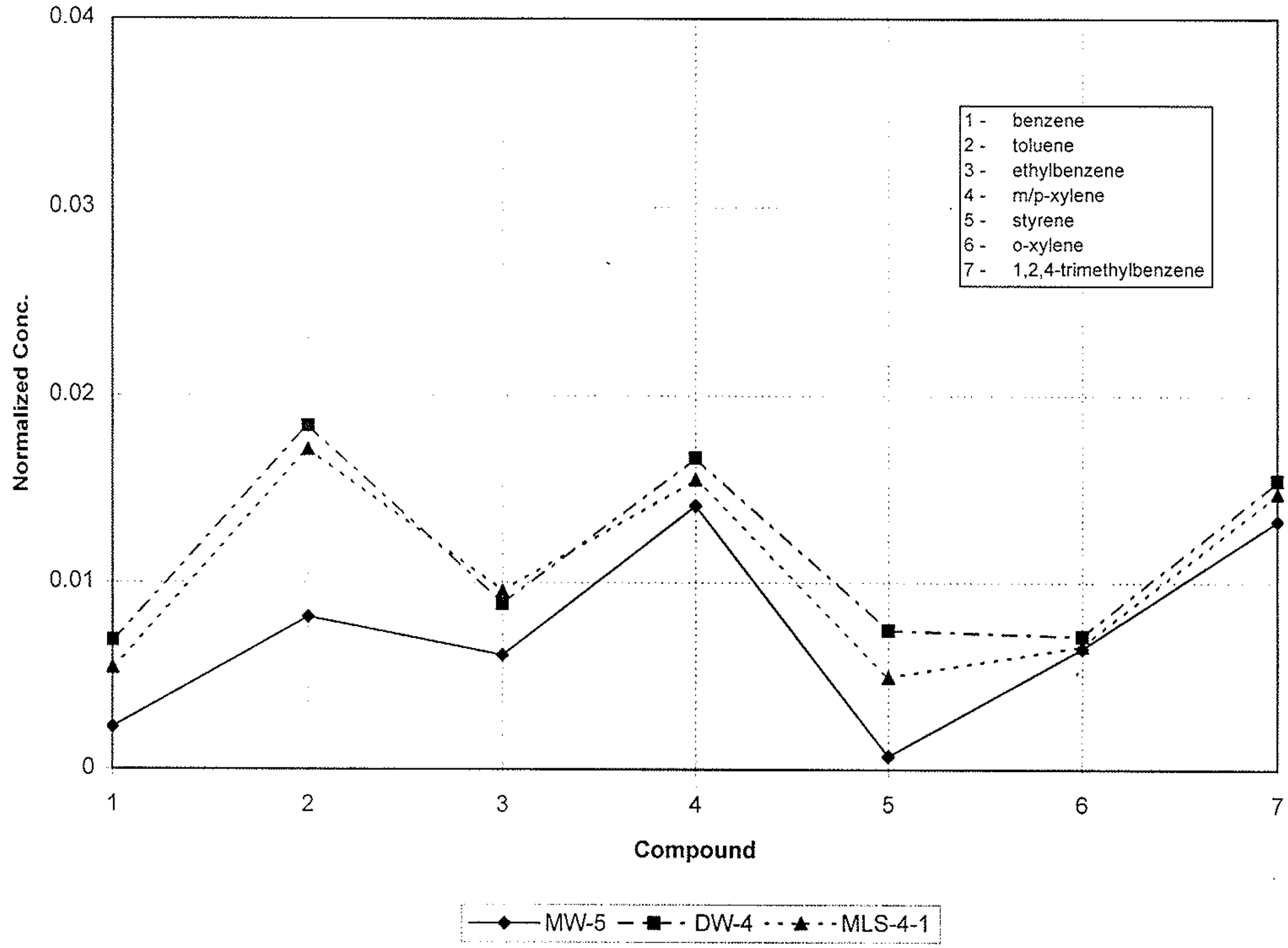


Figure 3-11

Normalized Concentration of PAHs in NAPL Samples from Gas Works Park

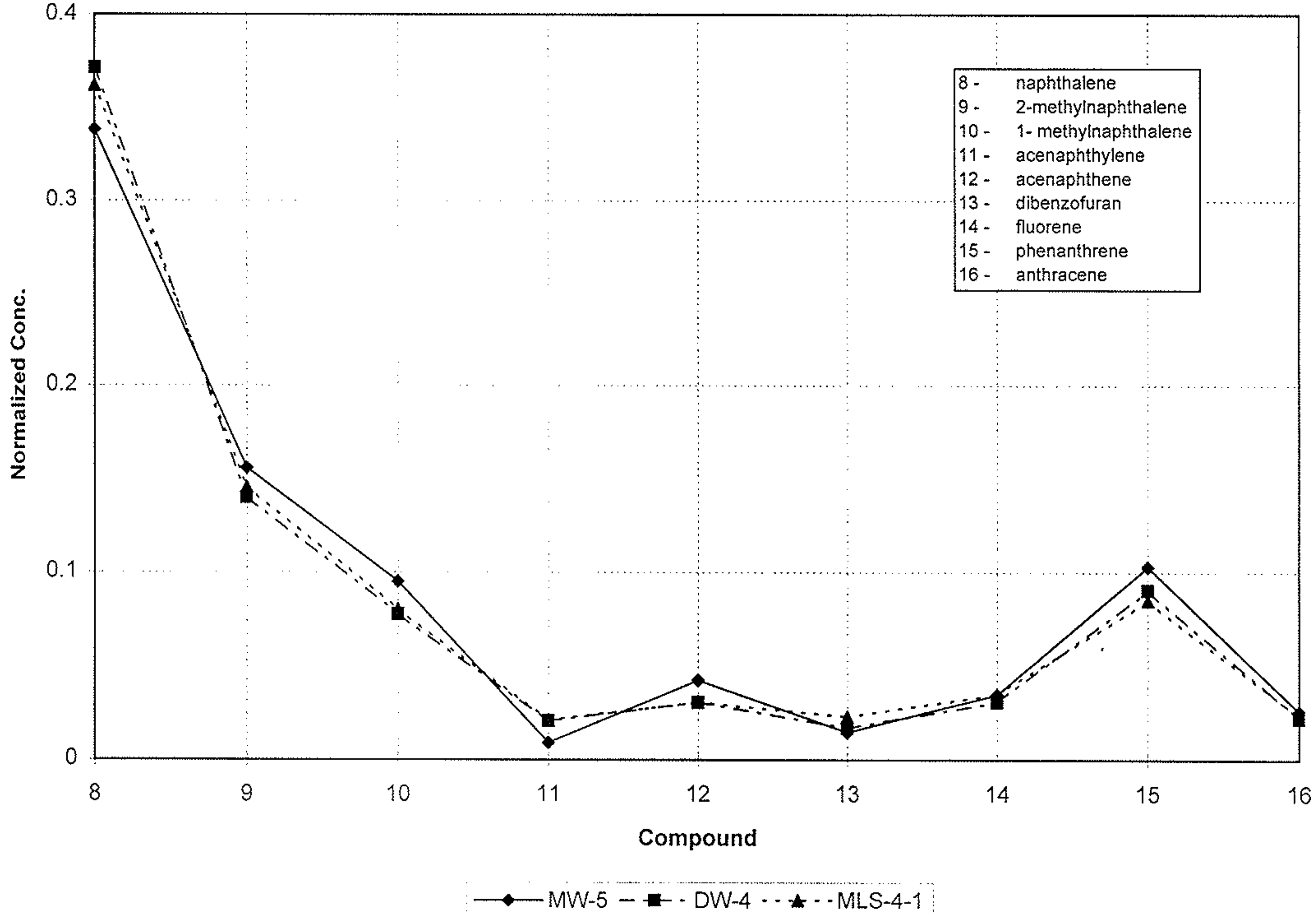


Table 3-8 Soil and Aqueous-Phase PAH Concentrations

Location: Depth (ft): Laboratory ID:	B-2 16.5 GW3	DW-5 7 GW5	DW-5 27.5 GW4	DW-7 15 GW6	MW-22 3 GW2	MW-23 3 GW1
Soil Concentrations (mg/kg)						
Naphthalene	6,695	968	1,306	316	164	57
2-Naphthalene	2,896	314	567	160	9	13
1-Naphthalene	1,722	220	327	103	5	7
Acenaphthalene	436	58	105	11	21	28
Acenaphthlene	447	115	76	71	1	5
Fluorene	570	148	122	31	9	13
Phenanthrene	1,550	506	331	90	197	183
Anthracene	409	152	87	23	30	52
Fluoranthene	516	200	112	33	353	577
Pyrene	612	234	133	40	477	773
benz(a)anthracene	194	74	43	13	105	236
Chrysene	175	68	37	10	119	211
Benzo(a)pyrene	146	65	34	8	191	289
Sum	16,369	3,121	3,281	908	1,681	2,445
Aqueous-phase Concentrations (μg/kg)						
Naphthalene	19,809	6,515	13,853	110	1,000	6
2-Naphthalene	2,229	761	1,629	55	10	0.26
1-Naphthalene	1,442	560	1,159	156	10	7
Acenaphthalene	256	81	270	20	15	14
Acenaphthlene	151	170	155	246	3	7
Fluorene	108	109	118	76	5	8
Phenanthrene	102	122	119	120	65	33
Anthracene	24	11	3	21	5	6
Fluoranthene	5	7	7	12	12	21
Pyrene	0.3	7	0.05	11	18	23
benz(a)anthracene	0.1	0.02	0.3	0.4	0.6	0.6
Chrysene	0.03	0.05	0.2	0.1	0.4	0.2
Benzo(a)pyrene	0.01	0.03	0.1	0.04	0.04	0.1
Sum	24,126	8,343	17,314	828	1,144	126

NOTES:

Depths are in feet below ground surface.

Altogether, six samples were used in this research. Leachability results are presented in Appendix D.

These laboratory tests indicate that the soils that have high concentrations of 2- and 3-ring PAHs generate relatively higher PAH concentration leachates. For example, soils containing greater than approximately 1,000 mg/kg of naphthalene create leachates that have total PAH concentrations greater than 8,000 μg/L. Soils with less than 320 mg/kg of naphthalene have leachates with total PAH concentrations less than 1,200 μg/L. Unlike the 2- and 3-ring PAHs, leachate concentrations of heavier PAHs are less variable and less sensitive to the soil concentrations. For example, aqueous-phase naphthalene concentrations ranged from 6 to 20,000 μg/L whereas, benzo(a)pyrene concentrations ranged from 0.01 to 0.1 μg/L.

Consistent with the known crystalline solubility of higher ring PAHs, the laboratory tests indicate that even when the soil concentrations for benzo(a)pyrene and chrysene are as high as 290 mg/kg, the leachate concentrations are still less than 0.5 μg/L. This implies that there is limited potential for leaching or release of the higher molecular weight PAHs (i.e., 4-, 5-, 6-ring compounds) from soils at the Gas Works Park site. When present, naphthalene presents the highest potential for leaching to groundwater. Anthracene, fluoranthene, and pyrene appear to leach in limited manner with the resulting water concentrations less than 25 μg/L.

3.5 Pump Test Results

The pump test evaluated hydraulic properties of the Stratified Drift. The drawdown data collected during the 50-hour constant-discharge pumping test and the recovery data were analyzed using the AQTESOLV™ (Duffield, 1996) computer program to evaluate transmissivity and storativity for the aquifer. Table 3-9 summarizes the transmissivity, storativity, and hydraulic conductivity values derived from each best-fit solution. Graphical results of time-drawdown data are provided in Appendix E. Transmissivity estimates ranged from 14 to 90 ft^2/day. Over half of the results were in the 20 to 45 ft^2/day range. Results using unconfined and semiconfined methods had a similar range of values. Storativity ranged from 0.0002 to 0.007. Assuming an aquifer thickness of 8.8 feet, hydraulic conductivity was calculated for each solution. Estimated hydraulic conductivity values ranged from 1.6 to 10 ft/day. Most of the results were in the 2 to 5 ft/day range. These hydraulic conductivity values are consistent with literature values for fine sands and silty sands. They are also consistent with similar fine sands in glacial outwash aquifers (Fetter, 1994).

Table 3-9 Aquifer Characteristics

Well	Aquifer Type	Reference	Transmissivity (ft^2/day)	Storativity	Hydraulic Conductivity (ft/day)
AQTESOLV Pump Test Analysis					
PZ-9 (drawdown)	Semiconfined	Hantush-Jacob (1955)	38	0.0020	4.3
	Semiconfined	Moench (1985)	90	0.00017	10
	Unconfined	Cooper-Jacob (1946)	45	0.0017	5.2
	Unconfined	Neuman (1974)	14	0.0018	1.6
PZ-9 (recovery)	Semiconfined	Hantush-Jacob (1955)	23	0.0070	2.6
	Semiconfined	Moench (1985)	28	0.0071	3.1
	Unconfined	Cooper-Jacob (1946)	43	0.0050	4.9
	Unconfined	Neuman (1974)	19	0.0059	2.1
PZ-10 (drawdown)	Semiconfined	Hantush-Jacob (1955)	58	0.0027	6.7
	Semiconfined	Hantush (1960)	20	0.0003	2.3
	Semiconfined	Moench (1985)	20	0.0003	2.3
	Unconfined	Theis (1935)	80	0.0015	9.1
	Unconfined	Cooper-Jacob (1946)	79	0.0012	9.1
Jacob Distance-Drawdown Analysis					
PZ-9 and PZ-10	Confined	Cooper-Jacob (1946)	29	0.045	3.3

Generally, the aquifer exists under unconfined, water table conditions. However, the drawdown for RW-1 and PZ-9 (Appendix E) trends toward a steady-state condition resulting in plots characteristic of a semiconfined/leaky aquifer. This trend suggests an additional source of water. Stratigraphic and storativity data also support semiconfined/leaky aquifer behavior. The stratified drift consists predominantly of interbedded sands and silty sands with occasional finer-grained layers. The presence of silty layers may result in a segmented aquifer where isolated sand layers behave as a semiconfined or leaky aquifer. The storativity results are representative of a confined or a semiconfined/ leaky aquifer. Storativity values for unconfined aquifers are typically similar to the specific yield which would be in the 0.1 to 0.3 range for the silts and sands observed.

4 Fate and Transport Modeling

An analytical groundwater transport and fate model was used to estimate the dispersion and attenuation of PAHs between individual shoreline monitoring wells and the Lake Union mudline. The model used was MYGRT version 2.0 (Tetra Tech, Inc., 1989), a groundwater solute transport code which simulates the processes of advection, dispersion, retardation, and decay to predict groundwater concentrations downgradient of a contaminant source. Source leachate concentration for each constituent of concern is required input for the model to predict concentrations at any downgradient (x-y) or (x-z) point. The model can be used to predict the plume centerline groundwater concentration of hydrocarbon at any downgradient distance x (i.e., the receptor location).

The model predicts groundwater concentrations as a function of time and space assuming:

- Uniform and constant aquifer properties
- One-dimensional groundwater flow
- First-order contaminant decay, degradation, or transformation
- Constant contaminant source that is rectangular in cross section in the plane perpendicular to groundwater flow

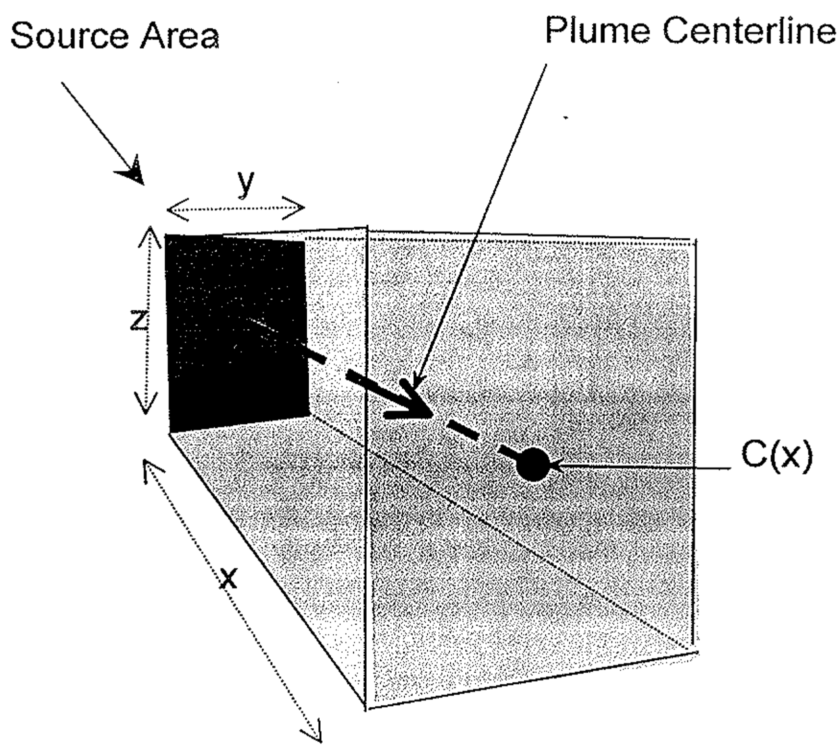
The objective of this modeling exercise was to simulate the concentration of PAHs at the mudline for selected shoreline locations based on concentrations measured in the MLS wells. The model was used to account for the changes in concentrations of PAHs as groundwater flows from the shoreline to the mudline.

Aquifer properties in the study area vary due to the complex interbedding encountered in the Stratified Drift unit. In addition, groundwater flow at the site is not one-dimensional, but rather has slight vertical components measured at the shoreline wells in the western study area. However, the assumptions of uniform and constant aquifer properties and one-dimensional flow yield conservative estimates of the concentrations in the plume downgradient of the source.

4.1 Model Input Parameters

The model input parameters are described in the following paragraphs, and the model is shown schematically on Figure 4-1.

Figure 4-1 Fate and Transport Model Schematic



Groundwater flow (perpendicular to source area plane)

C(x) Concentration at distance "x" from source along plume centerline

4.1.1 Groundwater Source Term

The model represents the contaminant source as a vertical plane, perpendicular to groundwater flow, releasing dissolved constituents into groundwater passing through this plane. The leachate source is assumed to have existed for a period of 50 years, with source zone concentrations set equal to measured PAH concentrations in the groundwater wells.

In the western study area, concentrations used for modeling were set equal to the maximum measured naphthalene concentration at each location over the groundwater sampling rounds. Naphthalene is by far the most prevalent PAH constituent, accounting for over 90 percent of the total mass of PAH at six of the eight locations. Once the model calculated the dilution attenuation factors for naphthalene at each location, this result was applied to predict the mudline concentrations for the remaining PAHs. Because naphthalene has the lowest retardation factor of all the modeled PAHs, its use for other PAHs yields a conservative estimate of groundwater quality at the mudline. Table 4-1 presents the specific locations and elevations of all screened intervals used as model inputs. Groundwater quality data from two clusters of shoreline wells were used as input values: wells MLS-6/DW-6 and MLS-7/DW-7. Data from MLS-6 and MLS-7 at screened interval number 5 were chosen to represent leachate concentrations at the top of the aquifer, while interval number 2 was used to model groundwater quality in the middle of the aquifer. Data from the corresponding deep wells were used to model conditions at the bottom of the aquifer.

Table 4-1 Locations of Groundwater Modeling Input Concentrations

Shoreline Well	Screen Interval Elevation (feet NAVD88)		Midpoint (feet NAVD88)	Distance to Mudline (feet)
	Top	Bottom		
MLS-6 #5	15.39	14.39	14.89	23.5
MLS-6 #2	1.89	0.89	1.39	31.5
DW-6	-15.61	-20.61	-18.11	52
MLS-7 #5	15.69	14.69	15.19	23.5
MLS-7 #2	2.19	1.19	1.69	31.5
DW-7	-15.70	-20.70	-18.20	52
MW-24	15.67	5.67	10.67	55
MW-25	14.72	4.72	9.72	59

Analytical results from monitoring wells MW-24 and MW-25 were used for the central shoreline area modeling. Each of these wells had higher PAH concentrations than the adjacent well in the well pairs and thus provide a more conservative estimate of concentrations at the mudline.

4.1.2 Flow and Dispersion Parameters

The groundwater flow and velocity are defined by the hydraulic conductivity, hydraulic gradient, and porosity. Dispersivity coefficients were obtained from the literature to calculate dispersion. A hydraulic conductivity value of 8 feet per day was chosen as a conservative estimate within the range of hydraulic conductivities measured during the pump test conducted at this site. The horizontal gradient for the portion of the study area located under the Harbor Patrol lot was input for modeling at the western study area well clusters, while the gradient measured in the central shoreline wells was used in modeling groundwater from shoreline wells MW-24 and MW-25. The porosity was based on literature values for similar glacial outwash soils. Input parameters are as follows:

Area	Hydraulic Conductivity (feet/day)	Gradient (feet/foot)	Porosity	Calculated Groundwater Velocity (feet/day)
Western	8.0	0.003	0.3	0.08
Central	8.0	0.002	0.3	0.05

4.1.3 First-order Degradation Parameters

Biodegradation is one of the principal mechanisms of mass reduction during contaminant transport in groundwater. The biodegradability of PAHs under aerobic conditions is well documented (Howard, 1991). Available literature (Rockne, *et al.*, 1997) also suggest that anaerobic biodegradation of PAHs also occurs, but at a lower rate than aerobic degradation. The DO and redox measurements in groundwater at the Gas Works site indicate that anaerobic conditions are pervasive in the subsurface throughout the area (Table 3-4). For the purposes of this modeling, a conservative anaerobic biodegradation rate of 0.001 year^{-1} was selected for all PAH constituents.

4.1.4 Retardation Factors

The concentrations and the rate of movement of contaminants are controlled by the sorption of dissolved chemicals onto the soil particles and organic matter in the geological materials. Sorption is represented by linear partition coefficients (K_d). For organic compounds, such as naphthalene, the K_d is commonly approximated by multiplying the organic carbon partitioning coefficient (K_{oc}) by the fraction of organic carbon in soil (f_{oc}). For the Gas Works Park application, a conservative f_{oc} value of 0.001 was used.

4.1.5 Distance to Receptor

Table 4-1 shows distances to the various receptors for which calculations were completed. Using all of the input parameters specified above, the model generated concentration at the receptors based on an initial source concentration, the source duration (i.e., period of time for leachate discharge), the aquifer thickness, the depth of the source below the water table, and a given distance to the receptor. For shallower sampling depths, the receptor distance (i.e., Lake Union mudline) was estimated as the horizontal distance between the source and the mudline. For the base of the aquifer, a shorter transport distance with some migration upwards toward the lake was postulated. For each screened interval, the elevation of the midpoint of the well screen was used to determine distances to the receptor. The mudline location was determined using bathymetry for Lake Union. Graphic representations of these distances are shown on Figures 4-2 and 4-3.

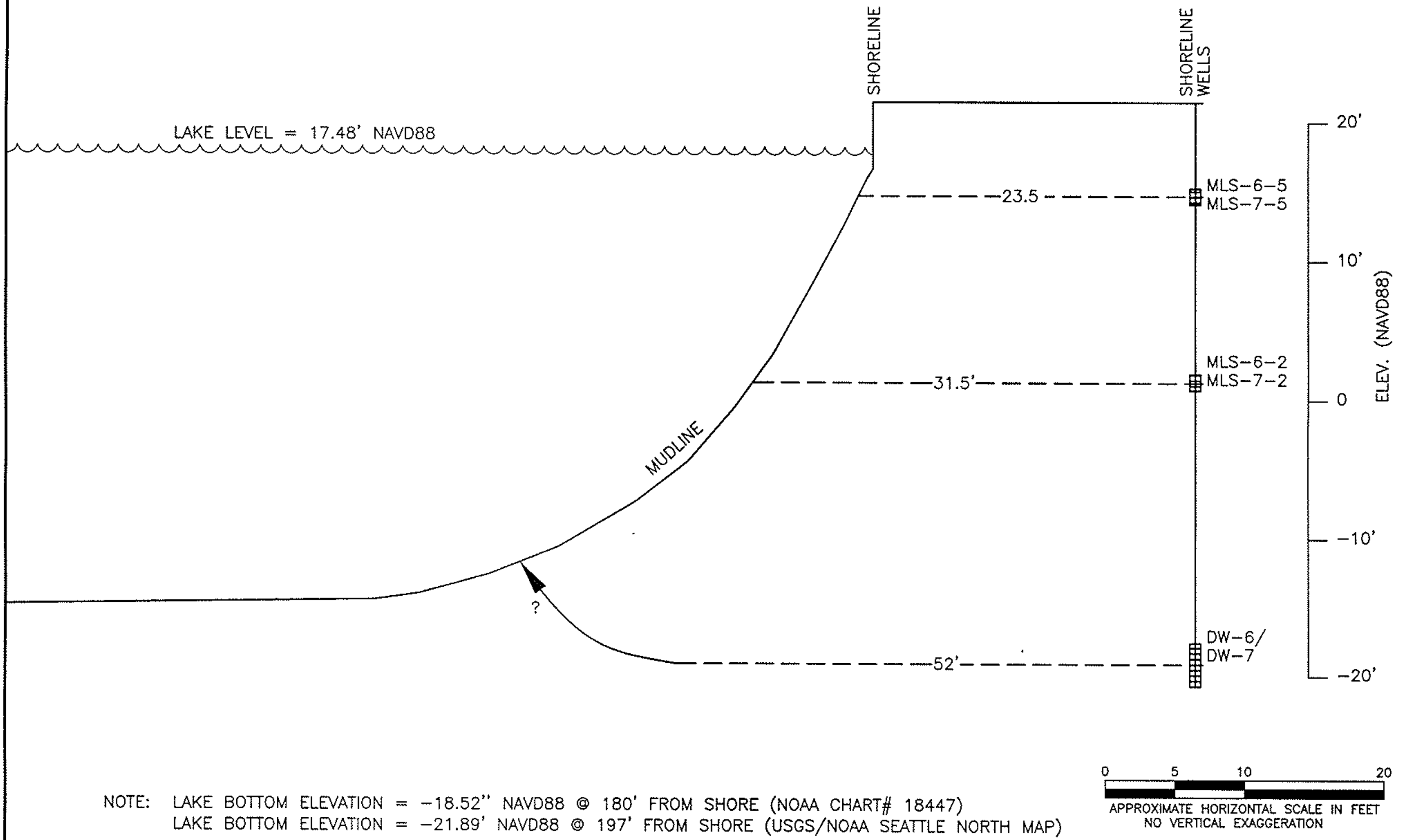
4.2 Model Output

The model was used to predict the concentration at the mudline (receptor location). A plot of concentration versus horizontal distance downgradient from the source was generated. Calculated mudline concentrations for the receptor points are presented in Table 4-2. Appendix I includes all of the data reports and concentration plots produced by the model.

As stated previously, the modeled attenuation factor for naphthalene was used to predict concentrations for the remaining PAHs. This attenuation factor was obtained by dividing the naphthalene source concentration by the predicted receptor concentration. Source concentrations for the other PAH compounds were then divided by this factor to produce their respective concentrations at the receptors. These calculated attenuation factors were compared to empirically derived attenuation factors based on groundwater sampling data from wells along the flow line. Groundwater quality data from MLS-5 and MLS-6 indicate a minimum site-specific attenuation factor of two to three. This suggests the attenuation factors produced in the shoreline modeling are conservative (Table 4-2).

4.3 Results of Fate and Transport Analysis

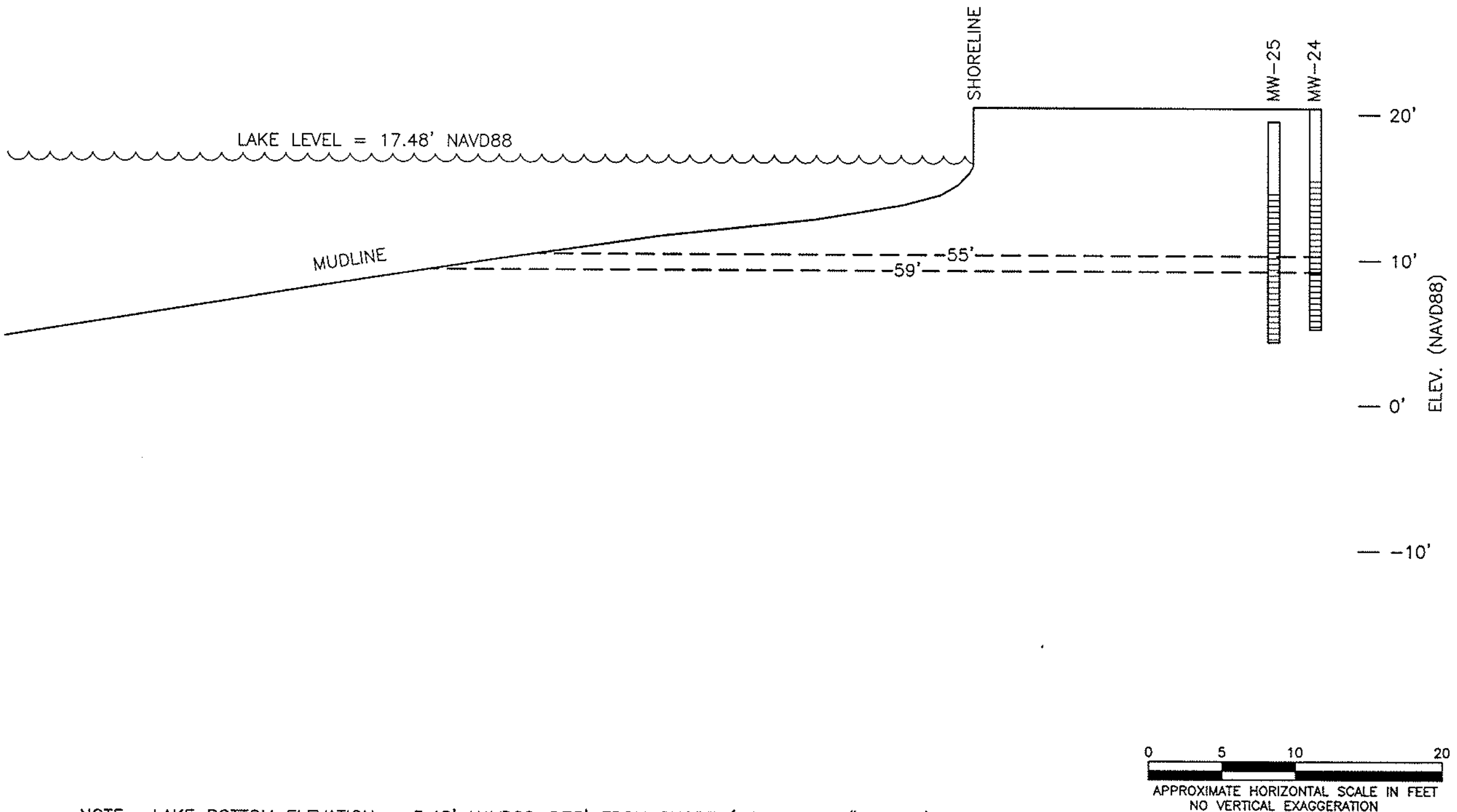
Target concentrations at the mudline were set at the MTCA Method B surface water cleanup criteria levels. Target concentrations for groundwater are 10 times



NOTE: LAKE BOTTOM ELEVATION = −18.52'' NAVD88 @ 180' FROM SHORE (NOAA CHART# 18447)
LAKE BOTTOM ELEVATION = −21.89' NAVD88 @ 197' FROM SHORE (USGS/NOAA SEATTLE NORTH MAP)

RETEC REMEDIATION TECHNOLOGIES INC

GAS WORKS PARK 5-3434-300				WESTERN STUDY AREA BATHYMETRY/MUDLINE DISTANCE	
CURRENT DATE	7/28/98	CADD FILE	3434S048	DRAWING NO.	FIGURE 4-2



NOTE: LAKE BOTTOM ELEVATION = 3.48' NAVD88 @75' FROM SHORE (NOAA CHART# 18447)

RETEC REMEDIATION TECHNOLOGIES INC

GAS WORKS PARK 5-3434-300				CENTRAL SHORELINE STUDY AREA BATHYMETRY/MUDLINE DISTANCE	
CURRENT DATE	7/28/98	CADD FILE	3434S047	DRAWING NO.	FIGURE 4-3

Table 4-2 Fate and Transport Modeling Results

		Sample Location: Distance to Mudline Receptor (ft.):	MLS-6-5 23.5		MLS-6-2 31.5		DW-6 52		MLS-7-5 23.5	
Compound	Solubility Limit	10 x Surface Water Criteria	Source Conc.	Conc. at Mudline	Source Conc.	Conc. at Mudline	Source Conc.	Conc. at Mudline	Source Conc.	Conc. at Mudline
Acenaphthene	0.13	6	<0.001	0.0005	0.16	0.08	0.12	0.06	0.0068	0.003
Acenaphthylene	3.93	NA	<0.001	<0.0005	<0.005	<0.0025	0.1	0.05	<0.001	<0.0005
Anthracene	1.29	259	<0.001	<0.0005	0.0078	0.004	0.0076	0.004	0.0019	0.001
Benzo(g,h,i)perylene	0.00026	NA	<0.001	<0.0005	<0.005	<0.0025	<0.005	<0.003	0.0017	0.0009
Fluoranthene	0.12	1	<0.001	<0.0005	0.0019	0.0009	0.001	0.0005	0.0046	0.002
Fluorene	1.9	35	<0.001	<0.0005	0.055	0.03	0.06	0.03	0.003	0.002
Naphthalene	32.9	99	0.72	0.36	8.8	4.36	15	7.40	0.028	0.014
Phenanthrene	1.6	NA	<0.001	<0.0005	0.051	0.03	0.042	0.02	0.01	0.005
Pyrene	0.16	26	<0.001	<0.0005	0.002	0.0010	0.001	0.0005	0.007	0.004
		Attenuation Factor:		2.00		2.02		2.03		2.00

NOTES:

Concentrations shown in mg/L.

NA - Surface water criteria not available.

Table 4-2 Fate and Transport Modeling Results (Continued)

		Sample Location: / Distance to Mudline Receptor (ft.):	MLS-7-2 31.5		DW-7 52		MW-24 55		MW-25 59	
Compound	**Solubility Limit**	**10 x Surface Water Criteria**	**Source Conc.**	**Conc. at Mudline**	**Source Conc.**	**Conc. at Mudline**	**Source Conc.**	**Conc. at Mudline**	**Source Conc.**	**Conc. at Mudline**
Acenaphthene	0.13	6	0.23	0.11	0.12	0.06	0.078	0.04	0.063	0.03
Acenaphthylene	3.93	NA	0.011	0.01	0.083	0.04	0.0035	0.002	0.0088	0.004
Anthracene	1.29	259	0.011	0.01	0.012	0.006	0.0052	0.003	<0.005	<0.002
Benzo(g,h,i)perylene	0.00026	NA	<0.001	<0.0005	<0.005	<0.003	<0.001	<0.0005	<0.005	<0.002
Fluoranthene	0.12	1	0.0017	0.0008	0.0028	0.0014	0.0037	0.002	0.0011	0.0005
Fluorene	1.9	35	0.087	0.04	0.063	0.03	0.031	0.01	0.014	0.007
Naphthalene	32.9	99	16	7.94	15	7.40	0.018	0.0087	1.2	0.57
Phenanthrene	1.6	NA	0.075	0.04	0.058	0.03	0.0014	0.0007	0.0081	0.004
Pyrene	0.16	26	0.0013	0.0006	0.0029	0.0014	0.0039	0.002	0.0014	0.0007
		Attenuation Factor:		2.02		2.03		2.07		2.11

NOTES:

Concentrations shown in mg/L.

NA - Surface water criteria not available.

the MTCA Method B surface water cleanup criteria levels to allow for dilution and attenuation. Of the modeled PAHs, most of the measured (source) concentrations were below the surface water criteria. As described below, modeling results support attenuation to below the surface water cleanup criteria.

4.3.1 Western Study Area

The western study area MLS and deep wells are located 23 to 52 feet inland from the mudline. Model results showing predicted PAH concentrations at the mudline are shown in Table 4-2. Location DW-6 had the highest predicted mudline concentrations of acenaphthylene. MLS-7-2 had the highest predicted concentrations of, acenaphthene, anthracene, fluorene, naphthalene, and phenanthrene. The highest modeled benzo(g,h,i)perylene, fluoranthene, and pyrene levels were at MLS-7-5. No predicted concentrations at the mudline exceeded the MTCA Method B surface water cleanup criteria.

4.3.2 Central Shoreline Study Area

The central shoreline wells are located 55 and 59 feet from the mudline. PAH concentrations in these wells are generally less than those measured in the western study area wells, and all are less than MTCA Method B cleanup levels.

5 Site Conceptual Model

The data collected from this and previous investigations at Gas Works Park have been integrated to delineate sources, and assess potential migration of DNAPL and dissolved PAHs through groundwater to potential receptor points.

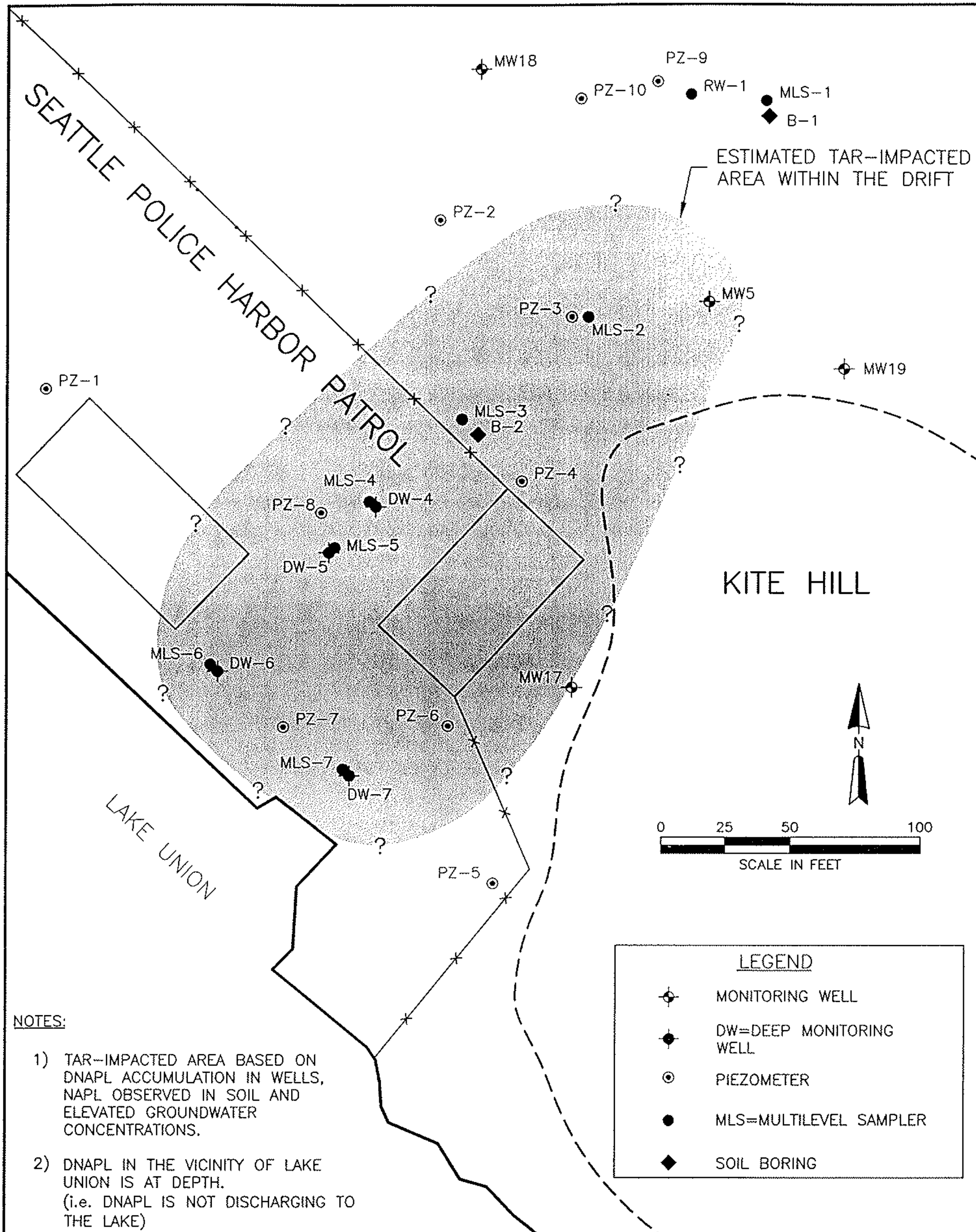
5.1 DNAPL Distribution and Source

The field work delineated the distribution of DNAPL in the western study area. The estimated footprint of the area of DNAPL is shown on Figure 5-1. The DNAPL distribution, both laterally and vertically, resembles the conceptual model shown on Figure 5-2.

A substantial amount of fill is present at the site. The majority of the fill is designated as the Gas Works Park Deposit which consists of a mixture of imported soil and debris that was redistributed during park construction. A limited amount of imported fill overlies the Gas Works Park Deposit. The underlying Stratified Drift consists of interbedded and discontinuous layers of finer and coarser grained soil and overlies a continuous low-permeability unit, the Vashon Till.

As shown on Figure 5-2, DNAPL released from a source area in the coarse upper layer migrated under gravitational forces downward until finer-grained discontinuous zones within the stratified drift were encountered. DNAPL may have penetrated some of these finer-grained layers where a sufficient thickness of DNAPL accumulated. Some or all of the DNAPL flowed horizontally downslope at the base of the coarser layers along the top of the finer grained layers. Due to the interbedded and discontinuous bedding within the Stratified Drift, the DNAPL gradually spread outward and downward in the downslope direction where finer-grained beds pinched out into coarser zones. Downslope of the DNAPL release area, the DNAPL migrated to greater and greater depths such that it did not impact shallower soils away from the source area. Over time, sufficient DNAPL migrated downward to the Vashon Till and pooled on this layer. DNAPL then flowed downslope along the top of the Vashon Till.

The soil borings and monitoring wells installed in the western study area support the conceptual model described above and depicted on Figure 5-2. Data indicate that residual tar is closer to the surface in the northern tip of the DNAPL footprint shown on Figure 5-1. At downslope locations, the DNAPL is absent from the surface soil and is found at progressively greater depths within the interbedded drift. Even further downslope, DNAPL is absent from the upper



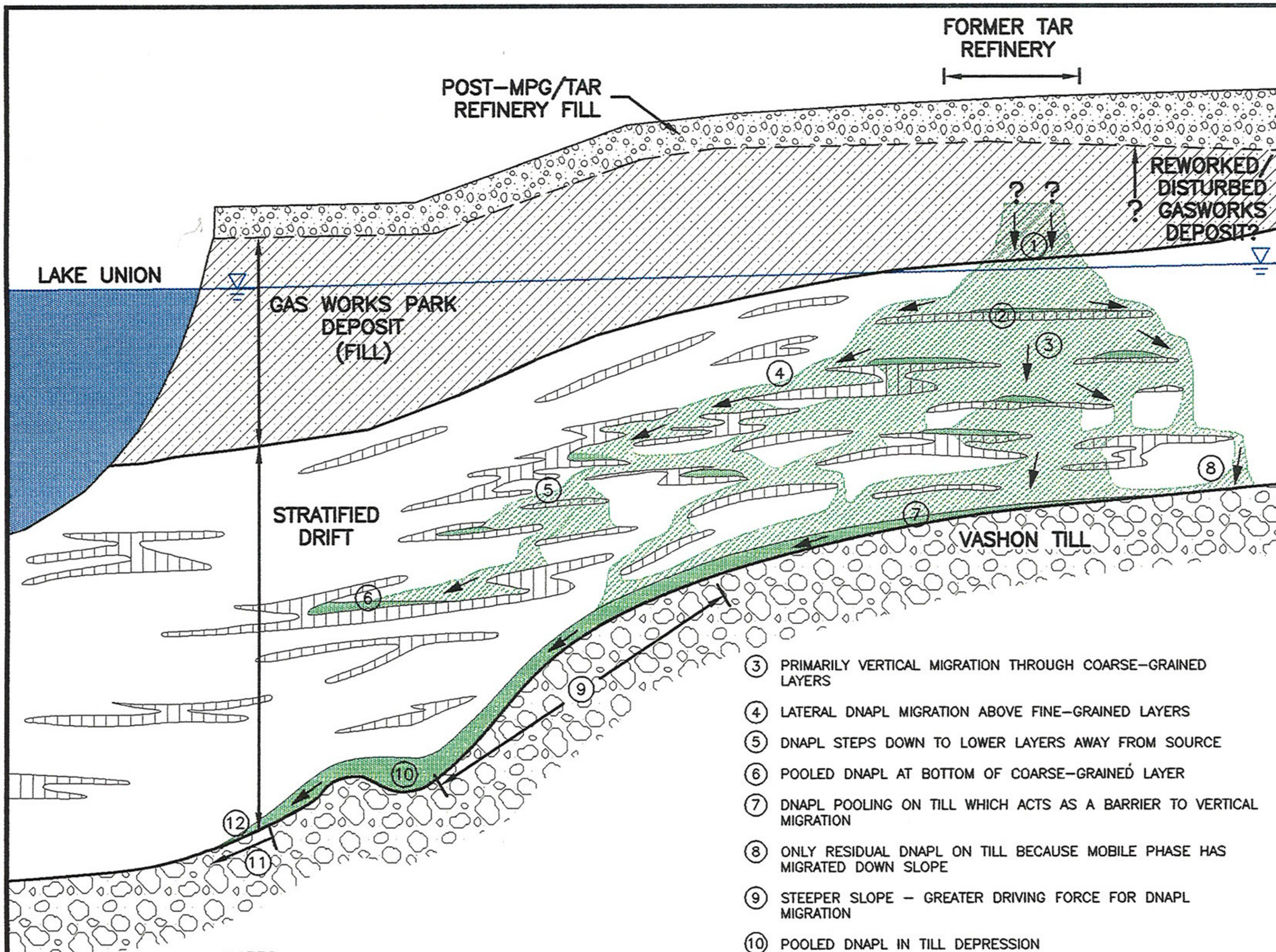
NOTES:

1) TAR-IMPACTED AREA BASED ON DNAPL ACCUMULATION IN WELLS, NAPL OBSERVED IN SOIL AND ELEVATED GROUNDWATER CONCENTRATIONS.

2) DNAPL IN THE VICINITY OF LAKE UNION IS AT DEPTH. (i.e. DNAPL IS NOT DISCHARGING TO THE LAKE)

RETEC
REMEDIATION TECHNOLOGIES INC

GAS WORKS PARK 5-3434-300	ESTIMATED DISTRIBUTION OF NAPL IN STRATIFIED DRIFT WESTERN STUDY AREA
CURRENT DATE 7/28/98 · CADD FILE 3434S046	DRAWING NO. FIGURE 5-1



LEGEND

- WATER TABLE
- RESIDUAL DNAPL
- FREE DNAPL
- SURFICIAL SAND AND GRAVEL FILL
- HETEROGENEOUS SILT, SAND, AND GRAVEL OF GAS WORKS PARK DEPOSIT
- SAND AND SILTY SAND OF STRATIFIED DRIFT
- FINER GRAINED SILTY AND CLAYEY BEDS WITHIN STRATIFIED DRIFT
- VASHON TILL CONGLOMERATE

NOTES:

1. VERTICAL MIGRATION THROUGH UNBEDDED GAS WORKS DEPOSIT
2. GREATER HEAD FROM ACCUMULATING DNAPL ALLOWS DNAPL TO PENETRATE FINER GRAINED LAYERS IN SOURCE AREA
3. PRIMARILY VERTICAL MIGRATION THROUGH COARSE-GRAINED LAYERS
4. LATERAL DNAPL MIGRATION ABOVE FINE-GRAINED LAYERS
5. DNAPL STEPS DOWN TO LOWER LAYERS AWAY FROM SOURCE
6. POOLED DNAPL AT BOTTOM OF COARSE-GRAINED LAYER
7. DNAPL POOLING ON TILL WHICH ACTS AS A BARRIER TO VERTICAL MIGRATION
8. ONLY RESIDUAL DNAPL ON TILL BECAUSE MOBILE PHASE HAS MIGRATED DOWN SLOPE
9. STEEPER SLOPE – GREATER DRIVING FORCE FOR DNAPL MIGRATION
10. POOLED DNAPL IN TILL DEPRESSION
11. DECREASING SLOPE – LESS DRIVING FORCE FOR DNAPL MIGRATION
12. POTENTIAL FUTURE DNAPL MIGRATION IS BELOW THE ELEVATION OF LAKE UNION

RETEC
REMEDIATION TECHNOLOGIES INC

GAS WORKS PARK				CONCEPTUAL MODEL OF DNAPL DISTRIBUTION GAS WORKS PARK WESTERN STUDY AREA	
5-3434-300					
CURRENT DATE	9/17/98	CADD FILE	3434G017	DRAWING NO.	FIGURE 5-2

portions of the interbedded drift, and found only at the base of the unit, having migrated along the top of the till from the upgradient source area.

As the release happened decades ago (all sources of tar were removed prior to the park opening in 1976) DNAPL is mostly residual with very little free DNAPL still present in the tar-impacted area, trapped in lenses of coarser material which pinch out in finer grained stratigraphic units. The bulk of the free DNAPL has migrated downslope through the more permeable layers to the top of the Vashon Till.

Currently, there is a limited amount of free DNAPL in the upslope areas. The volume that accumulated in PZ-3 (0.05 gallon) has not reaccumulated since removal. Only 0.05 gallon of DNAPL is now present in MW-5. Approximately 5.5 feet (0.9 gallon) of DNAPL is present in DW-4 which corresponds to an approximately 3- to 5-foot depression on the top of the till. Further downgradient, the thickness of DNAPL decreases to 3.5 feet (0.6 gallon) in well DW-5 and then 1 foot (0.2 gallon) in DW-6. Data suggest DNAPL has pooled in lows with lesser amounts present at other locations on the till surface.

DNAPL migration along the till is not likely to enter the floor of Lake Union. The surface of the till drops to an elevation of -20 feet, whereas the base of the lake is at an elevation of -13 feet in the vicinity of Gas Works Park. Bathymetric maps indicate that Lake Union does not extend to elevations deeper than -20 feet. Therefore, the DNAPL is below the base of the lake and will not seep into the lake sediments.

In the western study area, the former tar refinery is the likely source for the DNAPL in the Stratified Drift. Figure 5-3 shows the footprint of the tar-impacted area superimposed on an aerial photograph. The tar refinery was located at the furthest upslope location, where staining is found at the shallowest depths and tar impacts are evident across most of the soil column.

Traces of DNAPL have been identified further upgradient in PZ-10; however, this DNAPL was present only at the contact with the till and not in the upper portions of the drift material. This DNAPL is thought to be associated with pooling and lateral spreading on a relatively flat portion of the till or overlying fine-grained unit.

The tank formerly located upgradient of the tar refinery reportedly stored No. 4 and 5 fuel oil. Sample locations between the former location of this tank and the tar refinery show no evidence of DNAPL. Furthermore, chemical analysis of the DNAPL samples from DW-4 and DW-5 has identified this material to be tar and not lighter fuel oils.

PHOTO SOURCE:
WALKER & ASSOCIATES

RETEC
REMEDIATION TECHNOLOGIES INC

5-3434-300	LOCATION OF TAR-IMPACTED AREA RELATIVE TO FORMER TAR REFINERY AND MGP
CURRENT DATE 9/16/98 CADD FILE 3586B020	DRAWING NO. FIGURE 5-3

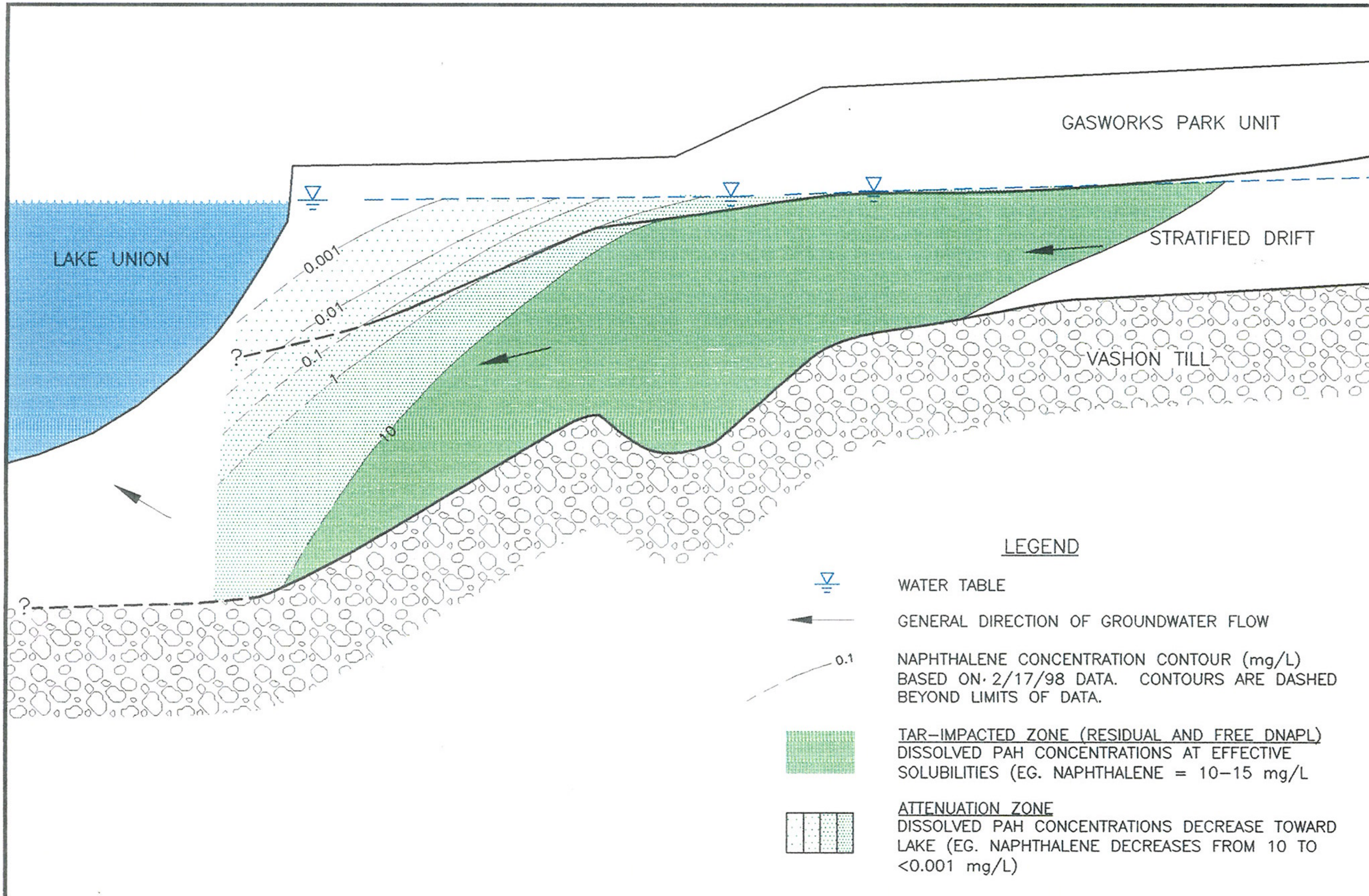
Tar is present across much of the soil column in the vicinity of the tar refinery. While some contamination is present in the Gas Works Park deposit, the bulk of the contamination was found in the Stratified Drift. The absence of tar in shallow portions of the Gas Works Deposit is not inconsistent with a tar refinery source. The tar refinery was likely built on a limited amount of fill. Releases of tar from tanks, piping, spills, or other sources at the tar refinery most likely were directly into the drift or perhaps into a thin layer of fill material over the drift. The surface fill and much of the Gas Works Park unit were likely emplaced after the tar refinery was demolished as part of the regrading activities to construct the park in 1973 to 1976.

5.2 Dissolved-phase Plume

The characteristics of the dissolved-phase plume were defined by sampling of a network of monitoring points, leachability testing, and fate and transport modeling. Figure 5-4 is a schematic diagram showing the distribution of PAH dissolved in groundwater.

Where tar is present in soils, it serves as a continuing source of dissolved PAHs to groundwater. Naphthalene concentrations of 10 to 15 mg/L in groundwater indicate presence of tar across an area measuring 100 to 150 feet wide and over 250 feet long in the western study area (Figure 5-1). The presence of a secondary source in this area is consistent with NAPL observations in soils and DNAPL accumulation in wells. Downgradient from the tar-impacted area, PAH concentrations in the plume decrease. The dissolved plume consists primarily of naphthalene; heavier PAHs are present at much lower concentrations. Field samples and leaching studies of tar-impacted soils indicate the plume contains non-detect to very low (less than 1 μg/L) concentrations of carcinogenic PAHs.

Attenuation processes (dispersion, sorption and some anaerobic degradation) reduce dissolved PAH concentrations downgradient from the tar-impacted area. Attenuation was measured in the field using wells MLS-5 and MLS-6. Naphthalene concentrations decrease by a factor of 2 to 3 over a distance of 65 feet. This empirically-derived attenuation factor is most likely applicable for a smaller transport distance than the 65 feet used because MLS-5 is located inside the tar-impacted secondary source area. Groundwater fate and transport modeling was used to estimate the decrease in concentrations between the measured concentrations in shoreline wells and the mudline. Attenuation factors for the shoreline to mudline transportation of PAHs were developed using a combination of site-specific parameters and conservative literature values. A naphthalene attenuation factor of 2 was estimated for transport from the shoreline to the mudline in the western shoreline area. In the central shoreline



RETEC
REMEDIATION TECHNOLOGIES INC

GAS WORKS PARK

5-3434-300

CURRENT DATE 9/16/98 | CADD FILE 3434G021

CONCEPTUAL MODEL OF DISSOLVED PAH DISTRIBUTION WESTERN STUDY AREA

DRAWING NO. FIGURE 5-4

area, where the transport distance is greater, the attenuation factor is 2.1. A higher rate of attenuation is expected for heavier PAHs due to their higher sorption rates and degradation near the mudline where there may be an addition of oxygen from the lake. The fate and transport modeling in combination with the groundwater sampling and leaching study results suggest the dissolved PAH plume downgradient of the tar-impacted area is well developed by the advection and attenuation processes.

6 Summary and Conclusions

Two areas of the Gas Works Park site were investigated. The western study area included a transect in the direction of groundwater flow from the original source of tar to the shoreline. The central shoreline area was studied to evaluate variations along the shoreline. The investigation included:

- continuous sampling of soils to determine the soil stratigraphy and distribution of tar in soils,
- installation and sampling of multilevel sampling wells and standard monitoring wells to define the distribution of DNAPL and associated dissolved-phase plumes,
- collection of soil samples containing residual tar to test the potential for leaching of PAHs,
- collection of DNAPL samples to characterize the chemical and physical properties of tar at up- and downgradient locations,
- a pump test to characterize aquifer properties, and
- fate and transport modeling to predict the downgradient attenuation of dissolved PAHs.

The distribution of tar impacts (residual tar in soils and DNAPL in wells) in the western study area was defined. The tar-impacted area is over 250 feet long and 100 to 150 feet wide. This investigation has shown that tar migrated as a DNAPL, spreading vertically and laterally under gravitational forces through the recessional drift unit. Tar moved downward through coarse layers and migrated laterally downslope where finer-grained layers were encountered. As a result, tar impacts are present throughout most of the soil column in the source area. In downgradient areas, tar impacts are at progressively lower elevations and, with some exceptions, are absent from shallower soils. This evidence suggests the main source is the tar refinery which operated from 1907 to sometime between the late 1940s and 1963 (EPA, 1995) in the northwest corner of the park. The tar eventually pooled along the contact with the fine-grained Vashon Till and slowly migrated downslope to the southwest. DNAPL is currently trapped in depressions along this contact layer, and is below the elevation of Lake Union near the shoreline so that it can no longer migrate to the mudline.

DNAPL and residual tar within soil layers act as secondary sources of dissolved PAHs in groundwater. Naphthalene concentrations of 10 to 15 mg/L indicate the presence of tar. Naphthalene accounts for roughly 90 percent of the total PAH concentration in the plume. Carcinogenic PAHs are not present at detectable concentrations in most of the groundwater samples analyzed. These results agree closely with the laboratory measurements showing that only the lightest PAHs are present at concentrations above typical detection limits in leachates from soils containing tar. These results suggest that historic detection of PAHs at higher concentrations than applicable solubility limits likely reflect suspended solids or tar droplets in groundwater samples that were analyzed.

PAH concentrations decrease rapidly with distance downgradient from tar sources. Residual tar is not present in the upper and middle parts of the recessional drift near the shoreline of the western study area. Dissolved PAH concentrations in this area indicate a reduction of PAH concentrations downgradient from the secondary source material. Over a distance of less than 65 feet PAH concentrations decrease to ⅓ to ½ of the concentration in the tar-impacted area. This reduction is supported by fate and transport modeling results. Using a site-specific hydraulic conductivity derived from the pump test and conservative values for other parameters, an attenuation factor of 2 was developed for naphthalene between the shoreline and mudline.

In the shoreline groundwater wells, only naphthalene exceeds the Washington State Surface Water Criteria in the recessional drift unit. Heavier PAHs are effectively insoluble (not present above standard detection limits). Fate and transport modeling results indicate that concentrations continue to decrease with distance towards the mudline. Predicted naphthalene concentrations decrease to below the State Surface Water Criteria at the mudline. Under current site conditions, the dissolved plume located downgradient of tar-impacted soils is well developed by the advection and attenuation processes.

7 References

Duffield, G. M., 1996. *AQTESOLV™ for Windows.* HydroSOLVE, Inc., Reston, Virginia.

EPRI, 1992. *Estimating Releases of Polycyclic Aromatic Hydrocarbons from Coal Tar at Manufactured Gas Plant Sites.* Report TR-101060. Electric Power Research Institute, Palo Alto, California.

EPRI, 1996. *Estimating Release of Polycyclic Aromatic Hydrocarbons from Coal Tar Contaminated Soil at Manufactured Gas Plant Sites.* Report TR-106291. Electric Power Research Institute, Palo Alto, California.

Fetter, C. W., 1980. *Applied Hydrogeology.* Charles E. Merril Publishing Co., Columbus, Ohio.

HDR Engineering, Inc., 1989. *Groundwater Contaminant Migration Control System Conceptual Design Report.*

Howard, *et al.*, 1991. *Handbook of Environmental Degradation Rates.* Lewis Publishers, Chelsea, Michigan.

National Oceanic and Atmospheric Administration, 1983. *Nautical Chart 18447: Lake Washington Ship Canal and Lake Washington, Washington.* National Oceanic and Atmospheric Administration, Washington, D.C.

Rockne, *et al.*, 1997. *Transformations of Polyaromatic Hydrocarbons in Sulfate- and Nitrate-Reducing Enrichments.* In Situ and On-Site Bioremediation: Papers from the Fourth International In-Situ and On-Site Symposium. April 28–May 1, 1997.

Tetra Tech, Inc., 1989. *MYGRT Version 2.0.* Electric Power Research Institute, Palo Alto, California.

Turney and Goerlitz, 1989. *Groundwater Contamination at an Inactive Coal and Oil Gasification Plant Site, Gas Works Park, Seattle, Washington.* Report 88-4224. United States Geological Survey, Springfield, Virginia.

United States Environmental Protection Agency, Office of Environmental Assessment, Region 10, 1995. *Expanded Site Inspection Report: Washington Natural Gas—Seattle Plant.*

United States Geological Survey and National Oceanic and Atmospheric Administration, 1983. *Metric Topographic/Bathymetric Map of Seattle: North.* United States Geological Survey, Reston, Virginia.

Appendix A

List of Reports

Ecology and Environment, Inc. July 18, 1984. Gas Works Park -- Summary of Results. Prepared for U.S. EPA, Region 10, Seattle, Washington. 6-page report plus data tables.

Soil sample data- composite samples at 24 locations
0-6 in - 24 samples - VOCs, SVOCs, metals, cyanide, pesticides/PCBs
0-3 ft - 24 samples - VOCs, SVOCs, metals, cyanide, pesticides/PCBs

HDR Engineering, Inc. April 1988. Environmental Testing for Gas Works Park Play Barn, Investigation Report. Prepared for city of Seattle Department of Parks and Recreation. 17 pages plus appendices.

Test results for air, sediment, pipe-lagging in basement.

HDR Engineering, Inc. June 17, 1988. Health and Safety Plan, Gas Works Park, Seattle, Washington. Prepared for City of Seattle Department of Parks and Recreation.

HDR Engineering, Inc. and EcoChem. June 17, 1988. Quality Assurance Plan, Gas Works Park, Seattle, Washington. Prepared for City of Seattle Department of Parks and Recreation. 13 pages.

HDR Engineering, Inc. June 17, 1988. Sampling Plan, Gas Works Park, Seattle, Washington Prepared for City of Seattle Department of Parks and Recreation. 34 pages plus appendices.

HDR Engineering, Inc. June 17, 1988. Site Management Plan, Gas Works Park, Seattle, Washington. Prepared for City of Seattle Department of Parks and Recreation. 16 pages plus appendices.

Parametrix, Inc. July 31, 1992. Lake Union Capping Feasibility Study. Prepared for City of Seattle Planning Department, funded by Washington Centennial Clean Water Fund Program.

Richard Haag Associates, Inc. April 1971. A Report Substantiating the Master Plan for Myrtle Edwards Park, City of Seattle.

Richard Haag Associates, Inc. April 1985. Contract Documents for Gas Works Parks Fence and Path Improvements, Prepared for the City of Seattle Department of Parks and Recreation.

Sabol, M.A, G.L. Turney and G.N. Ryals. 1988. Evaluation of Available Data on the Geohydrology, Soil Chemistry, and Groundwater Chemistry of Gas Works Park and Surrounding Region, Seattle, Washington. U.S. Geological Survey Water-Resources Investigations Report 87-4045. Prepared in cooperation with the Washington Department of Ecology.

Tetra Tech, Inc. March 1985. Sampling and Analysis Plan, Gas Works Park Supplemental Soils Testing. Prepared for City of Seattle Department of Parks and Recreation. 115 pages.

Tetra Tech, Inc. April 1985. Field Operations Plan, Gas Works Park Groundwater Investigation. Prepared for City of Seattle Department of Parks and Recreation. 36 pages.

Tetra Tech, Inc. September 1985. Gas Works Park Supplemental Soils Testing, Phase I Surface Soils Analysis. Prepared for City of Seattle Department of Parks and Recreation. 24 pages.

Soils data for surficial soil samples - upper 2 inches
    Table 3 - PAHs - 34 samples
    Table 4 - Cyanide - 4 samples

Tetra Tech, Inc. June 1987. Gas Works Park Groundwater Investigation and Site Evaluation. 57 pages. Prepared for City of Seattle Department of Parks and Recreation.

Table 9 - Floating product

Report of Seattle Gas Company to the Public Safety Committee, of the City Council of the City of Seattle on Steps Taken to Comply with Requirements of City Ordinance No. 64,604. June 18, 1935.

Gas Works Park, Record of Soil Sampling and Analyses, Information provided to EPA, Department of Parks and Recreation, April 1984.

Gas Works Park, Soils Tests, Information and Related Correspondence, 1970-1977.

2 soil samples - arsenic data

Appendix B

Boring Logs

RETEC

BORING LOG

B-1

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: 5-3434-210 Gas Works Park	CLIENT: EPRI
LOCATION: Seattle, Washington; ~100 feet Northeast of PZ-3	DRILLING CO.: Cascade Drilling
START DATE: 02/05/98 TIME: 12:45 — BORING ID: 8 inches	DRILLER: B. Gose
COMPLETION DATE: 02/05/98 TIME: 14:15 — BORING DEPTH: 25.5 feet bgs	RIG TYPE: CME-75
WATER LEVEL DURING DRILLING: 11.0' bgs — SURFACE ELEV.: 33.5 feet (NAVD88)	METHOD: Hollow-stem Auger*
DATE MEASURED: 02/05/98	LOGGED BY: G. Sega

SAMPLE DATA

DEPTH (in feet)	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
5	SS	15 17 17 15	30	
7	SS	26 50	30	
9	SS	44 29 26 23	75	
11	SS	10 10 14 21	80	
13	SS	20 30 50	75	
15	SS	22 32 46	75	
17	SS	17 17 27 55	75	
19	SS	35 50	50	

SOIL DESCRIPTION

U.S.C.S.	SOIL DESCRIPTION
	SOIL; Brown; sand with silt and gravel; abundant rootlets; dry to moist.
SP	SAND WITH GRAVEL, ASH AND CINDERS (GAS WORKS PARK UNIT); Light brown to tan; medium- to coarse-grained; <10% fines; 20% gravel to 4 cm maximum diameter; abundant ash and cinders; few brick fragments; dry.
	5.0' – No ash or cinders present; dry; slight odor; rock in tip of sampler.
	7.0' – Dry; slight odor; rock in tip of sampler.
	9.0' – Dry; slight odor.
	9.8' – Orange staining on sand to 10.0 feet bgs.
SP	SAND (STRATIFIED DRIFT UNIT); Light gray to brown; fine-grained; <10% fines; moist; no odor.
SP/SM	SAND WITH SILT; Light gray to brown; fine-grained; 10% to 15% fines; wet; no odor.
SP	SAND; Brown to gray; medium- to coarse-grained; <10% fines; wet.
SP	SAND; As at 10.0 feet bgs.
SP	SAND; Light brown; fine- to medium-grained; 10% fines; wet.
SM	SILTY SAND; Light gray to buff; fine-grained; 25% fines; wet.
SP	SAND WITH GRAVEL; Brown with gold (mica) flecks; medium- to coarse-grained; 20% gravel to 0.8 cm diameter; wet.
SW-SM	SAND WITH SILT AND GRAVEL; Light brown; fine- to coarse-grained; 10% fines; 15% to 20% gravel to 4 cm diameter; wet. 15.0' – Fines increasing to 20% at 16.0 feet bgs.
SM	SILTY SAND
SW-SM	SAND WITH SILT AND GRAVEL; Gray; fine- to coarse-grained; 10% fines; 20% gravel to 3 cm diameter; wet; slight odor.
SM	SILTY SAND WITH GRAVEL; Gray; fine- to coarse-grained; 20% fines to slightly clayey; 20% gravel to 3 cm diameter; wet; slight to moderate odor.

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
Hole was backfilled with hydrated bentonite chips.
PID was not working.
⊠ – Sample Interval
SS – Split Spoon

REMEDIATION TECHNOLOGIES, INC.
A Thermo Electron Company

RETEC

BORING LOG
B-1

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

DEPTH (in feet)	TYPE	DEPTH	BLOWS/6"*	% RECOVERY	PID (ppm)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION
20						SM		
	SS		36 50	50				*21.0'* – Slight to moderate odor.
	SS		30 40 50/ 3"	75		SP		SAND; Gray; medium- to coarse-grained; <10% fines; few gravels to 1 cm diameter; wet; slight odor.
						SM		SILTY SAND WITH GRAVEL; Light gray; fine-grained; 20% slightly clayey fines; 15% gravel to 3 cm diameter; wet; slight odor.
						SW-SM		SAND WITH SILT AND GRAVEL; Light gray; fine- to coarse-grained; 10% fines; 15% gravel to 3 cm diameter; wet; no odor.
25	SS		65	10		CL		CLAY WITH SAND (VASHON TILL UNIT); Thinly (~2 mm) laminated gray and white clay; 10% fine-grained sand; 10% gravel to 1 cm diameter; very hard; dry; no odor.
								Total depth = 25.5 feet bgs.
30								
35								
40								

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
Hole was backfilled with hydrated bentonite chips.
PID was not working.
⊠ – Sample Interval
SS – Split Spoon

REMEDIATION TECHNOLOGIES, INC.
A Thermo Electron Company

RETEC

BORING LOG
B-2

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: *5-3434-210 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; 5 feet North of North Harbor Patrol Fence*		DRILLING CO.: *Cascade Drilling*
START DATE: *02/05/98* TIME: *08:20*	BORING ID: *8 inches*	DRILLER: *B. Gose*
COMPLETION DATE: *02/05/98* TIME: *10:30*	BORING DEPTH: *29.0 feet bgs*	RIG TYPE: *CME-75*
WATER LEVEL DURING DRILLING: *12.0' bgs*	SURFACE ELEV.: *30.35 feet (NAVD88)*	METHOD: *Hollow-stem Auger**
DATE MEASURED: *02/05/98*		LOGGED BY: *G. Sega*

DEPTH (in feet)	SAMPLE DATA: TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION
0								SOIL: Sand with silt and gravel; abundant rootlets and organics; dry to moist.
					0	SP		SAND WITH ASH AND CINDERS (GAS WORKS PARK UNIT): Light gray to brown; fine- to medium-grained; ~10% gravel to 2 cm diameter; 10% ash and cinders; trace rootlets; dry.
					0			
5	SS		8 6 8 8	50				
					1.5			
	SS		10 15 12 17	100		SW		SAND WITH GRAVEL, ASH AND CINDERS: Light gray to brown; fine- to coarse-grained; 15% to 20% sub- to rounded gravel to 3 cm diameter; 10% to 20% ash; trace cinders; dry.
					0			
	SS		100/ 5"	5				*9.0'* – Rock in tip of sampler; few cinders in shoe.
10								

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
Hole was backfilled with hydrated bentonite chips.
■ - Analytical Sample
⊠ - Sample Interval
SS - Split Spoon

REMEDIATION TECHNOLOGIES, INC.
A Thermo Electron Company

RETEC	BORING LOG B-2	1011 S.W. Klickitat Way Suite #207 Seattle, Washington 98134 (206) 624-9349

DEPTH (in feet)	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)	U.S.C.S.	SOIL DESCRIPTION
10				0	SW	
	SS	39 17 22 25	75			*11.5'* – Reddish brick fragments.
					SW	SAND WITH GRAVEL (STRATIFIED DRIFT UNIT); Light brown to brown; fine- to coarse-grained; 15% gravel to 1 cm diameter; trace rootlets; ~10% fines; moist.
				0	SW-SM	SAND WITH SILT AND GRAVEL; Greenish-gray; fine- to coarse-grained; 15% gravel to 2 cm diameter; 10% to 15% fines; wet.
	SS	36 50	25			*13.5'* – Gravel increasing to 25% and 4 cm maximum diameter; wet.
				0		
15						
	SS	20 30 30 50	100		SM	SILTY SAND; Dark greenish-gray; fine- to medium-grained; 15% fines; wet; heavy staining and sheen; strong odor.
					SP	SAND WITH GRAVEL; Dark brown to black (product); medium- to coarse-grained; 10% to 15% gravel to 3 cm diameter; <10% fines; saturated with oily product; strong odor.
				736	SP	
					SP	SAND; Dark greenish-gray; medium- to coarse-grained; <10% fines; wet; product present; strong sheen and odor (saturated zone).
						SAND; Greenish-gray; fine-grained; wet; medium sheen.
	SS	19 36 50/ 5"	100		SP	*17.5'* – Sand increasing in grain size to medium- to coarse-grained at 17.75 feet bgs; increasing sheen to heavy sheen at 17.75 feet bgs. *18.0'* – 1-inch thick product zone; strong odor.
				235		SAND; Greenish-gray; medium- to coarse-grained; 40% fines; wet; moderate sheen at 18.0 to 18.25 feet bgs; heavy sheen at 18.25 to 19.0 feet bgs; 1-inch thick product zone at 19.0 feet bgs; strong odor.
					SP	
					SP	SAND; Greenish-gray; fine- to medium-grained; <10% fines; wet; medium sheen; strong odor.
20						

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
Hole was backfilled with hydrated bentonite chips.

■ – Analytical Sample
⊠ – Sample Interval
SS – Split Spoon

REMEDIATION TECHNOLOGIES, INC.
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RETEC

BORING LOG
B-2

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

DEPTH (in feet)	SAMPLE DATA: TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION
20	SS		26 50	50		SP		SAND; Greenish-gray; medium- to coarse-grained; <10% fines; trace gravel to 6 mm diameter; heavy sheen; local brown product staining; strong odor. *20.0'* – Grading to unit below.
					75	SW		SAND WITH GRAVEL; Greenish-gray; fine- to coarse-grained; <10% fines; 15% to 20% gravel to 3 cm diameter; heavy sheen; strong odor; product present at 20.8 to 21.0 feet bgs (may be remaining product inside auger from saturated zone at 16.5 feet bgs).
	SS		26 30 50/5"	50	145	GW		GRAVEL WITH SAND; Brown to gray (product); 80% well-graded gravel to 4 cm diameter; 20% medium- to coarse-grained sand; heavy sheen; strong odor; product present at 22.5 feet bgs (may be remaining product inside auger from saturated zone at 16.5 feet bgs).
25	SS		19 50/5"	50	116			*25.0'* – Product present (may be remaining product inside auger from saturated zone at 16.5 feet bgs.
	SS		85	30	88	GP		GRAVEL WITH SAND; Greenish-gray to brown (product); 60% poorly-graded gravel to 2 cm diameter; 40% medium- to coarse-grained sand; saturated with product.
						SP		SAND WITH CLAY (VASHON TILL); Light greenish-gray; fine-grained; 10% to 15% clayey fines; wet; no sheen; slight odor.
	SS		100/5"	25	0	GC		CLAYEY GRAVEL; Light greenish-gray; 75% well-graded gravel to 3 cm diameter; 15% clayey fines; 10% fine-grained sand; moist; no sheen or odor.
								Total depth = 29.0 feet bgs.
30								

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
Hole was backfilled with hydrated bentonite chips.
■ – Analytical Sample
☒ – Sample Interval
SS – Split Spoon

REMEDIATION TECHNOLOGIES, INC.
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WELL INSTALLATION LOG

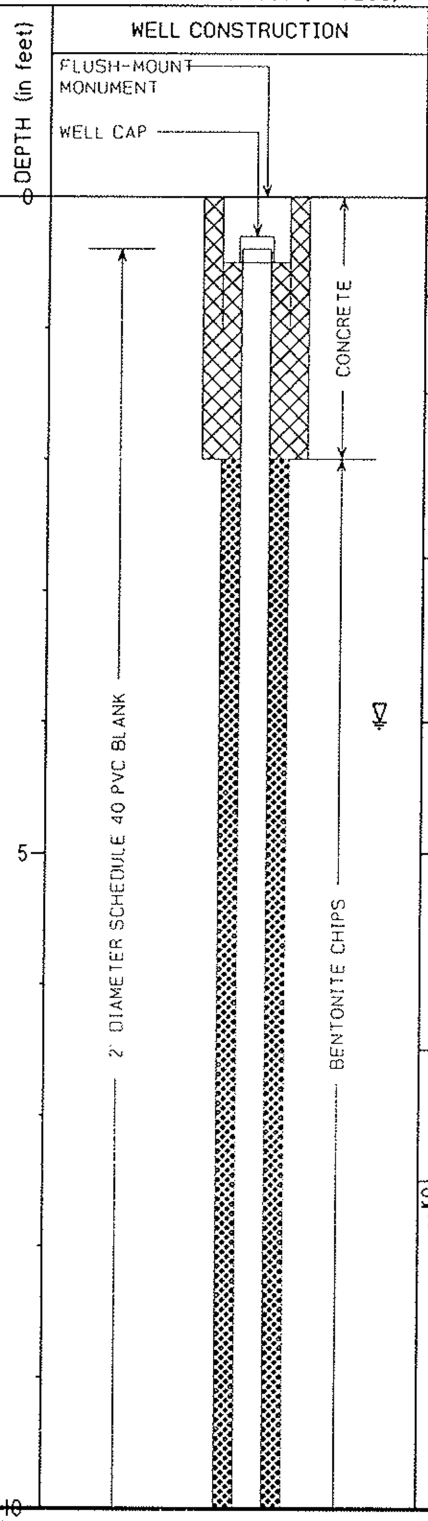
DW-4

RETEC
1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: 5-3434-210 Gas Works Park		CLIENT: EPRI
LOCATION: Seattle, Washington; Northeast End of Harbor Patrol Lot		DRILLING CO.: Cascade Drilling
START DATE: 02/06/98 TIME: 08:05	BORING ID: 8 inches	DRILLER: B. Gose
COMPLETION DATE: 02/06/98 TIME: 11:10	TOTAL DEPTH: 37.3 feet bgs	RIG TYPE: CME-75
WATER LEVEL DURING DRILLING: 4.0' bgs	TOP OF CASING: 21.76 feet (NAVD88)	METHOD: Hollow-stem Auger*
SURFACE ELEV.: 22.10 feet (NAVD88)		LOGGED BY: G. Sega

DEPTH (in feet): 0 – 10

WELL CONSTRUCTION



U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
	ASPHALT				
	SAND WITH GRAVEL, ASH AND CINDERS (GAS WORKS PARK UNIT); Dark brown; 20% gravel to cobbles; abundant cinders, ash, brick and wood fragments; dry.				
	CINDERS; Black; dry.				
	ASH; Gray; dry.				
	WOOD; Unable to hand dig; will drill through and begin sampling at 4.0 feet bgs.				
	WOOD, CINDERS AND ASH; Wet; slight odor.	SS	5, 13, 10, 8	25	
SP					0
	SAND WITH GRAVEL; Dark brown; medium- to coarse-grained; 15% gravel to 3 cm maximum diameter; abundant root fragments; wet; slight odor.	SS	11, 11, 16, 16	75	
SP	SAND (STRATIFIED DRIFT UNIT); Greenish-gray; medium- to coarse-grained; few gravels <1 cm diameter; <10% fines; wet; slight odor.				0
SP-SM	SAND WITH SILT; Light gray to brown; medium-grained; 10% fines; wet; slight odor.	SS	10, 14, 21, 21	100	
					19

REMARKS:
* Hand dug to 2.75 feet bgs; hollow-stem auger used to total depth.
⊠ - Sample Interval
NM - Not Measured
SS - Split Spoon

REMEDIATION TECHNOLOGIES, INC.
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RETEC

WELL INSTALLATION LOG
DW-4

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

DEPTH (in feet)	WELL CONSTRUCTION	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
10	2" DIAMETER SCHEDULE 40 PVC BLANK; BENTONITE CHIPS	SP-SM	*10.5'* – Wet; moderate odor; slight sheen grades to heavy sheen at 11.25 feet bgs.	SS	15 17 21 22	100	
		SP	SAND WITH GRAVEL (GRADED TOP CONTACT): Gray to brown (product); medium- to coarse-grained; 15% gravels to 3 cm diameter; wet; strong odor; moderate to heavy product at 11.25 to 12.0 feet bgs. *12.0'* – Heavy sheen only to 12.5 feet bgs.				108
		SW	SAND WITH GRAVEL: Gray; fine- to coarse-grained; 15% gravel to 0.8 cm diameter; wet; heavy sheen; strong odor. *13.25'* – 0.5 inch of product.	SS	22 30 50/4"	75	
		GW	GRAVEL WITH SAND: Gray to brown (product); 85% well-graded gravel to 2 cm diameter; 15% coarse-grained sand; wet; heavy sheen; strong odor. *14.3'* – Product present to 14.5 feet bgs.				295
15		SP	SAND: Gray; fine- to medium-grained; wet; heavy sheen; strong odor; no product.	SS	15 20 30 50/5"	75	
		SP	SAND WITH GRAVEL: Gray to brown (product); 75% medium- to coarse-grained sand; 25% gravel to 0.8 cm diameter; wet; moderate product present.				308
		SP	SAND: Gray with brown (product) streaks; medium-grained; wet; product to 16.5 feet bgs. *16.5'* – Heavy sheen to 16.8 feet bgs. *16.8'* – Product to 16.9 feet bgs. *16.9'* – Heavy sheen to 17.0 feet bgs.				
		SP	SAND: Gray; medium- to coarse-grained; <10% fines; heavy sheen; strong odor; no product.	SS	17 26 50	75	159
20							

REMARKS: * Hand dug to 2.75 feet bgs; hollow-stem auger used to total depth.
⊠ – Sample Interval
NM – Not Measured
SS – Split Spoon

REMEDIATION TECHNOLOGIES, INC.
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RETEC

WELL INSTALLATION LOG

DW-4

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL CONSTRUCTION: 2" DIAMETER SCHEDULE 40 PVC BLANK; BENTONITE CHIPS; RMC LONESTAR #2-12 SAND

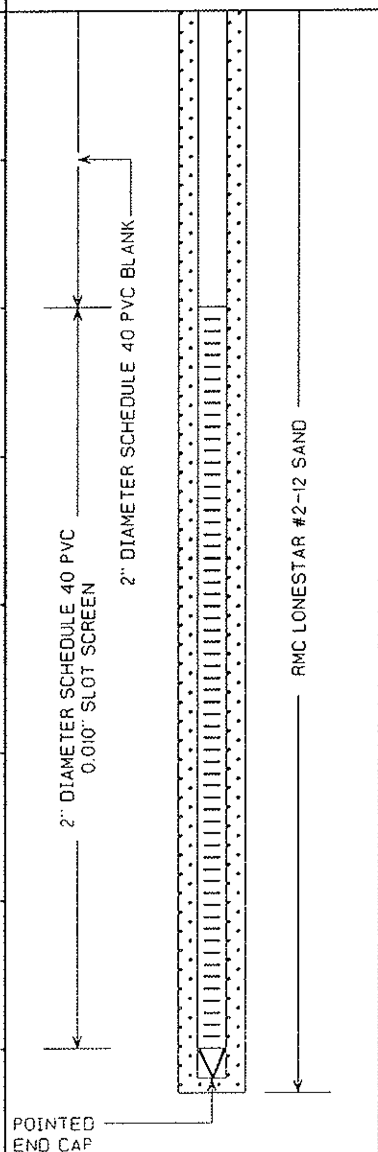
DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
20	SP	*20.5'* – Wet; medium sheen; strong odor to 21.25 feet bgs.	SS	36 50/ 5"	40	
						281
		22.5' – Wet; medium sheen; strong odor to 23.5 feet bgs.	SS	22 36 50/ 4"	100	
	SP	<u>SAND WITH GRAVEL</u>; Dark brown (product); 50% coarse-grained sand; 50% gravel to 2 cm diameter; saturated with product.				1566
	SP / SP	<u>SAND</u>; Dark brown (product); <10% fines; medium- to coarse-grained; saturated with product.				
	SP	<u>SAND</u>; Gray; fine- to medium-grained; <10% fines; wet; heavy sheen; no product.				
25		<u>SAND</u>; Gray to brown (product); medium-grained; <10% fines.	SS	60	50	
	SM	*25.25'* – Moderate product to 25.3 feet bgs. *25.3'* – Saturated with product to 25.5 feet bgs.				719
		<u>SILTY SAND WITH GRAVEL</u>; Gray; fine-grained; 20% slightly clayey fines; 15% gravel to 3 cm diameter; wet; no sheen or staining.				
	SP	<u>SAND WITH GRAVEL</u>; As at 23.5 feet bgs; saturated with product.	SS	24 36 50/ 5"	50	
	SM	<u>SILTY SAND WITH GRAVEL</u>; As at 25.5 feet bgs; strong sheen; no product.				
	SP / SM / SP	<u>SAND</u>; Brown; (product); medium- to coarse-grained; <10% fines; saturated with product.				968
		<u>SILTY SAND WITH GRAVEL</u>; As at 25.5 feet bgs; strong sheen; no product.				
	SP	<u>SAND WITH GRAVEL</u>; As at 23.5 feet bgs; saturated with product.				
30						

REMARKS:
× Hand dug to 2.75 feet bgs; hollow-stem auger used to total depth.
⊠ – Sample Interval
NM – Not Measured
SS – Split Spoon

RETEC

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL INSTALLATION LOG
DW-4



DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
30	SP	SAND; Brown (product); medium- to coarse-grained; <10% fines; few gravels to 1 cm diameter; saturated with product.	SS	65	50	
	SM	SILTY SAND WITH GRAVEL; As at 25.5 feet bgs; no sheen or staining.				1011
	SP	SAND; As at 30.0 feet bgs; saturated with product.	SS	100/ 4"	50	
	CL	CLAY (VASHON TILL UNIT); Thinly (~2 mm) laminated gray and white layers; very hard; no sheen or staining.				
	CL	GRAVELLY CLAY WITH SAND; Brown (product); 50% clayey fines; 30% gravel to 2 cm diameter; 20% fine-grained sand; saturated with product.				613
	CL	SANDY CLAY; Gray; 70% very hard fines; 20% fine-grained sand; 10% gravel to 1.5 cm diameter; moist; no sheen or staining.	SS	100/ 5"	0	
		NO RECOVERY				
35	CL	SANDY CLAY WITH GRAVEL; Gray to brown (product); 60% soft clayey fines; 20% gravel to 3 cm diameter; 20% fine-grained sand; wet; abundant product in coarse zones; no apparent bedding.	SS	100	50	731
		36.0' - Saturated with product to 36.3 feet bgs.	SS	100/ 5"	25	860
	CL	SANDY CLAY; Gray; 70% stiff clayey fines; 30% fine-grained sand; no sheen or odor.				
		37.0' - No sheen or odor to 37.3 feet bgs.	SS	100/ 5"	30	0
		Total depth = 37.3 feet bgs.				
40						

REMARKS:
* Hand dug to 2.75 feet bgs; hollow-stem auger used to total depth.
⊠ - Sample Interval
NM - Not Measured
SS - Split Spoon

REMEDIATION TECHNOLOGIES, INC.
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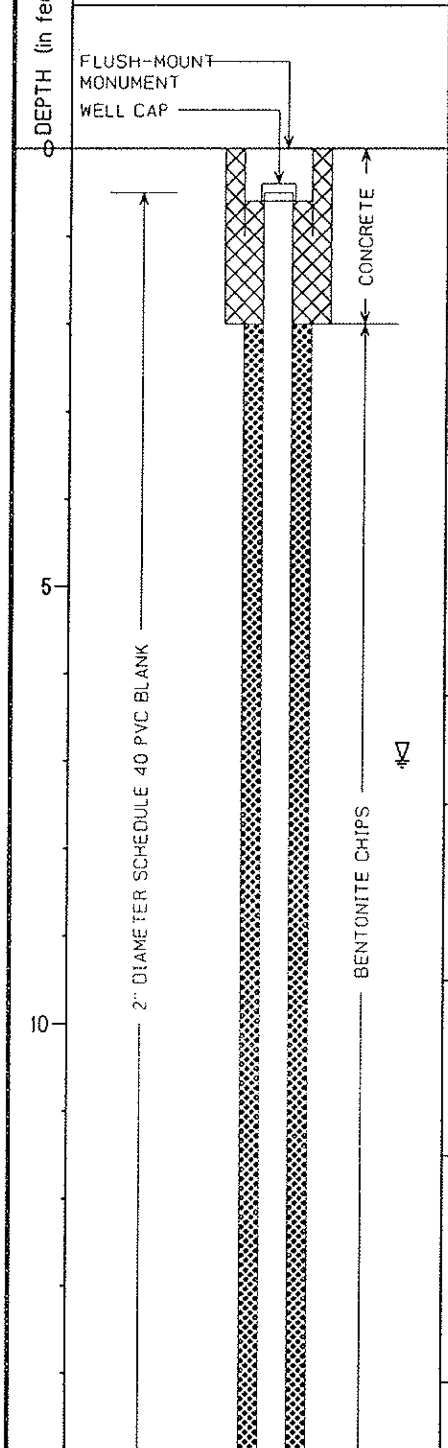
WELL INSTALLATION LOG
DW-5

RETEC

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: 5-3434-210 Gas Works Park		CLIENT: EPRI
LOCATION: Seattle, Washington; Harbor Patrol Lot, 8 feet North of Underground Tank		DRILLING CO.: Cascade Drilling
START DATE: 02/09/98 TIME: 08:00	BORING ID: 8 inches	DRILLER: S. Krueger
COMPLETION DATE: 02/09/98 TIME: 09:10	TOTAL DEPTH: 29.3 feet bgs	RIG TYPE: CME-75
WATER LEVEL DURING DRILLING: 7.0' bgs	TOP OF CASING: 21.59 feet (NAVD88)	METHOD: Hollow-stem Auger*
SURFACE ELEV.: 21.92 feet (NAVD88)		LOGGED BY: G. Sega

DEPTH (in feet) | WELL CONSTRUCTION | SOIL DESCRIPTION | SAMPLE DATA



U.S.C.S.	SOIL DESCRIPTION
	ASPHALT
SP	SAND WITH GRAVEL (GAS WORKS PARK UNIT); Brown; abundant ash and wood fragments; dry.
	WOOD; Large chunks; with sand; dry to moist.
SM	SILTY SAND WITH GRAVEL; Gray; medium- to coarse-grained; 20% fines; 15% gravel to 4 cm maximum diameter; abundant ash and wood fragments; dry. 5.0' - Dry to 5.5 feet bgs.
GP	GRAVEL; Dark brown (product); 50% gravel to 3 cm diameter; 50% wood fragments; saturated with product.
SP	SAND; Greenish-gray; medium- to coarse-grained; <10% fines; wet; slight sheen; slight odor. 9.0' - Wet; no sheen; slight odor.
SP	SAND WITH GRAVEL; Gray; medium- to coarse-grained; <10% fines; gravel to 2 cm diameter; wet; no sheen; slight odor.
SP	SAND; Gray; fine- to medium-grained; <10% fines; wet; no sheen; slight odor.
SP	

TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
SS	6 2 1 2	25	0
SS	8 14 10 10	50	84
SS	24 25 25 27	50	29
SS	14 18 24 24	60	38

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
■ - Analytical Sample
☒ - Sample Interval
SS - Split Spoon

REMEDIATION TECHNOLOGIES, INC.
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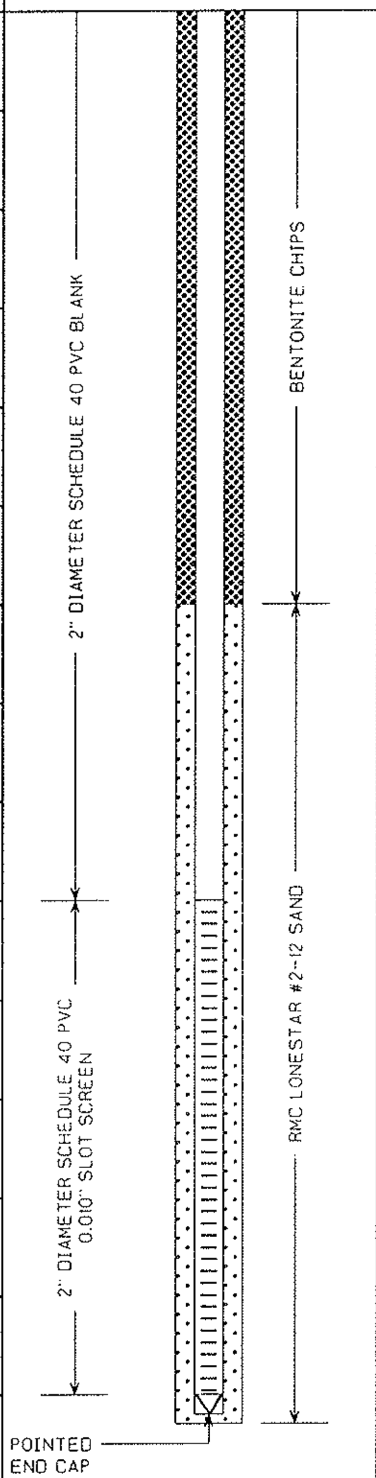
RETEC

WELL INSTALLATION LOG

DW-5

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL CONSTRUCTION



DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
15	SP	SAND; Dark gray; medium- to coarse-grained; <10% fines; local gravel to 1 cm diameter; wet; slight sheen; slight odor.	SS	18 21 23 26	75	39
	SM	SILTY SAND WITH GRAVEL; Greenish-gray; medium- to coarse-grained; 25% fines; 20% gravel to 5 cm diameter; wet; no sheen; slight odor.				
		17.5' - Percent fines decreasing to 15%.	SS	18 40 50/3"	20	45
20			SS	30 32 35 40	50	54
		22.5' - Percent fines increasing to 30%.	SS	32 50	50	20
25	SP	SAND WITH GRAVEL; Dark gray; medium- to coarse-grained; <10% fines; 20% gravel to 1.5 cm diameter; wet; strong sheen; strong odor; product on tip of sampler.	SS	42 50/4"	50	87
	SW	SAND WITH GRAVEL; Dark gray to brown (product); fine- to coarse-grained; 15% gravel to 5 cm diameter; <10% fines; wet; moderate product present.	SS	70	75	0
	CL	SANDY CLAY WITH GRAVEL; Gray; 20% fine-grained sand; 15% gravel to 3 cm diameter; very hard; dry; no sheen or odor.	SS	100/4"	30	0
30		Total depth = 29.3 feet bgs.				

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
■ - Analytical Sample
⊠ - Sample Interval
SS - Split Spoon

REMEDIATION TECHNOLOGIES, INC.
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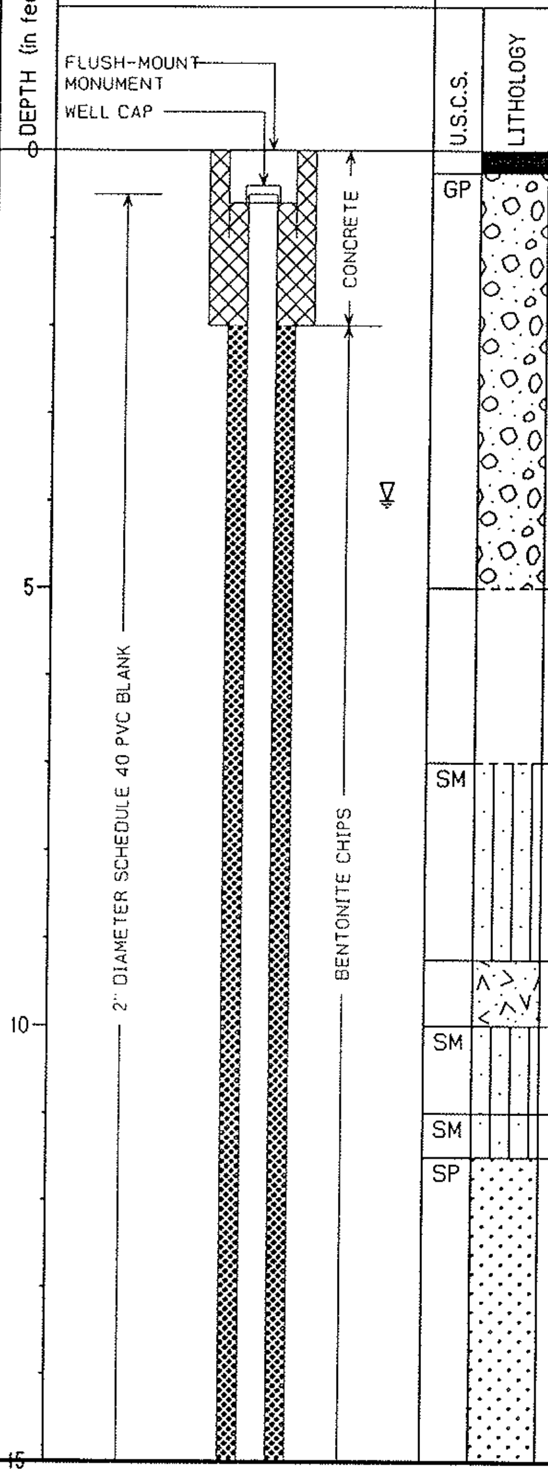
RETEC	WELL INSTALLATION LOG DW-6	1011 S.W. Klickitat Way Suite #207 Seattle, Washington 98134 (206) 624-9349

PROJECT NO: *5-3434-210 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Harbor Patrol Building, ~30 feet East of Southeast Corner*		DRILLING CO.: *Cascade Drilling*
START DATE: *02/09/98* TIME: *11:20*	BORING ID: *8 inches*	DRILLER: *S. Krueger*
COMPLETION DATE: *02/09/98* TIME: *13:20*	TOTAL DEPTH: *42.25 feet bgs*	RIG TYPE: *CME-75*
WATER LEVEL DURING DRILLING: *4.0' bgs*	TOP OF CASING: *21.04 feet (NAVD88)*	METHOD: *Hollow-stem Auger**
SURFACE ELEV.: *21.39 feet (NAVD88)*		LOGGED BY: *G. Sega*

WELL CONSTRUCTION



SOIL DESCRIPTION

U.S.C.S.	Description	Type	Blows/6"	% Recovery	PID (ppm)
	ASPHALT				
GP	GRAVEL WITH SAND (GAS WORKS PARK UNIT): Light brown; 75% gravel to 4 cm maximum diameter; 25% medium- to coarse-grained sand; local metal and wood debris. *4.0'* - Wet.				
	NO RECOVERY	SS	10 12 24 26	0	NM
SM	SILTY SAND WITH GRAVEL: Gray; fine- to coarse-grained; 20% slightly clayey fines; 15% gravel to 3 cm diameter; few brick fragments; wet. *9.0'* - Wet.	SS	5 16 7 7	30	1
	CINDERS: Black; wet; slight odor. *9.8'* - Wood fragments to 10.0 feet bgs.	SS	3 4 5 5	60	2
SM	SILTY SAND WITH GRAVEL: Dark gray; 15% fines; 15% gravel to 2 cm diameter; abundant shell fragments; wet; slight odor.				
SM	SILTY SAND WITH GRAVEL: As at 7.0 feet bgs.	SS	3 4 4 11	50	1
SP	SAND WITH GRAVEL: Gray; medium-grained; 15% gravel to 2 cm diameter; abundant ash and wood fragments; moist. *13.0'* - Moist; slight odor.	SS	4 9 9 8	33	2

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
⊠ - Sample Interval
NM - Not Measured
SS - Split Spoon

REMEDIATION TECHNOLOGIES, INC.
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RETEC

WELL INSTALLATION LOG
DW-6

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL CONSTRUCTION: 2" DIAMETER SCHEDULE 40 PVC BLANK; BENTONITE CHIPS

DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
15	SP	*15.0'* - Gravel increasing to 25%; few wood fragments; wet; slight odor.	SS	6, 7, 7, 7	50	1
	SM	SILTY SAND WITH GRAVEL; Gray; medium- to coarse-grained; 15% fines; 15% gravel to 2 cm diameter; wet; slight odor.				
		WOOD (FRAGMENTS); Wet; moderate odor.	SS	8, 9, 10, 10	15	46
	SM	SILTY SAND WITH GRAVEL (STRATIFIED DRIFT UNIT); Dark gray; fine- to coarse-grained; 40% gravel to 4 cm diameter; 15% fines; wet; slight odor.	SS	21, 25, 23, 23	30	11
20	GP	GRAVEL WITH SAND; Dark gray; 80% gravel to 5 cm diameter; 20% medium- to coarse-grained sand; <10% fines; wet; slight odor.	SS	31, 50	75	10
	SP	SAND WITH GRAVEL; Gray; medium- to coarse-grained; 30% gravel to 1 cm diameter; wet; slight odor.	SS	20, 21, 22	100	8
	ML	GRAVELLY SILT; Brown to gray; soft; 50% gravel to 4 cm diameter; moist to wet.				
	SM	SILTY SAND WITH GRAVEL; Gray; fine- to medium-grained; 20% fines; 20% gravel to 3 cm diameter; wet.				
25	SP	SAND WITH GRAVEL AND COBBLES; Gray; fine- to medium-grained; <10% fines; 30% gravel and cobbles to 8 cm diameter; wet; slight odor.	SS	32, 50	100	10
	GM	SILTY GRAVEL WITH SAND; Gray; 65% gravel to 4 cm diameter; 20% fine- to coarse-grained sand; 15% fines; wet; slight odor.	SS	45, 50/4"	75	7
	SP					
30						

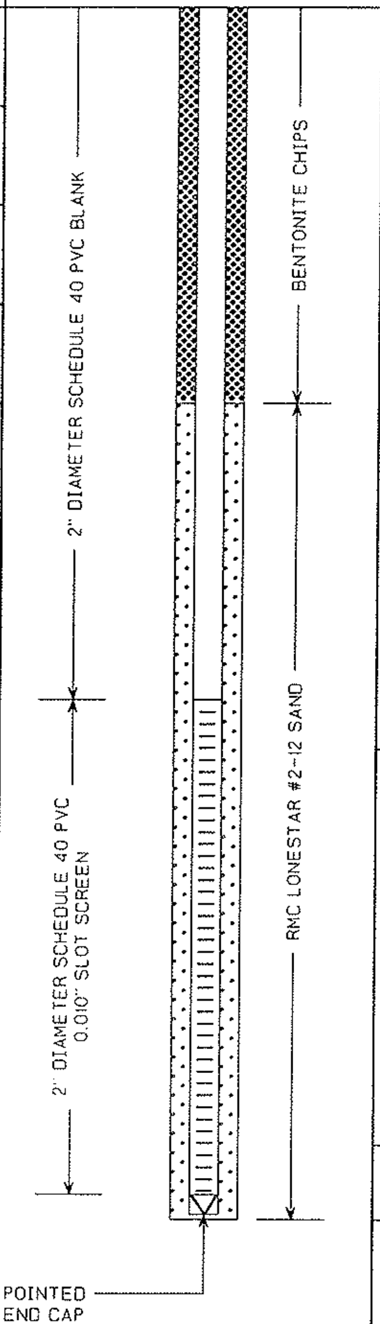
REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
⊠ - Sample Interval
NM - Not Measured
SS - Split Spoon

RETEC

WELL INSTALLATION LOG
DW-6

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL CONSTRUCTION



SOIL DESCRIPTION / SAMPLE DATA

DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
30	SP	SAND WITH GRAVEL; Gray; coarse-grained; <10% fines; 40% gravel to 1 cm diameter; few gravels to 5 cm diameter; wet; slight odor.	SS	36 50	100	30
		NO RECOVERY; ROCK IN TIP OF SAMPLER	SS	36 50/ 4"	0	NM
35	SM	SILTY SAND; Gray; fine-grained; 40% fines; wet; slight odor.	SS	50/ 5"	25	34
		NO RECOVERY; NO SHEEN OR PRODUCT ON SAMPLER	SS	60/ 3"	0	NM
40			SS	26 50	0	NM
	CL	SANDY CLAY WITH GRAVEL; Gray; 20% fine-grained sand; 15% gravel to 2 cm diameter; moist; no sheen or odor.	SS	100/ 5"	15	0
45		Total depth = 42.25 feet bgs.				

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
⊠ - Sample Interval
NM - Not Measured
SS - Split Spoon

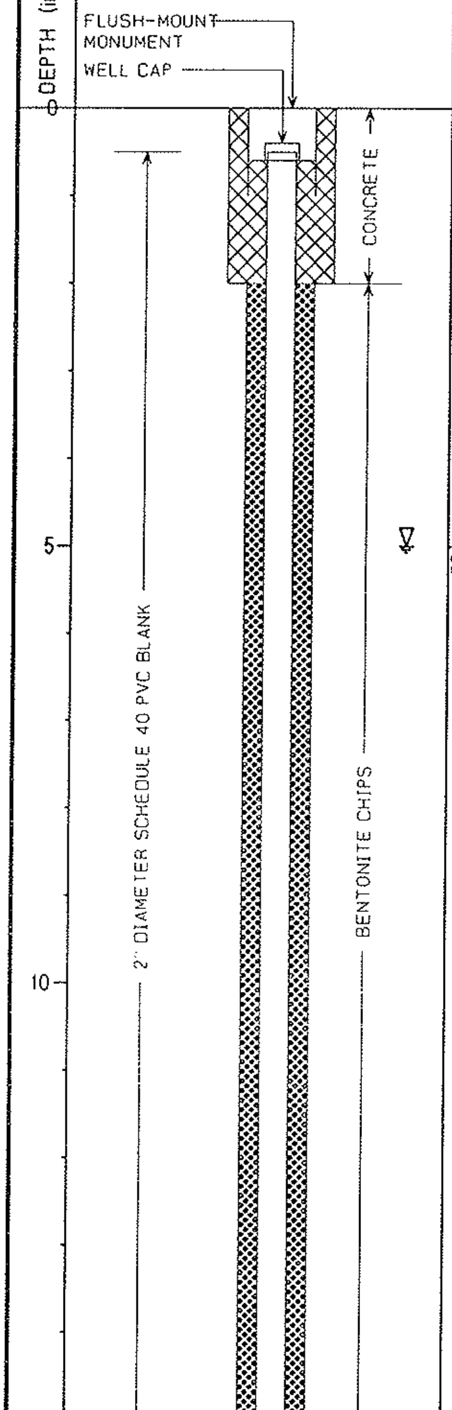
RETEC

WELL INSTALLATION LOG
DW-7

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: *5-3434-210 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Southeast End of Harbor Patrol Lot*		DRILLING CO.: *Cascade Drilling*
START DATE: *02/09/98* TIME: *08:00*	BORING ID: *8 inches*	DRILLER: *S. Krueger*
COMPLETION DATE: *02/09/98* TIME: *10:00*	TOTAL DEPTH: *42.9 feet bgs*	RIG TYPE: *CME-75*
WATER LEVEL DURING DRILLING: *5.0' bgs*	TOP OF CASING: *21.46 feet (NAVD88)*	METHOD: *Hollow-stem Auger**
SURFACE ELEV.: *21.80 feet (NAVD88)*		LOGGED BY: *G. Sega*

WELL CONSTRUCTION



SOIL DESCRIPTION

U.S.C.S.	Description
	ASPHALT
	CONCRETE
SW	SAND WITH GRAVEL, ASH AND CINDERS (GAS WORKS PARK UNIT); Gray to brown; local brick and wood fragments; dry.
SW-SM	SAND WITH SILT; Gray; fine- to coarse-grained; 20% fines; abundant brick and shell fragments; local cinders and ash; wet at 5.0 feet bgs.
	7.0' – No ash; few brick fragments; wet.
	9.0' – Wet to 10.2 feet bgs.
	11.0' – Local ash and glass shards; wet.
	13.0' – Wet to 14.2 feet bgs.
SW-SM	

SAMPLE DATA

TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
SS	5–7	1 1 1 2	100	0
SS	7–9	3 2 1 1	100	0
SS	9–11	1 1 2 2	60	0
SS	11–13	1 1 1 5	20	0
SS	13–15	1 2 2 5	30	0

REMARKS:
* Hand dug to 5.0 feet bgs. Hollow-stem auger used to total depth.
■ – Analytical Sample
⊠ – Sample Interval
SS – Split Spoon

RETEC

WELL INSTALLATION LOG
DW-7

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

DEPTH (in feet): 15 – 30

WELL CONSTRUCTION

2" DIAMETER SCHEDULE 40 PVC BLANK

BENTONITE CHIPS

SOIL DESCRIPTION

U.S.C.S.	Description
SW-SM	SAND WITH SILT; Gray to black (product); fine- to coarse-grained; 15% fines; abundant wood and shell fragments; wet; moderate product present.
SP	SAND (STRATIFIED DRIFT UNIT); Dark gray; medium- to coarse-grained; wet; strong sheen; moderate odor.
SP	SAND WITH GRAVEL; Dark gray; medium- to coarse-grained; 20% gravel to 3 cm maximum diameter; wet; strong sheen; moderate odor.
SP	SAND; Greenish-gray; fine- to medium-grained; <10% fines; wet; slight sheen and odor.
SP	SAND; Gray; medium- to coarse-grained; <10% fines; few shell fragments <3 mm diameter; wet; medium sheen; moderate odor.
	20.0' – Wet; medium sheen; moderate odor.
SP	SAND WITH GRAVEL; Dark gray; medium- to coarse-grained; 50% gravel to 1 cm diameter; wet; heavy sheen; strong odor.
GP	GRAVEL WITH SAND; Dark gray; 75% gravel to 3 cm diameter; 25% medium- to coarse-grained sand; wet; heavy sheen; strong odor.
SW	SAND WITH GRAVEL; Greenish-gray; fine- to coarse-grained; 20% gravel to 2 cm diameter; wet; slight sheen.
	NO RECOVERY
SP	SAND; Gray; medium- to coarse-grained; <10% fines; trace shell fragments; wet; no sheen; slight odor.
SP	SAND WITH GRAVEL; Gray; medium- to coarse-grained; 20% gravel to 3 cm diameter; 5% to 10% fines; wet; no sheen; slight odor.
SP	SAND WITH GRAVEL AND COBBLES; As above; gravels increasing to 10 cm maximum diameter.
SP	

SAMPLE DATA

TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
SS	12, 10, 17, 18	60	42
SS	26, 26, 28, 28	50	24
SS	6, 13, 29, 24	75	14
SS	32, 55	0	NM
SS	32, 50, 60	100	18
SS	26, 50/5"	60	13

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
■ – Analytical Sample
☒ – Sample Interval
SS – Split Spoon

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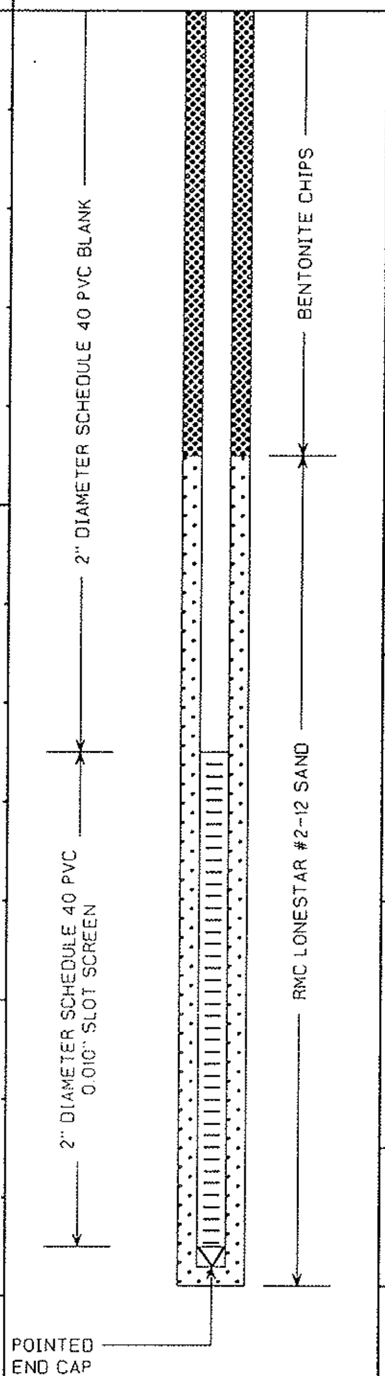
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL INSTALLATION LOG
DW-7

WELL CONSTRUCTION



DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
30	SP	SAND WITH GRAVEL; Gray; medium- to coarse-grained; <10% fines; 15% gravel to 3 cm diameter; wet; no sheen; slight odor.	SS	32 50/ 4"	75	16
	SM	SILTY SAND; Gray; fine- to medium-grained; 30% fines; 10% gravel to 2 cm diameter; wet; no sheen; slight odor.				
	SP	SAND WITH GRAVEL; As at 30.0 feet bgs; wet; no sheen; slight to moderate odor.	SS	26 50/ 4"	75	11
35		NO RECOVERY	SS	38 50/ 3"	0	NM
	GP	GRAVEL WITH SAND; Dark gray; 70% gravel to 2 cm diameter; 30% coarse-grained sand; wet; slight product present; strong sheen and odor.	SS	50 70/ 2"	35	110
40	SP	SAND; Greenish-gray; fine- to medium-grained; <10% fines; wet; strong sheen and odor.	SS	32 60	25	103
	CL	SANDY CLAY WITH GRAVEL; Gray; 20% fine-grained sand; 15% gravel to 3 cm diameter; moist; no sheen or odor.	SS	90/ 4"	30	0
		Total depth = 42.9 feet bgs.				
45						

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
■ – Analytical Sample
⊠ – Sample Interval
SS – Split Spoon

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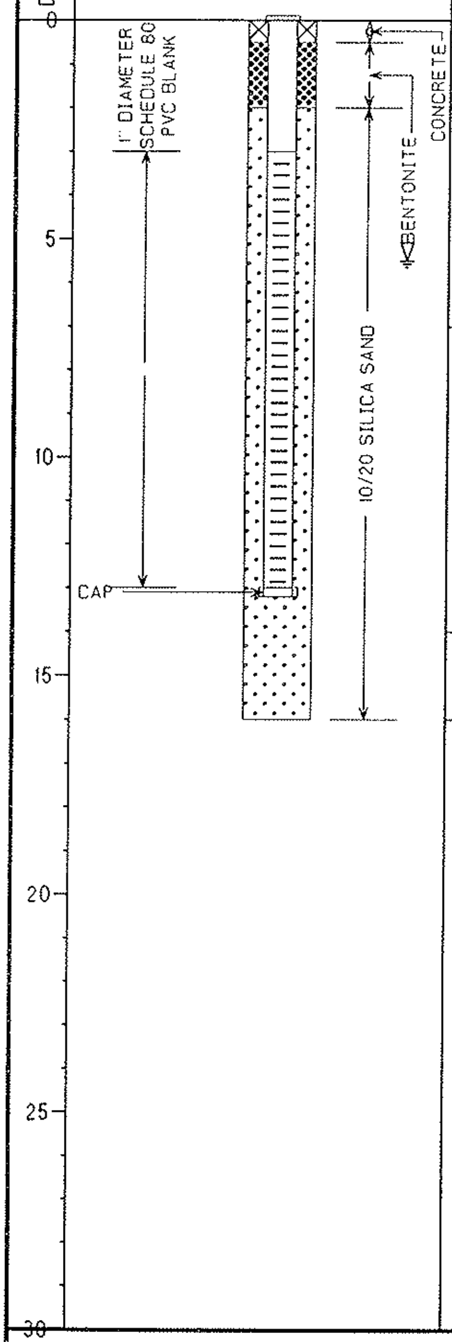
WELL INSTALLATION LOG
Piezometer PZ-1

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: *5-3434-110 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Gas Works Park*		DRILLING CO.: *TEG*
START DATE: *12/04/97* TIME: *08:00*	BORING ID: *inches*	DRILLER: *Todd*
COMPLETION DATE: *12/04/97* TIME: *10:00*	TOTAL DEPTH: *16.0 feet bgs*	RIG TYPE: *Strata Probe*
WATER LEVEL DURING DRILLING: *5.5' bgs*	TOP OF 2" CASING: *21.55 feet (NAVD88)*	METHOD: *Direct Push/Split Spoon*
SURFACE ELEV.: *22.00 feet (NAVD88)*		LOGGED BY: *J. F. Gibbens*

DEPTH (in feet) — WELL CONSTRUCTION



U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
	PAVEMENT: Underlain by gravel sub-base.				
GWP	SILTY SANDY GRAVEL; Black; with ash/wood fragments; some oily wood/coal; no sheen; no odor.	SS	HARD	50	0
	GRADES with wood; solid.				
	GRADES with wood; solid.	SS	SOFT	30	0
SD	SILTY COARSE SAND; Gray; with some wood debris; occasional well rounded gravel fragments; wet; no sheen; no odor.	SS	SOFT	80	0
	GRADES with brown/gray interbed of sandy silt.				
	GRADES to gray fine to medium sand; no sheen; no odor.	SS	SOFT	100	0
	GRADES to gray-brown sandy silt; with wood; no sheen; no odor.		HARD		
	GRADES to gray-black silty sandy coarse gravel; no sheen; no odor.	SS	VERY HARD	80	0
VT	SILTY SANDY COARSE GRAVEL; Gray; very hard; no sheen; no odor.				
	Total depth = 16.0 feet bgs.				

REMARKS:
■ - Analytical Sample
⊠ - Sample Interval
SS - Split Spoon

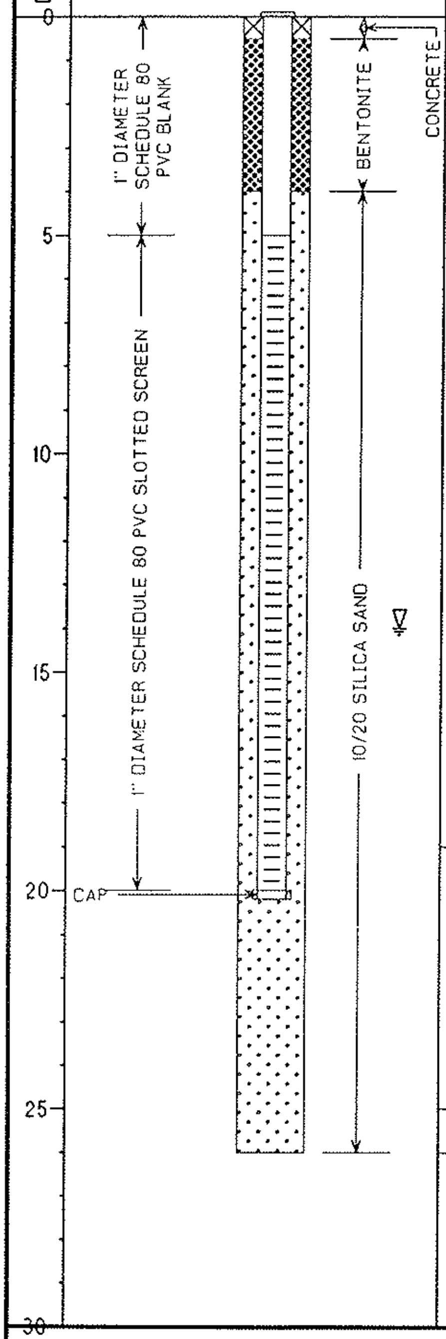
RETEC

WELL INSTALLATION LOG
Piezometer PZ-2

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: *5-3434-110 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Gas Works Park*		DRILLING CO.: *TEG*
START DATE: *12/04/97* TIME: *10:10*	BORING ID: *inches*	DRILLER: *Todd*
COMPLETION DATE: *12/04/97* TIME: *14:00*	TOTAL DEPTH: *26.0 feet bgs*	RIG TYPE: *Strata Probe*
WATER LEVEL DURING DRILLING: *14.0' bgs*	TOP OF 2" CASING: *30.95 feet (NAVD88)*	METHOD: *Direct Push/Split Spoon*
SURFACE ELEV.: *31.15 feet (NAVD88)*		LOGGED BY: *J. F. Gibbens*

WELL CONSTRUCTION



SOIL DESCRIPTION

U.S.C.S.	Description
	TOPSOIL; Black; wet; soft.
GWP	SILTY SANDY GRAVEL; Gray/brown/black; with wood, ash; highly heterogeneous; no sheen; moderate creosote odor.
	GRADES to gray/brown-black silty gravelly medium sand; some wood debris; brick fragments; no sheen; slight creosote odor.
	GRADES to gray gravelly sand; some wood debris; slight sheen; slight creosote odor.
	GRADES to gray silty fine sand; no sheen; slight odor.
	GRADES with gray/brown silt interbed.
	GRADES with gray/brown silt interbed.
	GRADES to uniform coarse gravel (pea gravel); strong sheen; stained and possible product; strong odor.
	GRADES to cobbly coarse gravel; strong sheen; stained and possible product; strong odor.
	GRADES to uniform fine to medium sand; stained black; moderate sheen; moderate odor.
	GRADES to black sandy gravel; with silt; wood; stained; moderate odor.
SD	FINE TO MEDIUM SAND; Black; moderate odor.
	GRADES to gray medium sand; with black-stained lenses; occasional dropstone (egg size); slight sheen; moderate odor.
	GRADES to gray medium sand; with dropstone gravel; coarser at bottom; no sheen; slight odor.
VT	SANDY SILTY GRAVEL; Gray; very hard; no sheen.
	Total depth = 26.0 feet bgs.

SAMPLE DATA

TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
SS	SOFT	60	0
SS	MOD SOFT	50	0
SS	VERY SOFT	40	0
SS	SOFT	10	0
	SL HARD		4.1
SS	HARD	50	12
SS	HARD	100	0.5
SS		40	0
SS	HARD	100	0
	VERY HARD		0

REMARKS: ⊠ - Sample Interval
SS - Split Spoon

RETEC

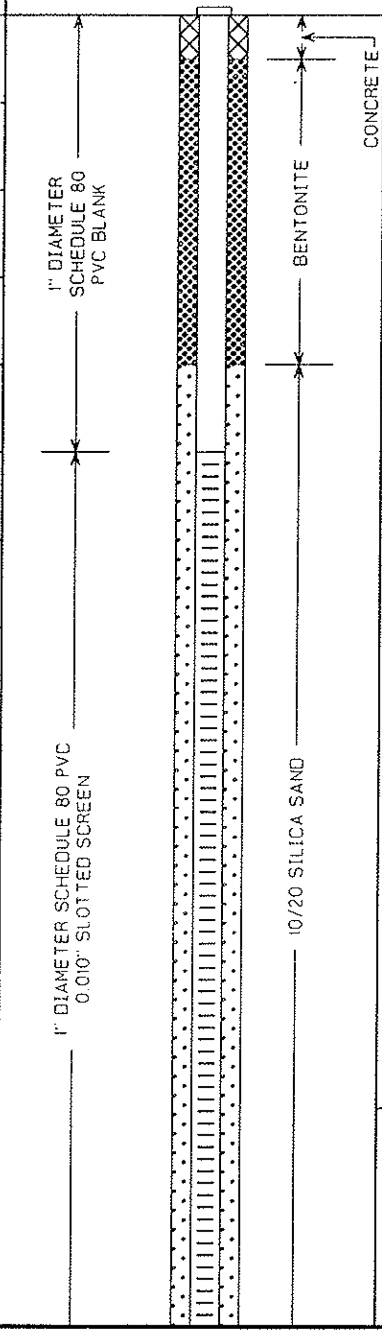
WELL INSTALLATION LOG
Piezometer PZ-3

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: 5-3434-110 Gas Works Park		CLIENT: EPRI
LOCATION: Seattle, Washington; Gas Works Park		DRILLING CO.: TEG
START DATE: 12/04/97 TIME: 14:00	BORING ID: inches	DRILLER: Todd
COMPLETION DATE: 12/04/97 TIME: 17:05	TOTAL DEPTH: 26.0 feet bgs	RIG TYPE: Strata Probe
WATER LEVEL DURING DRILLING: ' bgs	TOP OF 2" CASING: 30.83 feet (NAVD88)	METHOD: Direct Push/Split Spoon
SURFACE ELEV.: 31.03 feet (NAVD88)		LOGGED BY: J. F. Gibbens

DEPTH (in feet): 0, 5, 10, 15

WELL CONSTRUCTION



SOIL DESCRIPTION (U.S.C.S. / LITHOLOGY)

0' – FILL

GWP – SILTY SANDY GRAVEL; Black; no sheen; slight odor.

- *3.5'–4.5'* – Gray gravelly fine- to medium-grained sand; no sheen; moderate odor.
- *4.5'–6.0'* – Black sandy gravel; with brick fragments, glass and wood; stained; moderate odor.
- *6.0'–6.5'* – Some zones of medium-grained sand; stained with oil; moderate odor.
- *6.5'–8.0'* – Gray silty clay; with some vegetation; dry; hard; no sheen; no odor.
- *8.0'–8.25'* – Oil-soaked, matted vegetation; strong sheen; strong odor.
- *8.25'–10.0'* – Green sandy silty clay; dry; hard; no sheen; slight odor.
- *10.0'–10.25'* – Uniform pea gravel.
- *10.25'–11.0'* – Dark brown fine-grained sand; no sheen; slight odor.
- *11.0'–11.75'* – Gray gravelly silt; with wood debris; slight odor.
- *11.75'–12.5'* – Gray sandy gravel; slight odor.

SB – FINE- TO MEDIUM-GRAINED SAND; Uniform; oily; strong sheen/stain; strong odor.

- *13.5'–14.0'* – Tan/brown fine-grained sand; with thin (<½") silt interbeds.
- *14.0'–16.3'* – Very oily (saturated?); strong odor.

SAMPLE DATA

TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
SS		SOFT	100	
				0
SS		MOD HARD	80	
				0
SS		MOD HARD	100	
				0
SS		MOD HARD	100	
				0
SS		HARD	100	

REMARKS: ⊠ – Sample Interval
SS – Split Spoon

RETEC

WELL INSTALLATION LOG
Piezometer PZ-3

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL CONSTRUCTION: 1" DIAMETER SCHEDULE 80 PVC 0.010" SLOTTED SCREEN (15–20 ft); CAP (20 ft); 10/20 SILICA SAND (15–26 ft)

DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
15	SB					0
		16.3'–17.0' – Gray silty clay; with oily sand interbeds (<1"); strong odor.				
		17.0'–19.0' – Gray/brown; fine- to medium-grained sand; with some silt interbeds; and small oily sand lenses.	SS	MOD HARD	100	
						0
		19.0'–19.5' – Gray coarse sandy gravel.				
20		*19.5'–22.5'* – Brown medium-grained sand; with occasional dropstone; and thin (<1") silty lenses; slight sheen; slight odor.	SS	HARD	100	
						0
		22.5'–24.5' – Gray-brown coarse-grained sand; with gravel-sized dropstones; no sheen; slight odor.	SS	HARD	70	
						0
25	VT	SILTY SANDY GRAVEL; Gray; very hard; no sheen; slight odor.				
		Total depth = 26.0 feet bgs.				
30						

REMARKS: ⊠ – Sample Interval
SS – Split Spoon

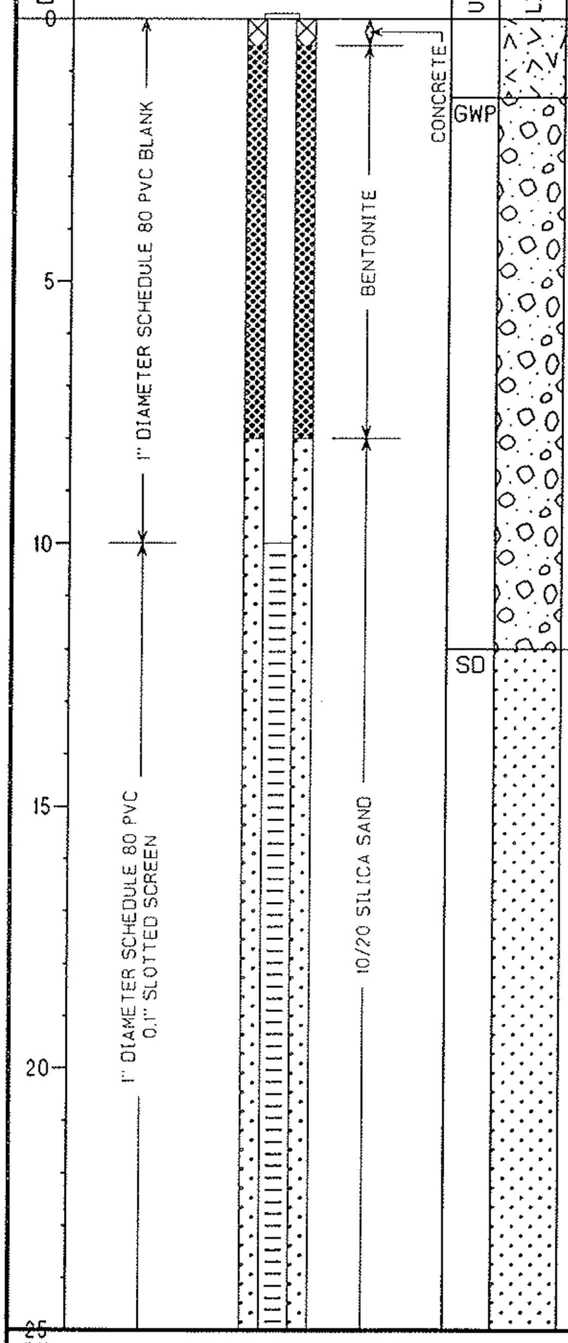
RETEC

WELL INSTALLATION LOG

Piezometer PZ-4

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: *5-3434-110 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Gas Works Park*		DRILLING CO.: *TEG*
START DATE: *12/05/97* TIME: *08:00*	BORING ID: *inches*	DRILLER: *Kevin*
COMPLETION DATE: *12/05/97* TIME:	TOTAL DEPTH: *33.0 feet bgs*	RIG TYPE: *Strata Probe*
WATER LEVEL DURING DRILLING: *' bgs*	TOP OF 2" CASING: *30.30 feet (NAVD88)*	METHOD: *Direct Push/Split Spoon*
SURFACE ELEV.: *30.48 feet (NAVD88)*		LOGGED BY: *J. F. Gibbens*



SOIL DESCRIPTION

GWP:

<u>GRAVEL</u>; Road; medium coarse; no sheen; no odor.

GRADES to gray silty sand; with some clay; no sheen; no odor.

<u>SILTY SANDY GRAVEL</u>; Dark brown; no sheen; no odor.

GRADES with black cinders and slag-type material; no sheen; no odor.

GRADES to black silty sand; with brick/wood fragments; no sheen; no odor.

GRADES with some clay lenses.

GRADES with occasional large rock fragments (broken).

GRADES with thin lenses of black ash; no sheen; no odor.

GRADES with reddish ashy cinders; no sheen; no odor.

GRADES with some iron-stained medium sand; no sheen; no odor.

GRADES with black ashy sand; some gravel; dry.

SD:

<u>COARSE SAND</u>; Reddish; with 40% gravel; wet.

GRADES to reddish sandy silt; no sheen; no odor.

GRADES to reddish uniform medium sand; no sheen; no odor.

GRADES to blue-gray medium sand.

GRADES to black sandy gravel; stained; strong odor.

GRADES to interbedded blue-gray uniform medium sand and blue-gray silt.

GRADES to blue/gray/brown fine to coarse sand; with gravel; sheen; odor.

GRADES to black-stained sandy gravel; strong odor.

GRADES to gray sandy coarse gravel; no sheen; moderate odor.

GRADES with oil-stained/saturated lenses <1" thick; strong odor.

SAMPLE DATA

TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
SS	⊠	SOFT	90	0
SS	⊠	MOD SOFT	50	0
SS	⊠	SOFT	40	0
SS	⊠	SOFT	50	0
SS	⊠	SOFT	90	0
SS	⊠	MOD HARD	100	0
				4
				42
				1
SS	⊠	MOD HARD	100	0
				0
SS	⊠	HARD	90	8
SS	⊠		80	>400

REMARKS: ⊠ - Sample Interval
SS - Split Spoon

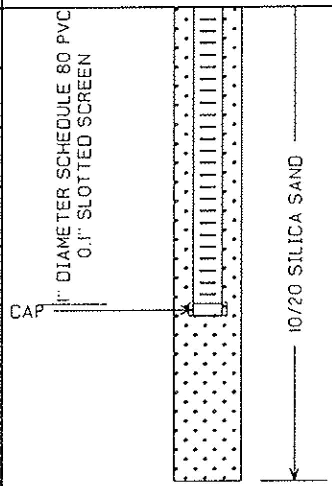
RETEC

WELL INSTALLATION LOG

Piezometer PZ-4

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

DEPTH (in feet) | WELL CONSTRUCTION | SOIL DESCRIPTION | SAMPLE DATA



DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
25	SD	*GRADES* to oil-stained medium sand; strong odor.				0
		GRADES to brown; uniform medium sand; moderate odor.				28
			SS	SOFT	90	0
		GRADES with black oil-stained lense ~1.5" thick; strong odor.				
		GRADES to brown uniform medium sand; moderate odor.				>150
30		*GRADES* with some thin (<1" thick) silt lenses.	SS	VERY HARD	80	>150
		GRADES to black, oily, stained medium sand; with occasional gravel; very strong odor.				>150
	VT	*GRADES* to black saturated medium sand; strong odor.				0
		SILTY SANDY COBBLY GRAVEL; Gray; no sheen; slight odor.				
		Total depth = 33.0 feet bgs.				
35						
40						
45						
50						

REMARKS: ⊠ - Sample Interval
SS - Split Spoon

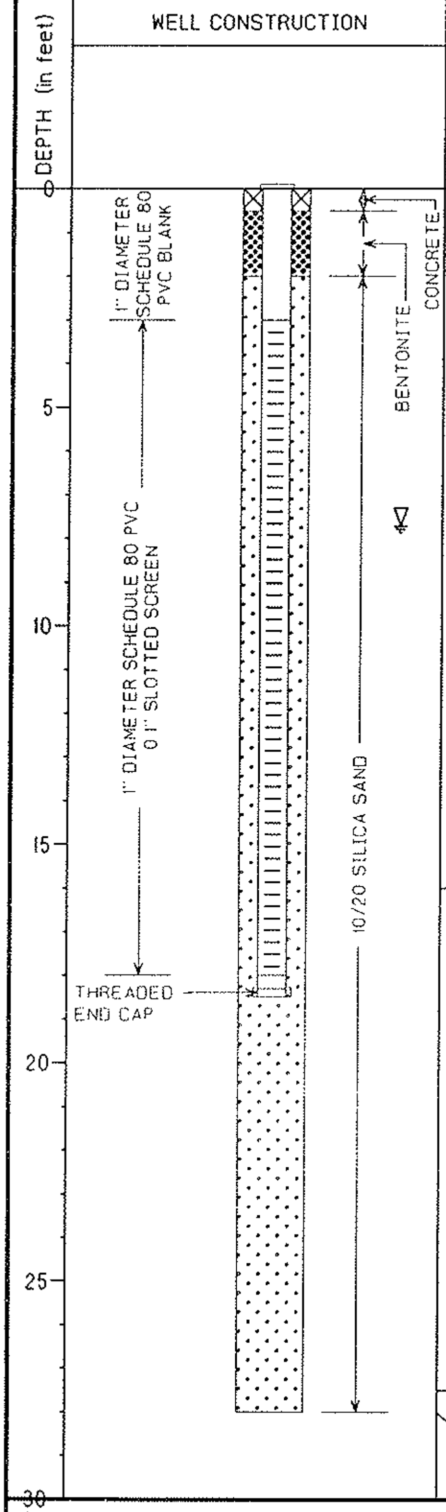
RETEC

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL INSTALLATION LOG
Piezometer PZ-5

PROJECT NO: *5-3434-110 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Seattle Harbor Police Lot*		DRILLING CO.: *TEG*
START DATE: *12/05/97* TIME: *11:35*	BORING ID: *inches*	DRILLER: *Kevin*
COMPLETION DATE: *12/05/97* TIME: *15:00*	TOTAL DEPTH: *28.0 feet bgs*	RIG TYPE: *Strata Probe*
WATER LEVEL DURING DRILLING: *7.72' bgs*	TOP OF 2" CASING: *24.28 feet (NAVD88)*	METHOD: *Direct Push/Split Spoon*
SURFACE ELEV.: *24.49 feet (NAVD88)*		LOGGED BY: *J. F. Gibbens*

WELL CONSTRUCTION



SOIL DESCRIPTION

U.S.C.S.	Description
	TOPSOIL/GRASS; Black. *GRADES* to gray uniform medium sand; dry.
GWP	SILTY SANDY ASH; Black; with wood-brick fragments; no sheen; no odor. *NO* – sheen; no odor on spoon. *NO* – sheen; no odor on spoon. *GRADES* to black silty sand; with brick fragments; slight sheen; moderate odor. *GRADES* to black sandy gravel; stained; strong odor. *GRADES* to black silty mud; strong odor. *GRADES* to black sandy gravel; stained; strong odor.
SD	SILTY SANDY GRAVEL; Gray. *GRADES* to gray sandy silt; with thin (<1") medium sand interbeds. *GRADES* to gray gravelly medium sand; no sheen; slight odor. *GRADES* to gray gravelly silt; no sheen; slight odor. *GRADES* to gray fine uniform sand. *GRADES* to gray silty sandy gravel; no sheen; slight odor. *GRADES* to gray silty fine sand; very hard; no sheen; slight odor. *GRADES* to gray silty gravelly sand; some iron staining; no sheen; no odor.
VT	GRAVELLY SILT; Gray; dry; very hard; no sheen; very slight odor.

Total depth = 28.0 feet bgs.

SAMPLE DATA

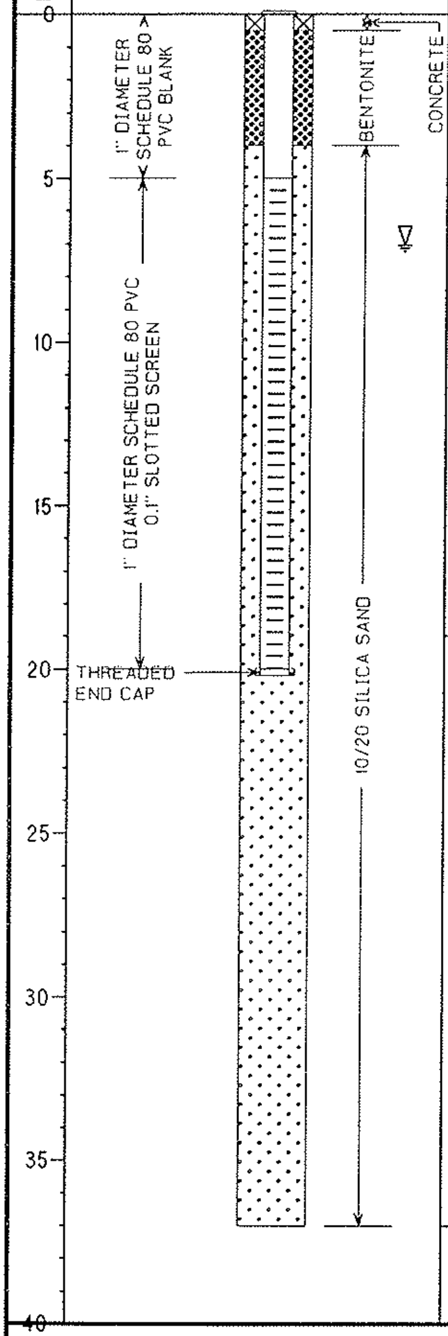
TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
SS	⊠	SOFT	60	0
SS	⊠		0	
SS	⊠		0	
SS	⊠	SOFT	20	0
SS	⊠	SOFT	40	
SS	⊠	SOFT	100	100
				4
SS	⊠	HARD	80	0
SS	⊠	VERY HARD HARD	50	0
SS	⊠	HARD	0	0
SS	⊠	VERY HARD	20	0

REMARKS: ⊠ – Sample Interval
SS – Split Spoon

RETEC	WELL INSTALLATION LOG Piezometer PZ-6	1011 S.W. Klickitat Way Suite #207 Seattle, Washington 98134 (206) 624-9349

PROJECT NO: *5-3434-110 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Seattle Harbor Police Lot*		DRILLING CO.: *TEG*
START DATE: *12/05/97* TIME: *15:00*	BORING ID: *inches*	DRILLER: *Kevin/Todd*
COMPLETION DATE: *12/08/97* TIME: *10:30*	TOTAL DEPTH: *37.0 feet bgs*	RIG TYPE: *Strata Probe*
WATER LEVEL DURING DRILLING: *7.03' bgs*	TOP OF 2" CASING: *23.55 feet (NAVD88)*	METHOD: *Direct Push/Split Spoon*
SURFACE ELEV.: *23.91 feet (NAVD88)*		LOGGED BY: *J. F. Gibbens*

DEPTH (in feet) | WELL CONSTRUCTION



SOIL DESCRIPTION

U.S.C.S.	LITHOLOGY	Description
		ASPHALT; Underlain by gravel sub-base.
GWP		ASHY CINDERS; Yellow/red.
		GRADES to black ash; with brick fragments and wood; no sheen; no odor.
		GRADES to yellowish ashy cinders; with gravel.
		GRADES to black oily wood fiber; slight odor.
		GRADES with some smelly black mud in catcher; strong odor.
		GRADES with black oily water; small amount of coarse gravel; scrap metal.
		GRADES to coarse gravel.
		GRADES with some coarse gravel in catcher.
		GRADES to black ashy fine sand.
		GRADES to gray silty sandy gravel; with black oily lenses; strong odor.
SD		GRAVELLY MEDIUM TO COARSE SAND; Gray; no sheen; slight odor.
		GRADES to gray gravelly medium sand; no sheen; slight odor.
		GRADES to gray uniform fine sand; no sheen; slight odor.
		GRADES to gray sandy gravel.
		GRADES to gray uniform medium sand.
		GRADES to black oily stained sand at bottom 2".
		GRADES to gray gravelly medium sand; stained at bottom; moderate odor.
		GRADES to gray uniform fine sand; sheen; strong odor.

Total depth = 37.0 feet bgs.

SAMPLE DATA

TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
SS	⊠	SOFT	70	0
SS	⊠	SOFT	20	0
SS	⊠	SOFT	0	
SS	⊠	SOFT	0	0
SS	⊠	MOD HARD	10	
SS	⊠	HARD	100	0 82 48
SS	⊠	HARD	100	0
SS	⊠	HARD	100	0
SS	⊠	HARD	90	0
SS	⊠	MOD HARD	100	0
SS	⊠	MOD HARD	100	64 0 41
SS	⊠	MOD HARD	100	

REMARKS: Hole collapsing – using piston sample from 13.0 feet bgs on.
⊠ – Sample Interval
SS – Split Spoon

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RETEC

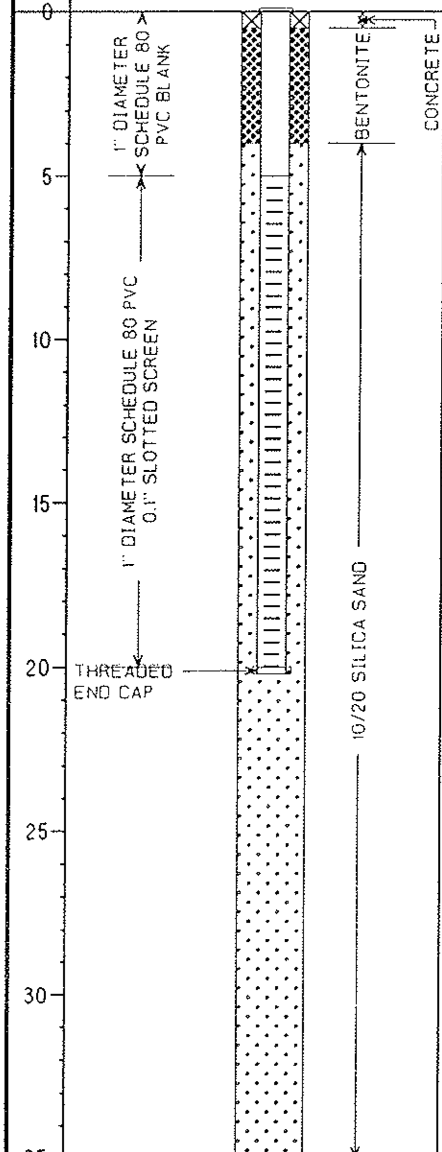
1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL INSTALLATION LOG

Piezometer PZ-7

PROJECT NO: 5-3434-110 Gas Works Park		CLIENT: EPRI
LOCATION: Seattle, Washington; Seattle Harbor Police Lot		DRILLING CO.: TEG
START DATE: 12/08/97 TIME: 10:45	BORING ID: inches	DRILLER: Todd
COMPLETION DATE: 12/08/97 TIME: 14:30	TOTAL DEPTH: 35.0 feet bgs	RIG TYPE: Strata Probe
WATER LEVEL DURING DRILLING: ' bgs	TOP OF 2" CASING: 21.12 feet (NAVD88)	METHOD: Direct Push/Split Spoon
SURFACE ELEV.: 21.28 feet (NAVD88)		LOGGED BY: J. F. Gibbens

WELL CONSTRUCTION



SOIL DESCRIPTION

U.S.C.S.	SOIL DESCRIPTION
	ASPHALT; Underlain by gravel sub-base.
GWP	COARSE GRAVEL; No sheen; no odor.
	GRADES to gray sandy gravel; no sheen; no odor.
	GRADES with wood; no sheen; no odor.
	GRADES with yellow sandy ash; no sheen; no odor.
	GRADES with soft asphalt material; no sheen; no odor.
	GRADES with soft black asphalt material; some coal tar; waste coal fragments; no sheen; no odor.
	GRADES to soft black ashy mush; coal fragments; wood fiber; no sheen; no odor.
	ROCK in shoe.
	GRADES with wood; with some black silt; slight sheen; slight odor.
SD	FINE TO MEDIUM SAND; Gray; highly stained; strong odor.
	GRADES to coarse uniform gravel.
	GRADES to gray gravelly fine to medium sand; slight sheen; strong odor.
	GRADES to gray sandy silty coarse gravel; no sheen; very slight odor.
	GRADES to gray fine to medium sand; no sheen; slight odor.
	GRADES to gray coarse sand.
	GRADES to gray silty sandy gravel.
	GRADES to gray very uniform fine sand; no sheen; very slight odor.
	Total depth = 35.0 feet bgs.

SAMPLE DATA

TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
SS	VERY SOFT	60	0
SS	VERY SOFT	30	0
SS	VERY SOFT	50	0
SS	SOFT	0	
SS	VERY SOFT	20	0
SS	MOD HARD	70	0
SS	MOD HARD	80	0
SS	MOD HARD	100	0
SS			
SS			

REMARKS: ⊠ - Sample Interval
SS - Split Spoon

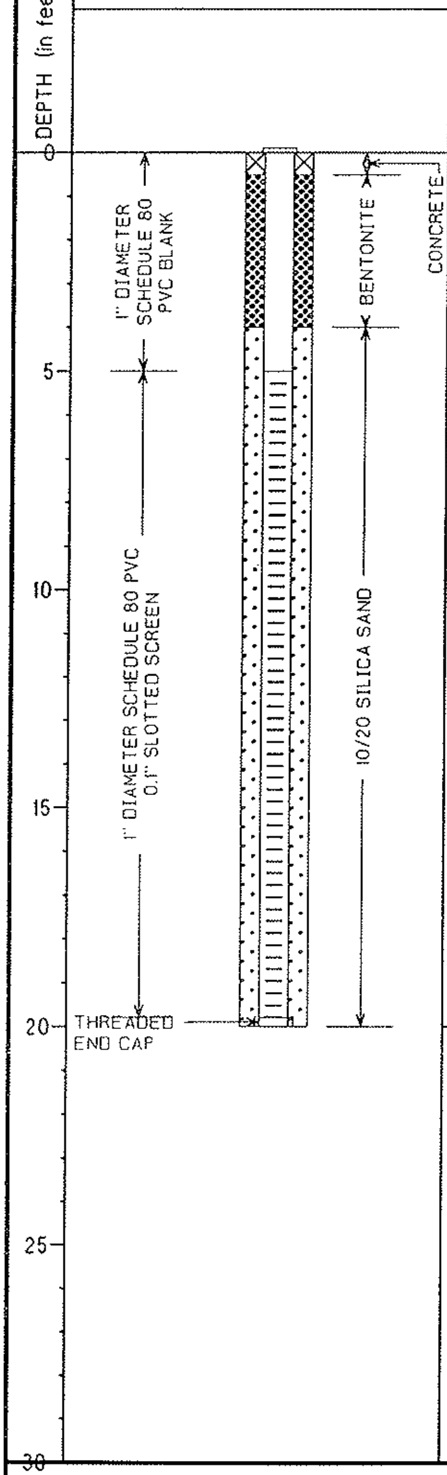
RETEC

WELL INSTALLATION LOG
Piezometer PZ-8

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: *5-3434-110 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Seattle Harbor Police Lot*		DRILLING CO.: *TEG*
START DATE: *12/08/97* TIME: *15:30*	BORING ID: *inches*	DRILLER: *Eric*
COMPLETION DATE: *12/08/97* TIME: *19:00*	TOTAL DEPTH: *20.0 feet bgs*	RIG TYPE: *Strata Probe*
WATER LEVEL DURING DRILLING: *' bgs*	TOP OF 2" CASING: *21.73 feet (NAVD88)*	METHOD: *Direct Push/Split Spoon*
SURFACE ELEV.: *21.92 feet (NAVD88)*		LOGGED BY: *J. F. Gibbens*

WELL CONSTRUCTION



SOIL DESCRIPTION

U.S.C.S.	Description
	ASPHALT; Underlain by coarse gravel sub-base.
GWP	SILTY ASH; Black; no sheen; no odor. *GRADES* to green-brown; silty fine sand; no sheen; no odor. *GRADES* with concrete; no sheen; no odor. *GRADES* to greenish silty fine sand; no sheen; no odor. *GRADES* with wood; no sheen; no odor.
SD	FINE TO MEDIUM SAND; Gray; no sheen; slight odor. *GRADES* to brown woody silt; no sheen; slight odor. *GRADES* to gray sandy medium gravel; stronng sheen; moderate odor. *GRADES* to gray silty fine sand; no sheen; slight odor. *GRADES* to gray uniform medium sand; no sheen; slight odor. *GRADES* to gray silty sandy medium gravel; no sheen; moderate odor. *GRADES* to gray uniform fine sand; no sheen; slight odor. *GRADES* to gray gravelly medium sand; no sheen; slight odor. *GRADES* to silty medium sand; highly stained; strong odor. *GRADES* to gray fine to medium sand; no sheen; slight odor.

Total depth = 20.0 feet bgs.

SAMPLE DATA

TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
SS	⊠	SOFT	100	0
SS	⊠	SOFT	50	0
SS	⊠	SOFT	60	6.1
				4.1
SS	⊠	MOD SOFT	90	0
SS	⊠	SOFT	80	0
SS	⊠	MOD SOFT	100	0
				7.0
				0

REMARKS: ⊠ - Sample Interval
SS - Split Spoon

RETEC

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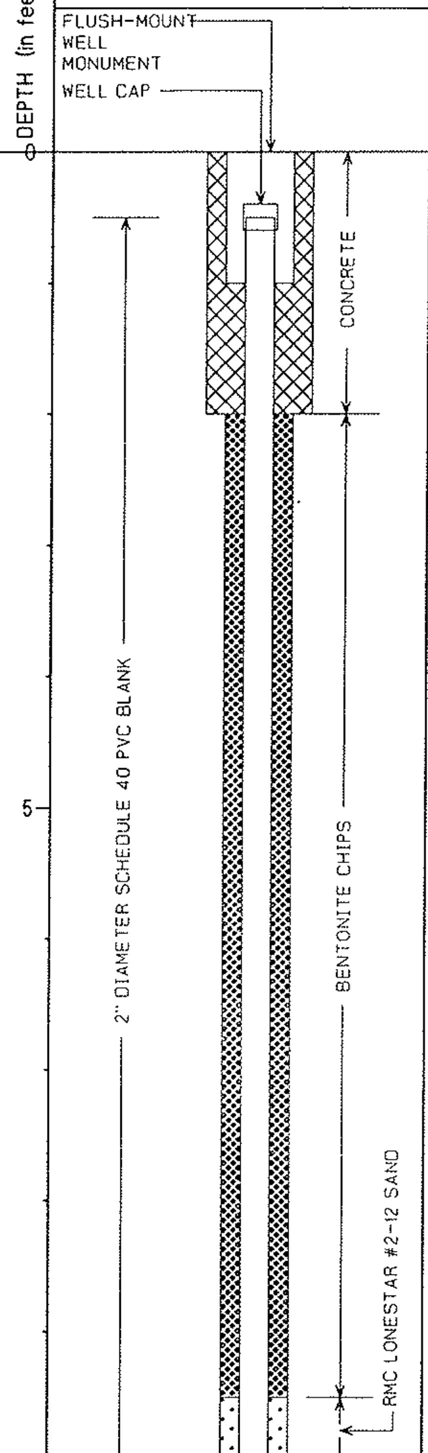
WELL INSTALLATION LOG

Piezometer PZ-9

PROJECT NO: 5-3434-210 Gas Works Park		CLIENT: EPRI
LOCATION: Seattle, Washington; Gas Works Park Old Railroad Grade, ~30' West of MLS-1		DRILLING CO.: Cascade Drilling
START DATE: 03/30/98 TIME: 12:15	BORING ID: 8 inches	DRILLER: James Goble
COMPLETION DATE: 03/30/98 TIME: 12:50	TOTAL DEPTH: 23.0 feet bgs	RIG TYPE: CME-55
WATER LEVEL DURING DRILLING: 19.0' bgs	TOP OF 2" CASING: 33.09 feet (NAVD88)	METHOD: Hollow-stem Auger*
SURFACE ELEV.: 33.51 feet (NAVD88)		LOGGED BY: G. Sega

DEPTH (in feet)	WELL CONSTRUCTION	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)



SOIL: Brown; sand with silt and gravel; abundant rootlets; dry to moist.

SP — SAND WITH GRAVEL, ASH AND CINDERS (GAS WORKS PARK UNIT): Light brown to tan; medium- to coarse-grained; <10% fines; 20% gravel to 4 cm maximum diameter; abundant ash and cinders; few brick fragments; dry.

5.0' – No ash or cinders present; dry; slight odor; rock in tip of sampler.

7.0' – Dry; slight odor; rock in tip of sampler.

9.0' – Dry; slight odor.

9.8' – Orange staining to 10.0 feet bgs.

SP

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
Lithology descriptions taken from Boring Log for B-1 (MLS-1).
⊠ – Sample Interval
SS – Split Spoon

WELL INSTALLATION LOG

Piezometer PZ-9

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DEPTH (in feet)	WELL CONSTRUCTION	U.S.C.S.	SOIL DESCRIPTION	TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
10	2" DIAMETER SCHEDULE 40 PVC BLANK	SP	SAND (STRATIFIED DRIFT UNIT); Light gray to brown; fine-grained; <10% fines; moist; no odor.					
		SP-SM	SAND WITH SILT; Light gray to brown; fine-grained; 10% to 15% fines; wet; no odor.					
		SP	SAND; Brown to gray; medium- to coarse-grained; <10% fines; wet.					
	2" DIAMETER SCHEDULE 40 PVC 0.010" SLOTTED SCREEN; RMC LONESTAR #2-12 SAND	SP	SAND; As at 10.0 feet bgs.					
		SP	SAND; Light brown; fine- to medium-grained; 10% fines; wet.					
		SM	SILTY SAND; Light gray to buff; fine-grained; 25% fines; wet.					
		SP						
		SW-SM	SAND WITH GRAVEL; Brown with gold (mica) flecks; medium- to coarse-grained; 20% gravel to 0.8 cm diameter; wet.					
15			SAND WITH SILT AND GRAVEL; Light brown; fine- to coarse-grained; 10% fines; 15% to 20% gravel to 4 cm diameter; wet. *15.0'* – Fines increasing to 20% at 16.0 feet bgs.					
		SM	SILTY SAND					
		SW-SM	SAND WITH SILT AND GRAVEL; Gray; fine- to coarse-grained; 10% fines; 20% gravel to 3 cm diameter; wet; slight odor.					
	∇	SM	SILTY SAND WITH GRAVEL; Brown; fine- to medium-grained; 20% fines; 10% gravel to 2 cm maximum diameter; wet; slight sheen; slight odor.	SS	⊠	50	30	
20								

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
Lithology descriptions taken from Boring Log for B-1 (MLS-1).
⊠ – Sample Interval
SS – Split Spoon

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WELL INSTALLATION LOG

Piezometer PZ-9

DEPTH (in feet)	WELL CONSTRUCTION	U.S.C.S.	SOIL DESCRIPTION	TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
20	2" DIAMETER SCHEDULE 40 PVC 0.010" SLOTTED SCREEN; RMC LONESTAR #2-12 SAND	SM						
		SC	CLAYEY SAND; Gray; fine-grained; 30% stiff fines; very hard; dry to moist; no sheen; no odor.	SS		50	30	
	POINTED END CAP		Total depth = 23.0 feet bgs.					
25								
30								

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
Lithology descriptions taken from Boring Log for B-1 (MLS-1).
☒ – Sample Interval
SS – Split Spoon

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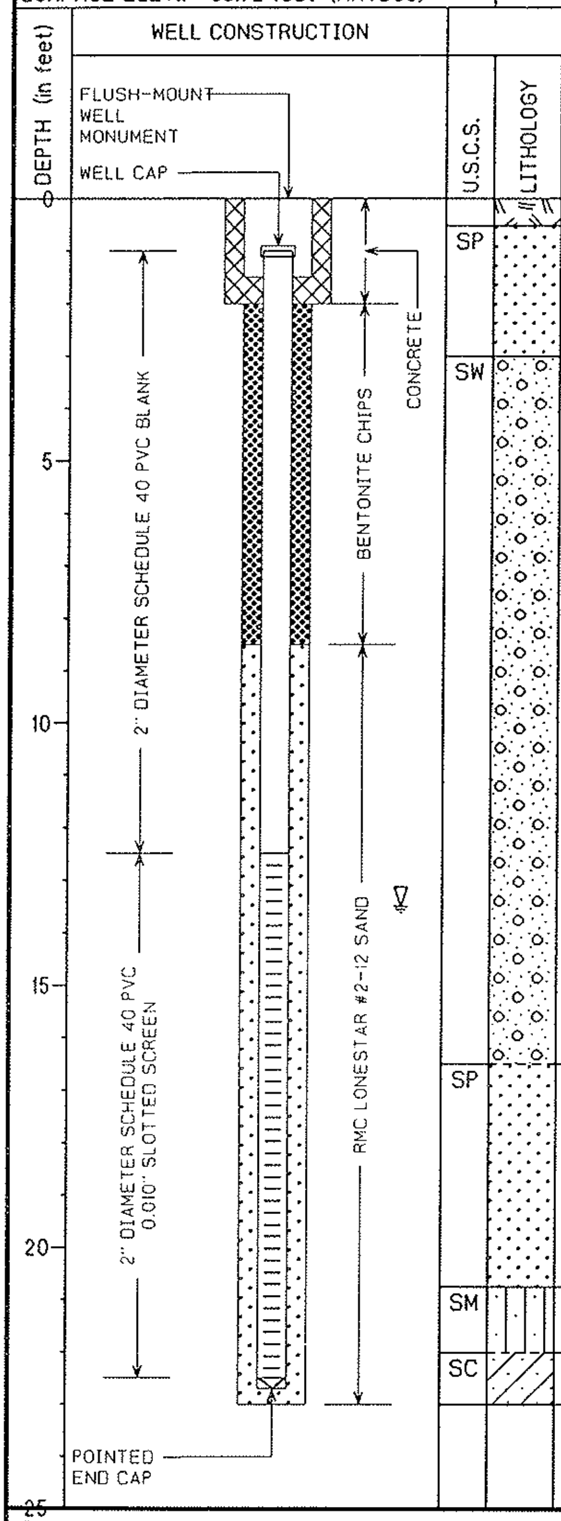
WELL INSTALLATION LOG
Piezometer PZ-10

PROJECT NO: *5-3434-210 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Gas Works Park Old Railroad Grade, ~60' West of MLS-1*		DRILLING CO.: *Cascade Drilling*
START DATE: *03/30/98* TIME: *09:10*	BORING ID: *8 inches*	DRILLER: *James Goble*
COMPLETION DATE: *03/30/98* TIME: *10:25*	TOTAL DEPTH: *23.0 feet bgs*	RIG TYPE: *CME-55*
WATER LEVEL DURING DRILLING: *13.5' bgs*	TOP OF 2" CASING: *32.83 feet (NAVD88)*	METHOD: *Hollow-stem Auger**
SURFACE ELEV.: *33.72 feet (NAVD88)*		LOGGED BY: *G. Sega*



SOIL DESCRIPTION

TOPSOIL

SAND WITH GRAVEL, ASH, AND CINDERS (GAS WORKS PARK UNIT); Black; medium- to coarse-grained; <10% fines; 20% gravel to 3 cm maximum diameter; abundant ash and cinders; dry.

SAND WITH GRAVEL; Brown; medium- to coarse-grained; 40% gravel to cobbles; dry.

13.5' – Becomes wet.

SAND; Gray to dark gray; medium- to coarse-grained; <10% fines; local gravel to 1 cm diameter; wet; strong sheen; strong odor.

20.0'-20.75' – Moderate staining; strong sheen; strong odor.

SILTY SAND; Gray to dark gray; fine- to medium-grained; 15% fines; wet; strong sheen; staining; strong odor.

CLAYEY SAND; Gray; fine-grained; 20% silty to clayey fines; hard; moist; no sheen; no staining; no odor.

Total depth = 23.0 feet bgs.

SAMPLE DATA

TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
SS		30 50	50	
SS		21 50	50	
SS		18 50	75	
SS		16 34 50/5"	80	
SS		65	30	

REMARKS: * Hand dug to 4.0 feet bgs; hollow-stem auger used to total depth.
⊠ – Sample Interval
SS – Split Spoon

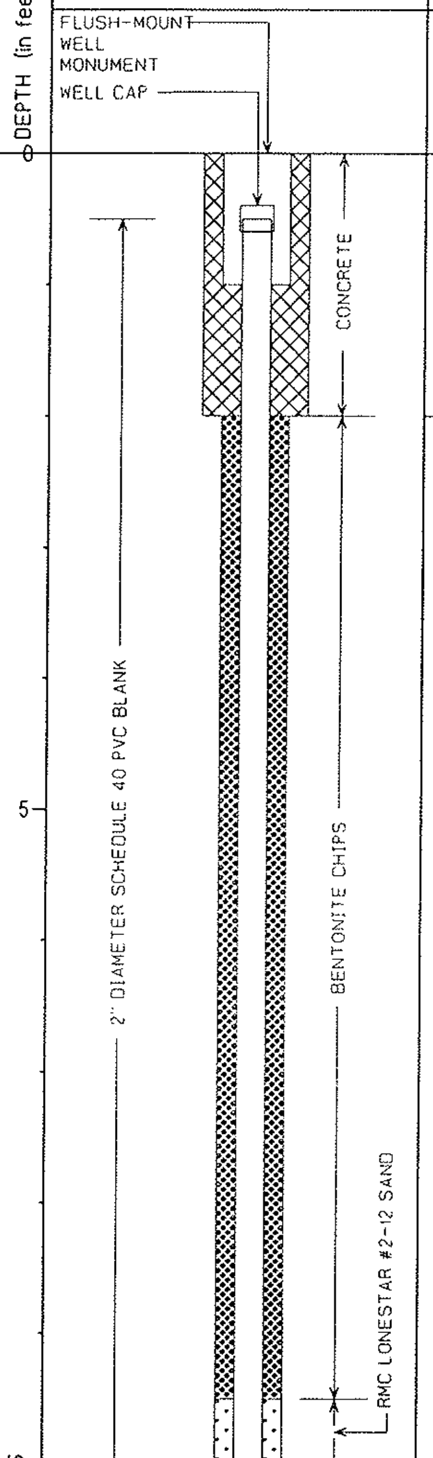
WELL INSTALLATION LOG
Recovery Well RW-1

RETEC

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: *5-3434-210 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Gas Works Park Old Railroad Grade, ~20' West of MLS-1*		DRILLING CO.: *Cascade Drilling*
START DATE: *03/30/98* TIME: *14:10*	BORING ID: *10 inches*	DRILLER: *James Goble*
COMPLETION DATE: *03/30/98* TIME: *16:30*	TOTAL DEPTH: *22.5 feet bgs*	RIG TYPE: *CME-55*
WATER LEVEL DURING DRILLING: *19.0' bgs*	TOP OF CASING: *33.31 feet (NAVD88)*	METHOD: *Hollow-stem Auger**
SURFACE ELEV.: *33.66 feet (NAVD88)*		LOGGED BY: *G. Sega*

DEPTH (in feet)	WELL CONSTRUCTION	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)



<u>SOIL</u>: Brown; sand with silt and gravel; abundant rootlets; dry to moist.

SP

<u>SAND WITH GRAVEL, ASH AND CINDERS (GAS WORKS PARK UNIT)</u>: Light brown to tan; medium- to coarse-grained; <10% fines; 20% gravel to 4 cm maximum diameter; abundant ash and cinders; few brick fragments; dry.

5.0' – No ash or cinders present; dry; slight odor; rock in tip of sampler.

7.0' – Dry; slight odor; rock in tip of sampler.

9.0' – Dry; slight odor.

9.8' – Orange staining to 10.0 feet bgs.

SP

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth. Lithology descriptions were taken from Monitoring Well Installation Log for PZ-9.

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WELL INSTALLATION LOG

Recovery Well RW-1

1011 S.W. Klickitat Way
Suite #207
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DEPTH (in feet)	WELL CONSTRUCTION	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
10	2" DIAMETER SCHEDULE 40 PVC BLANK	SP		SAND (STRATIFIED DRIFT UNIT); Light gray to brown; fine-grained; <10% fines; moist; no odor.					
		SP-SM		SAND WITH SILT; Light gray to brown; fine-grained; 10% to 15% fines; wet; no odor.					
		SP		SAND; Brown to gray; medium- to coarse-grained; <10% fines; wet.					
	2" DIAMETER SCHEDULE 40 PVC 0.010" SLOTTED SCREEN; RMC LONESTAR #2-12 SAND	SP		SAND; As at 10.0 feet bgs.					
		SP		SAND; Light brown; fine- to medium-grained; 10% fines; wet.					
		SM		SILTY SAND; Light gray to buff; fine-grained; 25% fines; wet.					
		SP		SAND WITH GRAVEL; Brown with gold (mica) flecks; medium- to coarse-grained; 20% gravel to 0.8 cm diameter; wet.					
15		SW-SM		SAND WITH SILT AND GRAVEL; Light brown; fine- to coarse-grained; 10% fines; 15% to 20% gravel to 4 cm diameter; wet. *15.0'* – Fines increasing to 20% at 16.0 feet bgs.					
		SM		SILTY SAND					
		SW-SM		SAND WITH SILT AND GRAVEL; Gray; fine- to coarse-grained; 10% fines; 20% gravel to 3 cm diameter; wet; slight odor.					
		SM		SILTY SAND WITH GRAVEL; Brown; fine- to medium-grained; 20% fines; 10% gravel to 2 cm maximum diameter; wet; slight sheen; slight odor.					
20									

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
Lithology descriptions were taken from Monitoring Well Installation Log for PZ-9.

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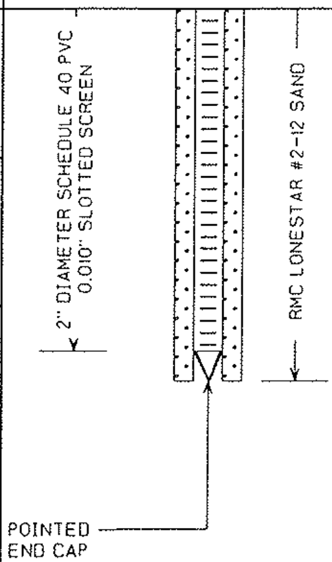
RETEC	WELL INSTALLATION LOG Recovery Well RW-1	1011 S.W. Klickitat Way Suite #207 Seattle, Washington 98134 (206) 624-9349

DEPTH (in feet)	WELL CONSTRUCTION	SOIL DESCRIPTION: U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	SAMPLE DATA: TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
20		SM							
		SC		CLAYEY SAND; Gray; fine-grained; 30% stiff fines; very hard; dry to moist; no sheen; no odor.					
				Total depth = 22.5 feet bgs.					
25									
30									

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth. Lithology descriptions were taken from Monitoring Well Installation Log for PZ-9.

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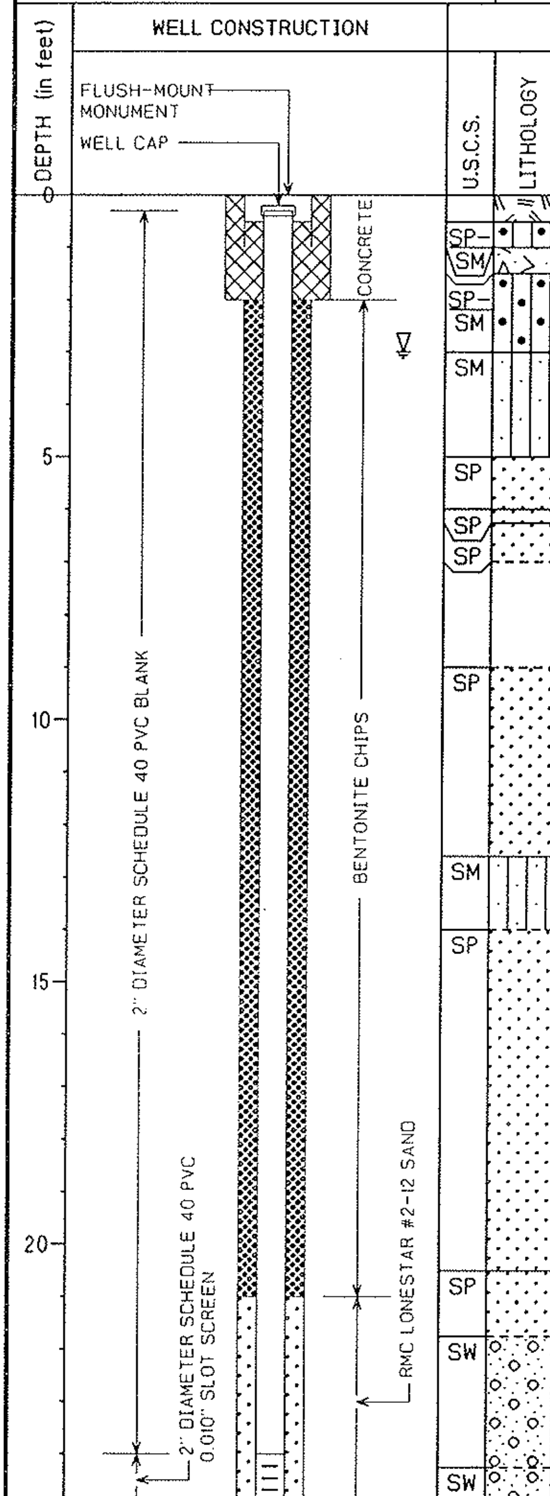
RETEC

WELL INSTALLATION LOG
Monitoring Well MW-22

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: 5-3434-210 Gas Works Park		CLIENT: EPRI
LOCATION: Seattle, Washington; Southwest End of Kite Valley, ~30' North of Lake		DRILLING CO.: Cascade Drilling
START DATE: 02/10/98 TIME: 12:00	BORING ID: 8 inches	DRILLER: S. Krueger
COMPLETION DATE: 02/10/98 TIME: 13:15	TOTAL DEPTH: 34.5 feet bgs	RIG TYPE: CME-75
WATER LEVEL DURING DRILLING: 3.0' bgs	TOP OF CASING: 20.40 feet (NAVD88)	METHOD: Hollow-stem Auger*
SURFACE ELEV.: 20.70 feet (NAVD88)		LOGGED BY: G. Sega



SOIL DESCRIPTION

U.S.C.S.	Description
	TOPSOIL; Sand, grass, roots; moist.
SP-SM	SAND WITH SILT AND GRAVEL (GAS WORKS PARK UNIT); Light brown; medium- to coarse-grained; 15% fines; 15% gravel to 3 cm maximum diameter; dry.
SP-SM	
SM	CINDERS; Black; dry; slight odor.
	SAND WITH SILT AND GRAVEL; As at 0.5 feet bgs; dry; no odor.
SP	SILTY SAND WITH GRAVEL; Black (staining?); medium- to coarse-grained; 20% soft, slightly clayey fines; 15% gravel to 3 cm diameter; abundant wood fragments; wet; slight odor. .
SP / SP	SAND WITH GRAVEL; Brown; medium- to coarse-grained; 25% gravel to 1 cm diameter; abundant brick fragments; wet; no odor.
SP	SAND; Dark gray to brown; fine- to medium-grained; <10% fines; abundant wood fragments; wet.
	SAND WITH GRAVEL (POSSIBLY STRATIFIED DRIFT UNIT); Gray; medium- to coarse-grained; <10% fines; 20% gravel to 2 cm diameter; wet.
	NO RECOVERY
SM	SAND WITH GRAVEL (STRATIFIED DRIFT UNIT); Greenish-gray; medium- to coarse-grained; 30% gravel to 2 cm diameter; wet.
SP	SILTY SAND WITH GRAVEL; Greenish-gray; medium- to coarse-grained; 20% fines; 30% gravel to 2 cm diameter; wet.
	SAND WITH GRAVEL; As at 9.0 feet bgs; wet.
SP	SAND; Greenish-gray; medium-grained; <10% fines; wet.
SW	SAND WITH GRAVEL; Greenish-gray; fine- to coarse-grained; <10% fines; 30% gravel to 5 cm diameter; wet.
SW	

SAMPLE DATA

TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
				0
SS		6 6 6 6	100	0
SS		3 3 4 13	0	NM
SS		17 18 20 23	100	0
SS		17 23 23 28	100	0
SS		17 25 32 35	100	0
SS		28 30 33 35	75	0
SS		22 25 27 28	50	0
SS		50 50/ 5"	75	0

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
■ - Analytical Sample
⊠ - Sample Interval
NM - Not Measured
SS - Split Spoon

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WELL INSTALLATION LOG

Monitoring Well MW-22

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

DEPTH (in feet)	WELL CONSTRUCTION	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
25	2" DIAMETER SCHEDULE 40 PVC 0.010" SLOT SCREEN; RMC LONESTAR #2-12 SAND	SW	SAND; Greenish-gray; fine- to coarse-grained; 5% to 10% fines; local gravel to 1 cm diameter; wet.	SS	42 50/ 4"	60	0
				SS	70	30	0
30		SM	SILTY SAND WITH GRAVEL; Gray; fine- to medium-grained; 20% fines; 15% gravel to 4 cm diameter; wet.	SS	80	30	0
		CL	SANDY CLAY WITH GRAVEL (VASHON TILL UNIT); Gray; 15% fine-grained sand; 15% gravel to 2 cm diameter; very hard; dry.	SS	35 50/ 5"	70	0
				SS	100	30	0
35	POINTED END CAP		Total depth = 34.5 feet bgs.				
40							
45							
50							

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
■ - Analytical Sample
⊠ - Sample Interval
NM - Not Measured
SS - Split Spoon

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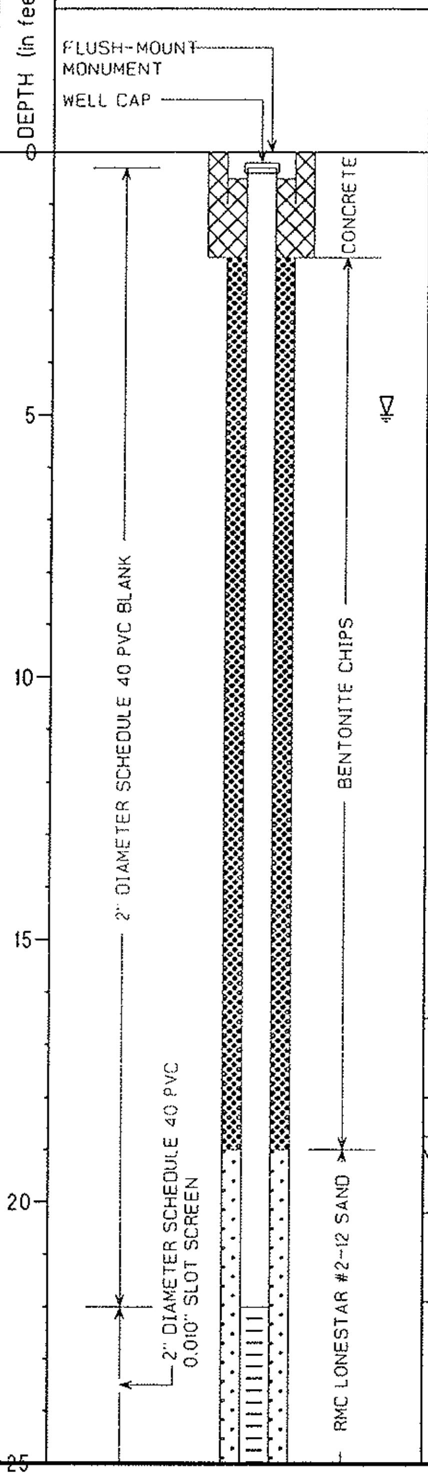
WELL INSTALLATION LOG
Monitoring Well MW-23

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: *5-3434-210 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Southwest Side of Kite Valley, ~30' North of Lake*		DRILLING CO.: *Cascade Drilling*
START DATE: *02/11/98* TIME: *08:05*	BORING ID: *8 inches*	DRILLER: *S. Krueger*
COMPLETION DATE: *02/11/98* TIME: *09:15*	TOTAL DEPTH: *33.0 feet bgs*	RIG TYPE: *CME-75*
WATER LEVEL DURING DRILLING: *5.0' bgs*	TOP OF CASING: *19.51 feet (NAVD88)*	METHOD: *Hollow-stem Auger**
SURFACE ELEV.: *19.96 feet (NAVD88)*		LOGGED BY: *G. Sega*

DEPTH (in feet) | **WELL CONSTRUCTION** | **SOIL DESCRIPTION** (U.S.C.S., LITHOLOGY) | **SAMPLE DATA**



U.S.C.S.	Soil Description
	TOPSOIL; Sand, grass, roots; moist.
SM	SILTY SAND WITH GRAVEL (GAS WORKS PARK UNIT); Black (staining?); medium- to coarse-grained; 30% soft, slightly clayey fines; 15% gravel to 4 cm diameter; moist; slight odor.
SM	SILTY SAND WITH GRAVEL; Black; fine- to coarse-grained; 20% gravel to 1.5 cm diameter; 15% fines; abundant brick and ash; wet; slight odor.
SP	SAND WITH GRAVEL (STRATIFIED DRIFT UNIT); Greenish-gray; medium- to coarse-grained; 50% gravel to 1.5 cm diameter; wet. *9.0'-9.5'* – Rock in tip of sampler. *12.5'-14.0'* – Percentage of gravel decreasing to 30%.
SP	SAND; Gray; medium-grained; <10% fines; wet.
SP	SAND WITH GRAVEL; Gray; medium- to coarse-grained; <10% fines; 15% gravel to 1 cm diameter; wet.
ML	SILT; Gray; soft to medium stiff; wet.
SM	SILTY SAND WITH GRAVEL; Greenish-gray; fine- to coarse-grained; 20% gravel to 2 cm diameter; 20% fines; wet.
SP	SAND; Gray; medium-grained: <10% fines; wet.
SM	SILTY SAND WITH GRAVEL; Gray; fine- to medium-grained; 20% fines; 15% gravel to 2 cm diameter; stiff; moist.

SAMPLE DATA

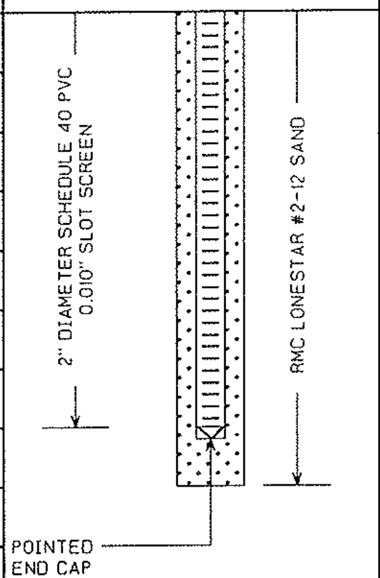
TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
			0
SS	5, 4, 2, 2	100	0
SS	9, 11, 16, 18	50	0
SS	22, 30, 33, 35	25	0
SS	14, 18, 50	75	0
SS	28, 44, 50/3"	30	0
SS	22, 28, 26, 30	75	0
SS	10, 18, 32, 35	60	2
SS	86	100	0

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
■ – Analytical Sample
☒ – Sample Interval
SS – Split Spoon

WELL INSTALLATION LOG
Monitoring Well MW-23

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL CONSTRUCTION



SOIL DESCRIPTION / SAMPLE DATA

DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION	TYPE	BLOWS/6"	% RECOVERY	PID (ppm)
25	SM	*25.0'-25.5'* – Wet.	SS	100	33	0
	CL	CLAY; Gray and white laminations (~2 mm thick); very hard; dry.	SS	80	50	0
	SM	SILTY SAND WITH GRAVEL; As at 22.5 feet bgs; stiff to hard; dry to moist.				
30	SM	SILTY SAND WITH GRAVEL; Gray; fine- to medium-grained; 10% to 15% fines; 15% gravel to 1 cm diameter; wet.	SS	65	33	0
	CL	CLAY WITH SAND (VASHON TILL UNIT); Gray; 20% fine-grained sand; very hard; dry.	SS	100	33	0
		Total depth = 33.0 feet bgs.				
35						
40						
45						
50						

REMARKS:
* Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth.
■ – Analytical Sample
⊠ – Sample Interval
SS – Split Spoon

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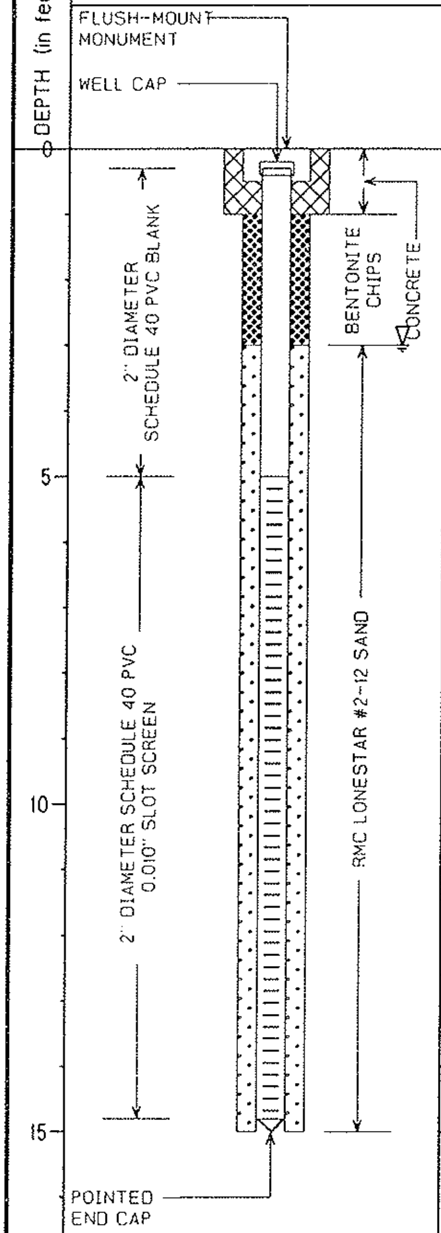
RETEC

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

WELL INSTALLATION LOG
Monitoring Well MW-24

PROJECT NO: *5-3434-210 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Southwest End of Kite Valley, ~30' North of Lake*		DRILLING CO.: *Cascade Drilling*
START DATE: *02/10/98* TIME: *14:30*	BORING ID: *8 inches*	DRILLER: *S. Krueger*
COMPLETION DATE: *02/10/98* TIME: *14:40*	TOTAL DEPTH: *15.0 feet bgs*	RIG TYPE: *CME-75*
WATER LEVEL DURING DRILLING: *3.0' bgs*	TOP OF CASING: *20.34 feet (NAVD88)*	METHOD: *Hollow-stem Auger**
SURFACE ELEV.: *20.67 feet (NAVD88)*		LOGGED BY: *G. Sega*

DEPTH (in feet) | WELL CONSTRUCTION



SOIL DESCRIPTION

U.S.C.S.	Description
	TOPSOIL; Sand, grass, roots; moist.
SP-SM	SAND WITH SILT AND GRAVEL (GAS WORKS PARK UNIT); Light brown; medium- to coarse-grained; 15% fines; 15% gravel to 3 cm maximum diameter; dry.
SM	CINDERS; Black; dry; slight odor.
SP-SM	SAND WITH SILT AND GRAVEL; As at 0.5 feet bgs; dry; no odor.
SM	SILTY SAND WITH GRAVEL; Black (staining?); medium- to coarse-grained; 20% soft, slightly clayey fines; 15% gravel to 3 cm diameter; abundant wood fragments; wet; slight odor.
SP	SAND WITH GRAVEL; Brown; medium- to coarse-grained; 25% gravel to 1 cm diameter; abundant brick fragments; wet; no odor.
SP	SAND; Dark gray to brown; fine- to medium-grained; <10% fines; abundant wood fragments; wet.
SP	SAND WITH GRAVEL (POSSIBLY STRATIFIED DRIFT UNIT); Gray; medium- to coarse-grained; <10% fines; 20% gravel to 2 cm diameter; wet.
	NO RECOVERY
SP	SAND WITH GRAVEL (STRATIFIED DRIFT UNIT); Greenish-gray; medium- to coarse-grained; 30% gravel to 2 cm diameter; wet.
SM	SILTY SAND WITH GRAVEL; Greenish-gray; medium- to coarse-grained; 20% fines; 30% gravel to 2 cm diameter; wet.
SP	SAND WITH GRAVEL; As at 9.0 feet bgs; wet.
	Total depth = 15.0 feet bgs.

SAMPLE DATA

TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth. No samples were collected. Lithologic descriptions are taken from well installation log for MW-22.

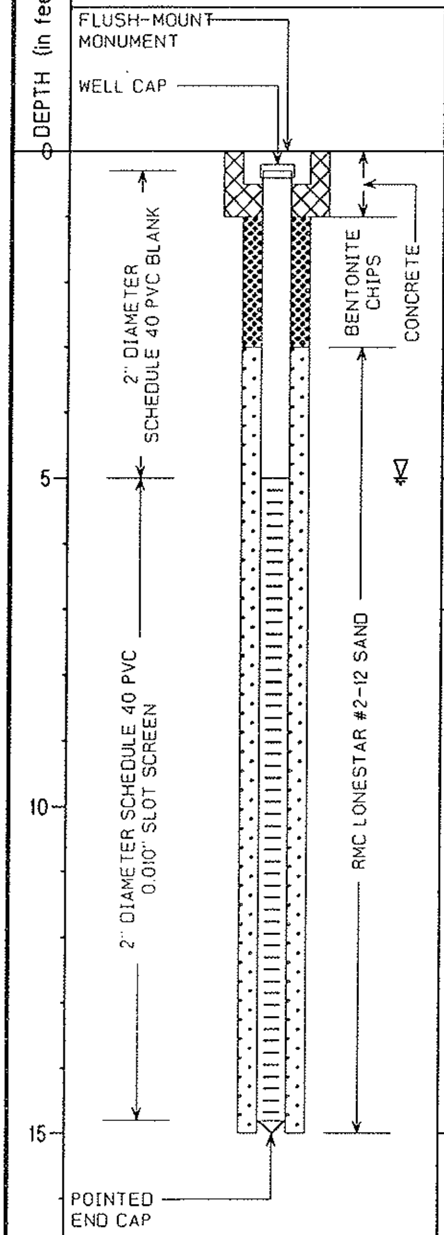
RETEC

WELL INSTALLATION LOG
Monitoring Well MW-25

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: *5-3434-210 Gas Works Park*		CLIENT: *EPRI*
LOCATION: *Seattle, Washington; Southeast End of Kite Valley, ~25' North of Water*		DRILLING CO.: *Cascade Drilling*
START DATE: *02/11/98* TIME: *10:20*	BORING ID: *8 inches*	DRILLER: *S. Krueger*
COMPLETION DATE: *02/11/98* TIME: *10:30*	TOTAL DEPTH: *15.0 feet bgs*	RIG TYPE: *CME-75*
WATER LEVEL DURING DRILLING: *5.0' bgs*	TOP OF CASING: *19.39 feet (NAVD88)*	METHOD: *Hollow-stem Auger**
SURFACE ELEV.: *19.72 feet (NAVD88)*		LOGGED BY: *G. Sega*

WELL CONSTRUCTION (DEPTH (in feet): 0–20)



SOIL DESCRIPTION / **SAMPLE DATA**

U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	TYPE	DEPTH	BLOWS/6"	% RECOVERY	PID (ppm)
		TOPSOIL; Sand, grass, roots; moist.					
SM		SILTY SAND WITH GRAVEL (GAS WORKS PARK UNIT); Black (staining?); medium- to coarse-grained; 30% soft, slightly clayey fines; 15% gravel to 4 cm diameter; moist; slight odor.					
SM		SILTY SAND WITH GRAVEL; Black; fine- to coarse-grained; 20% gravel to 1.5 cm diameter; 15% fines; abundant brick and ash; wet; slight odor.					
SP		SAND WITH GRAVEL (STRATIFIED DRIFT UNIT); Greenish-gray; medium- to coarse-grained; 50% gravel to 1.5 cm diameter; wet. *9.0'-9.5'* – Rock in tip of sampler. *12.5'-14.0'* – Percentage of gravel decreasing to 30%.					
		Total depth = 15.0 feet bgs.					

REMARKS: * Hand dug to 5.0 feet bgs; hollow-stem auger used to total depth. No samples were collected. Lithologic descriptions are taken from well installation log for MW-23.

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Appendix C

Groundwater Purge Data

Table C-1 Groundwater Sampling Purge Data

Well	Volume Purged (ml)	pH	Conductivity (μmhos/cm)	Temperature (°C)	Redox Potential (mV)	Dissolved Oxygen (mg/L)	Time	Flow Rate (L/min)	Turbidity (NTU)
December 29, 1997									
PZ-3	2,500	5.92	118	13.9	000	1.70	15:08	0.250	991
	3,250	5.90	117	14.0	000	1.70	15:11	0.250	915
	4,000	5.90	119	14.0	000	1.70	15:14	0.250	902
PZ-4	2,250	5.99	073	13.9	-001	1.65	14:32	0.250	OR
	3,000	5.92	065	13.8	000	1.65	14:35	0.250	OR
	3,750	5.90	067	13.8	000	1.65	14:38	0.250	OR
PZ-7	2,250	6.22	109	15.2	000	1.95	14:01	0.250	217
	3,250	6.22	107	15.2	000	1.90	14:04	0.250	175
	4,000	6.22	105	15.1	-001	1.85	14:07	0.250	122
	4,750	6.22	104	15.1	-001	1.85	14:10	0.250	128
February 17–18, 1998									
DW-7	3,000	6.69	351	14.0	003	1.15	10:49	0.30	3.01
	3,900	6.70	595	14.0	-033	1.00	10:52	0.30	2.14
	4,800	6.70	590	14.0	-039	0.95	10:55	0.30	2.25
MW-14	3,000	6.47	525	11.0	-065	1.10	16:10	0.30	48.2
	3,900	6.40	523	11.0	-066	0.65	16:13	0.250	45.8
	4,800	6.37	523	11.0	-066	0.60	16:16	0.250	44.1
MW-22	3,000	6.51	452	13.3	-042	0.65	15:09	0.30	7.98
	3,900	6.50	541	13.3	-042	0.45	15:12	0.30	8.26
	4,800	6.50	568	13.3	-041	0.45	15:15	0.30	7.72
MW-23	3,000	7.03	760	13.6	-037	0.80	13:41	0.30	5.62
	3,900	7.02	1,063	13.6	-041	0.75	13:44	0.30	5.58
	4,800	7.02	1,064	13.6	-042	0.75	13:47	0.30	5.82
MW-24	3,000	6.48	650	12.5	-056	0.40	15:38	0.30	34.5
	3,900	6.47	645	12.4	-057	0.45	15:41	0.30	18.6
	4,800	6.40	671	12.4	-058	0.40	15:44	0.30	16.9
MW-25	3,000	6.48	136	11.5	-025	0.45	14:14	0.30	2.08
	3,900	6.44	624	11.5	-052	0.40	14:17	0.30	2.20
	4,800	6.43	621	11.4	-052	0.40	14:20	0.30	1.99
MLS-1									
Port 1	500	7.12	1,103	10.6	-118	1.80	9:30		NM
	1,000	6.74	914	11.1	-108	2.10			NM
Port 2	500	7.09	802	10.7	-117	2.70	9:35		NM
	1,000	6.85	707	11.2	-129	1.80			NM
Port 3	500	7.40	216	10.1	008	4.70	9:40		NM
	1,000	7.25	205	10.6	-004	4.50			NM

Table C-1 Groundwater Sampling Purge Data

Well	Volume Purged (ml)	pH	Conductivity (µmhos/cm)	Temperature (°C)	Redox Potential (mV)	Dissolved Oxygen (mg/L)	Time	Flow Rate (L/min)	Turbidity (NTU)
February 17–18, 1998 (Continued)									
MLS-2									
Port 1	500	6.88	1,103	10.6	-118	1.80	10:35		NM
	1,000	6.93	914	11.1	-108	2.10			NM
Port 2	500	Product present – No readings taken							
	1,000								
Port 3	500	Product present – No readings taken							
	1,000								
MLS-3									
Port 1	500	7.05	430	11.3	-089	2.30	11:30		NM
	1,000	6.78	706	12.7	-089	2.35			NM
Port 2	500	7.02	668	12.3	-082	1.90	11:35		NM
	1,000	6.67	455	12.9	-096	2.10			NM
Port 3	500	6.62	738	11.8	-102	2.70	11:40		NM
	1,000	6.49	502	12.5	-102	2.60			NM
Port 4	150 (dry)								
Port 5	(dry)								
MLS-4									
Port 1	250 (dry)								
Port 2	500	6.85	759	12.7	-066	1.90	12:30		NM
	1,000	6.42	778	13.1	-078	1.70			NM
Port 3	500	6.77	736	12.6	-060	1.95	12:35		NM
	1,000	6.54	731	13.2	-064	1.60			NM
Port 4	500	6.75	446	12.2	-072	2.05	12:40		NM
	1,000	6.64	413	12.7	-066	1.80			NM
Port 5	500	6.54	617	11.6	-091	1.80	12:45		NM
	1,000	6.40	318	12.3	-098	1.60			NM
MLS-5									
Port 1	500	6.70	635	13.5	-063	1.30	14:15		NM
	1,000	6.49	684	13.9	-076	1.20			NM
Port 2	500	6.54	648	13.6	-054	1.10	14:20		NM
	1,000	6.46	647	14.1	-061	1.20			NM
Port 3	500	6.45	683	13.6	-061	1.05	14:25		NM
	1,000	6.41	674	14.0	-065	1.20			NM
Port 4	500	6.53	579	13.2	-070	1.25	14:30		NM
	1,000	6.49	577	13.7	-069	1.10			NM
Port 5	500	6.26	550	12.5	-071	1.30	14:35		NM
	1,000	6.27	543	12.6	-067	1.25			NM

Table C-1 Groundwater Sampling Purge Data

Well	Volume Purged (ml)	pH	Conductivity (μmhos/cm)	Temperature (°C)	Redox Potential (mV)	Dissolved Oxygen (mg/L)	Time	Flow Rate (L/min)	Turbidity (NTU)
February 17–18, 1998 (Continued)									
MLS-6									
Port 1	500	6.55	680	12.9	-055	1.25	15:20		NM
	1,000	6.30	661	13.9	-062	1.10			NM
Port 2	500	6.29	674	13.2	-052	1.35	15:00		NM
	1,000	6.12	635	13.6	-041	1.50			NM
Port 3	250 (dry)								
Port 4	500	6.69	273	12.0	-058	1.10	15:10		NM
	1,000	6.55	288	12.2	-056	1.30			NM
Port 5	500	7.13	082	11.1	-008	1.30	15:15		NM
	1,000	7.02	085	11.1	-017	1.50			NM
MLS-7									
Port 1	500	6.80	611	13.8	-042	1.80	15:35		NM
	1,000	6.63	424	14.1	-057	1.75			NM
Port 2	500	6.69	590	14.0	-040	1.20	15:40		NM
	1,000	6.56	597	14.3	-048	1.05			NM
Port 3	500	6.59	604	14.1	-046	1.25	15:45		NM
	1,000	6.46	611	14.4	-059	1.20			NM
Port 4	500	6.52	663	14.2	-087	1.10	15:50		NM
	1,000	6.46	659	14.5	-078	1.35			NM
Port 5	500	6.46	901	13.7	-089	1.50	15:55		NM
	1,000	6.31	855	14.0	-095	1.10			NM
April 15–16, 1998									
DW-6	750	6.00	0.178	14.0	-067	2.5	18:39	95	6.48
	1,500	6.00	0.136	13.9	-075	2.5	18:48	120	4.13
	2,700	5.95	0.123	13.8	-076	2.0	18:58	120	2.53
	3,900	5.92	0.115	13.8	-077	1.3	19:09	120	2.42
	5,100	5.94	0.113	13.7	-076	2.0	19:18	120	1.65
DW-7	500	6.55	0.089	19.3	-054	5.4	16:40	80	3.77
	» 1,500	6.00	0.076	17.4	-038	1.5	17:07	80	4.41
	» 6,000	6.05	0.077	17.0	-041	1.2	17:27	80	4.08
	» 7,250	5.96	0.073	16.4	-036	1.2	17:39	80	4.01
MW-13	» 1,500	5.69	0.086	12.9	001	2.7	8:50	109	29.9
	» 3,000	5.98	0.074	13.0	-007	2.9	9:04	109	56.2
	» 4,500	5.55	0.078	13.1	-026	2.7	9:16	109	44.0
	» 5,500	5.58	0.098	13.3	-019	2.3	9:34	109	—
MW-22	» 1,200	5.46	0.085	13.2	-024	2.8	10:05	109	6.15
	» 2,500	5.73	0.077	13.4	-024	3.8	10:18	109	3.73
	4,000	5.68	0.082	13.4	-010	2.7	10:30	109	3.02

Table C-1 Groundwater Sampling Purge Data

Well	Volume Purged (ml)	pH	Conductivity (µmhos/cm)	Temperature (°C)	Redox Potential (mV)	Dissolved Oxygen (mg/L)	Time	Flow Rate (L/min)	Turbidity (NTU)
April 15–16, 1998 (Continued)									
MW-23	» 1,400	5.50	0.170	14.1	-081	1.2	12:38	120	7.37
	» 3,000	5.47	0.190	14.2	-077	0.6	12:50	120	7.70
	4,300	5.45	0.169	14.3	-068	0.4	13:02	120	6.23
MW-24	» 1,200	5.41	0.078	13.6	-046	1.9	11:24	109	4.10
	» 2,500	5.39	0.086	13.4	-055	1.0	11:36	109	2.97
	» 4,000	5.40	0.094	13.3	-060	0.6	11:47	109	2.67
MW-25	» 1,000	5.43	0.023	14.0	-037	0.8	13:37	120	2.81
	» 2,500	5.51	0.111	13.1	-033	0.04	13:47	120	1.40
	3,500	5.56	0.121	12.9	-036	0.03	13:57	120	1.28
MLS-6									
Port 1	550	6.05	1.041	16.4	-074	5.0	12:22	80	1.91
	1,100	6.63	0.803	16.0	-063	3.3		80	2.64
Port 2	550	6.35	0.668	16.0	-068	4.1	12:28	80	3.31
	1,100	6.26	0.654	16.2	-058	3.7		80	3.83
Port 3	» 150 (dry)								
Port 4	550	6.29	0.387	15.7	-053	3.8	12:43	80	1.86
	1,100	6.63	0.346	15.4	-070	4.3		80	1.95
Port 5	550	6.07	0.381	15.2	-039	4.2	12:59	80	1.93
	1,100	6.17	0.373	15.3	-033	4.0		80	1.87
MLS-7									
Port 1	500	6.32	0.666	19.2	-039	5.5	14:50	92	4.17
	3,000	6.67	0.732	18.4	-074	2.5		92	4.00
Port 2	1,000	6.38	0.629	18.2	-040	5.6	15:00	92	4.15
Port 3	1,500	6.32	0.691	17.9	-060	4.0	15:13	92	2.00
Port 4	2,000	6.45	0.727	18.1	-097	4.4	15:24	92	1.98
Port 5	2,500	6.57	0.855	18.0	-093	3.5	15:33	92	2.07

NOTE:

NM - Not measured.

OR - Out of instrument range.

Appendix D

Leachability Testing Methods and Results

Estimating Release of PAHs from Gasworks Park Site Soils

September 2, 1998 *Revision*

Prepared by: Linda S. Lee and Connie Biegel
Purdue University; West Lafayette, IN

BACKGROUND

Six Gasworks Park site soil samples were received from RETEC on February 19, 1998. Upon receipt, samples were given Purdue identification numbers and visual observations recorded (See Table 1). All samples were very wet; however, most of the free water had leaked into the plastic bag surrounding the jars. A decantable water phase still remained in GW2 and GW4 for analysis. Prior to soil characterization, large rocks and pieces of wood were removed by hand, but samples were not sieved. In subsampling for individual experiments gravel and wood pieces greater than 3 mm were avoided.

Table 1. Sample labeling and selected observations.

Purdue ID	RETEC Label ID	Selected Observations
GW1	MW-23-3	Jet black; soil sticks to rocks
GW2	MW-22-3	Jet black; leaves black film on glassware
GW3	B-2-16.5	Strong odor noted; leaves gummy yellow-brown film on everything
GW4	DW-5-27.5	Glistening gray-brown sample
GW5	DW-5-7	Sample mostly wood; very little soil
GW6	DW-7-15	Sample mostly rocks; very little soil

OBJECTIVES

The primary objective of this study was to estimate aqueous-phase release concentrations for selected PAHs using laboratory methods. Additional studies were conducted to make a limited assessment of the role of kinetics in impacting release concentrations at the site.

MATERIAL & METHODS

Soils were assayed for selected PAHs and moisture content. Extraction of soils for selected PAHs was done by pre-mixing soils with anhydrous Na_2SO4 to remove residual water followed by sequential batch extraction with a 1:1 methanol:methylene chloride solutions. Samples were centrifuged and extracts filtered through a 0.2 μm silver filter prior to GC/FID analysis. Sequential extractions were performed until PAH concentrations were below limits of detection and all analyses were performed in duplicate.

Analytical Methods

All solutions were analyzed for selected PAHs using a gas chromatograph (GC) with a flame ionization detector (FID). A J&W DB 5.625 fused-silica capillary column (0.25 mm bore, length 30 m) was used. The flow rate of the helium carrier gas was set at 35 cm/s and the temperature program was set as follows: 60°C for 1 min., ramp at 20 °C/min. to 140°C, hold for 3 min., ramp at 5 °C/min. to 190°C, ramp at 10 °C/min. to 300°C, and hold for 9 min.

Aqueous-phase Batch Equilibration Studies

Approximately 10 grams of soil were weighed into 250 mL Teflon-lined sample jars followed by addition of 250 mL of 0.01 N $CaCl_2$ solution containing 50 mg/L mercuric chloride to minimize biological degradation. In all samples, small oil droplets were observed rising to the surface upon addition of the aqueous electrolyte solution. Samples were equilibrated for approximately nine days on a shaker plate with vigorous agitation to enhance approach to equilibrium. Two solution aliquots of approximately 100 mL each were removed and filtered using a stainless steel filter chamber. Filtered aqueous samples were extracted with hexane, concentrated, and analyzed using GC/FID as described above.

Cosolvent Batch-Rate Methodology

A cosolvent batch-rate technique as described in Lee et al. (1998) was employed to assess the potential for particle-scale mass-transfer constraints at the Gasworks Park site. Of the 4 Gasworks Park samples that contained sufficient soils for additional studies, GW1 and GW3 were selected. Total PAH concentration was the highest on GW1 with almost all individual PAH concentraitons also being the highest compared to hte other samples. GW1 had the highest concentrations of the larger multi-ringed PAHs but relatively low concentrations of the 2-ring PAHs suggesting that it was more weathered in comparison to the other samples from the site. Soils were equilibrated with methanol/water solutions of 0.3, 0.4, and 0.5 volume fraction methanol (f_c). Measurements in these solutions were then extrapolated to aqueous-phase systems (f_c=0) using a log-linear cosolvency model (Rao et al., 1991). Moist soil of approximately 5 g was weighed into 40 mL glass centrifuge tubes and 35 mL of the appropriate cosolvent (0.01 N $CaCl_2$ matrix) was added. The tubes were sealed with phenolic caps lined with Teflon and placed on a rotator with gentle end-over-end rotation. Soils were initially equilibrated for 64.4 hours, centrifuged at 300 RCF for 15 minutes, and all solution above the soil was replaced with the appropriate clean cosolvent- water solution and placed back on the rotator. This was considered time zero for the rate studies. At each sampling time, tubes were centrifuged at 300 RCF for 15 minutes and a 5 mL aliquot was taken for analysis. Once an aliquot was taken, the tubes were capped, shaken, and placed back on the rotator. The 5 mL aliquot taken at each time step was transferred to a small glass centrifuge tube for temporary storage until further handling. Each aliquot was filtered through 0.2 μm silver filter in a stainless steel holder into a preweighed tube containing 2 mL of hexane. The samples were sealed with Teflon lined caps, rotated overnight, and then allowed to stand for phase-separation. The hexane layer was then transferred to a 3 mL conical vial using a disposable pipette, concentrated under dry nitrogen to an approximate volume of 0.15 mL (final volume was measured carefully using a 0.5 mL gas-tight syringe), and placed in a vials for GC/FID analysis.

RESULTS AND DISCUSSION

Soil Characterization

Soil contamination levels of selected PAHs for all six Gasworks Park site soil samples are shown in Table 2. The total PAHs were highest for GW3 and GW4, but GW1 contained the highest level of greater than 3-ring PAHs. High concentrations of the larger multi-ringed PAHs relative to the more soluble 2-ring PAHs may suggest that soil in the area of the site where GW1 and GW2 was collected may be more weathered.

Table 2. Individual concentrations of selected PAHs (M_i, mg/kg), the total sum of selected PAHs (Total PAHs), and % moisture content (bottom row) for Gasworks Park site soil samples.

	M_i (mg/kg)					
PAH	GW1	GW2	GW3	GW4	GW5	GW6
Naphthalene	57	164	6695	1306	968	316
2-methylnaphthalene	13	9	2896	567	314	160
1-methylnaphthalene	7	5	1722	327	220	103
Acenaphthylene	28	21	436	105	58	11
Acenaphthlene	5	1	447	76	115	71
Fluorene	13	9	570	122	148	31
Phenanthrene	183	197	1550	331	506	90
Anthracene	52	30	409	87	152	23
Fluoranthene	577	353	516	112	200	33
Pyrene	773	477	612	133	234	40
Benz(a)anthracene	236	105	194	43	74	13
Chrysene	211	119	175	37	68	10
Benzo(a)pyrene	289	191	146	34	65	8
Total PAHs	**2445**	**1681**	**16369**	**3281**	**3121**	**908**
% moisture	17	21	11	10	19	15

Aqueous-phase Batch Equilibration Studies

Results from the 9-day aqueous-batch equilibration using vigorous shaking conditions to speed equilibration are shown in Table 3.

Table 3. Aqueous-phase PAH concentrations (C_w, µg/L) measured in the aqueous batch study with the Gasworks Park site soil samples (soil mass to electrolyte solution ratio was 10/250).

	C_w, µg/L (ppb)					
PAH	GW1	GW2	GW3	GW4	GW5	GW6
Naphthalene	6	1000	19809	13853	6515	110
2-methylnaphthalene	0.26	10	2229	1629	761	55
1-methylnaphthalene	7	10	1442	1159	560	156
Acenaphthylene	14	15	256	270	81	20
Acenaphthene	7	3	151	155	170	246
Fluorene	8	5	108	118	109	76
Phenanthrene	33	65	102	119	122	120
Anthracene	6	5	24	3	11	21
Fluoranthene	21	12	5	7	7	12
Pyrene	23	18	0.3	0.05	7	11
Benz(a)anthracene	0.6	0.6	0.1	0.3	0.02	0.4
Chrysene	0.2	0.4	0.03	0.2	0.05	0.1
Benzo(a)pyrene	0.1	0.04	0.01	0.1	0.03	0.04

Using M_i and C_w presented in Tables 2 and 3, respectively, soil-water distribution coefficients (K_d, L/kg) were estimated for each PAH-soil combination and are shown in Table 4. Also shown in Table 4 are regression results that will be discussed later. Using the K_d values calculated from the aqueous-phase batch equilibration study, the following equation can be used to estimate expected release concentration of each PAH in the field:

$$C_w\left(\mu g/L\right)=\left(\frac{M_i}{K_d+\theta_v/\rho}\right)*1000 \qquad (1)$$

where M_i is the soil concentration (mg/kg) of a given PAH, and θ_V and ρ are the volumetric water content (cm^3/cm^3) and soil bulk density (g/cm^3), respectively. Field aqueous-phase concentrations in the saturated zone calculated assuming a θ_V = 0.35 and ρ = 1.5 are shown in Table 5. Differences in mass to volumes ratios between the laboratory experiment and field conditions only impacted C_w values for soils that had high concentration of the more soluble PAHs (i.e., the naphthalenes) and for PAH-soil combinations that had log K_d values ≤ 2.

Table 4. Soil-water distribution coefficients (K_d, L/kg) estimated for each PAH-soil combination using the soil characterization data and the results from the 9 day aqueous-batch equilibration.

	log [K_d, L/kg]					
PAH	GW1	GW2	GW3	GW4	GW5	GW6
Naphthalene	3.98	2.14	2.50	1.84	2.09	3.46
2-methylnaphthalene	4.72	2.92	3.11	2.51	2.59	3.46
1-methylnaphthalene	2.98	2.64	3.07	2.41	2.57	2.80
Acenaphthylene	3.31	3.15	3.22	2.56	2.84	2.71
Acenaphthene	2.82	2.62	3.47	2.67	2.81	2.42
Fluorene	3.18	3.26	3.72	3.00	3.12	2.58
Phenanthrene	3.74	3.48	4.18	3.44	3.62	2.86
Anthracene	3.92	3.79	4.24	4.50	4.15	3.03
Fluoranthene	4.45	4.48	5.02	4.18	4.44	3.45
Pyrene	4.53	4.43	6.31	6.43	4.53	3.58
Benz(a)anthracene	5.62	5.21	6.44	5.15	6.51	4.48
Chrysene	6.03	5.44	6.76	5.18	6.17	4.84
Benzo(a)pyrene	6.42	6.72	7.00	5.45	6.33	5.32

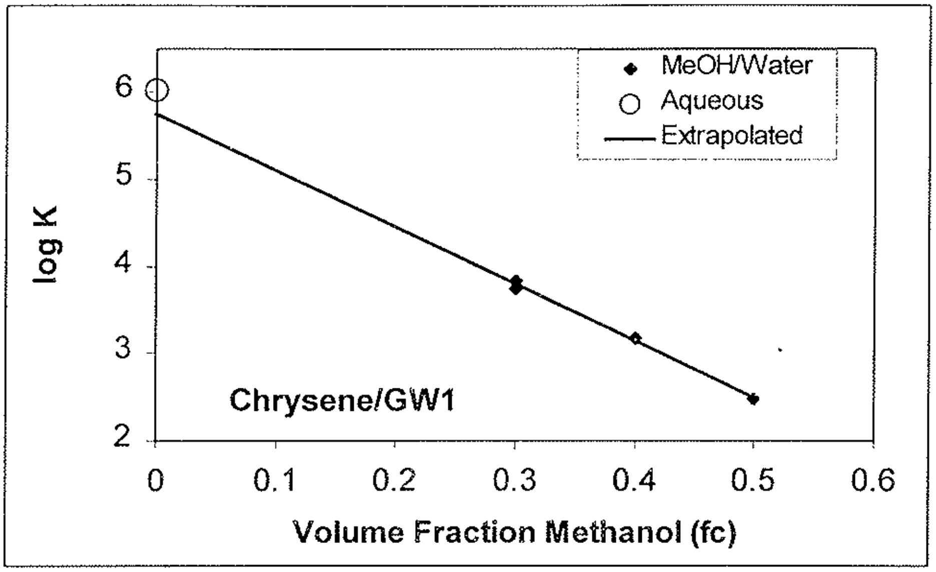
Table 5. Estimated field aqueous-phase PAH concentrations (C_w, μg/L) assuming $\theta_V = 0.35$ and $\rho = 1.5$ for the Gasworks Park site.

	Cw, ug/L (ppb)					
PAH	GW1	GW2	GW3	GW4	GW5	GW6
Naphthalene	6	1178	21375	18786	7817	111
2-naphthalene	0.3	10	2273	1754	810	55
1-naphthalene	7	11	1473	1271	598	162
Acenaphthylene	14	15	260	288	84	21
Acenaphthene	7	3	152	163	177	269
Fluorene	8	5	108	121	111	80
Phenanthrene	33	65	102	121	122	124
Anthracene	6	5	24	3	11	22
Fluoranthene	21	12	5	7	7	12
Pyrene	23	18	0.3	0.05	7	11
Benz(a)anthracene	0.6	0.6	0.1	0.3	0.02	0.4
Chrysene	0.2	0.4	0.03	0.2	0.05	0.1
Benzo(a)pyrene	0.1	0.04	0.01	0.1	0.03	0.04

Cosolvent Batch-Rate Methodology

GW1 and GW3 were selected for assessing if mass-transfer constraints may significantly reduce release concentrations under site conditions. Adding water-miscible organic cosolvents to an aqueous-phase reduces K_d thus increasing the driving force of a contaminant from the soil to the solution phase, which facilitates the measurement of concentration changes over time with more accuracy and precision. GW1 and GW2 were equilibrated with methanol/water solutions of 0.3, 0.4, and 0.5 volume fraction organic cosolvent (f_c) for times ranging from approximately 3 to 50 days. Measurements in these solutions for each time were then extrapolated to aqueous-phase systems (f_c=0) using a log-linear cosolvency model (Rao et al., 1991) to estimate a time-dependent soil-water distribution coefficients (K). An example of the application of log-linear extrapolation to f_c=0 is shown in Figure 1 for chrysene from GW1 after a 20.6 day equilibration. Also shown for comparison is the K_d measured in an aqueous system where samples were vigorously shaken for 9 days.

Figure 1. Log K versus volume fraction methanol (f_c) for chrysene on GW1 after 20.6 days.



In a desorption mode, solution concentrations will increase or apparent (*) soil-water distribution coefficients ($^*K_{d,t}$) will decrease over time (t). It was very evident over the time course of the batch-rate study that GW3 had little to no mass-transfer constraints whereas GW1 exemplified considerable nonequilibrium. Methanol/water data at each time was extrapolated to apparent aqueous $^*K_{d,t}$ values (as exemplified in Figure 1) and plotted as a function of time in Figure 2A and 2B for acenaphthylene, phenanthrene, and chrysene from GW1. Changes in $^*K_d$ with time are evident. Decreases in $^*K_{d,t}$ values with time will result in increases in C_w with increasing residence time (Figure 3) until sufficient contact time has elapsed to obtain equilibrium.

For GW3, no measurable differences in $^*K_{d,t}$ values were observed at the times selected in the study. As an example, a comparison of K_d values measured at 64 h and after 1000 h is shown for PAHs from GW3 in Figure 4 along with the 1:1 correlation line. All values fall on or near the 1:1 line indicating that GW3 was near equilibrium with water after 3 days unlike the changes observed with time for GW1. GW1 the more weathered tar appears to behaving more like a soil matrix where nonequilibrium is expected (Karickhoff, 1980) whereas the GW3 sample with relatively high concentrations of the 2-ring compounds appears to be behave more like a free tar phase. Mass-transfer constraints in liquid-liquid partitioning such as tar-water are minimal compared to what is typically observed with diffusion in and out of organic domains incorporated in soil particles (Lee et al., 1992; 1998).

Figure 2. Log$^*K_{d,t}$ versus time for (A) acenaphthylene and phenanthrene; and (B) chrysene with GW1.

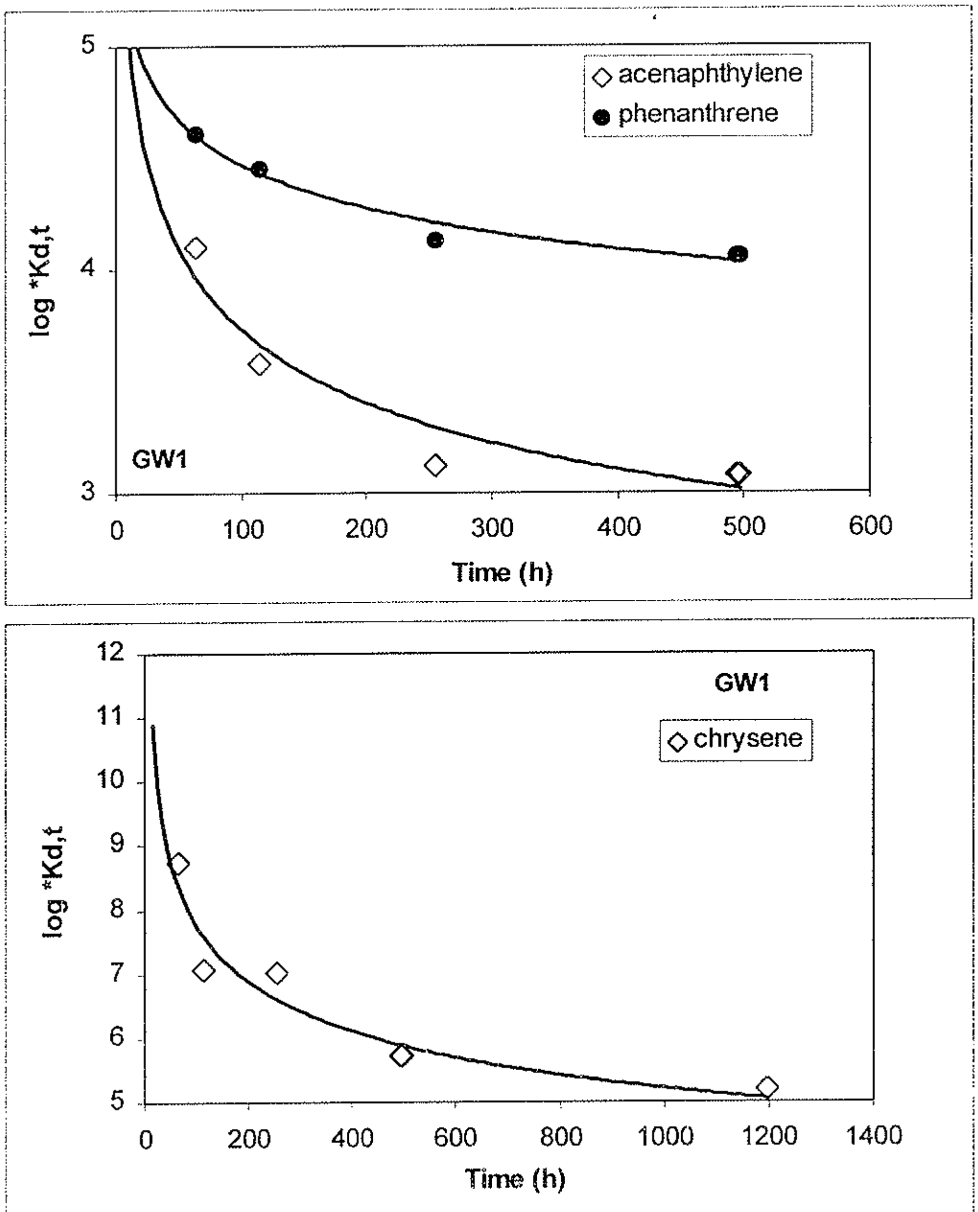


Figure 3. Aqueous release concentrations from GW1 for acenaphthylene, phenanthrene, and chrysene.

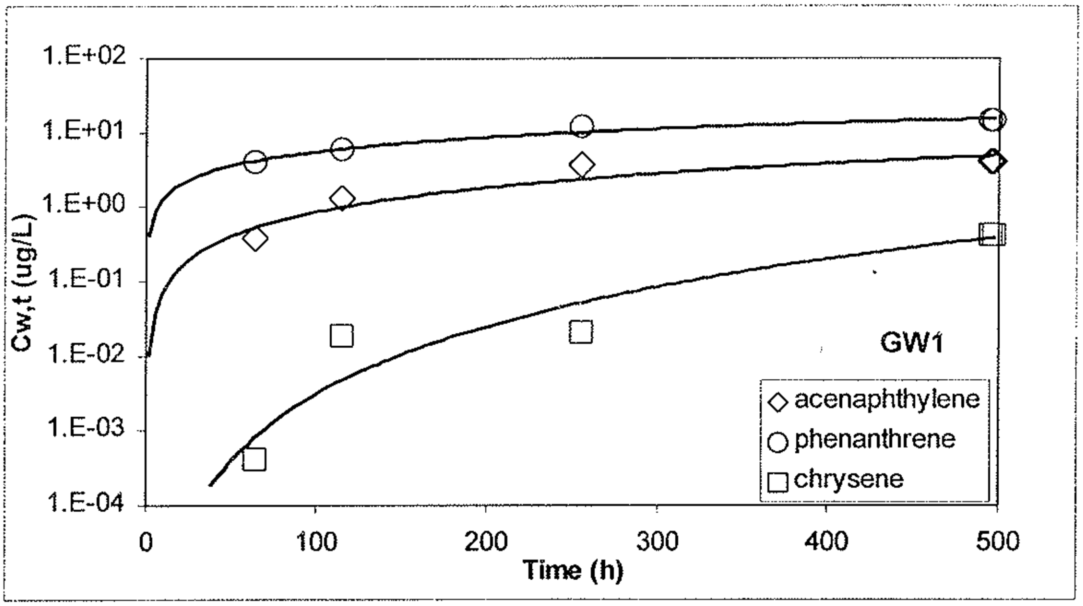
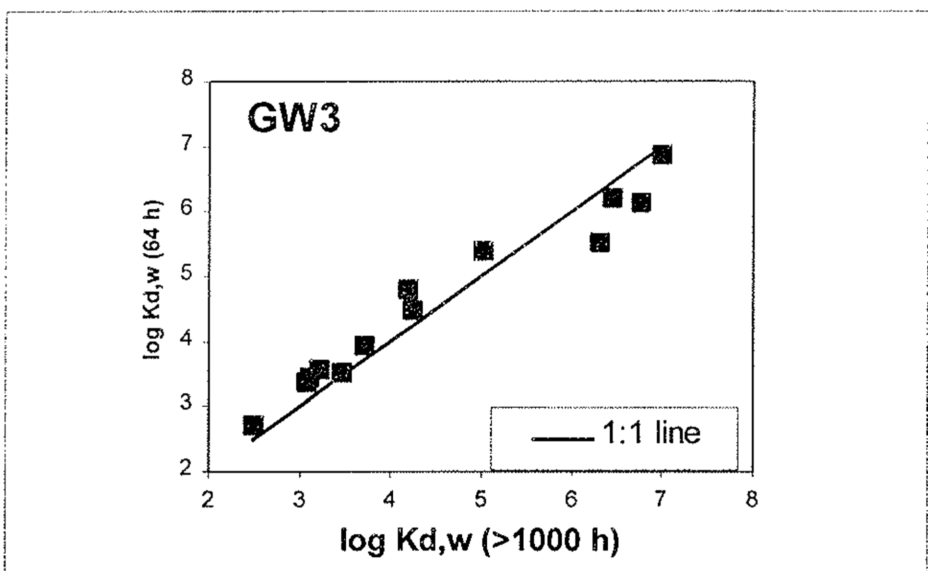


Figure 4. A comparison of log K_d values measured at 64 h and after 1000 h for each PAH from GW3. Also shown is a 1:1 line which would result if no changes occurred with time.



REFERENCES

Lee, L.S., P.S.C. Rao, and I. Okuda (1992) Equilibrium partitioning of polynuclear aromatic hydrocarbons from coal tar into water. *Environ. Sci. Technol.* 26:2110-2115.

Lee, L.S., N.D. Priddy, and D.C.M. Augustijn. 1998. Estimating mass-transfer of polyaromatic hydrocarbons from coal-tar contaminated soil. **IN:** *Soil and Aquifer Pollution: Non-Aqueous Phase Liquids - Contamination and Reclamation*, H. Rubin and J. Carberry (eds.) Springer-Verlaag, Berlin, Germany, Chapter 6, p. 91-108

Means, J.C., Wood, S.G., Hassett, J.J., and W.L. Banwart. 1980. Sorption of polynuclear aromatic hydrocarbons by sediments and soils ments. *Environ. Sci. Technol.* 14:1524.

Karickhoff, S.W., P.S. Brown, and T.A. Scott. 1979. Sorption of hydrophobic pollutants on natural sediments. *Water Res.* 13:241-248.

Karickhoff, S.W. 1980. Sorption kinetics of hydrophobic pollutants in natural sediments. In: R.A. Baker (Ed.) Contaminants and Sediments, Vol. 2. Analysis, Chemistry, Biology. Ann Arbor Science Publishers, Inc. (Ann Arbor, MI) pp. 193-205.

Rao, P.S.C., L.S. Lee, and A.L. Wood. 1991. Solubility, sorption and transport of hydrophobic organic chemicals in complex mixtures. EPA/600/M-91/009 Robert S. Kerr Environ. Res. Lab., Ada, OK 74820. March 1991.

Appendix E

Pump Test Data

Table E-1 Pumping and Recovery Test Measurement Frequencies

Well	Step Test: Data-Collection Interval	Pump Test: Well-Gauging Interval	Recovery Test: Data-Collection Interval
Transducer Wells			
RW-1		(RW-1 and PZ-9 only)	
	0-2 min.: 10 seconds (12x)	0-15 min.: 5 minutes	0–5.5 min.: 0.5 seconds (361x)
PZ-9	2-5 min.: 30 seconds (6x)	15-60 min.: 15 minutes	5.5–234.5 min.: 30 seconds (458x)
PZ-10	5-15 min.: 1 minute (10x)	1-2 hours: 30 minutes	234.5–410 min.: 1 minute (122x)
PZ-2	15-50 min.: 5 minutes (7x)	2-12 hours: 1 hour	
First-Tier Wells			
MW-18		0-2 hours: 15 minutes	
		2-5 hours: 30 minutes	
PZ-3		5-12 hours: 1 hour	
		12+ hours: 4 hours	
Second-Tier Wells			
MW-19		0-6 hours: 1 hour	
PZ-4		6-12 hours: 2 hours	
MW-17		12+ hours: 4 hours	
Background Well			
MW-8		8 hours	

Figure E-1 MW-8 (Background Well) Groundwater Elevations

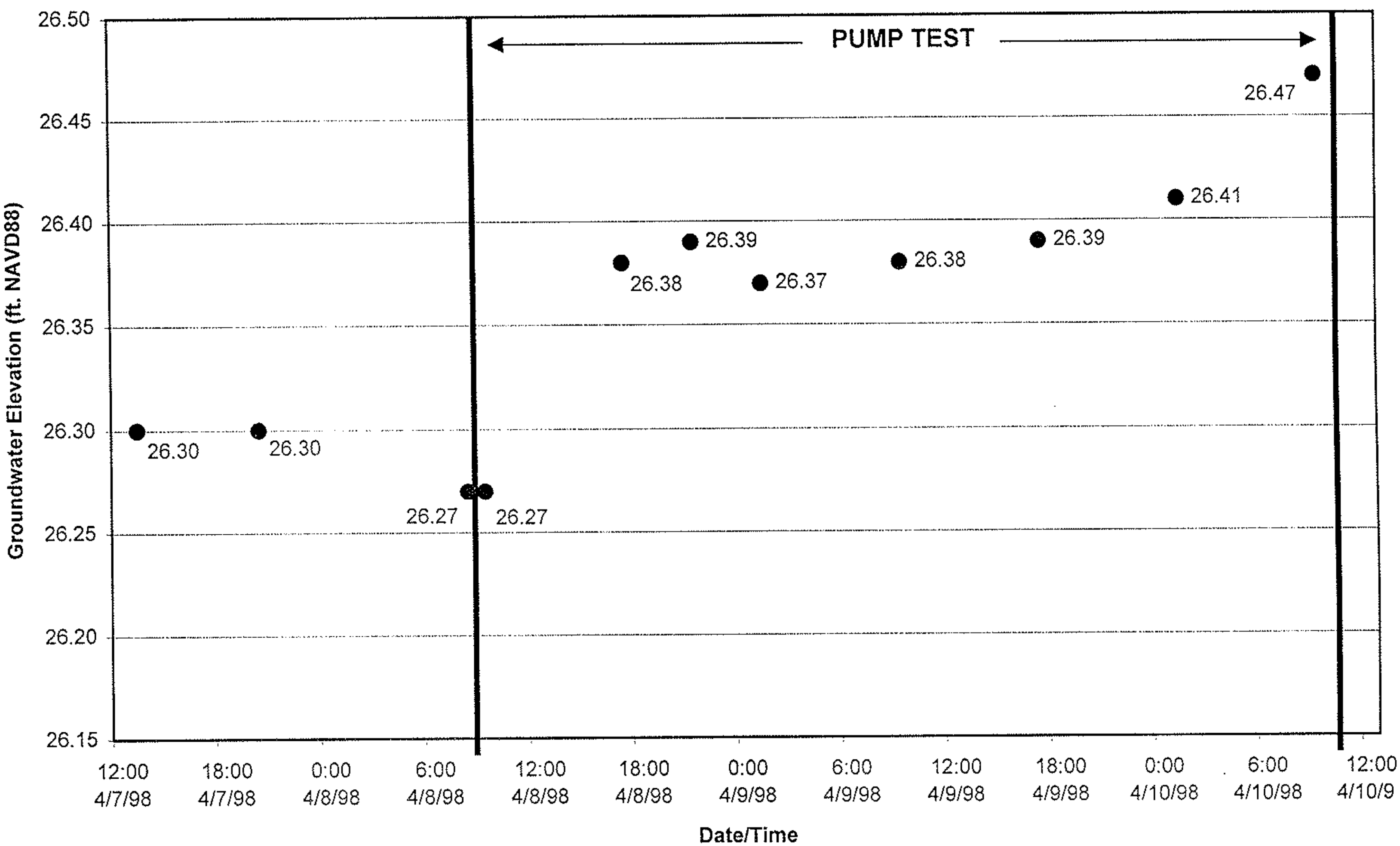
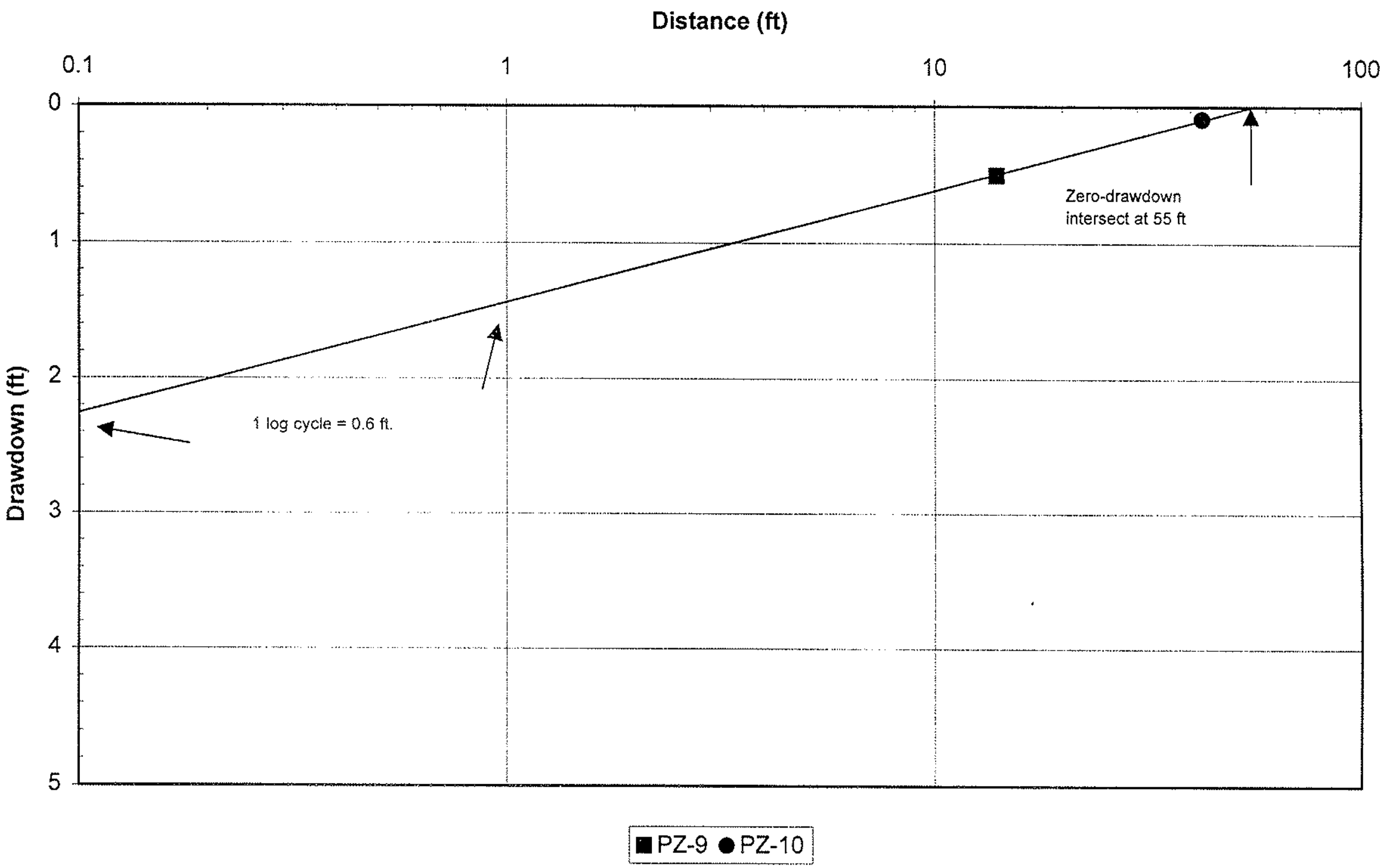


Figure E-2 Distance-Drawdown Graph



Jacob Distance-Drawdown Calculations

Transmissivity Calculations

$$T = \frac{70Q}{\Delta s}$$

where,

- T = transmissivity (square feet per day)
- Q = pumping rate (gpm)
- Δs = drawdown across 1 log cycle (feet)

Given:

Q = 0.25 gpm and Δs = 0.6 feet,
T = 29 ft^2/day

Storativity Calculation

$$S = \frac{T_t}{640 r_o^2}$$

where,

- S = storativity
- T = transmissivity (square feet per day)
- t = time (from pump on) when drawdowns measured (minutes)
- r_o = distance (feet) from pumping well to where straight line intersects zero drawdown line

Given:

T = 29 ft^2/day; t = 2,965 minutes; and r_o = 55 feet,
S = 0.045

Figure E-3 RW-1 Drawdown

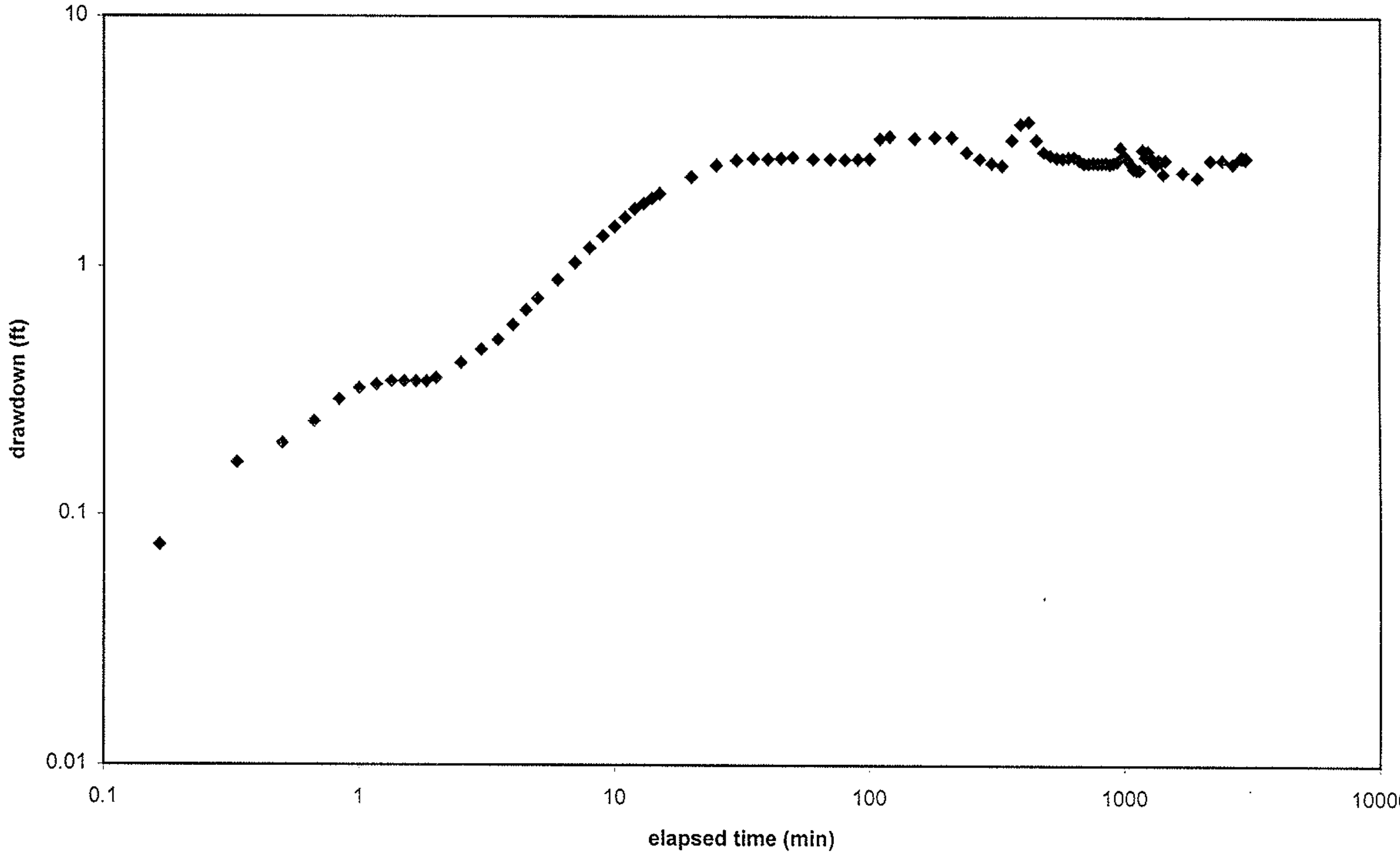


Figure E-4 RW-1 Recovery

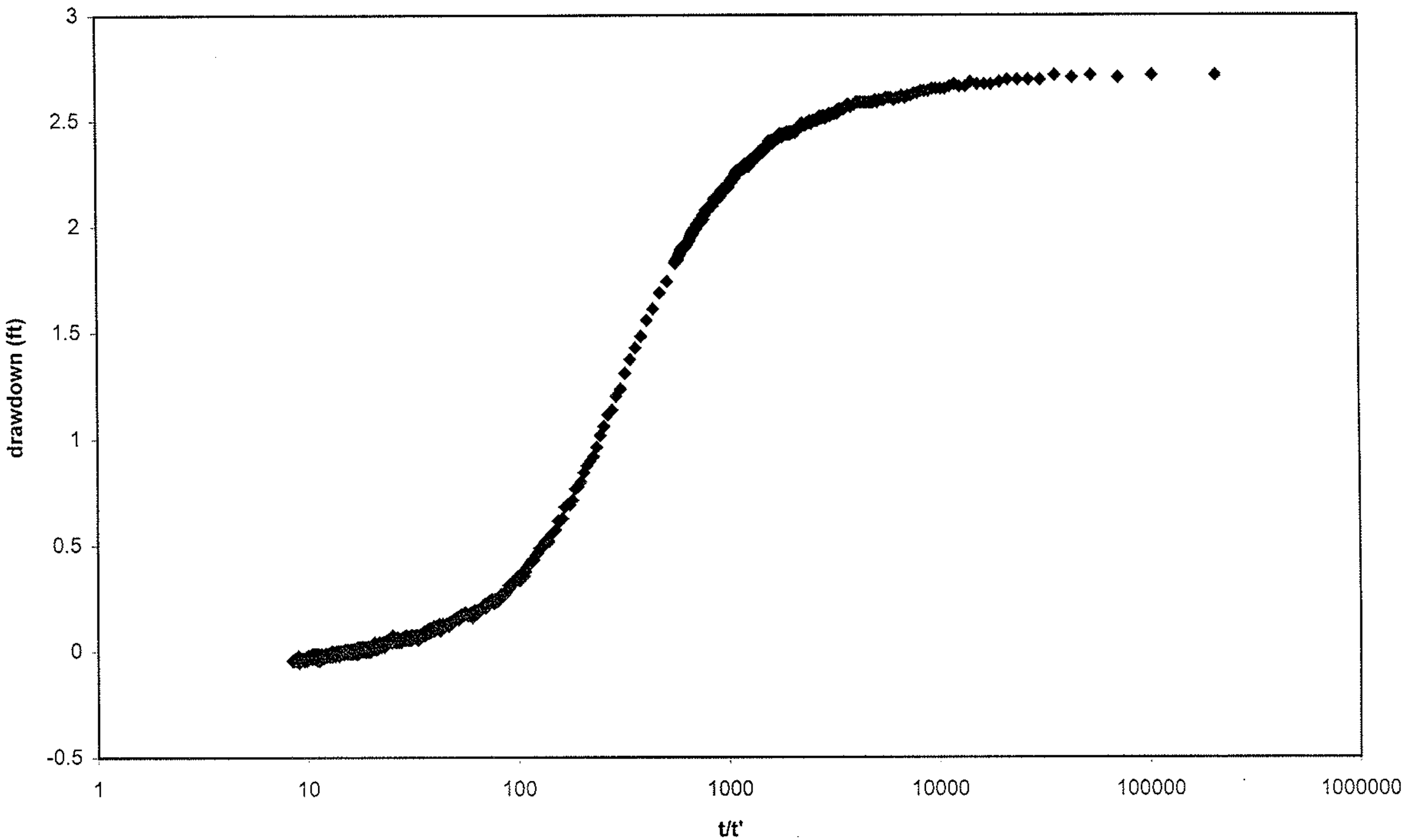


Figure E-5 PZ-9 Drawdown

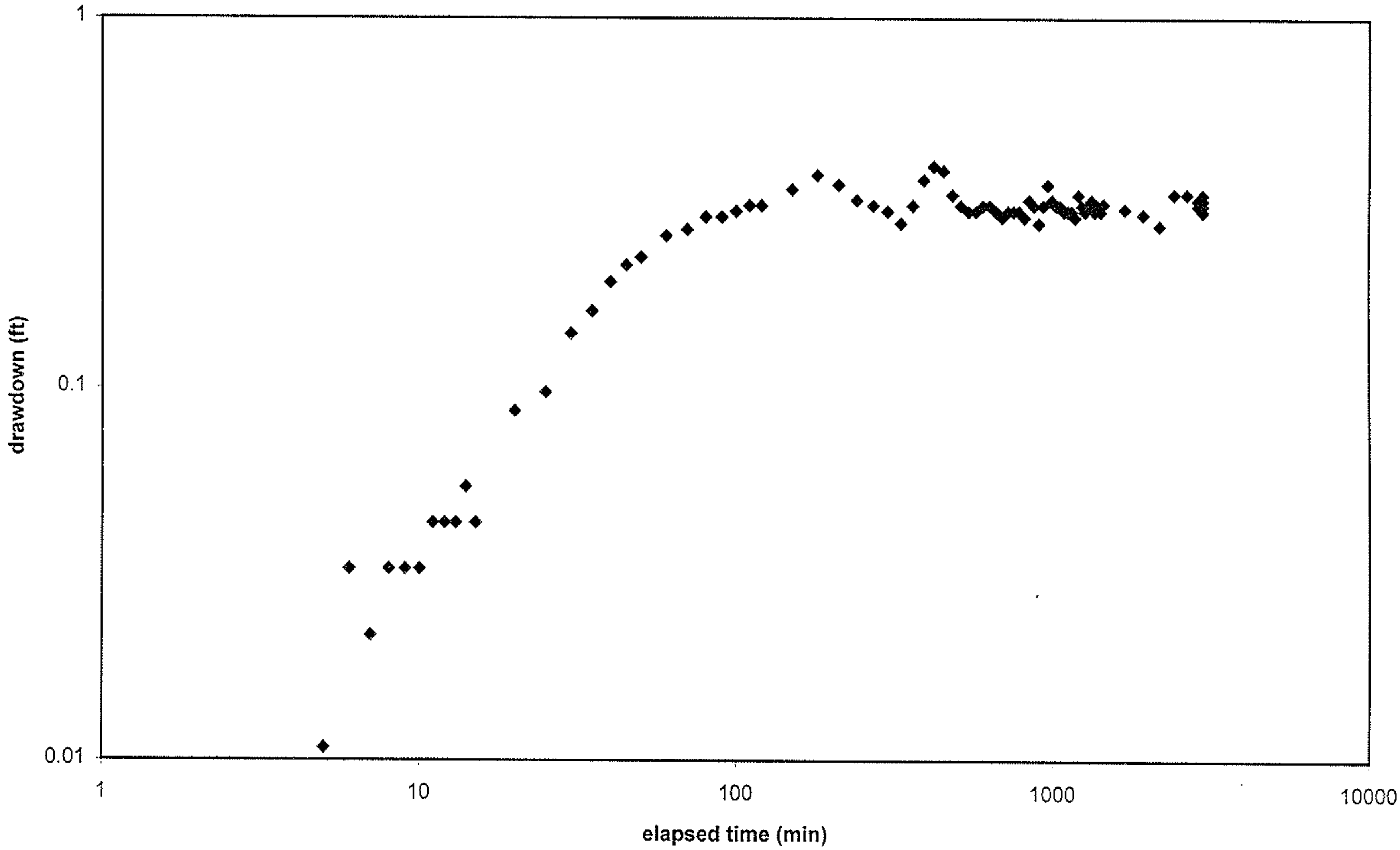


Figure E-6 PZ-9 Recovery

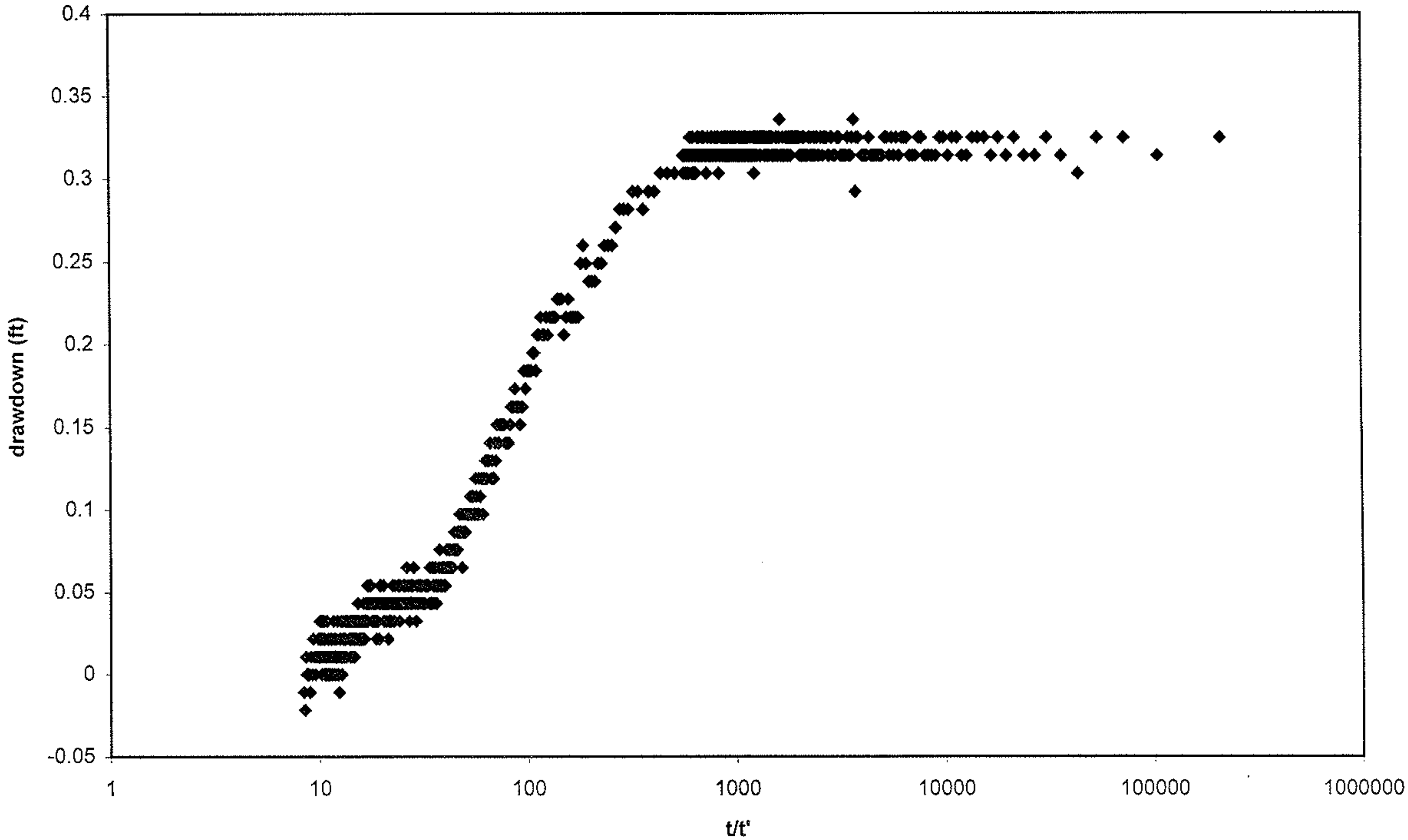


Figure E-7 PZ-10 Drawdown

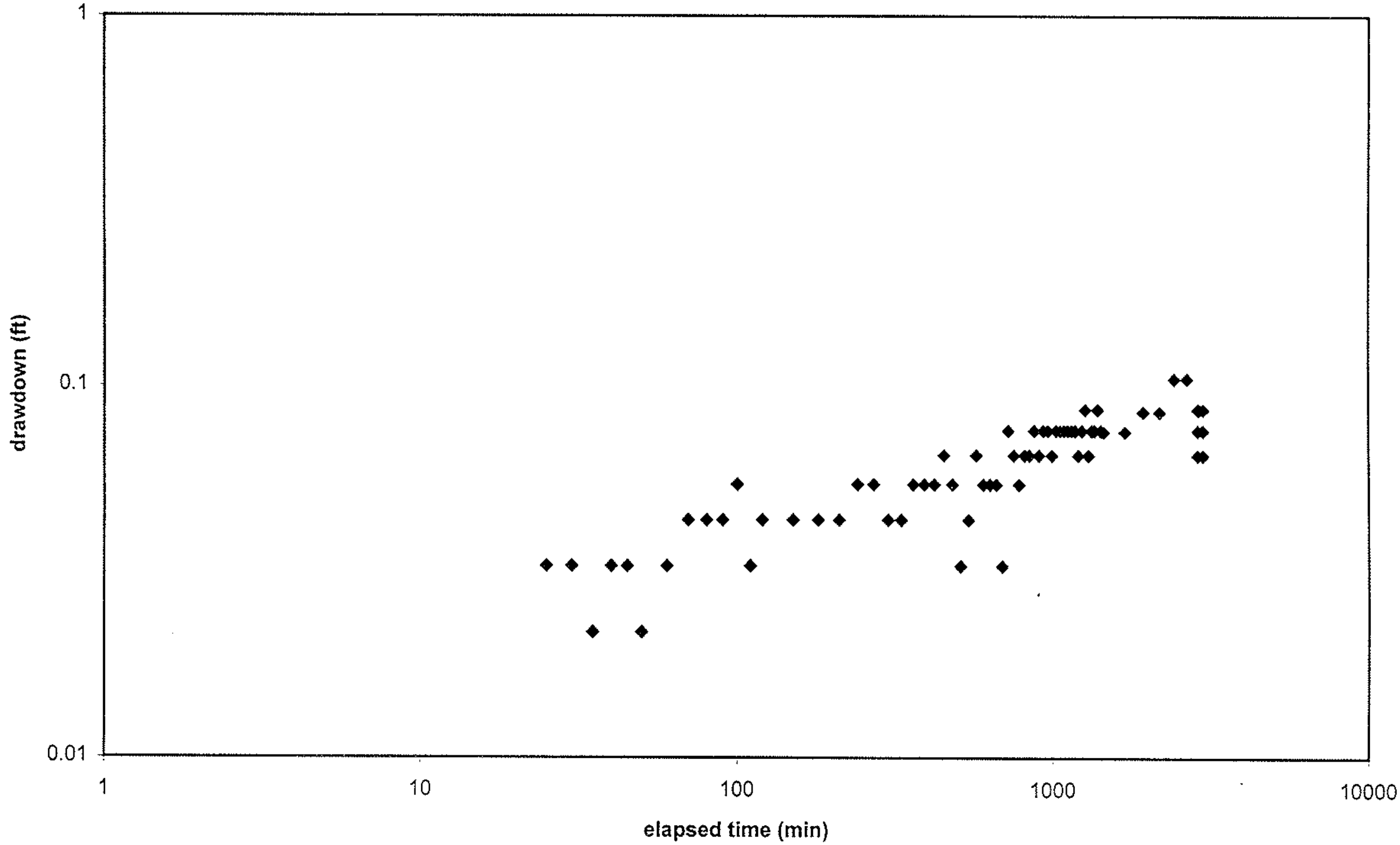


Figure E-8 PZ-10 Recovery

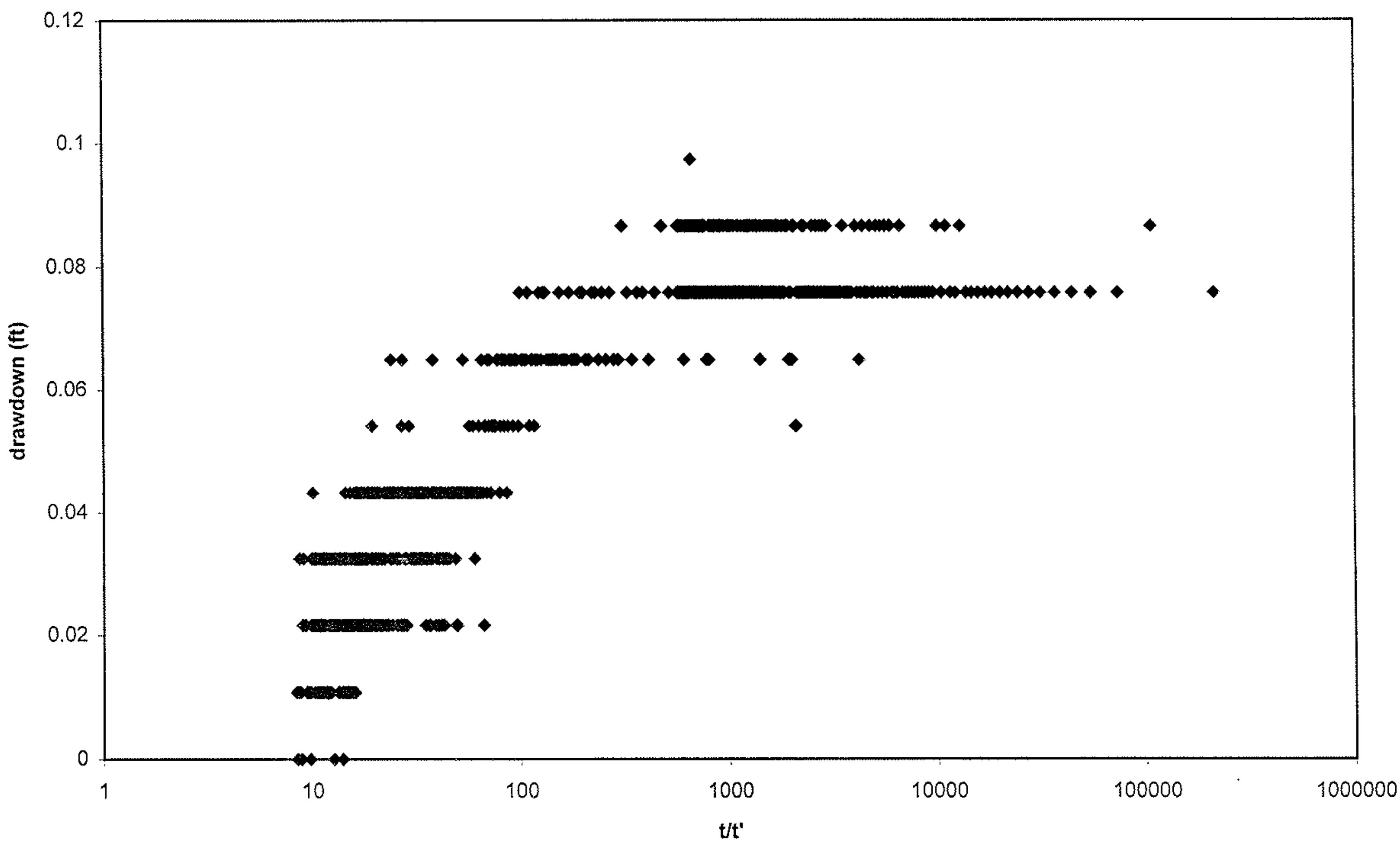


Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
PUMP TEST											
4/8/84 9:00:00	0	NA	5.988	0	6.8975	0	6.4752	0	2.7395	0	0
4/8/84 9:00:10	0.1656	NA	5.9122	0.0758	6.8975	0	6.4969	-0.0217	2.7503	-0.0108	0.000381944
4/8/84 9:00:20	0.33264	NA	5.8255	0.1625	6.9083	-0.0108	6.486	-0.0108	2.7612	-0.0217	0.000763889
4/8/84 9:00:30	0.49968	NA	5.793	0.195	6.8975	0	6.4752	0	2.7287	0.0108	0.001145833
4/8/84 9:00:40	0.66672	NA	5.7497	0.2383	6.8975	0	6.4969	-0.0217	2.7503	-0.0108	0.001527778
4/8/84 9:00:50	0.83232	NA	5.6956	0.2924	6.93	-0.0325	6.4752	0	2.7395	0	0.001909722
4/8/84 9:01:00	0.99936	NA	5.6631	0.3249	6.9083	-0.0108	6.4752	0	2.7612	-0.0217	0.002291667
4/8/84 9:01:10	1.1664	NA	5.6523	0.3357	6.8975	0	6.4752	0	2.7395	0	0.002673611
4/8/84 9:01:20	1.33344	NA	5.6415	0.3465	6.9083	-0.0108	6.4969	-0.0217	2.7503	-0.0108	0.003055556
4/8/84 9:01:30	1.49904	NA	5.6415	0.3465	6.9083	-0.0108	6.4752	0	2.7395	0	0.0034375
4/8/84 9:01:40	1.66608	NA	5.6415	0.3465	6.8975	0	6.4752	0	2.7612	-0.0217	0.003819444
4/8/84 9:01:50	1.83312	NA	5.6415	0.3465	6.9083	-0.0108	6.4969	-0.0217	2.7395	0	0.004201389
4/8/84 9:02:01	2.0016	NA	5.6306	0.3574	6.8975	0	6.486	-0.0108	2.7179	0.0216	0.004583333
4/8/84 9:02:30	2.49984	NA	5.5765	0.4115	6.9083	-0.0108	6.4752	0	2.7395	0	0.004965278
4/8/84 9:03:00	2.99952	NA	5.5223	0.4657	6.8975	0	6.4752	0	2.7503	-0.0108	0.005347222
4/8/84 9:03:30	3.4992	NA	5.479	0.509	6.8975	0	6.486	-0.0108	2.7503	-0.0108	0.005729167
4/8/84 9:04:00	3.99888	NA	5.4032	0.5848	6.9083	-0.0108	6.486	-0.0108	2.7503	-0.0108	0.006111111
4/8/84 9:04:30	4.5	NA	5.3166	0.6714	6.9192	-0.0217	6.4969	-0.0217	2.7395	0	0.006493056
4/8/84 9:05:00	5.00112	NA	5.2408	0.7472	6.8867	0.0108	6.4969	-0.0217	2.7503	-0.0108	0.006875
4/8/84 9:06:00	5.99904	NA	5.1	0.888	6.865	0.0325	6.4969	-0.0217	2.7395	0	0.007256944
4/8/84 9:07:00	6.99984	NA	4.9485	1.0395	6.8759	0.0216	6.4644	0.0108	2.7503	-0.0108	0.007638889
4/8/84 9:08:00	7.9992	NA	4.7969	1.1911	6.865	0.0325	6.4644	0.0108	2.7179	0.0216	0.008020833
4/8/84 9:09:00	9	NA	4.6561	1.3319	6.865	0.0325	6.4752	0	2.7503	-0.0108	0.008402778
4/8/84 9:10:00	9.99936	NA	4.537	1.451	6.865	0.0325	6.4752	0	2.7395	0	0.008784722
4/8/84 9:11:00	11.0002	NA	4.407	1.581	6.8542	0.0433	6.4752	0	2.7395	0	0.009166667
4/8/84 9:12:00	11.9995	NA	4.2771	1.7109	6.8542	0.0433	6.486	-0.0108	2.7287	0.0108	0.009548611
4/8/84 9:13:00	12.9989	NA	4.1905	1.7975	6.8542	0.0433	6.4644	0.0108	2.7179	0.0216	0.009930556
4/8/84 9:14:00	13.9997	NA	4.1039	1.8841	6.8434	0.0541	6.4752	0	2.7612	-0.0217	0.0103125
4/8/84 9:15:00	15.0005	NA	4.0172	1.9708	6.8542	0.0433	6.486	-0.0108	2.7503	-0.0108	0.010694444
4/8/84 9:20:00	20.0002	NA	3.6924	2.2956	6.8109	0.0866	6.4752	0	2.7503	-0.0108	0.011076389
4/8/84 9:25:00	24.9998	NA	3.4325	2.5555	6.8001	0.0974	6.4427	0.0325	2.7287	0.0108	0.011458333
4/8/84 9:30:01	30.0024	NA	3.3134	2.6746	6.7568	0.1407	6.4427	0.0325	2.7503	-0.0108	0.011840278
4/8/84 9:35:00	34.9992	NA	3.2701	2.7179	6.7351	0.1624	6.4536	0.0216	2.7503	-0.0108	0.012222222
4/8/84 9:40:00	39.9989	NA	3.2809	2.7071	6.7026	0.1949	6.4427	0.0325	2.7395	0	0.012604167
4/8/84 9:45:00	45	NA	3.2593	2.7287	6.681	0.2165	6.4427	0.0325	2.7395	0	0.012986111
4/8/84 9:50:00	49.9997	NA	3.2376	2.7504	6.6701	0.2274	6.4536	0.0216	2.7503	-0.0108	0.013368056
4/8/84 10:00:00	59.999	NA	3.2809	2.7071	6.6376	0.2599	6.4427	0.0325	2.7287	0.0108	0.01375
4/8/84 10:10:00	69.9998	NA	3.2809	2.7071	6.6268	0.2707	6.4319	0.0433	2.7503	-0.0108	0.016041667
4/8/84 10:20:00	79.9978	NA	3.2918	2.6962	6.6052	0.2923	6.4319	0.0433	2.7503	-0.0108	0.018333333
4/8/84 10:30:00	90	NA	3.2809	2.7071	6.6052	0.2923	6.4319	0.0433	2.7395	0	0.020625
4/8/84 10:40:00	99.9994	NA	3.2701	2.7179	6.5943	0.3032	6.4211	0.0541	2.7395	0	0.022916667
4/8/84 10:50:00	110	NA	2.7179	3.2701	6.5835	0.314	6.4427	0.0325	2.7287	0.0108	0.025208333
4/8/84 11:00:00	120	NA	2.6529	3.3351	6.5835	0.314	6.4319	0.0433	2.7395	0	0.0275
4/8/84 11:30:00	149.998	NA	2.707	3.281	6.551	0.3465	6.4319	0.0433	2.707	0.0325	0.034375
4/8/84 12:00:00	180	NA	2.6745	3.3135	6.5185	0.379	6.4319	0.0433	2.7179	0.0216	0.04125
4/8/84 12:30:00	210	NA	2.6745	3.3135	6.5402	0.3573	6.4319	0.0433	2.6854	0.0541	0.048125
4/8/84 13:00:00	239.999	NA	3.0968	2.8912	6.5727	0.3248	6.4211	0.0541	2.707	0.0325	0.055
4/8/84 13:30:00	270	NA	3.2701	2.7179	6.5835	0.314	6.4211	0.0541	2.7395	0	0.061875
4/8/84 14:00:01	300.002	NA	3.3675	2.6205	6.5943	0.3032	6.4319	0.0433	2.7287	0.0108	0.06875
4/8/84 14:30:00	329.998	NA	3.4217	2.5663	6.616	0.2815	6.4319	0.0433	2.7179	0.0216	0.075625
4/8/84 15:00:00	360	NA	2.7503	3.2377	6.5835	0.314	6.4211	0.0541	2.7179	0.0216	0.0825
4/8/84 15:30:00	389.998	NA	2.2414	3.7466	6.5294	0.3681	6.4211	0.0541	2.7179	0.0216	0.089375
4/8/84 16:00:00	419.998	NA	2.1656	3.8224	6.4969	0.4006	6.4211	0.0541	2.707	0.0325	0.09625
4/8/84 16:30:00	450	NA	2.7503	3.2377	6.5077	0.3898	6.4103	0.0649	2.7287	0.0108	0.103125
4/8/84 17:00:00	480	NA	3.086	2.902	6.5618	0.3357	6.4211	0.0541	2.7287	0.0108	0.11
4/8/84 17:30:00	509.998	NA	3.1726	2.8154	6.5835	0.314	6.4427	0.0325	2.707	0.0325	0.11125
4/8/84 18:00:00	540	NA	3.2376	2.7504	6.5943	0.3032	6.4319	0.0433	2.6962	0.0433	0.1125
4/8/84 18:30:00	570	NA	3.2484	2.7396	6.5943	0.3032	6.4103	0.0649	2.7179	0.0216	0.11375
4/8/84 19:00:00	599.999	NA	3.2268	2.7612	6.5835	0.314	6.4211	0.0541	2.7287	0.0108	0.115
4/8/84 19:30:00	630	NA	3.216	2.772	6.5835	0.314	6.4211	0.0541	2.7179	0.0216	0.11625
4/8/84 20:00:00	660	NA	3.2918	2.6962	6.5943	0.3032	6.4211	0.0541	2.6529	0.0866	0.1175
4/8/84 20:30:00	689.999	NA	3.3675	2.6205	6.6052	0.2923	6.4427	0.0325	2.6204	0.1191	0.11875
4/8/84 21:00:00	720	NA	3.3675	2.6205	6.5943	0.3032	6.3994	0.0758	2.6312	0.1083	0.12
4/8/84 21:30:00	750	NA	3.3567	2.6313	6.5943	0.3032	6.4103	0.0649	2.6312	0.1083	0.1175
4/8/84 22:00:00	779.999	NA	3.3675	2.6205	6.5943	0.3032	6.4211	0.0541	2.6312	0.1083	0.115
4/8/84 22:30:00	810	NA	3.3675	2.6205	6.6052	0.2923	6.4103	0.0649	2.6421	0.0974	0.1125
4/8/84 23:00:00	840	NA	3.3567	2.6313	6.5727	0.3248	6.4103	0.0649	2.6204	0.1191	0.11
4/8/84 23:30:00	869.998	NA	3.3784	2.6096	6.5835	0.314	6.3994	0.0758	2.5663	0.1732	0.1075
4/9/84 0:00:00	900	NA	3.3567	2.6313	6.616	0.2815	6.4103	0.0649	2.6096	0.1299	0.105
4/9/84 0:30:00	930	NA	3.3242	2.6638	6.5835	0.314	6.3994	0.0758	2.5988	0.1407	0.1025
4/9/84 1:00:00	959.999	NA	2.9561	3.0319	6.5402	0.3573	6.3994	0.0758	2.6529	0.0866	0.1
4/9/84 1:30:00	990	NA	3.1618	2.8262	6.5727	0.3248	6.4103	0.0649	2.6529	0.0866	0.100625
4/9/84 2:00:00	1020	NA	3.2701	2.7179	6.5835	0.314	6.3994	0.0758	2.6096	0.1299	0.10125
4/9/84 2:30:00	1050	NA	3.3675	2.6205	6.5835	0.314	6.3994	0.0758	2.6637	0.0758	0.101875
4/9/84 3:00:00	1080	NA	3.4975	2.4905	6.5943	0.3032	6.3994	0.0758	2.6204	0.1191	0.1025
4/9/84 3:30:00	1110	NA	3.5191	2.4689	6.5943	0.3032	6.3994	0.0758	2.5988	0.1407	0.103125
4/9/84 4:00:00	1140	NA	3.5191	2.4689	6.5943	0.3032	6.3994	0.0758	2.6421	0.0974	0.10375
4/9/84 4:30:00	1170	NA	3.021	2.967	6.6052	0.2923	6.3994	0.0758	2.6529	0.0866	0.104375
4/9/84 5:00:00	1200	NA	3.216	2.772	6.5618	0.3357	6.4103	0.0649	2.6096	0.1299	0.105
4/9/84 5:30:00	1230	NA	3.0644	2.9236	6.5835	0.314	6.3994	0.0758	2.6204	0.1191	0.105625
4/9/84 6:00:00	1260	NA	3.2051	2.7829	6.5943	0.3032	6.3886	0.0866	2.6637	0.0758	0.10625
4/9/84 6:30:00	1290	NA	3.3242	2.6638	6.5835	0.314	6.4103	0.0649	2.6854	0.0541	0.106875

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
4/9/84 7:00:00	1320	NA	3.4	2.586	6.5727	0.3248	6.3994	0.0758	2.7287	0.0108	0.1075
4/9/84 7:30:00	1350	NA	3.2918	2.6962	6.5943	0.3032	6.3994	0.0758	2.7287	0.0108	0.108125
4/9/84 8:00:00	1380	NA	3.3242	2.6638	6.5835	0.314	6.3886	0.0866	2.7503	-0.0108	0.10875
4/9/84 8:30:00	1410	NA	3.6058	2.3822	6.5943	0.3032	6.3994	0.0758	2.7395	0	0.109375
4/9/84 9:00:00	1439.99	NA	3.29	2.698	6.58	0.3175	6.4	0.0752	2.76	-0.0205	0.11
4/9/84 13:00:00	1679.99	NA	3.58	2.408	6.59	0.3075	6.4	0.0752	2.76	-0.0205	0.115
4/9/84 17:00:00	1919.99	NA	3.69	2.298	6.6	0.2975	6.39	0.0852	2.78	-0.0405	0.12
4/9/84 21:00:00	2159.99	NA	3.3	2.688	6.62	0.2775	6.39	0.0852	2.76	-0.0205	0.13
4/10/84 1:00:00	2399.99	NA	3.29	2.698	6.56	0.3375	6.37	0.1052	2.75	-0.0105	0.14
4/10/84 5:00:00	2639.99	NA	3.38	2.608	6.56	0.3375	6.37	0.1052	2.78	-0.0405	0.17
4/10/84 8:30:05	2850.07	NA	3.2376	2.7504	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	0.170612245
4/10/84 8:30:09	2850.14	NA	3.2268	2.7612	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	0.17122449
4/10/84 8:30:12	2850.18	NA	3.216	2.772	6.5727	0.3248	6.3994	0.0758	2.7612	-0.0217	0.171836735
4/10/84 8:30:14	2850.23	NA	3.2268	2.7612	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	0.17244898
4/10/84 8:30:19	2850.3	NA	3.216	2.772	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	0.173061224
4/10/84 8:30:21	2850.35	NA	3.2376	2.7504	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	0.173673469
4/10/84 8:30:24	2850.4	NA	3.2376	2.7504	6.5727	0.3248	6.3994	0.0758	2.7612	-0.0217	0.174285714
4/10/84 8:30:27	2850.45	NA	3.2376	2.7504	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	0.174897959
4/10/84 8:30:31	2850.51	NA	3.2268	2.7612	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	0.175510204
4/10/84 8:30:34	2850.56	NA	3.216	2.772	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	0.176122449
4/10/84 8:30:37	2850.61	NA	3.2268	2.7612	6.5835	0.314	6.3994	0.0758	2.7612	-0.0217	0.176734694
4/10/84 8:30:41	2850.68	NA	3.2268	2.7612	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	0.177346939
4/10/84 8:30:44	2850.73	NA	3.2376	2.7504	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	0.177959184
4/10/84 8:30:47	2850.77	NA	3.2268	2.7612	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	0.178571429
4/10/84 8:30:51	2850.84	NA	3.2268	2.7612	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	0.179183673
4/10/84 8:30:54	2850.89	NA	3.216	2.772	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	0.179795918
4/10/84 8:30:57	2850.94	NA	3.216	2.772	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	0.180408163
4/10/84 8:31:01	2851.01	NA	3.2268	2.7612	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	0.181020408
4/10/84 8:31:04	2851.06	NA	3.216	2.772	6.5835	0.314	6.3994	0.0758	2.7612	-0.0217	0.181632653
4/10/84 8:31:07	2851.1	NA	3.2268	2.7612	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	0.182244898
4/10/84 8:31:10	2851.15	NA	3.2376	2.7504	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	0.182857143
4/10/84 8:31:14	2851.22	NA	3.2268	2.7612	6.5727	0.3248	6.4103	0.0649	2.772	-0.0325	0.183469388
4/10/84 8:31:17	2851.27	NA	3.2268	2.7612	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	0.184081633
4/10/84 8:31:20	2851.32	NA	3.216	2.772	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	0.184693878
4/10/84 8:31:24	2851.39	NA	3.2268	2.7612	6.5727	0.3248	6.3994	0.0758	2.7503	-0.0108	0.185306122
4/10/84 8:31:27	2851.43	NA	3.216	2.772	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	0.185918367
4/10/84 8:31:29	2851.48	NA	3.2268	2.7612	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	0.186530612
4/10/84 8:31:34	2851.55	NA	3.2376	2.7504	6.5727	0.3248	6.4103	0.0649	2.7828	-0.0433	0.187142857
4/10/84 8:31:36	2851.6	NA	3.2268	2.7612	6.5727	0.3248	6.3994	0.0758	2.7612	-0.0217	0.187755102
4/10/84 8:31:39	2851.65	NA	3.2268	2.7612	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	0.188367347
4/10/84 8:31:43	2851.71	NA	3.2268	2.7612	6.5835	0.314	6.4103	0.0649	2.772	-0.0325	0.188979592
4/10/84 8:31:46	2851.76	NA	3.216	2.772	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	0.189591837
4/10/84 8:31:49	2851.81	NA	3.216	2.772	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	0.190204082
4/10/84 8:31:52	2851.86	NA	3.2268	2.7612	6.5835	0.314	6.4103	0.0649	2.772	-0.0325	0.190816327
4/10/84 8:31:56	2851.93	NA	3.216	2.772	6.5835	0.314	6.4103	0.0649	2.7612	-0.0217	0.191428571
4/10/84 8:31:59	2851.98	NA	3.2268	2.7612	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	0.192040816
4/10/84 8:32:02	2852.03	NA	3.2268	2.7612	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	0.192653061
4/10/84 8:32:06	2852.09	NA	3.216	2.772	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	0.193265306
4/10/84 8:32:09	2852.14	NA	3.2268	2.7612	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	0.193877551
4/10/84 8:32:12	2852.19	NA	3.2376	2.7504	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	0.194489796
4/10/84 8:32:16	2852.26	NA	3.216	2.772	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	0.195102041
4/10/84 8:32:19	2852.31	NA	3.2268	2.7612	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	0.195714286
4/10/84 8:32:22	2852.36	NA	3.216	2.772	6.5835	0.314	6.4103	0.0649	2.772	-0.0325	0.196326531
4/10/84 8:32:25	2852.4	NA	3.2268	2.7612	6.5835	0.314	6.3886	0.0866	2.7612	-0.0217	0.196938776
4/10/84 8:32:29	2852.47	NA	3.216	2.772	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	0.19755102
4/10/84 8:32:32	2852.52	NA	3.2376	2.7504	6.5835	0.314	6.3994	0.0758	2.7503	-0.0108	0.198163265
4/10/84 8:32:35	2852.57	NA	3.216	2.772	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	0.19877551
4/10/84 8:32:39	2852.64	NA	3.2268	2.7612	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	0.199387755
4/10/84 9:00:00	2880	NA	3.2268	2.7612	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	0.2
4/10/84 10:20:04	2960.06	NA	3.2701	2.7179	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	0.2
4/10/84 10:20:55	2960.9	NA	3.2484	2.7396	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	0.2
4/10/84 10:21:05	2961.08	NA	3.2701	2.7179	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	0.2
4/10/84 10:21:15	2961.25	NA	3.2701	2.7179	6.5835	0.314	6.4103	0.0649	2.7828	-0.0433	0.2
4/10/84 10:21:25	2961.41	NA	3.2376	2.7504	6.5727	0.3248	6.4103	0.0649	2.7828	-0.0433	0.2
4/10/84 10:21:35	2961.58	NA	3.2376	2.7504	6.5727	0.3248	6.4103	0.0649	2.7828	-0.0433	0.2
4/10/84 10:21:45	2961.75	NA	3.2484	2.7396	6.5943	0.3032	6.4103	0.0649	2.7828	-0.0433	0.2
4/10/84 10:21:55	2961.91	NA	3.2484	2.7396	6.5835	0.314	6.4103	0.0649	2.7828	-0.0433	0.2
4/10/84 10:22:05	2962.08	NA	3.2484	2.7396	6.5943	0.3032	6.3994	0.0758	2.7828	-0.0433	0.2
4/10/84 10:22:15	2962.25	NA	3.2593	2.7287	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	0.2
4/10/84 10:22:25	2962.41	NA	3.2593	2.7287	6.5943	0.3032	6.3886	0.0866	2.772	-0.0325	0.2
4/10/84 10:22:35	2962.58	NA	3.2593	2.7287	6.5835	0.314	6.4103	0.0649	2.7828	-0.0433	0.2
4/10/84 10:22:45	2962.75	NA	3.2484	2.7396	6.5835	0.314	6.4103	0.0649	2.772	-0.0325	0.2
4/10/84 10:22:55	2962.91	NA	3.2593	2.7287	6.5618	0.3357	6.4103	0.0649	2.7828	-0.0433	0.2
4/10/84 10:23:05	2963.08	NA	3.2593	2.7287	6.5835	0.314	6.3994	0.0758	2.7937	-0.0542	0.2
4/10/84 10:23:15	2963.25	NA	3.2593	2.7287	6.5943	0.3032	6.3994	0.0758	2.7828	-0.0433	0.2
4/10/84 10:23:25	2963.41	NA	3.2484	2.7396	6.5835	0.314	6.3994	0.0758	2.7937	-0.0542	0.2
4/10/84 10:23:35	2963.58	NA	3.2701	2.7179	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	0.2
4/10/84 10:23:45	2963.75	NA	3.2484	2.7396	6.5835	0.314	6.4103	0.0649	2.7828	-0.0433	0.2
4/10/84 10:23:55	2963.91	NA	3.2593	2.7287	6.5835	0.314	6.3994	0.0758	2.7937	-0.0542	0.2
4/10/84 10:24:05	2964.08	NA	3.2484	2.7396	6.5943	0.3032	6.4103	0.0649	2.7828	-0.0433	0.2
4/10/84 10:24:15	2964.25	NA	3.2484	2.7396	6.5835	0.314	6.4103	0.0649	2.7828	-0.0433	0.2
4/10/84 10:24:25	2964.41	NA	3.2268	2.7612	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	0.2
4/10/84 10:24:35	2964.58	NA	3.2376	2.7504	6.5835	0.314	6.4103	0.0649	2.7828	-0.0433	0.2

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
4/10/84 10:24:45	2964.75	NA	3.2484	2.7396	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	0.2
4/10/84 10:24:55	2964.91	NA	3.2268	2.7612	6.5943	0.3032	6.3994	0.0758	2.7828	-0.0433	0.2
RECOVERY TEST											
4/10/84 11:30:00	3029.98	0	3.2593	2.7287	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:00	3030	210416.6	3.2701	2.7179	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:01	3030.01	105208.8	3.2701	2.7179	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:30:02	3030.03	72558.11	3.2809	2.7071	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:03	3030.04	53953.71	3.2701	2.7179	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:04	3030.05	43837.58	3.2809	2.7071	6.5943	0.3032	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:05	3030.07	36279.55	3.2701	2.7179	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:05	3030.08	30944.47	3.2918	2.6962	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:06	3030.1	27327.7	3.2918	2.6962	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:07	3030.11	24186.7	3.2918	2.6962	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:08	3030.12	21693.33	3.2918	2.6962	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:09	3030.14	19851.53	3.3026	2.6854	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:10	3030.15	18140.28	3.3134	2.6746	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:10	3030.16	16834.25	3.3134	2.6746	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:11	3030.18	15587.34	3.3134	2.6746	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:12	3030.19	14512.42	3.3026	2.6854	6.5727	0.3248	6.3994	0.0758	2.7937	-0.0542	NA
4/10/84 11:30:13	3030.21	13664.35	3.3242	2.6638	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:14	3030.22	12831.22	3.3242	2.6638	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:30:14	3030.23	12163.75	3.3134	2.6746	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:15	3030.25	11499.12	3.3242	2.6638	6.5727	0.3248	6.3994	0.0758	2.7937	-0.0542	NA
4/10/84 11:30:16	3030.26	10903.36	3.3351	2.6529	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:30:17	3030.28	10417.61	3.3351	2.6529	6.5835	0.314	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:30:18	3030.29	9926.264	3.3351	2.6529	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:30:19	3030.3	9522.068	3.3351	2.6529	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:19	3030.32	9109.9	3.3459	2.6421	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:20	3030.33	8731.938	3.3459	2.6421	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:21	3030.34	8417.624	3.3459	2.6421	6.5835	0.314	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:30:22	3030.36	8093.908	3.3567	2.6313	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:23	3030.37	7794.17	3.3567	2.6313	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:24	3030.39	7542.778	3.3675	2.6205	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:24	3030.4	7281.817	3.3675	2.6205	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:25	3030.41	7061.926	3.3784	2.6096	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:26	3030.43	6832.675	3.3675	2.6205	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:27	3030.44	6617.843	3.3784	2.6096	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:30:28	3030.46	6435.728	3.3784	2.6096	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:29	3030.47	6244.786	3.3892	2.5988	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:29	3030.48	6082.376	3.3784	2.6096	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:30	3030.5	5911.551	3.3784	2.6096	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:30:31	3030.51	5750.06	3.3784	2.6096	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:32	3030.52	5612.083	3.3892	2.5988	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:30:33	3030.54	5466.34	3.3892	2.5988	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:34	3030.55	5327.977	3.3892	2.5988	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:30:34	3030.57	5209.307	3.4	2.588	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:35	3030.58	5083.502	3.3892	2.5988	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:30:36	3030.59	4975.364	3.4	2.588	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:37	3030.61	4860.483	3.4	2.588	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:38	3030.62	4761.534	3.4	2.588	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:30:39	3030.64	4656.212	3.4	2.588	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:39	3030.65	4555.45	3.4	2.588	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:40	3030.66	4468.423	3.4	2.588	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:41	3030.68	4375.545	3.4	2.588	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:30:42	3030.69	4286.45	3.4	2.588	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:43	3030.7	4209.312	3.4	2.588	6.5835	0.314	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 11:30:44	3030.72	4126.796	3.4	2.588	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:44	3030.73	4047.454	3.4109	2.5771	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:30:46	3030.77	3883.207	3.4217	2.5663	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:47	3030.78	3812.877	3.4109	2.5771	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:48	3030.79	3751.724	3.4109	2.5771	6.6052	0.2923	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:49	3030.81	3692.502	3.4217	2.5663	6.5618	0.3357	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:50	3030.82	3622.611	3.4325	2.5555	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:50	3030.83	3567.366	3.4325	2.5555	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:51	3030.85	3513.781	3.4325	2.5555	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:30:52	3030.86	3450.436	3.4325	2.5555	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:53	3030.88	3400.283	3.4325	2.5555	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:54	3030.89	3351.567	3.4542	2.5338	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:55	3030.9	3299.05	3.4433	2.5447	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:55	3030.92	3248.154	3.4542	2.5338	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:56	3030.93	3203.673	3.4542	2.5338	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:57	3030.95	3155.657	3.4542	2.5338	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:30:58	3030.96	3109.059	3.465	2.523	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:30:59	3030.97	3068.283	3.4542	2.5338	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:31:00	3030.99	3028.563	3.465	2.523	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:01	3031	2981.391	3.465	2.523	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:01	3031.01	2943.876	3.4758	2.5122	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:31:02	3031.03	2907.293	3.465	2.523	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:03	3031.04	2867.698	3.465	2.523	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:04	3031.06	2829.167	3.4758	2.5122	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:31:05	3031.07	2795.364	3.4758	2.5122	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:05	3031.08	2758.74	3.465	2.523	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1		PZ-9		PZ-10		PZ-2		Delta H; Groundwater Correction From Background Well
			Feet of Water Above Transducer	Drawdown (ft)	Feet of Water Above Transducer	Drawdown (ft)	Feet of Water Above Transducer	Drawdown (ft)	Feet of Water Above Transducer	Drawdown (ft)	
4/10/84 11:31:06	3031.1	2723.065	3.4758	2.5122	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:31:07	3031.11	2691.737	3.4867	2.5013	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:08	3031.13	2657.763	3.4867	2.5013	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:09	3031.14	2624.636	3.4867	2.5013	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:10	3031.15	2595.52	3.4867	2.5013	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:10	3031.17	2567.044	3.4867	2.5013	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:11	3031.18	2533.077	3.4975	2.4905	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:12	3031.19	2505.948	3.4975	2.4905	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:31:13	3031.21	2479.393	3.4867	2.5013	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:14	3031.22	2450.541	3.4975	2.4905	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:31:15	3031.24	2422.353	3.4975	2.4905	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:15	3031.25	2397.533	3.4975	2.4905	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:16	3031.26	2370.545	3.5083	2.4797	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:17	3031.28	2344.158	3.5083	2.4797	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:18	3031.29	2320.907	3.5083	2.4797	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:19	3031.31	2295.609	3.5083	2.4797	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:31:20	3031.32	2270.855	3.4975	2.4905	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:20	3031.33	2249.03	3.5083	2.4797	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:21	3031.35	2227.62	3.5083	2.4797	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:22	3031.36	2204.305	3.5191	2.4689	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:23	3031.37	2181.473	3.53	2.458	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:24	3031.39	2161.324	3.53	2.458	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:31:25	3031.4	2139.37	3.53	2.458	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:25	3031.42	2117.857	3.5408	2.4472	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:31:26	3031.43	2098.862	3.5408	2.4472	6.5835	0.314	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 11:31:27	3031.44	2078.153	3.5408	2.4472	6.5835	0.314	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 11:31:28	3031.46	2057.848	3.5408	2.4472	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:29	3031.47	2039.911	3.5408	2.4472	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:30	3031.49	2020.344	3.5408	2.4472	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:31:30	3031.5	2001.148	3.5516	2.4364	6.5727	0.3248	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:31:31	3031.51	1984.182	3.5408	2.4472	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:32	3031.53	1967.501	3.5516	2.4364	6.5727	0.3248	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:31:33	3031.54	1949.293	3.5516	2.4364	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:34	3031.55	1931.418	3.5408	2.4472	6.5727	0.3248	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:31:34	3031.57	1915.61	3.5516	2.4364	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:31:35	3031.58	1898.345	3.5516	2.4364	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:36	3031.6	1881.39	3.5516	2.4364	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:37	3031.61	1866.387	3.5516	2.4364	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:38	3031.62	1849.995	3.5516	2.4364	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:31:39	3031.64	1833.889	3.5625	2.4255	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:31:39	3031.65	1819.631	3.5625	2.4255	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:40	3031.67	1804.047	3.5516	2.4364	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:31:41	3031.68	1788.728	3.5625	2.4255	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:42	3031.69	1775.162	3.5516	2.4364	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:43	3031.71	1761.8	3.5625	2.4255	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:44	3031.72	1747.188	3.5733	2.4147	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:44	3031.73	1732.816	3.5625	2.4255	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:45	3031.75	1720.082	3.5733	2.4147	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:31:46	3031.76	1706.151	3.5733	2.4147	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:47	3031.78	1692.444	3.5733	2.4147	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:48	3031.79	1680.294	3.5733	2.4147	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:49	3031.8	1666.998	3.5841	2.4039	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:31:49	3031.82	1653.911	3.5841	2.4039	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:50	3031.83	1642.307	3.5949	2.3931	6.5618	0.3357	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:51	3031.85	1629.604	3.5841	2.4039	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:52	3031.86	1618.337	3.5841	2.4039	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:31:53	3031.87	1606.001	3.5841	2.4039	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:54	3031.89	1595.058	3.5949	2.3931	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:54	3031.9	1583.072	3.5841	2.4039	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:31:55	3031.91	1571.266	3.5949	2.3931	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:31:56	3031.93	1560.789	3.6058	2.3822	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:31:58	3031.96	1535.76	3.6166	2.3714	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:31:59	3031.97	1523.544	3.6166	2.3714	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:00	3031.99	1513.693	3.6274	2.3606	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:00	3032	1503.969	3.6274	2.3606	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:01	3032.02	1492.252	3.6274	2.3606	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:02	3032.03	1482.8	3.6274	2.3606	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:03	3032.04	1473.467	3.6383	2.3497	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:04	3032.06	1462.219	3.6383	2.3497	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:05	3032.07	1453.144	3.6383	2.3497	6.5727	0.3248	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:32:05	3032.08	1444.18	3.6274	2.3606	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:06	3032.1	1433.373	3.6383	2.3497	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:07	3032.11	1424.651	3.6491	2.3389	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:08	3032.13	1416.034	3.6491	2.3389	6.5727	0.3248	6.3886	0.0866	2.7937	-0.0542	NA
4/10/84 11:32:09	3032.14	1407.521	3.6491	2.3389	6.5727	0.3248	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 11:32:10	3032.15	1397.255	3.6491	2.3389	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:10	3032.17	1388.966	3.6491	2.3389	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:11	3032.18	1380.774	3.6599	2.3281	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:12	3032.2	1370.893	3.6599	2.3281	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:32:13	3032.21	1362.913	3.6599	2.3281	6.5727	0.3248	6.3994	0.0758	2.7937	-0.0542	NA
4/10/84 11:32:14	3032.22	1355.026	3.6599	2.3281	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:32:15	3032.24	1345.509	3.6707	2.3173	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:16	3032.25	1337.821	3.6599	2.3281	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
4/10/84 11:32:16	3032.26	1330.22	3.6707	2.3173	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:17	3032.28	1322.706	3.6816	2.3064	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:18	3032.29	1313.636	3.6816	2.3064	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:19	3032.31	1306.308	3.6816	2.3064	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:20	3032.32	1299.06	3.6707	2.3173	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:21	3032.33	1290.311	3.6816	2.3064	6.5727	0.3248	6.3994	0.0758	2.837	-0.0975	NA
4/10/84 11:32:21	3032.35	1283.24	3.6816	2.3064	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:22	3032.36	1276.246	3.6816	2.3064	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:23	3032.38	1267.801	3.7032	2.2848	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:32:24	3032.39	1260.974	3.6924	2.2956	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:25	3032.4	1254.22	3.6924	2.2956	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:26	3032.42	1246.063	3.7032	2.2848	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:26	3032.43	1239.467	3.6924	2.2956	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:32:27	3032.44	1232.941	3.6924	2.2956	6.5943	0.3032	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:28	3032.46	1226.484	3.7032	2.2848	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:29	3032.47	1218.683	3.7032	2.2848	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:30	3032.49	1212.374	3.6924	2.2956	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:30	3032.5	1206.129	3.714	2.274	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:31	3032.51	1198.585	3.714	2.274	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:32	3032.53	1192.481	3.7032	2.2848	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:33	3032.54	1186.44	3.714	2.274	6.5727	0.3248	6.3994	0.0758	2.7937	-0.0542	NA
4/10/84 11:32:34	3032.56	1179.139	3.714	2.274	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:35	3032.57	1173.232	3.714	2.274	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:35	3032.58	1167.384	3.714	2.274	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:36	3032.6	1160.315	3.714	2.274	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:37	3032.61	1154.594	3.7249	2.2631	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:38	3032.62	1148.93	3.714	2.274	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:39	3032.64	1143.321	3.7249	2.2631	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:40	3032.65	1136.54	3.7249	2.2631	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:40	3032.67	1131.052	3.7249	2.2631	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:41	3032.68	1125.616	3.7357	2.2523	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:42	3032.69	1119.043	3.7357	2.2523	6.5835	0.314	6.3994	0.0758	2.7937	-0.0542	NA
4/10/84 11:32:43	3032.71	1113.721	3.7357	2.2523	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:44	3032.72	1108.451	3.7249	2.2631	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:45	3032.74	1102.076	3.7465	2.2415	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:32:45	3032.75	1096.915	3.7465	2.2415	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:46	3032.76	1091.801	3.7357	2.2523	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:47	3032.78	1086.176	3.7574	2.2306	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:48	3032.79	1080.608	3.7574	2.2306	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:49	3032.8	1075.646	3.7574	2.2306	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:49	3032.82	1070.729	3.7574	2.2306	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:50	3032.83	1064.78	3.7574	2.2306	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:51	3032.85	1059.961	3.7682	2.2198	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:52	3032.86	1055.186	3.7574	2.2306	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:32:53	3032.87	1049.409	3.7682	2.2198	6.5835	0.314	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:32:54	3032.89	1044.728	3.779	2.209	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:54	3032.9	1040.089	3.7682	2.2198	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:55	3032.92	1034.475	3.779	2.209	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:56	3032.93	1029.927	3.779	2.209	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:57	3032.94	1025.419	3.779	2.209	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:32:58	3032.96	1020.455	3.7898	2.1982	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:32:59	3032.97	1015.54	3.8007	2.1873	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:32:59	3032.98	1011.157	3.7898	2.1982	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:00	3033	1006.811	3.8007	2.1873	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:01	3033.01	1001.55	3.8007	2.1873	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:33:02	3033.03	997.286	3.8007	2.1873	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:33:03	3033.04	993.0585	3.8007	2.1873	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:04	3033.05	987.94	3.8007	2.1873	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:04	3033.07	983.7912	3.8115	2.1765	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:33:05	3033.08	979.6772	3.8115	2.1765	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:06	3033.1	975.1463	3.8115	2.1765	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:07	3033.11	970.6571	3.8115	2.1765	6.5835	0.314	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:33:08	3033.12	966.6521	3.8115	2.1765	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:10	3033.16	956.5658	3.8115	2.1765	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:11	3033.17	952.2459	3.8115	2.1765	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:11	3033.18	948.3913	3.8223	2.1657	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:12	3033.2	944.5677	3.8115	2.1765	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:33:13	3033.21	939.9362	3.8332	2.1548	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:14	3033.22	936.1804	3.8332	2.1548	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:15	3033.24	932.4546	3.8223	2.1657	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:16	3033.25	927.941	3.844	2.144	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:16	3033.27	924.2804	3.8332	2.1548	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:17	3033.28	920.6486	3.8332	2.1548	6.5835	0.314	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:33:18	3033.29	916.6466	3.844	2.144	6.5835	0.314	6.3886	0.0866	2.7612	-0.0217	NA
4/10/84 11:33:19	3033.31	912.6794	3.844	2.144	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:20	3033.32	909.1381	3.844	2.144	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:33:21	3033.34	905.2355	3.844	2.144	6.5727	0.3248	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:33:21	3033.35	901.3663	3.844	2.144	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:22	3033.36	897.9122	3.844	2.144	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:33:23	3033.38	894.1053	3.844	2.144	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:24	3033.4	888.4551	3.844	2.144	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:25	3033.41	884.7278	3.8548	2.1332	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:33:26	3033.43	880.2963	3.8548	2.1332	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
4/10/84 11:33:27	3033.45	875.5453	3.8656	2.1224	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:28	3033.46	872.2861	3.8656	2.1224	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:29	3033.48	867.2643	3.8548	2.1332	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:30	3033.5	863.7126	3.8656	2.1224	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:31	3033.51	859.4888	3.8765	2.1115	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:32	3033.53	854.9594	3.8765	2.1115	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:33:33	3033.55	851.8516	3.8873	2.1007	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:34	3033.57	847.0619	3.8873	2.1007	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:33:35	3033.58	842.9992	3.8873	2.1007	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:33:36	3033.6	839.9777	3.8873	2.1007	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:37	3033.61	835.6513	3.8873	2.1007	6.5943	0.3032	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:33:38	3033.63	831.6972	3.8981	2.0899	6.5727	0.3248	6.3994	0.0758	2.7937	-0.0542	NA
4/10/84 11:33:39	3033.65	828.4306	3.8981	2.0899	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:40	3033.66	824.5444	3.8981	2.0899	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:33:41	3033.68	820.3754	3.8981	2.0899	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:42	3033.7	817.5138	3.8981	2.0899	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:43	3033.71	813.4154	3.909	2.079	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:33:44	3033.73	809.358	3.8981	2.0899	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:45	3033.75	806.5727	3.8981	2.0899	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:46	3033.76	802.5832	3.909	2.079	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:33:47	3033.78	798.6331	3.909	2.079	6.5727	0.3248	6.4103	0.0649	2.7937	-0.0542	NA
4/10/84 11:33:48	3033.8	795.921	3.909	2.079	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:49	3033.82	791.7388	3.9198	2.0682	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:50	3033.83	788.4835	3.909	2.079	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:51	3033.85	785.5474	3.9198	2.0682	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:52	3033.87	781.7629	3.9306	2.0574	6.5835	0.314	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 11:33:54	3033.9	775.4409	3.9306	2.0574	6.5727	0.3248	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:55	3033.91	772.3182	3.9306	2.0574	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:56	3033.93	769.5011	3.9523	2.0357	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:33:57	3033.94	766.426	3.9306	2.0574	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:33:58	3033.96	763.9282	3.9523	2.0357	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:33:59	3033.97	761.172	3.9523	2.0357	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:34:00	3033.99	758.163	3.9523	2.0357	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:00	3034	755.7188	3.9523	2.0357	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:34:01	3034.01	753.0214	3.9631	2.0249	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:02	3034.03	749.81	3.9631	2.0249	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:34:03	3034.05	746.6258	3.9631	2.0249	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:34:04	3034.06	743.7307	3.9523	2.0357	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:05	3034.08	740.5979	3.9631	2.0249	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:06	3034.1	737.7493	3.9631	2.0249	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:07	3034.11	734.6667	3.9739	2.0141	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:34:08	3034.13	731.6097	3.9739	2.0141	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:09	3034.15	728.8298	3.9739	2.0141	6.5943	0.3032	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:34:10	3034.17	725.5716	3.9739	2.0141	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:11	3034.18	723.333	3.9739	2.0141	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:34:12	3034.2	720.1237	3.9739	2.0141	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:13	3034.22	716.9428	3.9848	2.0032	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:34:14	3034.23	714.7571	3.9739	2.0141	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:15	3034.25	711.6234	3.9956	1.9924	6.5727	0.3248	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:34:16	3034.27	708.7551	3.9956	1.9924	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:17	3034.28	706.3825	3.9956	1.9924	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:18	3034.3	703.3218	3.9956	1.9924	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:19	3034.31	700.9854	3.9956	1.9924	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:20	3034.33	698.2021	3.9956	1.9924	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:34:21	3034.35	695.2118	3.9956	1.9924	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:22	3034.36	693.1566	3.9956	1.9924	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:23	3034.38	690.2093	4.0064	1.9816	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:24	3034.4	687.287	4.0064	1.9816	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:34:25	3034.41	685.2784	4.0172	1.9708	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:26	3034.43	682.1771	4.0064	1.9816	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:28	3034.47	677.1427	4.0281	1.9599	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:29	3034.48	674.7611	4.0281	1.9599	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:30	3034.49	672.825	4.0172	1.9708	6.5727	0.3248	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:34:31	3034.51	670.6868	4.0281	1.9599	6.5835	0.314	6.3886	0.0866	2.7612	-0.0217	NA
4/10/84 11:34:32	3034.52	668.3505	4.0281	1.9599	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:33	3034.54	666.451	4.0281	1.9599	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:34	3034.55	664.3531	4.0389	1.9491	6.5835	0.314	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:34:35	3034.57	662.0606	4.0389	1.9491	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:35	3034.58	660.1967	4.0497	1.9383	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:36	3034.6	657.5229	4.0497	1.9383	6.5835	0.314	6.3778	0.0974	2.772	-0.0325	NA
4/10/84 11:34:37	3034.62	655.2774	4.0497	1.9383	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:34:38	3034.63	653.2492	4.0497	1.9383	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:34:39	3034.65	650.832	4.0605	1.9275	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:40	3034.67	648.2335	4.0605	1.9275	6.5943	0.3032	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:41	3034.68	646.4466	4.0605	1.9275	6.5835	0.314	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:34:42	3034.7	643.883	4.0605	1.9275	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:43	3034.72	641.3396	4.0714	1.9166	6.5943	0.3032	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:34:44	3034.73	639.5906	4.0605	1.9275	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:45	3034.75	637.081	4.0714	1.9166	6.5943	0.3032	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:46	3034.77	634.7819	4.0714	1.9166	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:47	3034.78	632.8787	4.0714	1.9166	6.5943	0.3032	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:34:48	3034.8	630.6098	4.0822	1.9058	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:49	3034.82	628.1702	4.0822	1.9058	6.5727	0.3248	6.3994	0.0758	2.772	-0.0325	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1		PZ-9		PZ-10		PZ-2		Delta H; Groundwater Correction From Background Well
			Feet of Water Above Transducer	Drawdown (ft)	Feet of Water Above Transducer	Drawdown (ft)	Feet of Water Above Transducer	Drawdown (ft)	Feet of . Water Above Transducer	Drawdown (ft)	
4/10/84 11:34:50	3034.83	626.4923	4.0822	1.9058	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:51	3034.85	623.8999	4.0714	1.9166	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:34:52	3034.86	622.0614	4.0822	1.9058	6.5943	0.3032	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:53	3034.88	619.8694	4.0822	1.9058	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:34:54	3034.9	617.5122	4.0822	1.9058	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:34:55	3034.91	615.8907	4.093	1.895	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:56	3034.93	613.3853	4.093	1.895	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:34:57	3034.95	611.7855	4.093	1.895	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:34:58	3034.96	609.4893	4.0822	1.9058	6.5727	0.3248	6.3994	0.0758	2.7937	-0.0542	NA
4/10/84 11:34:59	3034.98	607.2103	4.093	1.895	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:35:00	3035	605.6425	4.093	1.895	6.5835	0.314	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 11:35:02	3035.03	601.1586	4.093	1.895	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:35:03	3035.05	599.6219	4.1039	1.8841	6.5943	0.3032	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:35:04	3035.06	597.9237	4.093	1.895	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:35:05	3035.08	596.0667	4.1039	1.8841	6.5943	0.3032	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:35:06	3035.09	594.556	4.1147	1.8733	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:35:07	3035.1	592.8864	4.1147	1.8733	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:35:08	3035.12	591.0606	4.1147	1.8733	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:35:08	3035.13	589.5751	4.1147	1.8733	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:35:09	3035.15	587.7697	4.1147	1.8733	6.5835	0.314	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:35:10	3035.16	585.9753	4.1255	1.8625	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:35:11	3035.18	584.0302	4.1255	1.8625	6.5943	0.3032	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:35:12	3035.2	582.2586	4.1363	1.8517	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:35:13	3035.21	580.3381	4.1363	1.8517	6.5943	0.3032	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:35:14	3035.23	578.5888	4.1472	1.8408	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:35:15	3035.25	576.535	4.1472	1.8408	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:35:16	3035.26	575.1217	4.1363	1.8517	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:35:17	3035.28	573.0924	4.1472	1.8408	6.5835	0.314	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:35:18	3035.3	571.0775	4.1472	1.8408	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:35:19	3035.31	569.6908	4.1472	1.8408	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:35:20	3035.33	567.5471	4.1472	1.8408	6.5943	0.3032	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:35:21	3035.35	566.1775	4.1472	1.8408	6.5835	0.314	6.3886	0.0866	2.772	-0.0325	NA
4/10/84 11:35:22	3035.36	564.2109	4.158	1.83	6.5835	0.314	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:35:23	3035.38	562.2579	4.158	1.83	6.5835	0.314	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:35:53	3035.88	514.71	4.2446	1.7434	6.5943	0.3032	6.3994	0.0758	2.7937	-0.0542	NA
4/10/84 11:36:23	3036.38	474.589	4.2988	1.6892	6.5943	0.3032	6.3886	0.0866	2.7828	-0.0433	NA
4/10/84 11:36:53	3036.88	440.281	4.3746	1.6134	6.5943	0.3032	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:37:23	3037.38	410.5282	4.4287	1.5593	6.6052	0.2923	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:37:53	3037.88	384.6201	4.5045	1.4835	6.6052	0.2923	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:38:23	3038.38	361.7949	4.5586	1.4294	6.616	0.2815	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:38:53	3038.88	341.5334	4.6128	1.3752	6.6052	0.2923	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:39:23	3039.38	323.3772	4.6778	1.3102	6.6052	0.2923	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:39:53	3039.88	307.1036	4.7535	1.2345	6.616	0.2815	6.3886	0.0866	2.7937	-0.0542	NA
4/10/84 11:40:23	3040.38	292.394	4.786	1.202	6.616	0.2815	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:40:53	3040.88	279.0333	4.851	1.137	6.616	0.2815	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:41:23	3041.38	266.8441	4.8727	1.1153	6.6268	0.2707	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:41:53	3041.88	255.6479	4.9268	1.0612	6.6376	0.2599	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:42:23	3042.38	245.3851	4.9701	1.0179	6.6376	0.2599	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:42:53	3042.88	235.9175	5.0243	0.9637	6.6376	0.2599	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:43:23	3043.38	227.1561	5.0676	0.9204	6.6485	0.249	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:43:53	3043.88	219.0021	5.0892	0.8988	6.6485	0.249	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:44:23	3044.38	211.4366	5.1109	0.8771	6.6593	0.2382	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 11:44:53	3044.88	204.3787	5.1434	0.8446	6.6593	0.2382	6.4103	0.0649	2.7612	-0.0217	NA
4/10/84 11:45:23	3045.38	197.7786	5.1867	0.8013	6.6593	0.2382	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:45:53	3045.88	191.5938	5.2083	0.7797	6.6485	0.249	6.3994	0.0758	2.772	-0.0325	NA
4/10/84 11:46:23	3046.38	185.7696	5.2192	0.7688	6.6376	0.2599	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:46:53	3046.88	180.306	5.2733	0.7147	6.6485	0.249	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:47:23	3047.38	175.1563	5.295	0.693	6.681	0.2165	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 11:47:53	3047.88	170.2941	5.295	0.693	6.681	0.2165	6.3994	0.0758	2.7612	-0.0217	NA
4/10/84 11:48:23	3048.38	165.6831	5.3058	0.6822	6.681	0.2165	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:48:53	3048.88	161.3289	5.3599	0.6281	6.681	0.2165	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:49:23	3049.38	157.1989	5.3708	0.6172	6.6701	0.2274	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:49:53	3049.88	153.2765	5.3708	0.6172	6.681	0.2165	6.3994	0.0758	2.7937	-0.0542	NA
4/10/84 11:50:23	3050.38	149.5461	5.4141	0.5739	6.6918	0.2057	6.4103	0.0649	2.7937	-0.0542	NA
4/10/84 11:50:53	3050.88	145.9842	5.4249	0.5631	6.6701	0.2274	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:51:23	3051.38	142.5987	5.4357	0.5523	6.6701	0.2274	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:51:53	3051.88	139.3676	5.4682	0.5198	6.6701	0.2274	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:52:23	3052.38	136.2807	5.4682	0.5198	6.681	0.2165	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:52:53	3052.88	133.3202	5.4682	0.5198	6.681	0.2165	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 11:53:23	3053.38	130.4945	5.4899	0.4981	6.681	0.2165	6.3994	0.0758	2.7937	-0.0542	NA
4/10/84 11:53:53	3053.88	127.7869	5.5007	0.4873	6.681	0.2165	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:54:23	3054.38	125.1903	5.5007	0.4873	6.6918	0.2057	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:54:53	3054.88	122.6979	5.5223	0.4657	6.681	0.2165	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:55:23	3055.38	120.2967	5.5332	0.4548	6.6918	0.2057	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:55:53	3055.88	117.9951	5.5548	0.4332	6.6918	0.2057	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:56:23	3056.38	115.7805	5.5548	0.4332	6.681	0.2165	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 11:56:53	3056.88	113.6482	5.5657	0.4223	6.6918	0.2057	6.4103	0.0649	2.7937	-0.0542	NA
4/10/84 11:57:23	3057.38	111.5937	5.5765	0.4115	6.6918	0.2057	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:57:53	3057.88	109.6072	5.5873	0.4007	6.7134	0.1841	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 11:58:23	3058.38	107.6962	5.609	0.379	6.7026	0.1949	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 11:58:53	3058.88	105.8513	5.6306	0.3574	6.7026	0.1949	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 11:59:23	3059.38	104.0691	5.6306	0.3574	6.7134	0.1841	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 11:59:53	3059.88	102.3416	5.6198	0.3682	6.7134	0.1841	6.4103	0.0649	2.7612	-0.0217	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
4/10/84 12:00:23	3060.38	100.6758	5.6523	0.3357	6.7134	0.1841	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 12:00:53	3060.88	99.06385	5.6306	0.3574	6.7134	0.1841	6.3994	0.0758	2.7828	-0.0433	NA
4/10/84 12:01:23	3061.38	97.50321	5.6415	0.3465	6.7243	0.1732	6.4211	0.0541	2.772	-0.0325	NA
4/10/84 12:01:53	3061.88	95.99147	5.6523	0.3357	6.7134	0.1841	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:02:23	3062.38	94.5222	5.6523	0.3357	6.7351	0.1624	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:02:53	3062.88	93.10172	5.6631	0.3249	6.7351	0.1624	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:03:23	3063.38	91.72375	5.6739	0.3141	6.7459	0.1516	6.4211	0.0541	2.772	-0.0325	NA
4/10/84 12:03:53	3063.88	90.38641	5.6848	0.3032	6.7351	0.1624	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:04:23	3064.38	89.08423	5.6739	0.3141	6.7351	0.1624	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:04:53	3064.88	87.82302	5.6956	0.2924	6.7351	0.1624	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:05:23	3065.38	86.59743	5.7064	0.2816	6.7243	0.1732	6.4211	0.0541	2.772	-0.0325	NA
4/10/84 12:05:53	3065.88	85.40595	5.7173	0.2707	6.7351	0.1624	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:06:23	3066.38	84.24719	5.7173	0.2707	6.7351	0.1624	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:06:53	3066.88	83.11661	5.7173	0.2707	6.7351	0.1624	6.4211	0.0541	2.772	-0.0325	NA
4/10/84 12:07:23	3067.38	82.01944	5.7173	0.2707	6.7459	0.1516	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:07:53	3067.88	80.95121	5.7389	0.2491	6.7568	0.1407	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 12:08:23	3068.38	79.91078	5.7281	0.2599	6.7568	0.1407	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 12:08:53	3068.88	78.8942	5.7497	0.2383	6.7568	0.1407	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:09:23	3069.38	77.90629	5.7497	0.2383	6.7568	0.1407	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:09:53	3069.88	76.94312	5.7389	0.2491	6.7459	0.1516	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:10:23	3070.38	76.00378	5.7606	0.2274	6.7459	0.1516	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 12:10:53	3070.88	75.08478	5.7497	0.2383	6.7459	0.1516	6.4211	0.0541	2.772	-0.0325	NA
4/10/84 12:11:23	3071.38	74.19058	5.7389	0.2491	6.7459	0.1516	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 12:11:53	3071.88	73.31771	5.7497	0.2383	6.7459	0.1516	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 12:12:23	3072.38	72.46541	5.7497	0.2383	6.7568	0.1407	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 12:12:53	3072.88	71.63296	5.7497	0.2383	6.7568	0.1407	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:13:23	3073.38	70.81737	5.7606	0.2274	6.7459	0.1516	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:13:53	3073.88	70.02267	5.7606	0.2274	6.7676	0.1299	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 12:14:23	3074.38	69.24585	5.7822	0.2058	6.7568	0.1407	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:14:53	3074.88	68.48632	5.7606	0.2274	6.7784	0.1191	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:15:23	3075.38	67.7414	5.7714	0.2166	6.7784	0.1191	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 12:15:53	3075.88	67.01481	5.7822	0.2058	6.7676	0.1299	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 12:16:23	3076.38	66.30387	5.7822	0.2058	6.7784	0.1191	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 12:16:53	3076.88	65.60808	5.7822	0.2058	6.7568	0.1407	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:17:23	3077.38	64.92696	5.793	0.195	6.7676	0.1299	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 12:17:53	3077.88	64.25815	5.793	0.195	6.7676	0.1299	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:18:23	3078.38	63.60506	5.8039	0.1841	6.7676	0.1299	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:18:53	3078.88	62.96531	5.793	0.195	6.7784	0.1191	6.4211	0.0541	2.772	-0.0325	NA
4/10/84 12:19:23	3079.38	62.3385	5.8039	0.1841	6.7676	0.1299	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:19:53	3079.88	61.7225	5.8147	0.1733	6.7784	0.1191	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:20:23	3080.38	61.12046	5.793	0.195	6.7784	0.1191	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:20:53	3080.88	60.53024	5.8147	0.1733	6.8001	0.0974	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:21:23	3081.38	59.9515	5.8255	0.1625	6.7784	0.1191	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 12:21:53	3081.88	59.38391	5.8147	0.1733	6.7784	0.1191	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:22:23	3082.38	58.82555	5.8039	0.1841	6.7892	0.1083	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 12:22:53	3082.88	58.27932	5.8147	0.1733	6.8001	0.0974	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:23:23	3083.38	57.74333	5.8147	0.1733	6.7784	0.1191	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:23:53	3083.88	57.21726	5.8147	0.1733	6.8001	0.0974	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 12:24:23	3084.38	56.70087	5.8147	0.1733	6.8001	0.0974	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 12:24:53	3084.88	56.19242	5.8147	0.1733	6.7892	0.1083	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:25:23	3085.38	55.6946	5.8039	0.1841	6.7784	0.1191	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:25:53	3085.88	55.20568	5.8039	0.1841	6.8001	0.0974	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:26:23	3086.38	54.72542	5.8147	0.1733	6.8001	0.0974	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:26:53	3086.88	54.25225	5.8147	0.1733	6.7892	0.1083	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:27:23	3087.38	53.78866	5.8147	0.1733	6.7892	0.1083	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:27:53	3087.88	53.33308	5.8147	0.1733	6.8001	0.0974	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:28:23	3088.38	52.88529	5.8255	0.1625	6.8001	0.0974	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 12:28:53	3088.88	52.4451	5.8147	0.1733	6.7892	0.1083	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:29:23	3089.38	52.01108	5.8255	0.1625	6.8001	0.0974	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:29:53	3089.88	51.58554	5.8364	0.1516	6.8001	0.0974	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:30:23	3090.38	51.16704	5.8255	0.1625	6.8001	0.0974	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:30:53	3090.88	50.7554	5.8255	0.1625	6.8001	0.0974	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:31:23	3091.38	50.34931	5.8255	0.1625	6.8001	0.0974	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:31:53	3091.88	49.95094	5.8364	0.1516	6.8109	0.0866	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:32:23	3092.38	49.55894	5.8364	0.1516	6.8109	0.0866	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 12:32:53	3092.88	49.17317	5.8364	0.1516	6.8001	0.0974	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:33:23	3093.38	48.7924	5.8364	0.1516	6.8109	0.0866	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 12:33:53	3093.88	48.41867	5.8472	0.1408	6.8109	0.0866	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 12:34:23	3094.38	48.05074	5.8472	0.1408	6.8325	0.065	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:34:53	3094.88	47.68847	5.8472	0.1408	6.8001	0.0974	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:35:23	3095.38	47.33174	5.8472	0.1408	6.8109	0.0866	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 12:35:53	3095.88	46.97942	5.8472	0.1408	6.8109	0.0866	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:36:23	3096.38	46.6334	5.8472	0.1408	6.8001	0.0974	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:36:53	3096.88	46.29255	5.8688	0.1192	6.8109	0.0866	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:37:23	3097.38	45.95676	5.858	0.13	6.8109	0.0866	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:37:53	3097.88	45.62496	5.858	0.13	6.8217	0.0758	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:38:23	3098.38	45.29895	5.858	0.13	6.8109	0.0866	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 12:38:53	3098.88	44.97768	5.858	0.13	6.8217	0.0758	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:39:23	3099.38	44.66103	5.8688	0.1192	6.8217	0.0758	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:39:53	3099.88	44.34891	5.8688	0.1192	6.8217	0.0758	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 12:40:23	3100.38	44.04034	5.8688	0.1192	6.8109	0.0866	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 12:40:53	3100.88	43.737	5.8688	0.1192	6.8217	0.0758	6.4427	0.0325	2.7503	-0.0108	NA
4/10/84 12:41:23	3101.38	43.4379	5.858	0.13	6.8217	0.0758	6.4319	0.0433	2.772	-0.0325	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
4/10/84 12:41:53	3101.88	43.14296	5.8797	0.1083	6.8325	0.065	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 12:42:23	3102.38	42.85126	5.8688	0.1192	6.8325	0.065	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 12:42:53	3102.88	42.5644	5.8688	0.1192	6.8325	0.065	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 12:43:23	3103.38	42.28143	5.8905	0.0975	6.8325	0.065	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:43:53	3103.88	42.0023	5.8797	0.1083	6.8217	0.0758	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 12:44:23	3104.38	41.72691	5.858	0.13	6.8325	0.065	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:44:53	3104.88	41.45442	5.8797	0.1083	6.8217	0.0758	6.4536	0.0216	2.7937	-0.0542	NA
4/10/84 12:45:23	3105.38	41.18633	5.8797	0.1083	6.8325	0.065	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:45:53	3105.88	40.92176	5.8797	0.1083	6.8325	0.065	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 12:46:23	3106.38	40.66065	5.8797	0.1083	6.8325	0.065	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:46:53	3106.88	40.40293	5.8797	0.1083	6.8217	0.0758	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 12:47:23	3107.38	40.14782	5.8688	0.1192	6.8325	0.065	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 12:47:53	3107.88	39.8967	5.8797	0.1083	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:48:23	3108.38	39.64879	5.8905	0.0975	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:48:53	3108.88	39.40402	5.8905	0.0975	6.8325	0.065	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 12:49:23	3109.38	39.16163	5.8688	0.1192	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:49:53	3109.88	38.92297	5.8905	0.0975	6.8325	0.065	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 12:50:23	3110.38	38.68728	5.8905	0.0975	6.8325	0.065	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:50:53	3110.88	38.45449	5.8905	0.0975	6.8434	0.0541	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:51:23	3111.38	38.22457	5.8797	0.1083	6.8325	0.065	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:51:53	3111.88	37.9968	5.8905	0.0975	6.8434	0.0541	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 12:52:23	3112.38	37.77244	5.8797	0.1083	6.8434	0.0541	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 12:52:53	3112.88	37.55079	5.9013	0.0867	6.8434	0.0541	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 12:53:23	3113.38	37.3318	5.8905	0.0975	6.8217	0.0758	6.4319	0.0433	2.7503	-0.0108	NA
4/10/84 12:53:53	3113.88	37.11479	5.8797	0.1083	6.8325	0.065	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 12:54:23	3114.38	36.90097	5.9013	0.0867	6.8434	0.0541	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 12:54:53	3114.88	36.68967	5.8905	0.0975	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 12:55:23	3115.38	36.48084	5.8905	0.0975	6.8434	0.0541	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 12:55:53	3115.88	36.27386	5.9013	0.0867	6.8434	0.0541	6.4536	0.0216	2.7937	-0.0542	NA
4/10/84 12:56:23	3116.38	36.06985	5.9013	0.0867	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:56:53	3116.88	35.86819	5.9122	0.0758	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 12:57:23	3117.38	35.66884	5.8905	0.0975	6.8325	0.065	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 12:57:53	3117.88	35.47176	5.9013	0.0867	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 12:58:23	3118.38	35.27634	5.9013	0.0867	6.8325	0.065	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 12:58:53	3118.88	35.08368	5.9013	0.0867	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 12:59:23	3119.38	34.89317	5.9013	0.0867	6.8434	0.0541	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 12:59:53	3119.88	34.70478	5.9122	0.0758	6.8434	0.0541	6.4319	0.0433	2.7612	-0.0217	NA
4/10/84 13:00:23	3120.38	34.51794	5.9013	0.0867	6.8325	0.065	6.4427	0.0325	2.7503	-0.0108	NA
4/10/84 13:00:53	3120.88	34.33369	5.9122	0.0758	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:01:23	3121.38	34.15145	5.923	0.065	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 13:01:53	3121.88	33.9712	5.9122	0.0758	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 13:02:23	3122.38	33.79289	5.9122	0.0758	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:02:53	3122.88	33.616	5.9122	0.0758	6.8325	0.065	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:03:23	3123.38	33.4415	5.9122	0.0758	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:03:53	3123.88	33.26887	5.9122	0.0758	6.8542	0.0433	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 13:04:23	3124.38	33.09806	5.9338	0.0542	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:04:53	3124.88	32.92856	5.9122	0.0758	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:05:23	3125.38	32.76132	5.9122	0.0758	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:05:53	3125.88	32.59583	5.9122	0.0758	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:06:23	3126.38	32.43205	5.9122	0.0758	6.8434	0.0541	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 13:06:53	3126.88	32.26997	5.9122	0.0758	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:07:23	3127.38	32.10908	5.923	0.065	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:07:53	3127.88	31.9503	5.9122	0.0758	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:08:23	3128.38	31.79313	5.923	0.065	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:08:53	3128.88	31.63755	5.923	0.065	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:09:23	3129.38	31.48353	5.923	0.065	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 13:09:53	3129.88	31.33061	5.923	0.065	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:10:23	3130.38	31.17966	5.9122	0.0758	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 13:10:53	3130.88	31.0302	5.9122	0.0758	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 13:11:23	3131.38	30.88221	5.9122	0.0758	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 13:11:53	3131.88	30.73526	5.9338	0.0542	6.8434	0.0541	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 13:12:23	3132.38	30.59016	5.923	0.065	6.8434	0.0541	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 13:12:53	3132.88	30.44646	5.9122	0.0758	6.8434	0.0541	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 13:13:23	3133.38	30.30416	5.923	0.065	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:13:53	3133.88	30.16323	5.923	0.065	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 13:14:23	3134.38	30.02324	5.9338	0.0542	6.8434	0.0541	6.4319	0.0433	2.7503	-0.0108	NA
4/10/84 13:14:53	3134.88	29.88499	5.923	0.065	6.8434	0.0541	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 13:15:23	3135.38	29.74805	5.923	0.065	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:15:53	3135.88	29.6124	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:16:23	3136.38	29.47764	5.923	0.065	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 13:16:53	3136.88	29.34453	5.9122	0.0758	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:17:23	3137.38	29.21265	5.923	0.065	6.8434	0.0541	6.4211	0.0541	2.7612	-0.0217	NA
4/10/84 13:17:53	3137.88	29.082	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 13:18:23	3138.38	28.95218	5.923	0.065	6.8434	0.0541	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 13:18:53	3138.88	28.82392	5.9122	0.0758	6.865	0.0325	6.4319	0.0433	2.7503	-0.0108	NA
4/10/84 13:19:23	3139.38	28.69683	5.923	0.065	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 13:19:53	3139.88	28.5709	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7612	-0.0217	NA
4/10/84 13:20:23	3140.38	28.44611	5.9338	0.0542	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:20:53	3140.88	28.32209	5.9338	0.0542	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 13:21:23	3141.38	28.19953	5.923	0.065	6.8542	0.0433	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 13:21:53	3141.88	28.07808	5.9338	0.0542	6.8325	0.065	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:22:23	3142.38	27.9577	5.9338	0.0542	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:22:53	3142.88	27.83804	5.923	0.065	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
4/10/84 13:23:23	3143.38	27.71978	5.9338	0.0542	6.8542	0.0433	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 13:23:53	3143.88	27.60256	5.9446	0.0434	6.8434	0.0541	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:24:23	3144.38	27.48636	5.9338	0.0542	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:24:53	3144.88	27.37117	5.9338	0.0542	6.8434	0.0541	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:25:23	3145.38	27.25666	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:25:53	3145.88	27.14346	5.9338	0.0542	6.8542	0.0433	6.4103	0.0649	2.7828	-0.0433	NA
4/10/84 13:26:23	3146.38	27.03123	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:26:53	3146.88	26.91995	5.9446	0.0434	6.8542	0.0433	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 13:27:23	3147.38	26.80931	5.923	0.065	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:27:53	3147.88	26.69993	5.9338	0.0542	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:28:23	3148.38	26.59147	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:28:53	3148.88	26.48392	5.923	0.065	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:29:23	3149.38	26.37727	5.9446	0.0434	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:29:53	3149.88	26.2712	5.923	0.065	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:30:23	3150.38	26.16632	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:30:53	3150.88	26.06231	5.9338	0.0542	6.8542	0.0433	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 13:31:23	3151.38	25.95915	5.9446	0.0434	6.8325	0.065	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 13:31:53	3151.88	25.85684	5.923	0.065	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:32:23	3152.38	25.75507	5.9338	0.0542	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:32:53	3152.88	25.65442	5.9338	0.0542	6.8434	0.0541	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 13:33:23	3153.38	25.55458	5.923	0.065	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:33:53	3153.88	25.45556	5.9338	0.0542	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:34:23	3154.38	25.35704	5.9338	0.0542	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:34:53	3154.88	25.2596	5.9338	0.0542	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:35:23	3155.38	25.16293	5.9446	0.0434	6.8434	0.0541	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 13:35:53	3155.88	25.06703	5.9122	0.0758	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:36:23	3156.38	24.97188	5.9446	0.0434	6.8434	0.0541	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 13:36:53	3156.88	24.87722	5.9446	0.0434	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:37:23	3157.38	24.78357	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:37:53	3157.88	24.69065	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 13:38:23	3158.38	24.59845	5.9446	0.0434	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:38:53	3158.88	24.50671	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:39:23	3159.38	24.41594	5.9338	0.0542	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:39:53	3159.88	24.32586	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 13:40:23	3160.38	24.23648	5.9338	0.0542	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:40:53	3160.88	24.14752	5.9338	0.0542	6.8434	0.0541	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:41:23	3161.38	24.0595	5.9446	0.0434	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:41:53	3161.88	23.97214	5.9446	0.0434	6.865	0.0325	6.4103	0.0649	2.772	-0.0325	NA
4/10/84 13:42:23	3162.38	23.88544	5.9446	0.0434	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:42:53	3162.88	23.79939	5.9338	0.0542	6.8434	0.0541	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 13:43:23	3163.38	23.71375	5.9446	0.0434	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:43:53	3163.88	23.62898	5.9338	0.0542	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:44:23	3164.38	23.54485	5.9446	0.0434	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 13:44:53	3164.88	23.46134	5.9446	0.0434	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:45:23	3165.38	23.37821	5.9446	0.0434	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:45:53	3165.88	23.29593	5.9446	0.0434	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 13:46:23	3166.38	23.21425	5.9446	0.0434	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 13:46:53	3166.88	23.13317	5.9555	0.0325	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 13:47:23	3167.38	23.05268	5.9446	0.0434	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:47:53	3167.88	22.97254	5.9663	0.0217	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 13:48:23	3168.38	22.89321	5.9446	0.0434	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:48:53	3168.88	22.81445	5.9555	0.0325	6.8542	0.0433	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 13:49:23	3169.38	22.73625	5.9555	0.0325	6.8434	0.0541	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:49:53	3169.88	22.65839	5.9446	0.0434	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:50:23	3170.38	22.58131	5.9446	0.0434	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:50:53	3170.88	22.50477	5.9446	0.0434	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:51:23	3171.38	22.42878	5.9555	0.0325	6.8542	0.0433	6.4536	0.0216	2.7937	-0.0542	NA
4/10/84 13:51:53	3171.88	22.35332	5.9555	0.0325	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 13:52:23	3172.38	22.27817	5.9663	0.0217	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:52:53	3172.88	22.20377	5.9663	0.0217	6.8542	0.0433	6.4319	0.0433	2.7503	-0.0108	NA
4/10/84 13:53:23	3173.38	22.12988	5.9555	0.0325	6.8434	0.0541	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 13:53:53	3173.88	22.05651	5.9663	0.0217	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:54:23	3174.38	21.98365	5.9555	0.0325	6.8542	0.0433	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 13:54:53	3174.88	21.91107	5.9555	0.0325	6.865	0.0325	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 13:55:23	3175.38	21.83921	5.9663	0.0217	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:55:53	3175.88	21.76784	5.9446	0.0434	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:56:23	3176.38	21.69696	5.9555	0.0325	6.865	0.0325	6.4536	0.0216	2.7937	-0.0542	NA
4/10/84 13:56:53	3176.88	21.62635	5.9555	0.0325	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:57:23	3177.38	21.55643	5.9663	0.0217	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:57:53	3177.88	21.48698	5.9555	0.0325	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 13:58:23	3178.38	21.41799	5.9663	0.0217	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 13:58:53	3178.88	21.34947	5.9771	0.0109	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 13:59:23	3179.38	21.28122	5.9555	0.0325	6.865	0.0325	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 13:59:53	3179.88	21.21361	5.9771	0.0109	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:00:23	3180.38	21.14645	5.9555	0.0325	6.8759	0.0216	6.4319	0.0433	2.7612	-0.0217	NA
4/10/84 14:00:53	3180.88	21.07974	5.9555	0.0325	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:01:23	3181.38	21.01328	5.9771	0.0109	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:01:53	3181.88	20.94744	5.9663	0.0217	6.8542	0.0433	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 14:02:53	3182.88	20.81706	5.9771	0.0109	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:03:23	3183.38	20.75233	5.9555	0.0325	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:03:53	3183.88	20.68819	5.9663	0.0217	6.865	0.0325	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 14:04:23	3184.38	20.62448	5.9446	0.0434	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:04:53	3184.88	20.56117	5.9663	0.0217	6.8542	0.0433	6.4427	0.0325	2.7937	-0.0542	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
4/10/84 14:05:23	3185.38	20.49827	5.9663	0.0217	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:05:53	3185.88	20.4356	5.9771	0.0109	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:06:23	3186.38	20.3735	5.9771	0.0109	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:06:53	3186.88	20.3118	5.9663	0.0217	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:07:23	3187.38	20.25049	5.9555	0.0325	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:07:53	3187.88	20.1894	5.9555	0.0325	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:08:23	3188.38	20.12886	5.9771	0.0109	6.8434	0.0541	6.4536	0.0216	2.7937	-0.0542	NA
4/10/84 14:08:53	3188.88	20.06871	5.9663	0.0217	6.8542	0.0433	6.4319	0.0433	2.7937	-0.0542	NA
4/10/84 14:09:23	3189.38	20.00893	5.9771	0.0109	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:09:53	3189.88	19.94953	5.9663	0.0217	6.8542	0.0433	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 14:10:23	3190.38	19.89033	5.9771	0.0109	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:10:53	3190.88	19.83166	5.988	0	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:11:23	3191.38	19.77336	5.988	0	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:11:53	3191.88	19.71542	5.988	0	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:12:23	3192.38	19.65767	5.988	0	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:12:53	3192.88	19.60044	5.988	0	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:13:23	3193.38	19.54356	5.988	0	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:13:53	3193.88	19.48702	5.9663	0.0217	6.8434	0.0541	6.4319	0.0433	2.7612	-0.0217	NA
4/10/84 14:14:23	3194.38	19.43083	5.9663	0.0217	6.8542	0.0433	6.4211	0.0541	2.7828	-0.0433	NA
4/10/84 14:14:53	3194.88	19.37482	5.988	0	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 14:15:23	3195.38	19.31931	5.9663	0.0217	6.8434	0.0541	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:15:53	3195.88	19.26413	5.9663	0.0217	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 14:16:23	3196.38	19.20929	5.988	0	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:16:53	3196.88	19.15477	5.988	0	6.8759	0.0216	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:17:23	3197.38	19.10042	5.9771	0.0109	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 14:17:53	3197.88	19.04655	5.9663	0.0217	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:18:23	3198.38	18.99301	5.9771	0.0109	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:18:53	3198.88	18.93977	5.988	0	6.8542	0.0433	6.4536	0.0216	2.7503	-0.0108	NA
4/10/84 14:19:23	3199.38	18.8867	5.988	0	6.865	0.0325	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 14:19:53	3199.88	18.8341	5.9771	0.0109	6.865	0.0325	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:20:23	3200.38	18.7818	5.988	0	6.865	0.0325	6.4319	0.0433	2.7612	-0.0217	NA
4/10/84 14:20:53	3200.88	18.72981	5.9663	0.0217	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:21:23	3201.38	18.67812	5.988	0	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:21:53	3201.88	18.62659	5.9771	0.0109	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:22:23	3202.38	18.5755	5.9771	0.0109	6.8759	0.0216	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:22:53	3202.88	18.5247	5.9663	0.0217	6.865	0.0325	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:23:23	3203.38	18.4742	5.988	0	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:23:53	3203.88	18.42385	5.9771	0.0109	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:24:23	3204.38	18.37392	5.988	0	6.865	0.0325	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:24:53	3204.88	18.32429	5.9771	0.0109	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:25:23	3205.38	18.27493	5.9771	0.0109	6.865	0.0325	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:25:53	3205.88	18.22572	5.988	0	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:26:23	3206.38	18.17692	5.9771	0.0109	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:26:53	3206.88	18.1284	5.9663	0.0217	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:27:23	3207.38	18.08016	5.9663	0.0217	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:27:53	3207.88	18.03218	5.9663	0.0217	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:28:23	3208.38	17.98434	5.988	0	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:28:53	3208.88	17.9369	5.988	0	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:29:23	3209.38	17.88973	5.9771	0.0109	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:29:53	3209.88	17.84281	5.988	0	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:30:23	3210.38	17.79603	5.9771	0.0109	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:30:53	3210.88	17.74963	5.9771	0.0109	6.865	0.0325	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 14:31:23	3211.38	17.7035	5.988	0	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:31:53	3211.88	17.65761	5.9771	0.0109	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:32:23	3212.38	17.61198	5.9663	0.0217	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:32:53	3212.88	17.56646	5.988	0	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:33:23	3213.38	17.52133	5.9771	0.0109	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:33:53	3213.88	17.47643	5.988	0	6.8434	0.0541	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 14:34:23	3214.38	17.43179	5.988	0	6.8434	0.0541	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:34:53	3214.88	17.38725	5.988	0	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:35:23	3215.38	17.34309	5.988	0	6.8434	0.0541	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:35:53	3215.88	17.29916	5.988	0	6.8434	0.0541	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 14:36:23	3216.38	17.25546	5.9988	-0.0108	6.8434	0.0541	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 14:36:53	3216.88	17.212	5.9988	-0.0108	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:37:23	3217.38	17.16865	5.988	0	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:37:53	3217.88	17.12565	5.9663	0.0217	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 14:38:23	3218.38	17.08288	5.9988	-0.0108	6.8542	0.0433	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 14:38:53	3218.88	17.04034	5.9771	0.0109	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:39:23	3219.38	16.99802	5.9771	0.0109	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:39:53	3219.88	16.95581	5.988	0	6.8542	0.0433	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:40:23	3220.38	16.91393	5.9771	0.0109	6.865	0.0325	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:40:53	3220.88	16.87228	5.9988	-0.0108	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:41:23	3221.38	16.83084	5.988	0	6.8434	0.0541	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:41:53	3221.88	16.7895	5.988	0	6.8542	0.0433	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 14:42:23	3222.38	16.74849	5.988	0	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:42:53	3222.88	16.7077	5.9771	0.0109	6.8542	0.0433	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:43:23	3223.38	16.66711	5.988	0	6.865	0.0325	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:43:53	3223.88	16.62674	5.988	0	6.8542	0.0433	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:44:23	3224.38	16.58646	5.9771	0.0109	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:44:53	3224.88	16.5465	5.9771	0.0109	6.865	0.0325	6.4319	0.0433	2.7612	-0.0217	NA
4/10/84 14:45:23	3225.38	16.50674	5.9771	0.0109	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:45:53	3225.88	16.46719	5.988	0	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:46:23	3226.38	16.42772	5.988	0	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

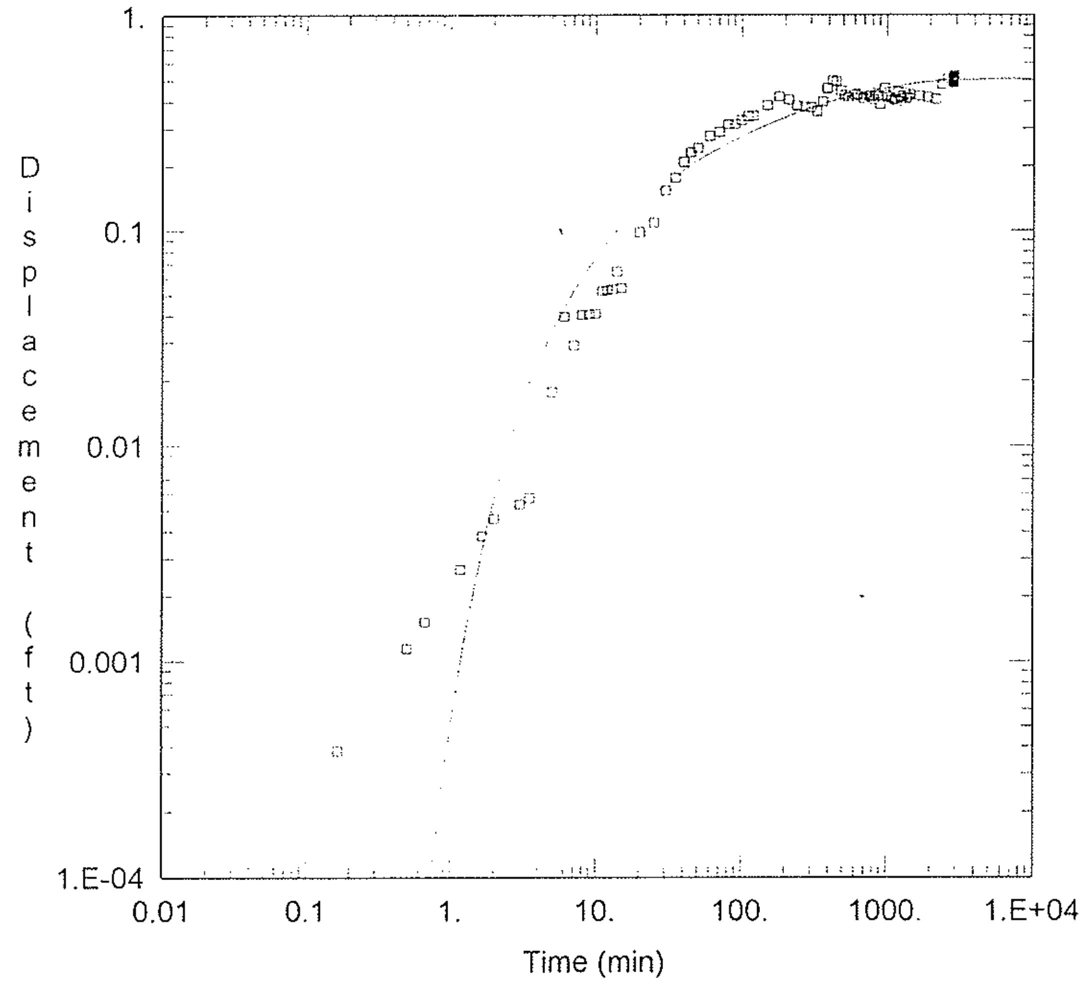
Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
4/10/84 14:46:53	3226.88	16.38857	5.9771	0.0109	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:47:23	3227.38	16.34962	5.9771	0.0109	6.8759	0.0216	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:47:53	3227.88	16.31086	5.988	0	6.865	0.0325	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:48:23	3228.38	16.27219	5.988	0	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:48:53	3228.88	16.23382	5.9988	-0.0108	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:49:23	3229.38	16.19564	5.988	0	6.865	0.0325	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 14:49:53	3229.88	16.15766	5.9988	-0.0108	6.8542	0.0433	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:50:23	3230.38	16.11986	5.988	0	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:50:53	3230.88	16.08215	5.9771	0.0109	6.8759	0.0216	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:51:23	3231.38	16.04473	5.9771	0.0109	6.865	0.0325	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 14:51:53	3231.88	16.0075	5.988	0	6.865	0.0325	6.4427	0.0325	2.7503	-0.0108	NA
4/10/84 14:52:23	3232.38	15.97045	5.9771	0.0109	6.865	0.0325	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:52:53	3232.88	15.93347	5.988	0	6.8759	0.0216	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 14:53:23	3233.38	15.89679	5.9988	-0.0108	6.8759	0.0216	6.4319	0.0433	2.7612	-0.0217	NA
4/10/84 14:53:53	3233.88	15.86028	5.9988	-0.0108	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:54:23	3234.38	15.82395	5.9988	-0.0108	6.865	0.0325	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:54:53	3234.88	15.7878	5.988	0	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:55:23	3235.38	15.75172	5.988	0	6.865	0.0325	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 14:55:53	3235.88	15.71592	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:56:23	3236.38	15.68029	5.988	0	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 14:56:53	3236.88	15.64484	5.988	0	6.8759	0.0216	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 14:57:23	3237.38	15.60946	5.988	0	6.8759	0.0216	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 14:57:53	3237.88	15.57434	5.988	0	6.8759	0.0216	6.4536	0.0216	2.7937	-0.0542	NA
4/10/84 14:58:23	3238.38	15.5394	5.988	0	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:58:53	3238.88	15.50462	5.988	0	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 14:59:23	3239.38	15.47001	5.988	0	6.865	0.0325	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 14:59:53	3239.88	15.43546	5.9771	0.0109	6.8759	0.0216	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:00:23	3240.38	15.40118	5.988	0	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:00:53	3240.88	15.36706	5.988	0	6.8759	0.0216	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:01:23	3241.38	15.3331	5.988	0	6.865	0.0325	6.4536	0.0216	2.7503	-0.0108	NA
4/10/84 15:01:53	3241.88	15.2993	5.9988	-0.0108	6.865	0.0325	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 15:02:23	3242.38	15.26556	5.988	0	6.8759	0.0216	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:02:53	3242.88	15.23208	5.988	0	6.865	0.0325	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 15:03:23	3243.38	15.19875	5.988	0	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:03:53	3243.88	15.16559	5.988	0	6.8542	0.0433	6.4319	0.0433	2.7828	-0.0433	NA
4/10/84 15:04:23	3244.38	15.13248	5.988	0	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:04:53	3244.88	15.09961	5.988	0	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:05:23	3245.38	15.06691	5.988	0	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:05:53	3245.88	15.03435	5.988	0	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:06:23	3246.38	15.00194	5.988	0	6.865	0.0325	6.4644	0.0108	2.7612	-0.0217	NA
4/10/84 15:06:53	3246.88	14.96959	5.9771	0.0109	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:07:23	3247.38	14.93748	5.988	0	6.8759	0.0216	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 15:07:53	3247.88	14.90552	5.988	0	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 15:08:23	3248.38	14.87371	5.9988	-0.0108	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:08:53	3248.88	14.84195	5.9988	-0.0108	6.865	0.0325	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 15:09:23	3249.38	14.81042	5.9988	-0.0108	6.8759	0.0216	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:09:53	3249.88	14.77904	5.988	0	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:10:23	3250.38	14.7478	5.988	0	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:10:53	3250.88	14.71661	5.9988	-0.0108	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:11:23	3251.38	14.68566	5.988	0	6.865	0.0325	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 15:11:53	3251.88	14.65484	5.9988	-0.0108	6.865	0.0325	6.4644	0.0108	2.7612	-0.0217	NA
4/10/84 15:12:23	3252.38	14.62416	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 15:12:53	3252.88	14.59362	5.988	0	6.8867	0.0108	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:13:23	3253.38	14.56312	5.988	0	6.865	0.0325	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:13:53	3253.88	14.53286	5.988	0	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:14:23	3254.38	14.50272	5.988	0	6.8759	0.0216	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:14:53	3254.88	14.47272	5.988	0	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 15:15:23	3255.38	14.44277	5.9988	-0.0108	6.865	0.0325	6.4536	0.0216	2.7937	-0.0542	NA
4/10/84 15:15:53	3255.88	14.41303	5.9988	-0.0108	6.865	0.0325	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 15:16:23	3256.38	14.38343	5.988	0	6.865	0.0325	6.4644	0.0108	2.7937	-0.0542	NA
4/10/84 15:16:53	3256.88	14.35396	5.9988	-0.0108	6.865	0.0325	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 15:17:23	3257.38	14.32461	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:17:53	3257.88	14.29531	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.7937	-0.0542	NA
4/10/84 15:18:23	3258.38	14.26623	5.988	0	6.865	0.0325	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 15:18:53	3258.88	14.23727	5.9988	-0.0108	6.865	0.0325	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 15:19:23	3259.38	14.20843	5.9988	-0.0108	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 15:19:53	3259.88	14.17964	5.988	0	6.8867	0.0108	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 15:20:23	3260.38	14.15106	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:20:53	3260.88	14.1226	5.988	0	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:21:23	3261.38	14.09426	5.988	0	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 15:21:53	3261.88	14.06605	5.9988	-0.0108	6.865	0.0325	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 15:22:23	3262.38	14.03787	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:22:53	3262.88	14.0099	5.988	0	6.865	0.0325	6.4644	0.0108	2.7612	-0.0217	NA
4/10/84 15:23:23	3263.38	13.98205	6.0096	-0.0216	6.865	0.0325	6.4752	0	2.772	-0.0325	NA
4/10/84 15:23:53	3263.88	13.95431	5.988	0	6.8759	0.0216	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 15:24:23	3264.38	13.9267	5.9988	-0.0108	6.8867	0.0108	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:24:53	3264.88	13.89912	5.988	0	6.865	0.0325	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 15:25:23	3265.38	13.87166	5.988	0	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 15:26:23	3266.38	13.81732	5.988	0	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:27:23	3267.38	13.76329	5.988	0	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 15:28:23	3268.38	13.70979	5.9988	-0.0108	6.8759	0.0216	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:29:23	3269.38	13.65665	5.9988	-0.0108	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 15:30:23	3270.38	13.60404	5.9988	-0.0108	6.865	0.0325	6.4427	0.0325	2.772	-0.0325	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1 Feet of Water Above Transducer	RW-1 Drawdown (ft)	PZ-9 Feet of Water Above Transducer	PZ-9 Drawdown (ft)	PZ-10 Feet of Water Above Transducer	PZ-10 Drawdown (ft)	PZ-2 Feet of Water Above Transducer	PZ-2 Drawdown (ft)	Delta H; Groundwater Correction From Background Well
4/10/84 15:31:23	3271.38	13.55178	5.988	0	6.865	0.0325	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 15:32:23	3272.38	13.50004	5.9988	-0.0108	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:33:23	3273.38	13.44864	6.0096	-0.0216	6.865	0.0325	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:34:23	3274.38	13.39774	5.9988	-0.0108	6.8867	0.0108	6.4644	0.0108	2.7612	-0.0217	NA
4/10/84 15:35:23	3275.38	13.34725	5.9988	-0.0108	6.865	0.0325	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:36:23	3276.38	13.2971	5.9988	-0.0108	6.865	0.0325	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 15:37:23	3277.38	13.24742	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:38:23	3278.38	13.19808	5.9988	-0.0108	6.865	0.0325	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 15:39:23	3279.38	13.1492	5.988	0	6.8867	0.0108	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:40:23	3280.38	13.10064	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:41:23	3281.38	13.05254	6.0096	-0.0216	6.8867	0.0108	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:42:23	3282.38	13.00475	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:43:23	3283.38	12.9574	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:44:23	3284.38	12.91043	6.0096	-0.0216	6.8759	0.0216	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:45:23	3285.38	12.86376	5.988	0	6.865	0.0325	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:46:23	3286.38	12.81752	5.9988	-0.0108	6.8759	0.0216	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:47:23	3287.38	12.77157	6.0096	-0.0216	6.8867	0.0108	6.4427	0.0325	2.7503	-0.0108	NA
4/10/84 15:48:23	3288.38	12.72604	5.9988	-0.0108	6.8975	0	6.4427	0.0325	2.7503	-0.0108	NA
4/10/84 15:49:23	3289.38	12.6808	5.9988	-0.0108	6.8867	0.0108	6.4752	0	2.7828	-0.0433	NA
4/10/84 15:50:23	3290.38	12.63597	6.0096	-0.0216	6.8867	0.0108	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:51:23	3291.38	12.59149	5.9988	-0.0108	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:52:23	3292.38	12.54728	5.9988	-0.0108	6.8867	0.0108	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 15:53:23	3293.38	12.50346	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 15:54:23	3294.38	12.45992	6.0096	-0.0216	6.8759	0.0216	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 15:55:23	3295.38	12.41677	5.9988	-0.0108	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 15:56:23	3296.38	12.37388	5.9988	-0.0108	6.9083	-0.0108	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 15:57:23	3297.38	12.33137	6.0096	-0.0216	6.8867	0.0108	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 15:58:23	3298.38	12.28912	5.9988	-0.0108	6.8867	0.0108	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 15:59:23	3299.38	12.24724	6.0096	-0.0216	6.8975	0	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 16:00:23	3300.38	12.20561	5.9988	-0.0108	6.8975	0	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 16:01:23	3301.38	12.16435	5.9988	-0.0108	6.8975	0	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:02:23	3302.38	12.12339	6.0096	-0.0216	6.8975	0	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:03:23	3303.38	12.08267	6.0096	-0.0216	6.865	0.0325	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:04:23	3304.38	12.04231	6.0096	-0.0216	6.8867	0.0108	6.4644	0.0108	2.7612	-0.0217	NA
4/10/84 16:05:23	3305.38	12.00218	5.9988	-0.0108	6.8867	0.0108	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 16:06:23	3306.38	11.9624	6.0096	-0.0216	6.8759	0.0216	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 16:07:23	3307.38	11.92285	6.0096	-0.0216	6.8759	0.0216	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:08:23	3308.38	11.88364	6.0204	-0.0324	6.8867	0.0108	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:09:23	3309.38	11.84471	6.0096	-0.0216	6.8867	0.0108	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 16:10:23	3310.38	11.806	6.0096	-0.0216	6.8975	0	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 16:11:23	3311.38	11.76763	6.0096	-0.0216	6.8867	0.0108	6.4644	0.0108	2.7937	-0.0542	NA
4/10/84 16:12:23	3312.38	11.72947	6.0204	-0.0324	6.8867	0.0108	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 16:13:23	3313.38	11.69163	6.0204	-0.0324	6.8759	0.0216	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 16:14:23	3314.38	11.65401	6.0204	-0.0324	6.8759	0.0216	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 16:15:23	3315.38	11.6167	6.0096	-0.0216	6.8975	0	6.4427	0.0325	2.7503	-0.0108	NA
4/10/84 16:16:23	3316.38	11.5796	6.0096	-0.0216	6.865	0.0325	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:17:23	3317.38	11.54281	5.9988	-0.0108	6.8867	0.0108	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 16:18:23	3318.38	11.50623	6.0204	-0.0324	6.8867	0.0108	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 16:19:23	3319.38	11.46995	6.0096	-0.0216	6.8867	0.0108	6.4427	0.0325	2.7503	-0.0108	NA
4/10/84 16:20:23	3320.38	11.43392	6.0204	-0.0324	6.8975	0	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:21:23	3321.38	11.39808	6.0096	-0.0216	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 16:22:23	3322.38	11.36254	6.0096	-0.0216	6.8975	0	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 16:23:23	3323.38	11.3272	6.0204	-0.0324	6.8975	0	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:24:23	3324.38	11.29214	6.0313	-0.0433	6.8867	0.0108	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:25:23	3325.38	11.25727	6.0204	-0.0324	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 16:26:23	3326.38	11.22269	6.0204	-0.0324	6.8867	0.0108	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:27:23	3327.38	11.18829	6.0096	-0.0216	6.8975	0	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:28:23	3328.38	11.15416	5.9988	-0.0108	6.8975	0	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:29:23	3329.38	11.12027	6.0204	-0.0324	6.8975	0	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 16:30:23	3330.38	11.08655	6.0096	-0.0216	6.8867	0.0108	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:31:23	3331.38	11.05311	6.0313	-0.0433	6.8975	0	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 16:32:23	3332.38	11.01984	6.0096	-0.0216	6.8867	0.0108	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:33:23	3333.38	10.98683	6.0204	-0.0324	6.8759	0.0216	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:34:23	3334.38	10.954	6.0096	-0.0216	6.8975	0	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:35:23	3335.38	10.92143	6.0204	-0.0324	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 16:36:23	3336.38	10.88907	5.9988	-0.0108	6.8759	0.0216	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 16:37:23	3337.38	10.85687	6.0204	-0.0324	6.8975	0	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:38:23	3338.38	10.82493	6.0096	-0.0216	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 16:39:23	3339.38	10.79315	6.0204	-0.0324	6.8867	0.0108	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:40:23	3340.38	10.76162	6.0204	-0.0324	6.865	0.0325	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 16:41:23	3341.38	10.73025	6.0204	-0.0324	6.8975	0	6.4427	0.0325	2.7937	-0.0542	NA
4/10/84 16:42:23	3342.38	10.69912	6.0204	-0.0324	6.8867	0.0108	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:43:23	3343.38	10.66815	5.9988	-0.0108	6.8975	0	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:44:23	3344.38	10.63741	6.0204	-0.0324	6.8975	0	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 16:45:23	3345.38	10.60683	6.0096	-0.0216	6.8867	0.0108	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 16:46:23	3346.38	10.57649	6.0096	-0.0216	6.8867	0.0108	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 16:47:23	3347.38	10.54634	6.0204	-0.0324	6.8759	0.0216	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:48:23	3348.38	10.51633	5.9988	-0.0108	6.8759	0.0216	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 16:49:23	3349.38	10.48656	6.0204	-0.0324	6.8975	0	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 16:50:23	3350.38	10.45692	6.0096	-0.0216	6.865	0.0325	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 16:51:23	3351.38	10.42752	6.0204	-0.0324	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 16:52:23	3352.38	10.39825	6.0096	-0.0216	6.8867	0.0108	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 16:53:23	3353.38	10.36921	6.0096	-0.0216	6.8867	0.0108	6.4427	0.0325	2.7503	-0.0108	NA

Table E-2 Gasworks Park Pump/Recovery Test Data

Date/Time	Total Elapsed Time (min)	T/T': (recovery test only)	RW-1		PZ-9		PZ-10		PZ-2		Delta H;
			Feet of Water Above Transducer	Drawdown (ft)	Feet of Water Above Transducer	Drawdown (ft)	Feet of Water Above Transducer	Drawdown (ft)	Feet of Water Above Transducer	Drawdown (ft)	Groundwater Correction From Background Well
4/10/84 16:54:23	3354.38	10.34035	6.0204	-0.0324	6.8867	0.0108	6.4536	0.0216	2.7828	-0.0433	NA
4/10/84 16:55:23	3355.38	10.31162	6.0096	-0.0216	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 16:56:23	3356.38	10.28311	6.0204	-0.0324	6.865	0.0325	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 16:57:23	3357.38	10.25473	6.0204	-0.0324	6.8759	0.0216	6.4644	0.0108	2.7828	-0.0433	NA
4/10/84 16:58:23	3358.38	10.22657	6.0096	-0.0216	6.8759	0.0216	6.4536	0.0216	2.7503	-0.0108	NA
4/10/84 16:59:23	3359.38	10.19854	6.0096	-0.0216	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 17:00:23	3360.38	10.17071	6.0096	-0.0216	6.8975	0	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 17:01:23	3361.38	10.14302	6.0204	-0.0324	6.8759	0.0216	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 17:02:23	3362.38	10.11553	6.0204	-0.0324	6.8759	0.0216	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 17:03:23	3363.38	10.08817	6.0096	-0.0216	6.865	0.0325	6.4319	0.0433	2.772	-0.0325	NA
4/10/84 17:04:23	3364.38	10.06101	6.0204	-0.0324	6.8867	0.0108	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 17:05:23	3365.38	10.03401	6.0204	-0.0324	6.8759	0.0216	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 17:06:23	3366.38	10.00713	6.0096	-0.0216	6.8759	0.0216	6.4536	0.0216	2.7395	0	NA
4/10/84 17:07:23	3367.38	9.980453	6.0204	-0.0324	6.865	0.0325	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 17:08:23	3368.38	9.953893	6.0204	-0.0324	6.8867	0.0108	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 17:09:23	3369.38	9.927529	6.0204	-0.0324	6.8867	0.0108	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 17:10:23	3370.38	9.901281	6.0204	-0.0324	6.8759	0.0216	6.4536	0.0216	2.7503	-0.0108	NA
4/10/84 17:11:23	3371.38	9.875225	6.0096	-0.0216	6.8759	0.0216	6.4427	0.0325	2.7612	-0.0217	NA
4/10/84 17:12:23	3372.38	9.849283	6.0313	-0.0433	6.8867	0.0108	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 17:13:23	3373.38	9.82353	6.0204	-0.0324	6.8759	0.0216	6.4644	0.0108	2.7612	-0.0217	NA
4/10/84 17:14:23	3374.38	9.797926	6.0204	-0.0324	6.8867	0.0108	6.4644	0.0108	2.7612	-0.0217	NA
4/10/84 17:15:24	3375.38	9.772397	6.0204	-0.0324	6.8867	0.0108	6.4752	0	2.7612	-0.0217	NA
4/10/84 17:20:23	3380.38	9.647264	6.0313	-0.0433	6.8867	0.0108	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 17:25:23	3385.38	9.525615	6.0313	-0.0433	6.8975	0	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 17:30:23	3390.38	9.407309	6.0204	-0.0324	6.8867	0.0108	6.4644	0.0108	2.772	-0.0325	NA
4/10/84 17:35:23	3395.38	9.292273	6.0313	-0.0433	6.8759	0.0216	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 17:40:23	3400.38	9.180343	6.0313	-0.0433	6.8975	0	6.4536	0.0216	2.7612	-0.0217	NA
4/10/84 17:45:23	3405.38	9.071394	6.0421	-0.0541	6.8867	0.0108	6.4427	0.0325	2.772	-0.0325	NA
4/10/84 17:50:23	3410.38	8.96531	6.0096	-0.0216	6.9083	-0.0108	6.4536	0.0216	2.772	-0.0325	NA
4/10/84 17:55:23	3415.38	8.861948	6.0204	-0.0324	6.8975	0	6.4752	0	2.772	-0.0325	NA
4/10/84 18:00:23	3420.38	8.761263	6.0313	-0.0433	6.8975	0	6.4644	0.0108	2.7612	-0.0217	NA
4/10/84 18:05:23	3425.38	8.663124	6.0204	-0.0324	6.8975	0	6.4427	0.0325	2.7828	-0.0433	NA
4/10/84 18:10:23	3430.38	8.567437	6.0313	-0.0433	6.8867	0.0108	6.4644	0.0108	2.7612	-0.0217	NA
4/10/84 18:15:23	3435.38	8.474082	6.0313	-0.0433	6.9192	-0.0217	6.4752	0	2.772	-0.0325	NA
4/10/84 18:20:23	3440.38	8.383029	6.0313	-0.0433	6.9083	-0.0108	6.4644	0.0108	2.772	-0.0325	NA



GASWORKS PARK PUMP TEST - PZ-9

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\PZ-9_COR.AQT
Date: 06/22/98 Time: 13:02:22

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

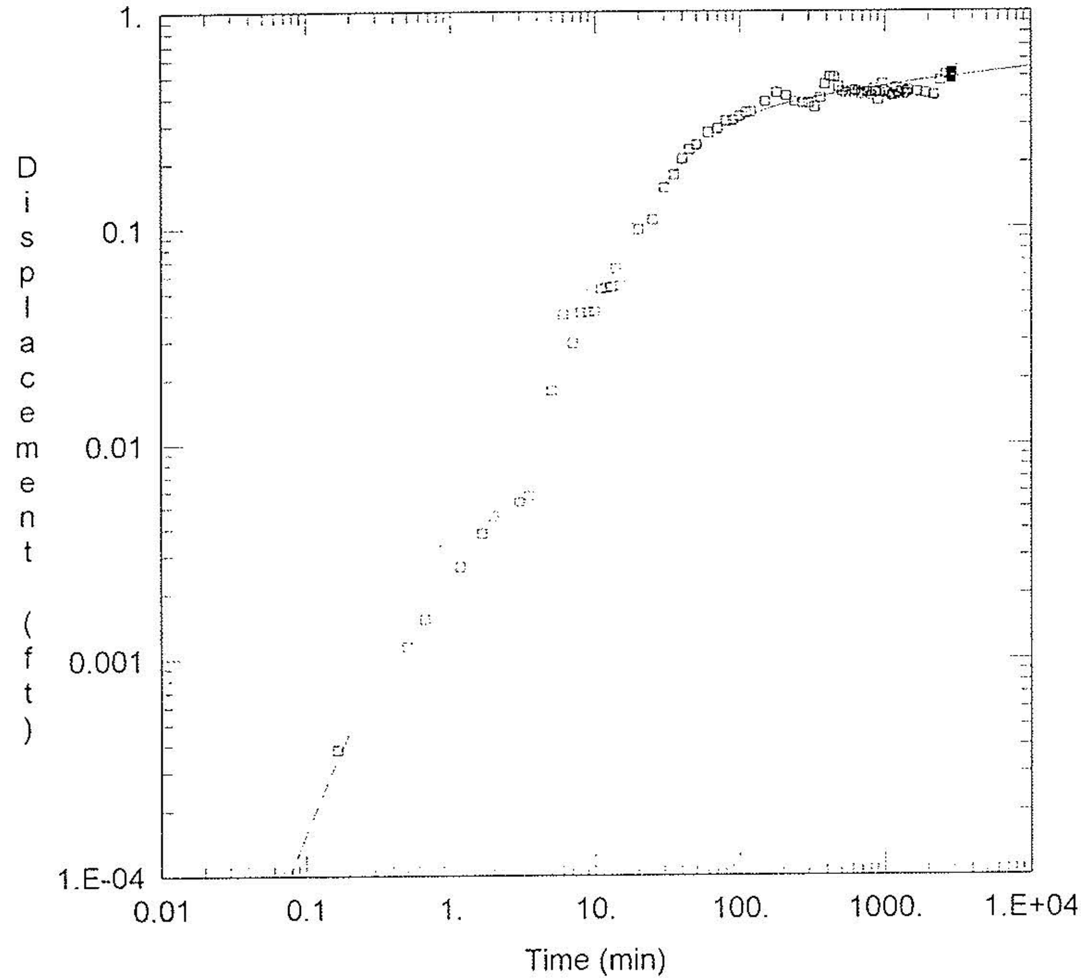
Observation Wells

Well Name	X (ft)	Y (ft)
▫ PZ-9	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 37.7 ft^2/day
S = 0.002043
r/B = 0.09346



GASWORKS PARK PUMP TEST - PZ-9

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\PZ-9_COR.AQT
Date: 06/22/98 Time: 13:03:45

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

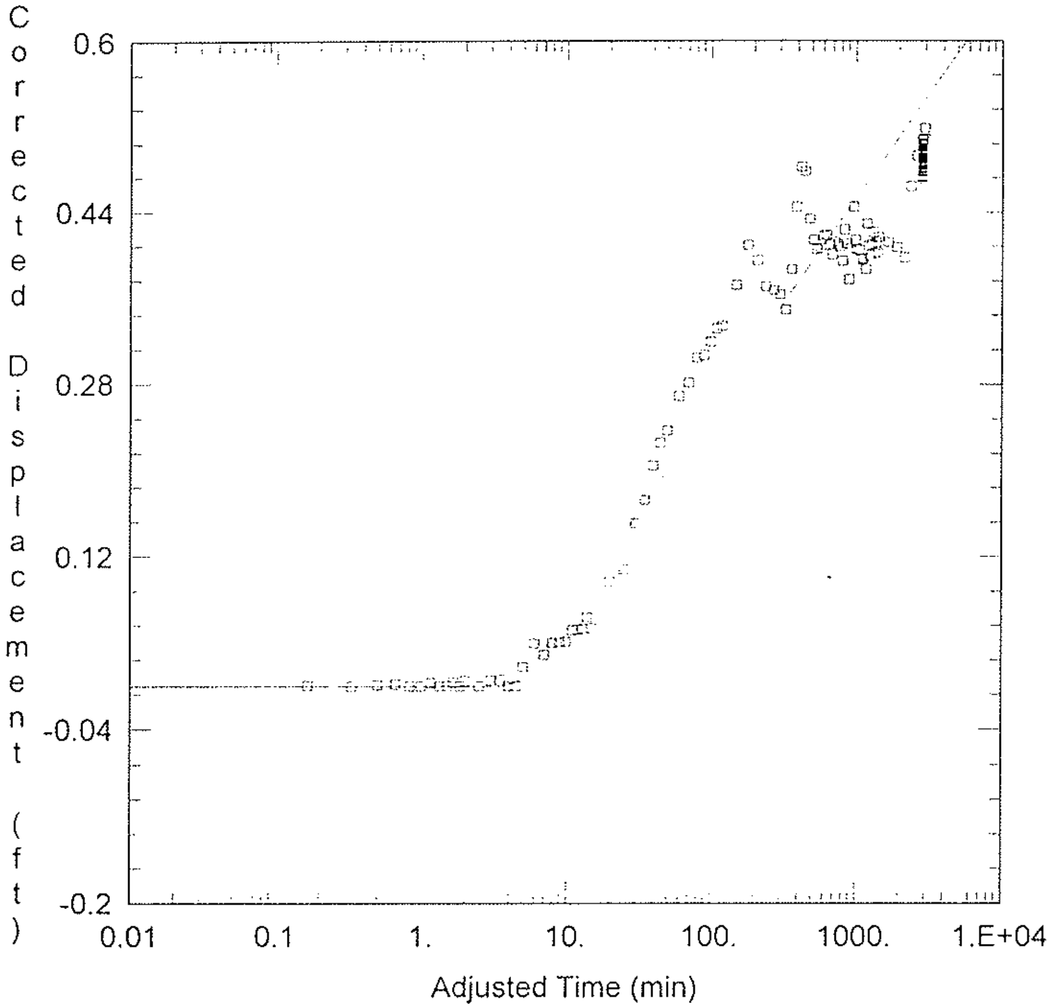
Observation Wells

Well Name	X (ft)	Y (ft)
▫ PZ-9	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Leaky
Solution Method: Moench

T = 90.41 ft^2/day
S = 1.665E-05
r/B = 0.0002013
ß = 1.E-05
Sw = 6.819
Rw = 3.484E-05 ft



GASWORKS PARK PUMP TEST - PZ-9

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\PZ-9_COR.AQT
Date: 06/22/98 Time: 13:05:46

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

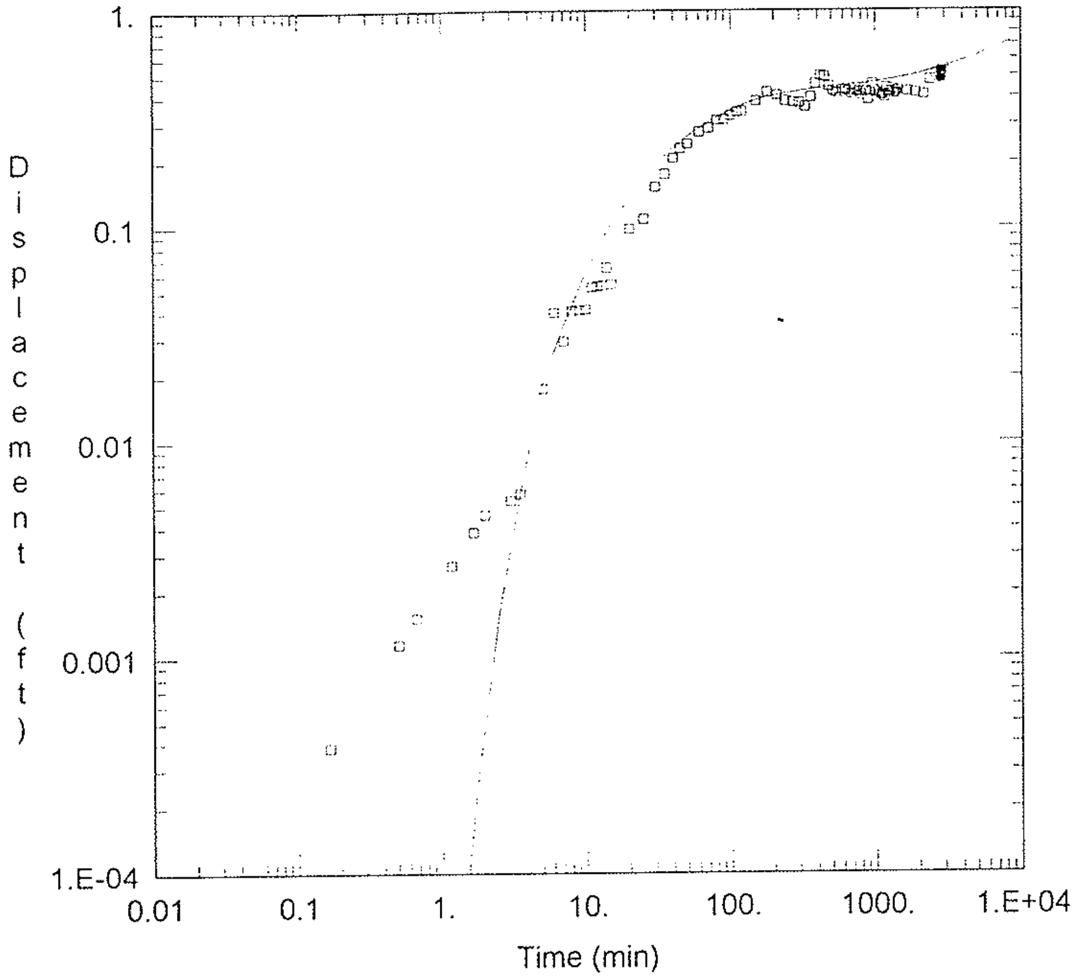
Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005	▫ PZ-9	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Unconfined T = 45.39 ft^2/day
Solution Method: Cooper-Jacob S = 0.001709



GASWORKS PARK PUMP TEST - PZ-9

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\PZ-9_COR.AQT
Date: 06/22/98 Time: 13:08:15

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

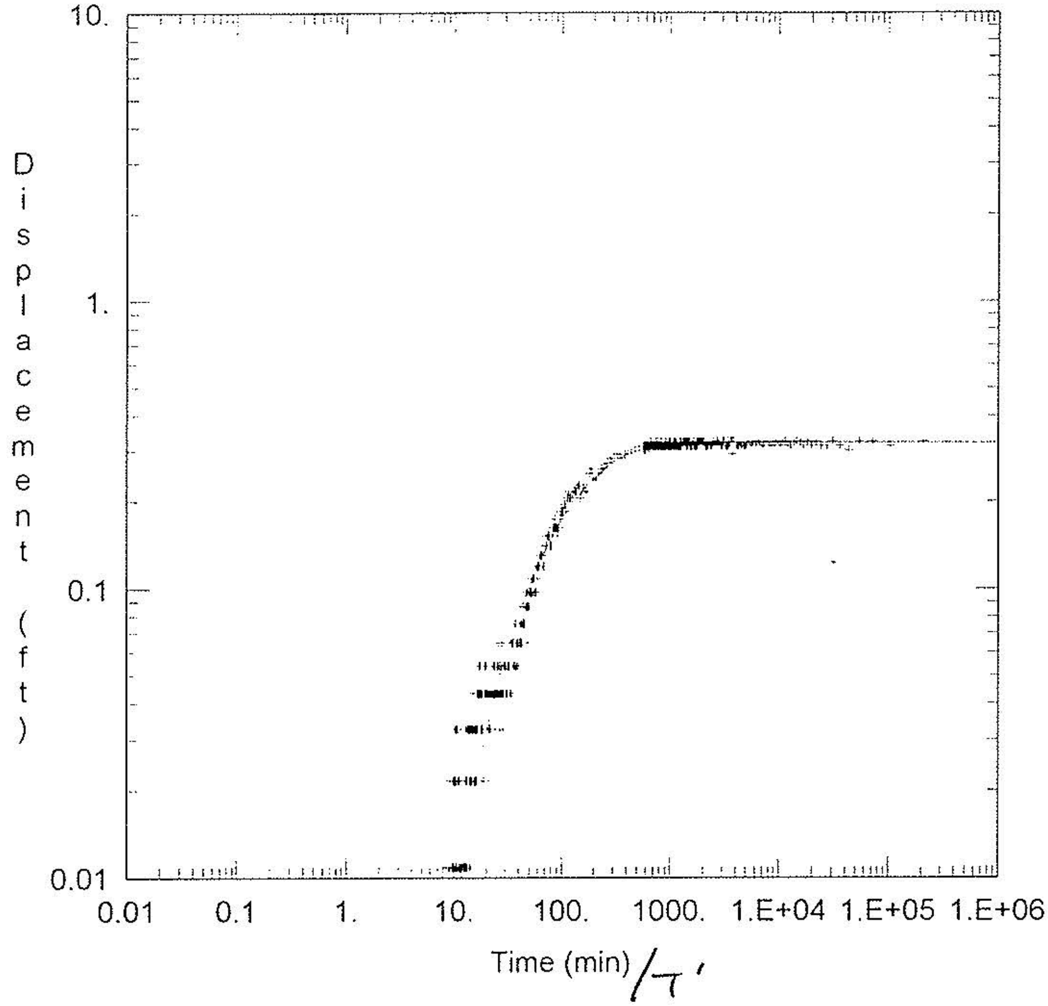
Observation Wells

Well Name	X (ft)	Y (ft)
PZ-9	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Unconfined
Solution Method: Quick Neuman

T = 14.21 ft^2/day
S = 0.001815
Sy = 0.08415
ß = 0.1



GASWORKS PARK RECOVERY TEST - PZ-9

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\AQTESOLV\PZ-9_REC.AQT
Date: 06/22/98 Time: 15:27:44

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

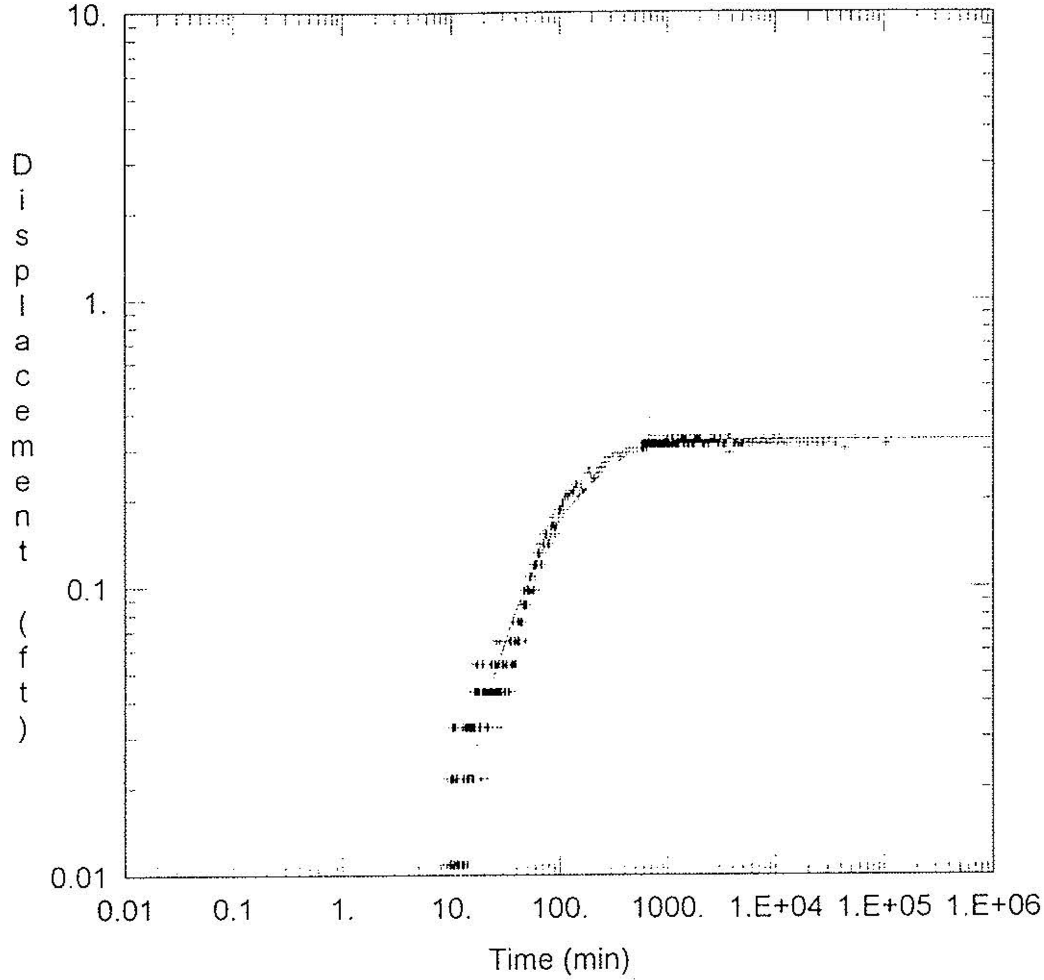
Observation Wells

Well Name	X (ft)	Y (ft)
PZ-9	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 23.03 ft^2/day
S = 0.006952
r/B = 0.4755



GASWORKS PARK RECOVERY TEST - PZ-9

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\AQTESOLV\PZ-9_REC.AQT
Date: 06/22/98 Time: 15:33:09

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

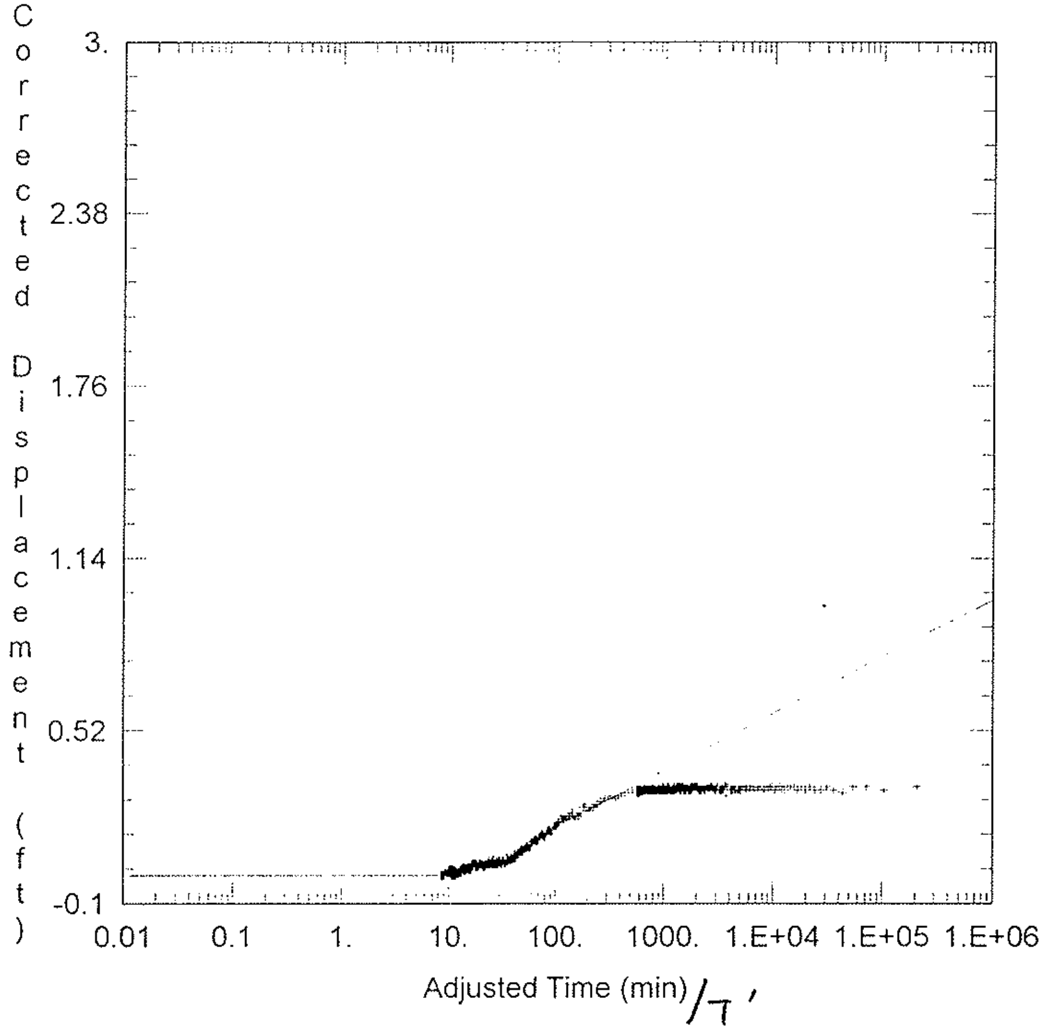
Observation Wells

Well Name	X (ft)	Y (ft)
+ PZ-9	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Leaky
Solution Method: Moench

T = 27.51 ft^2/day
S = 0.007087
r/B = 0.3778
ß = 0.002835
Sw = 0.



GASWORKS PARK RECOVERY TEST - PZ-9

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\AQTESOLV\PZ-9_REC.AQT
Date: 06/22/98 Time: 15:34:25

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

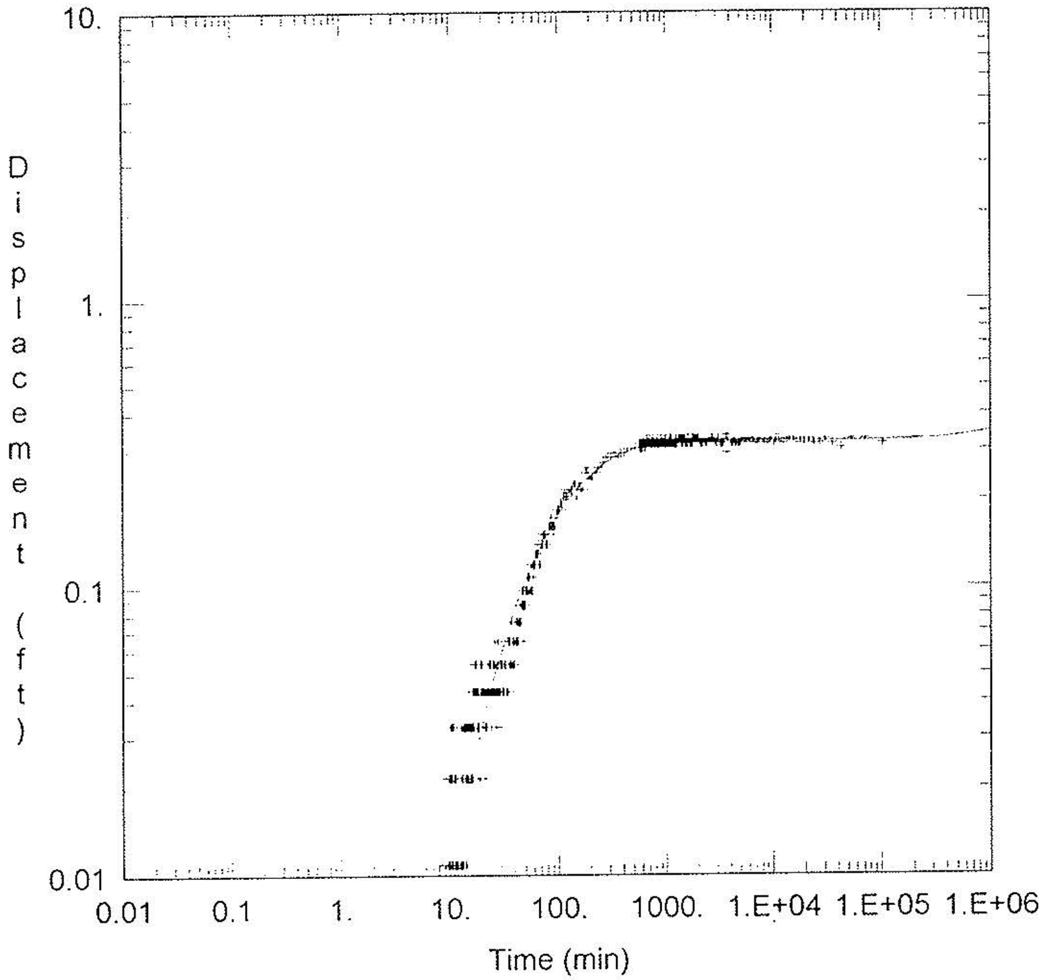
Observation Wells

Well Name	X (ft)	Y (ft)
PZ-9	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Unconfined
Solution Method: Cooper-Jacob

T = 43.16 ft^2/day
S = 0.005011



GASWORKS PARK RECOVERY TEST - PZ-9

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\AQTESOLV\PZ-9_REC.AQT
Date: 06/22/98 Time: 15:35:42

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

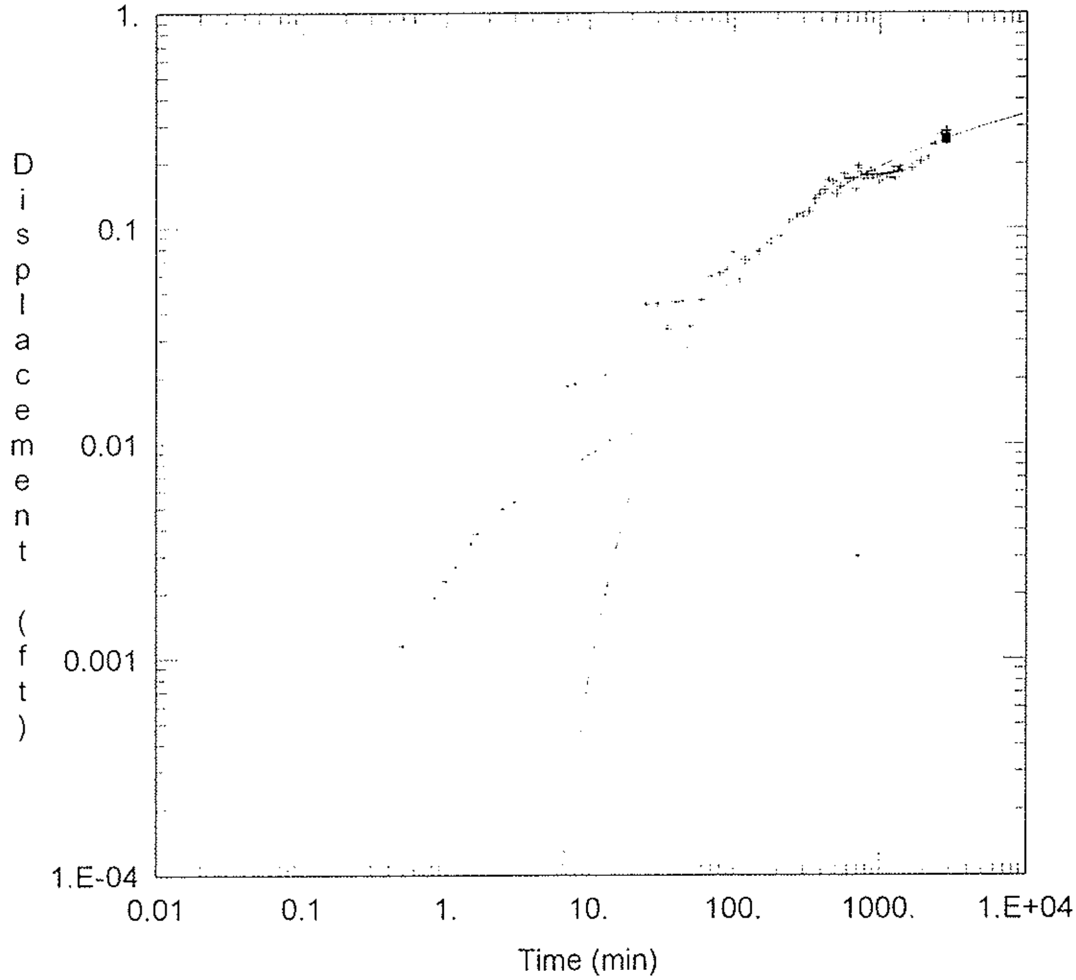
Observation Wells

Well Name	X (ft)	Y (ft)
+ PZ-9	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Unconfined
Solution Method: Quick Neuman

T = 18.61 ft^2/day
S = 0.005941
Sy = 163.8
ß = 0.1



GASWORKS PARK PUMP TEST - PZ-10

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\PZ-10_CR.AQT
Date: 06/22/98 Time: 13:12:45

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

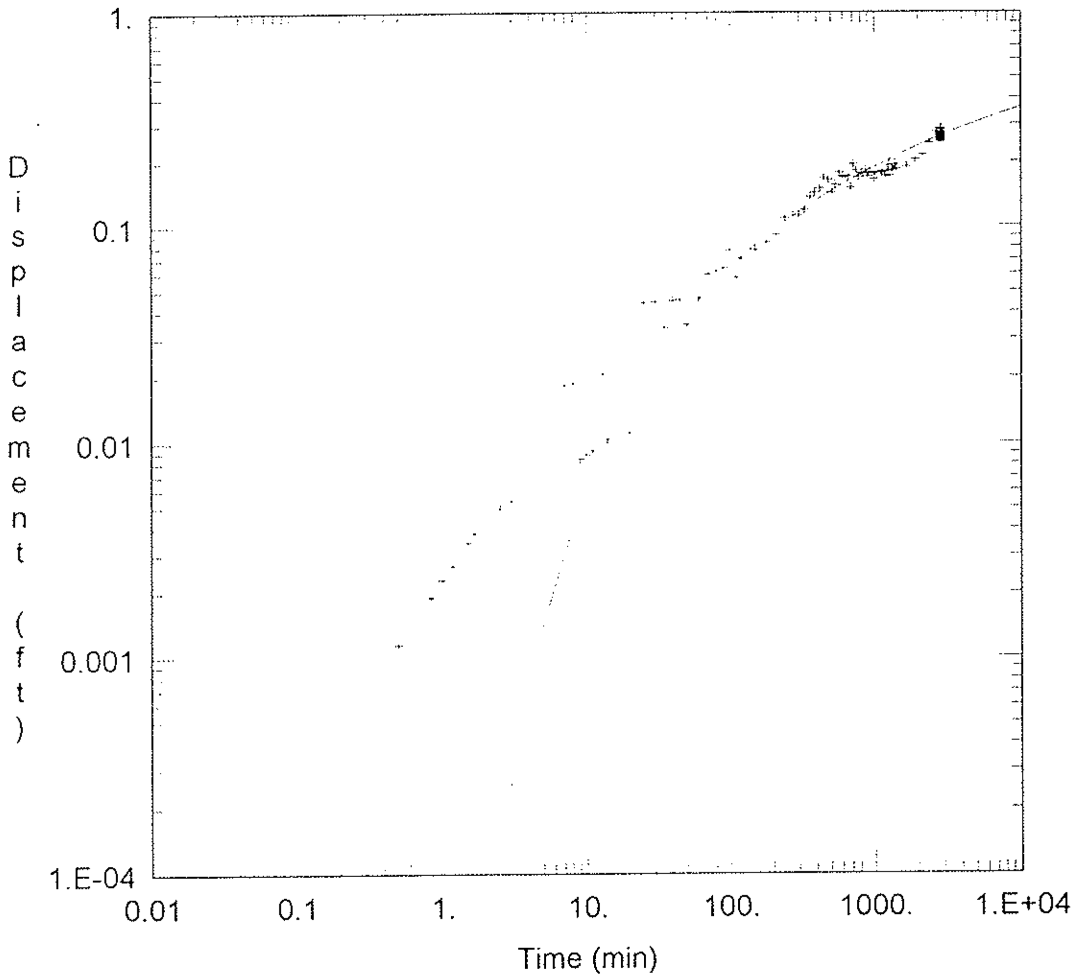
Observation Wells

Well Name	X (ft)	Y (ft)
PZ-10	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 58.43 ft^2/day
S = 0.002729
r/B = 1.E-05



GASWORKS PARK PUMP TEST - PZ-10

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\PZ-10_CR.AQT
Date: 06/22/98 Time: 13:13:15

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

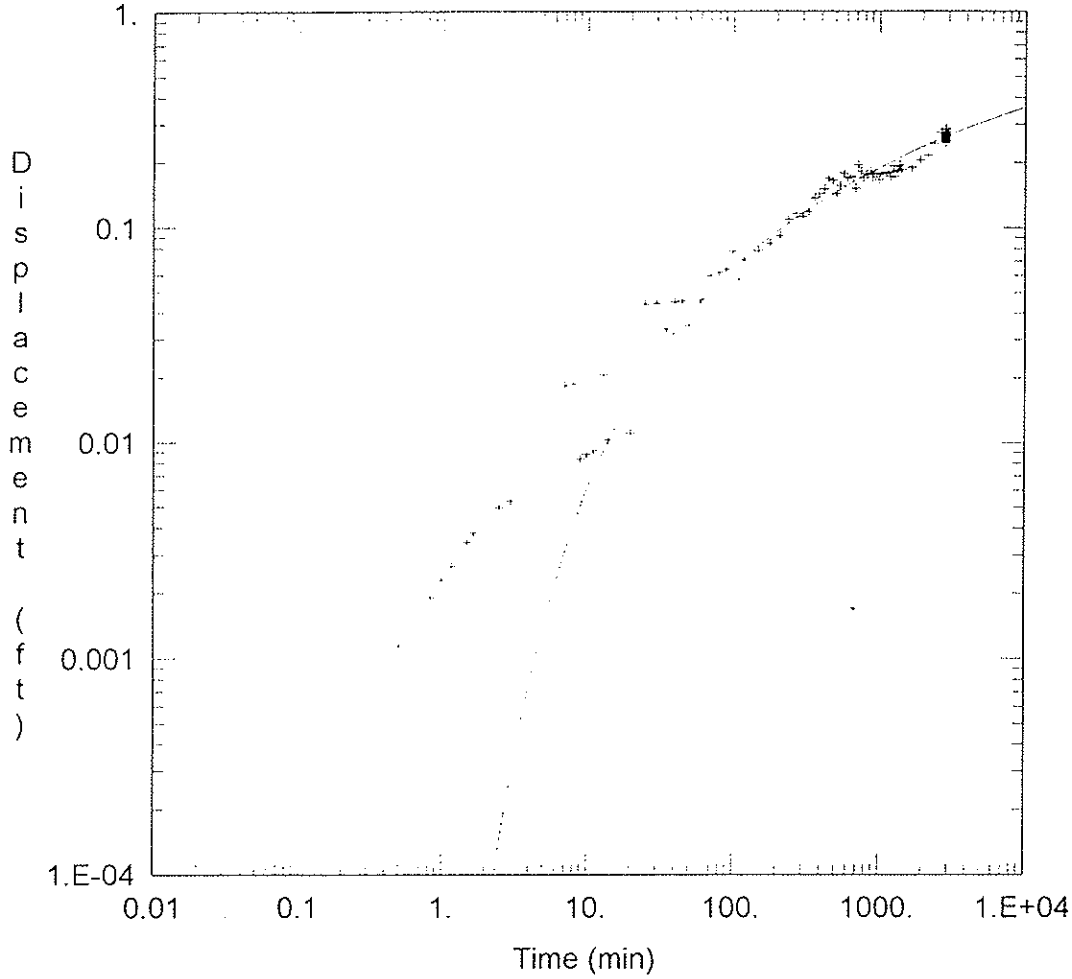
Observation Wells

Well Name	X (ft)	Y (ft)
- PZ-10	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 20.31 ft^2/day
S = 0.0002677
ß = 1.279



GASWORKS PARK PUMP TEST - PZ-10

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\PZ-10_CR.AQT
Date: 06/22/98 Time: 13:37:19

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

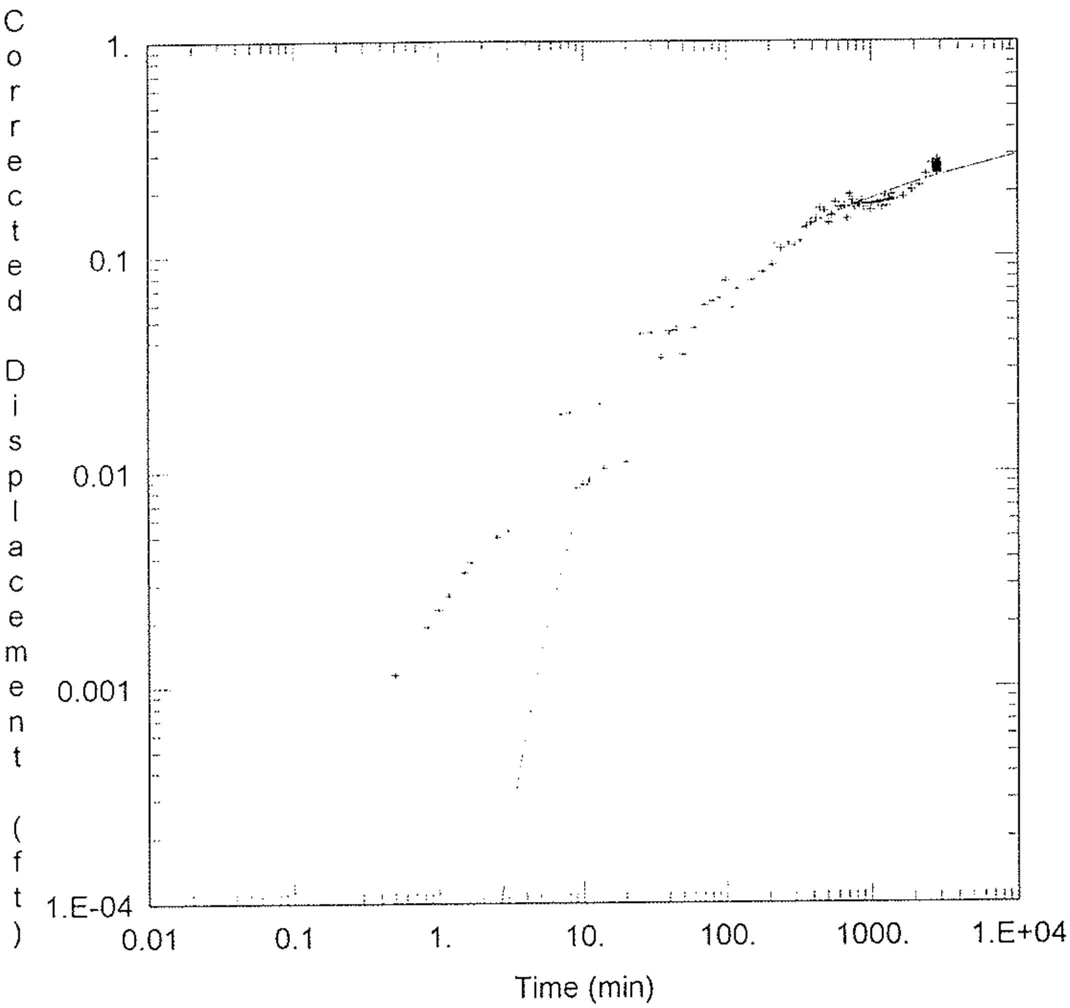
Observation Wells

Well Name	X (ft)	Y (ft)
PZ-10	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Leaky
Solution Method: Moench

T = 20.31 ft^2/day
S = 0.000268
r/B = 1.E-05
ß = 1.281
Sw = 0.
Rw = 10. ft



GASWORKS PARK PUMP TEST - PZ-10

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\PZ-10_CR.AQT
Date: 06/22/98 Time: 13:38:14

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

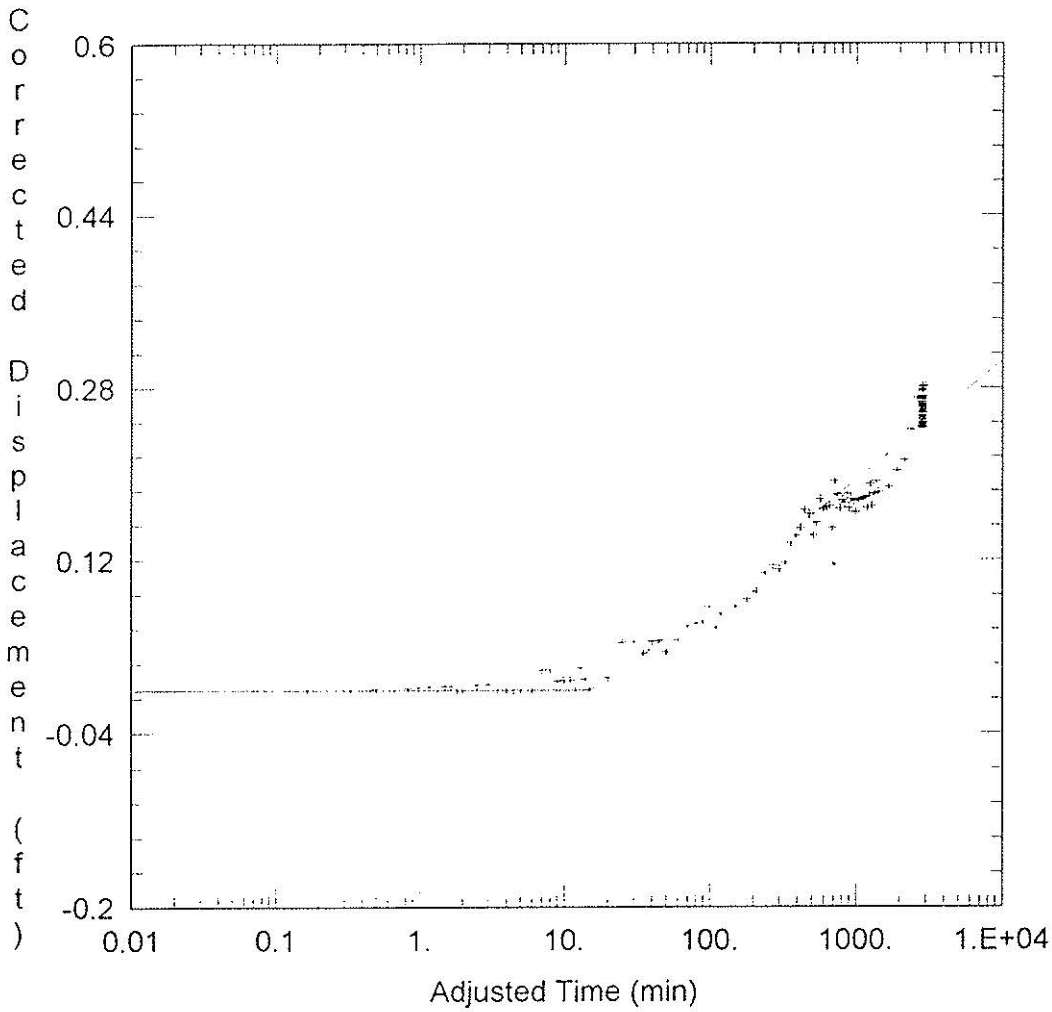
Observation Wells

Well Name	X (ft)	Y (ft)
PZ-10	1.27E+006	2.393E+005

SOLUTION

Aquifer Model: Unconfined
Solution Method: Theis

T = 79.76 ft^2/day
S = 0.001454



GASWORKS PARK PUMP TEST - PZ-10

Data Set: F:\USERS\GSEGA\GASWORKS\PUMPTEST\PZ-10_CR.AQT
Date: 06/22/98 Time: 13:38:56

PROJECT INFORMATION

Company: RETEC
Client: PSE
Project: 5-3434-240
Test Location: Seattle, WA
Test Well: RW-1
Test Date: 4/8-10/98

AQUIFER DATA

Saturated Thickness: 8.77 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
RW-1	1.27E+006	2.393E+005

Observation Wells

Well Name	X (ft)	Y (ft)
PZ-10	1.27E+006	2.393E+005

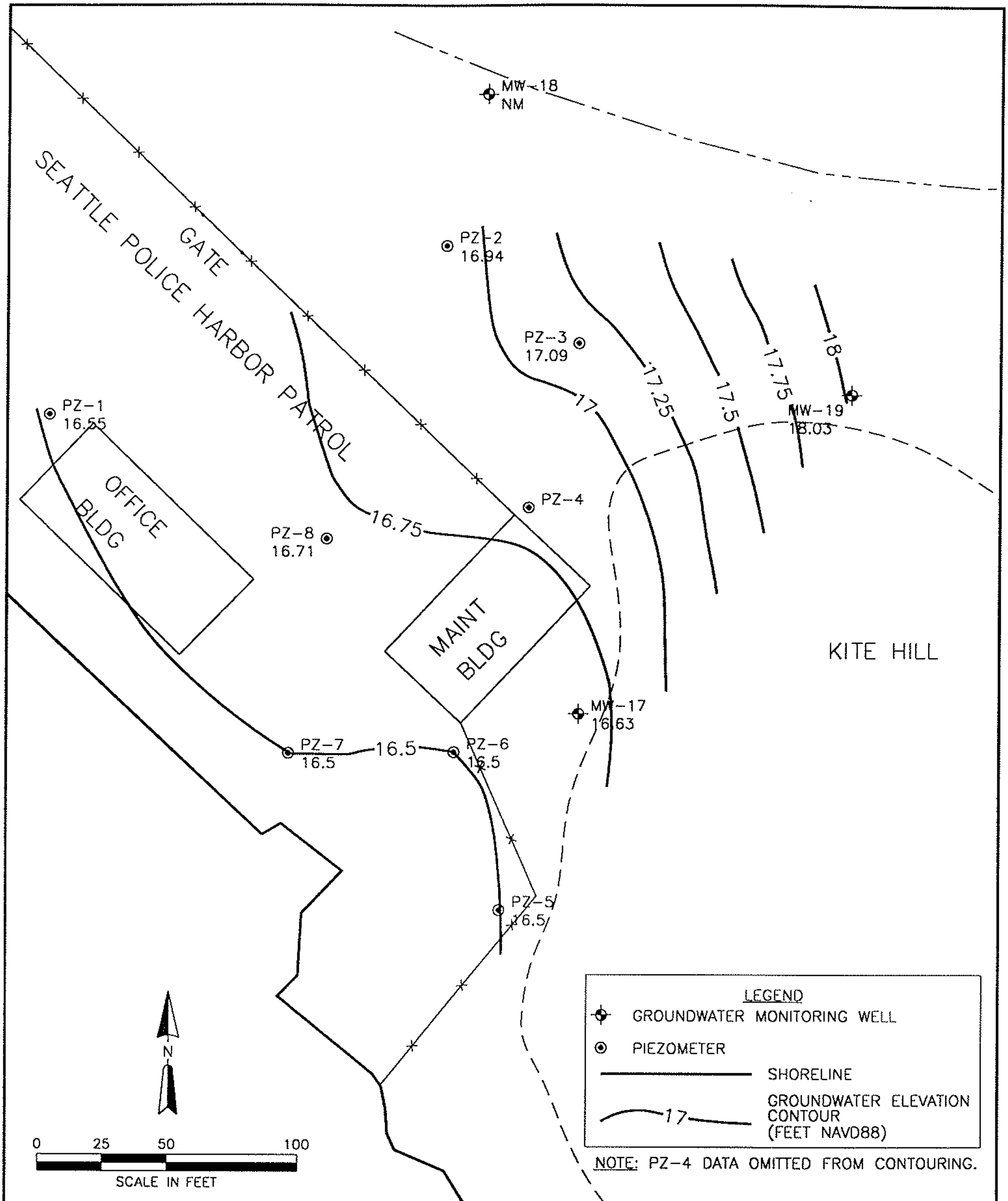
SOLUTION

Aquifer Model: Unconfined
Solution Method: Cooper-Jacob

T = 79.38 ft^2/day
S = 0.001222

Appendix F

Potentiometric Surface Maps



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NO	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE	

5-3434-300

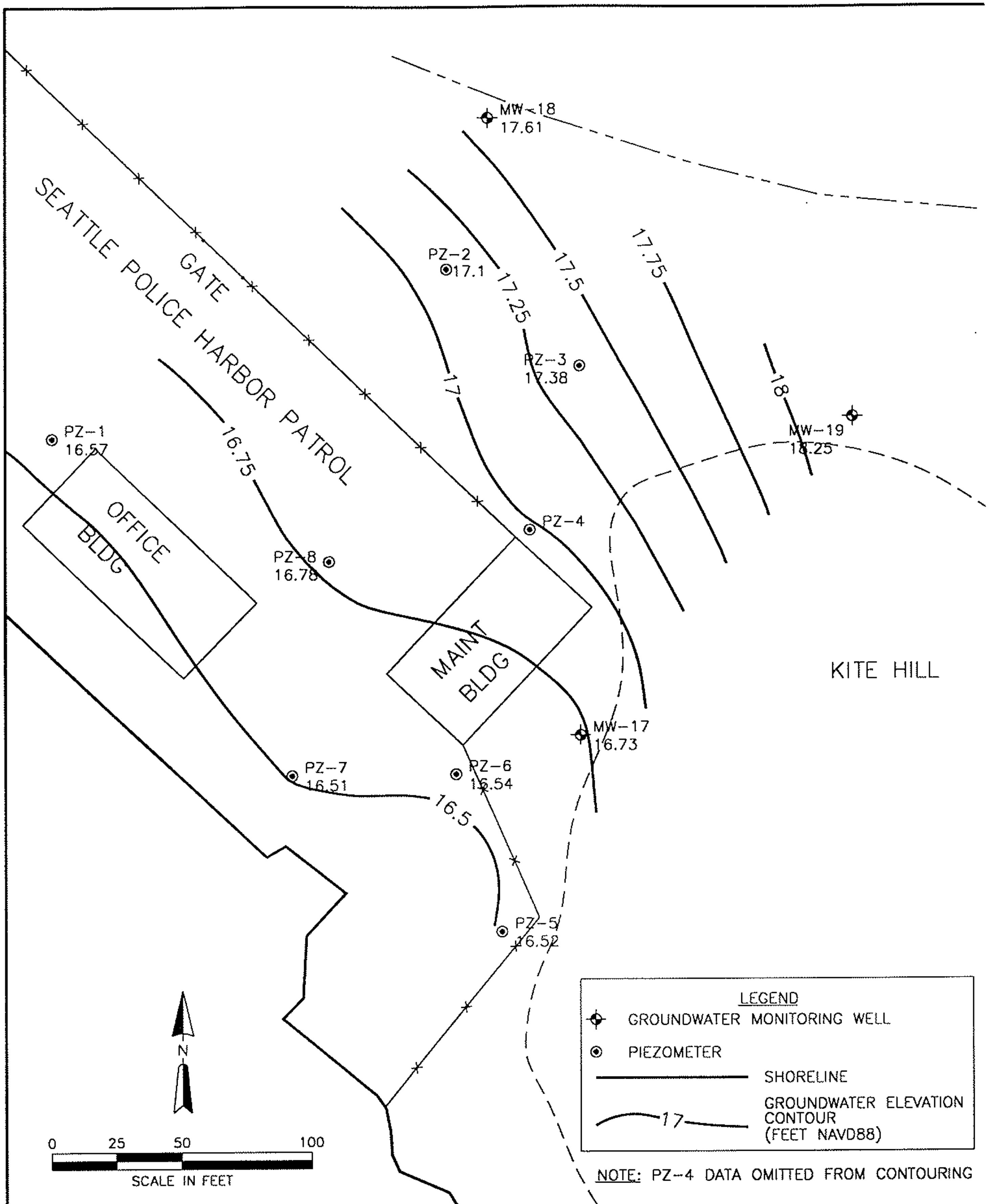
CUR. DATE: 4/16/98

CAD FILE 3434S014

DECEMBER 9, 1997
GROUNDWATER ELEVATION
CONTOURS

RETEC
REMEDIATION TECHNOLOGIES INC

DRAWING NO.
REV. 0



REF DWG	DESC.						
		5-3434-300					
1							
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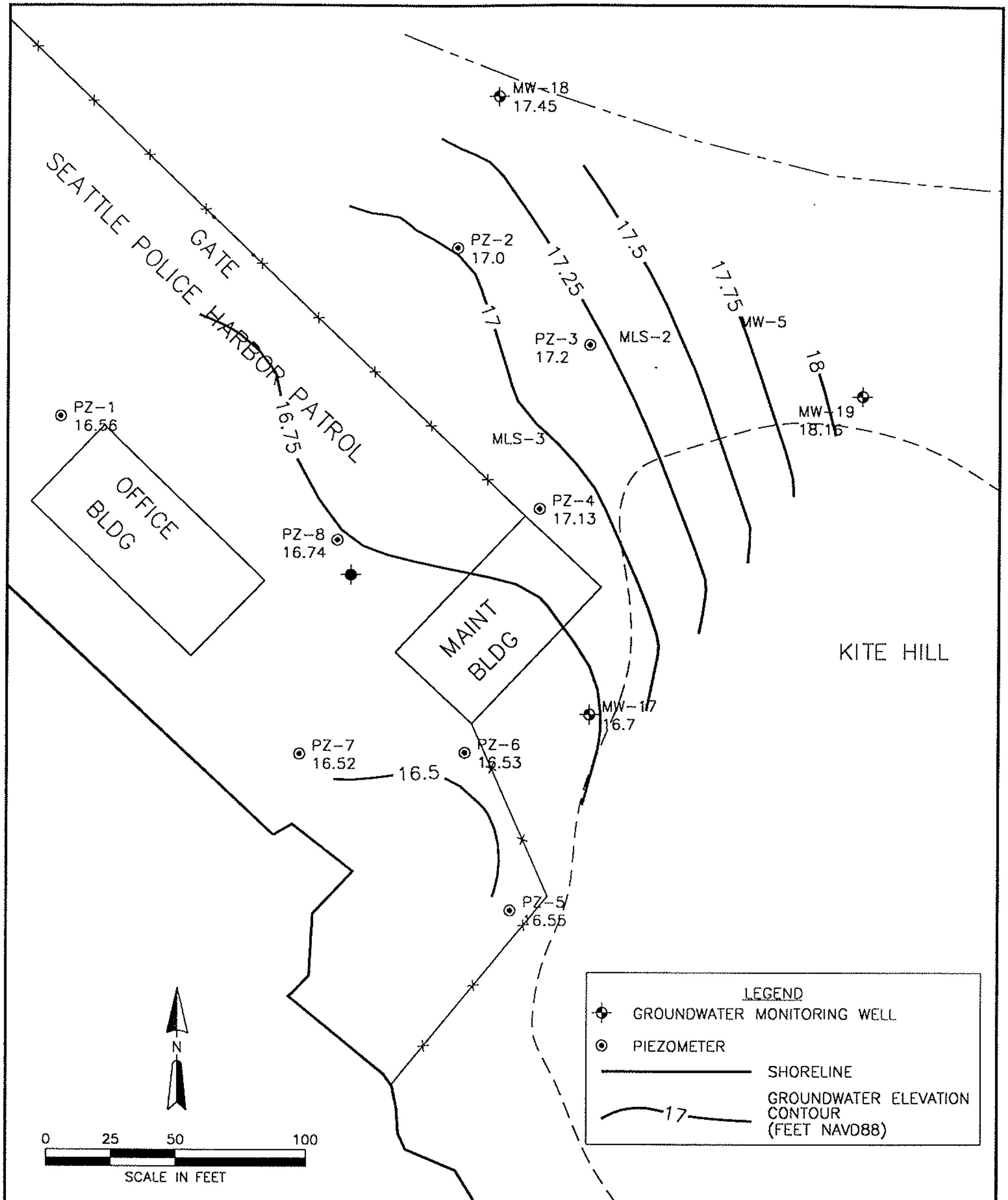
NO	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE

CUR. DATE: 4/15/98
CAD FILE: 3434S015

DECEMBER 18, 1997
GROUNDWATER ELEVATION CONTOURS

RETEC
REMEDIATION TECHNOLOGIES INC

DRAWING NO.
REV. C



REF DWG	DESC.					
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NO	DRWN	DATE	REVISION	CHKD DATE	APPVD DATE	

5-3434-300

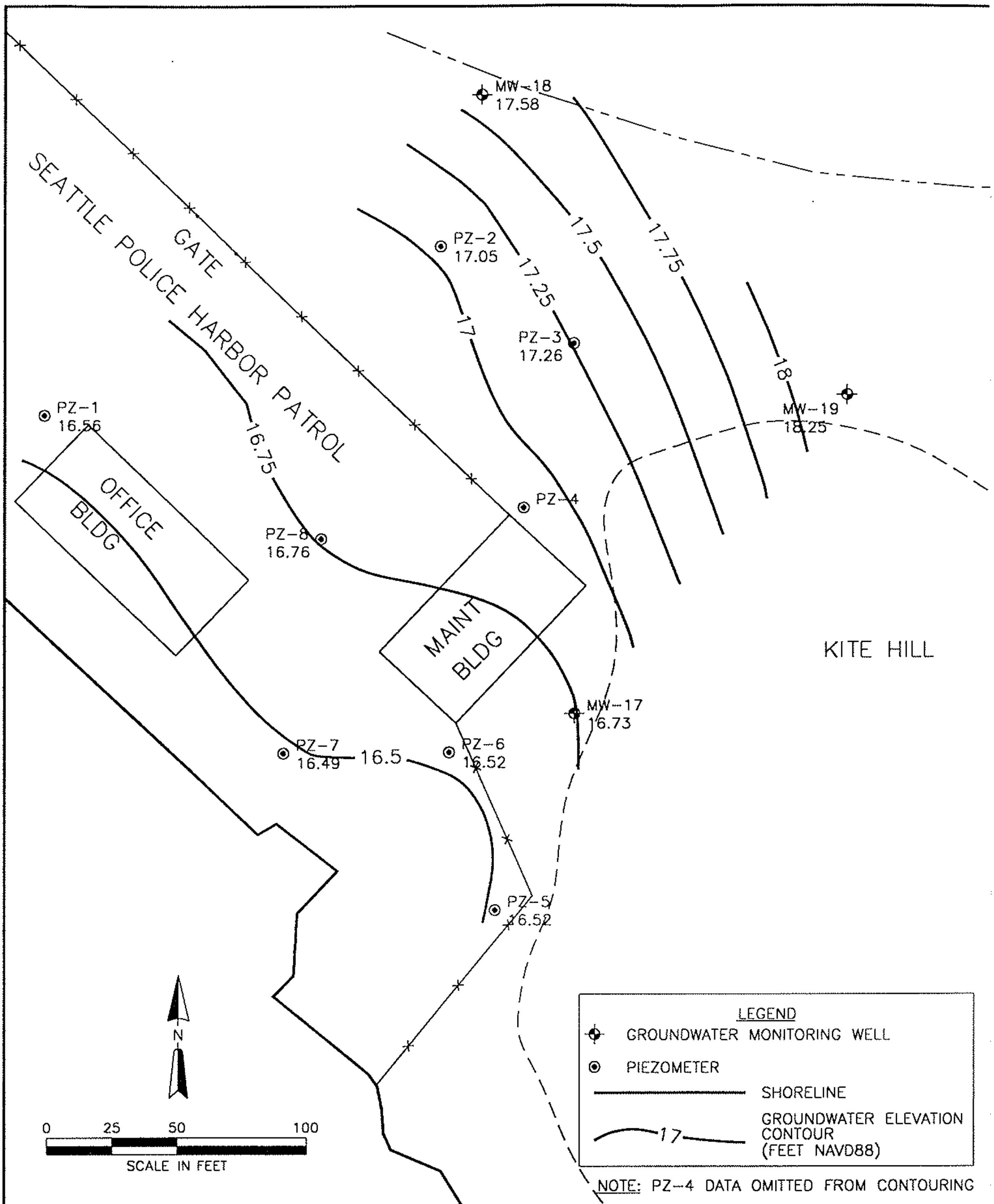
CUR. DATE: 4/16/98

CAD FILE 3434S017

DECEMBER 29, 1997
GROUNDWATER ELEVATION
CONTOURS

RETEC
REMEDIATION TECHNOLOGIES INC

DRAWING NO. REV. 0



NOTE: PZ-4 DATA OMITTED FROM CONTOURING

REF DWG	DESC.	5-3434-300					
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0	N.S.	4/15/1998	DRAFT				
NO	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE

CUR. DATE: 4/15/98

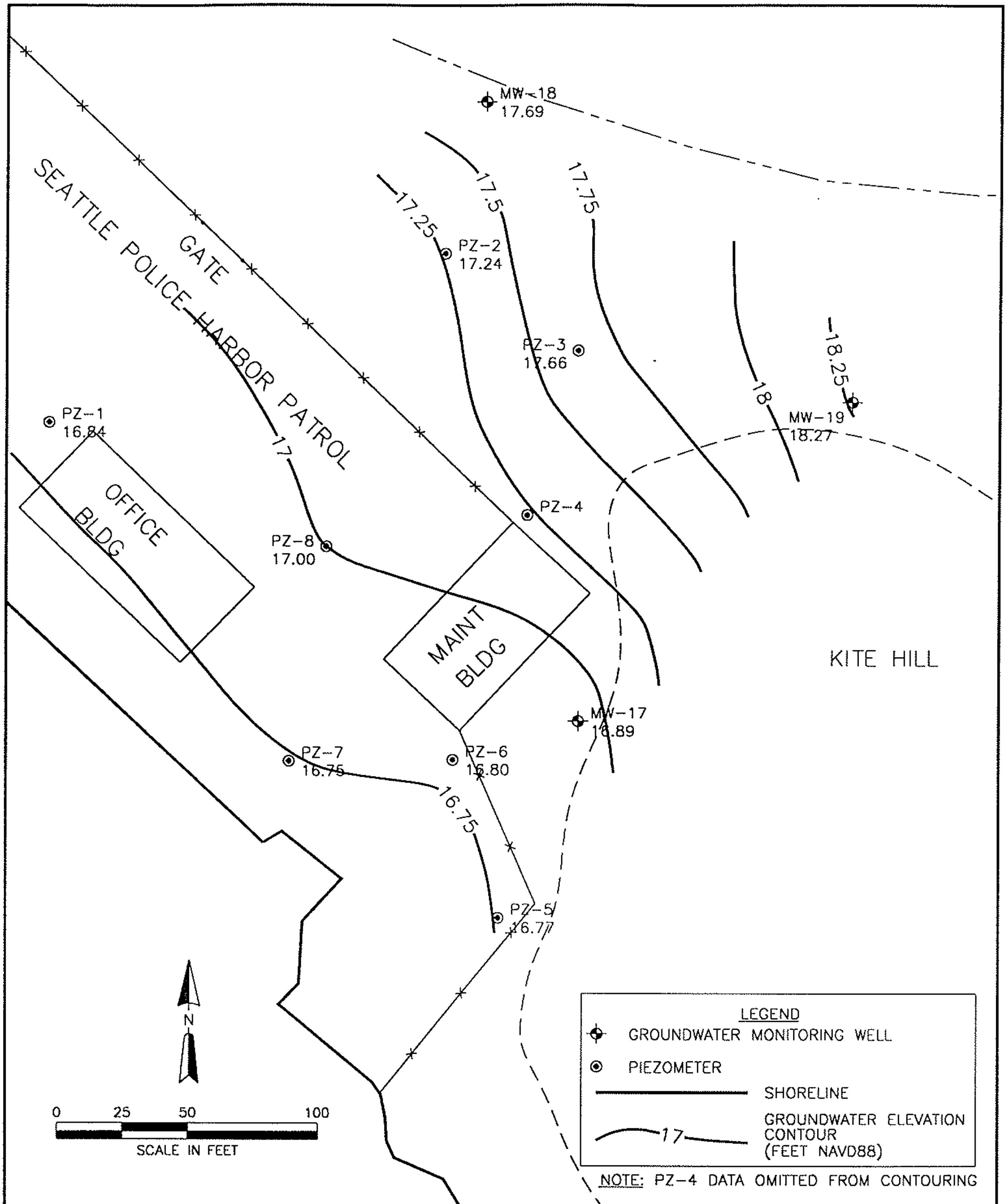
CAD FILE 3434S016

DECEMBER 23, 1997
GROUNDWATER ELEVATION
CONTOURS

RETEC
REMEDIATION TECHNOLOGIES INC

DRAWING NO.

REV. 0



REF DWG	DESC.						
1							
0	N.S.	4/15/1998	DRAFT				
NO	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE

5-3434-300

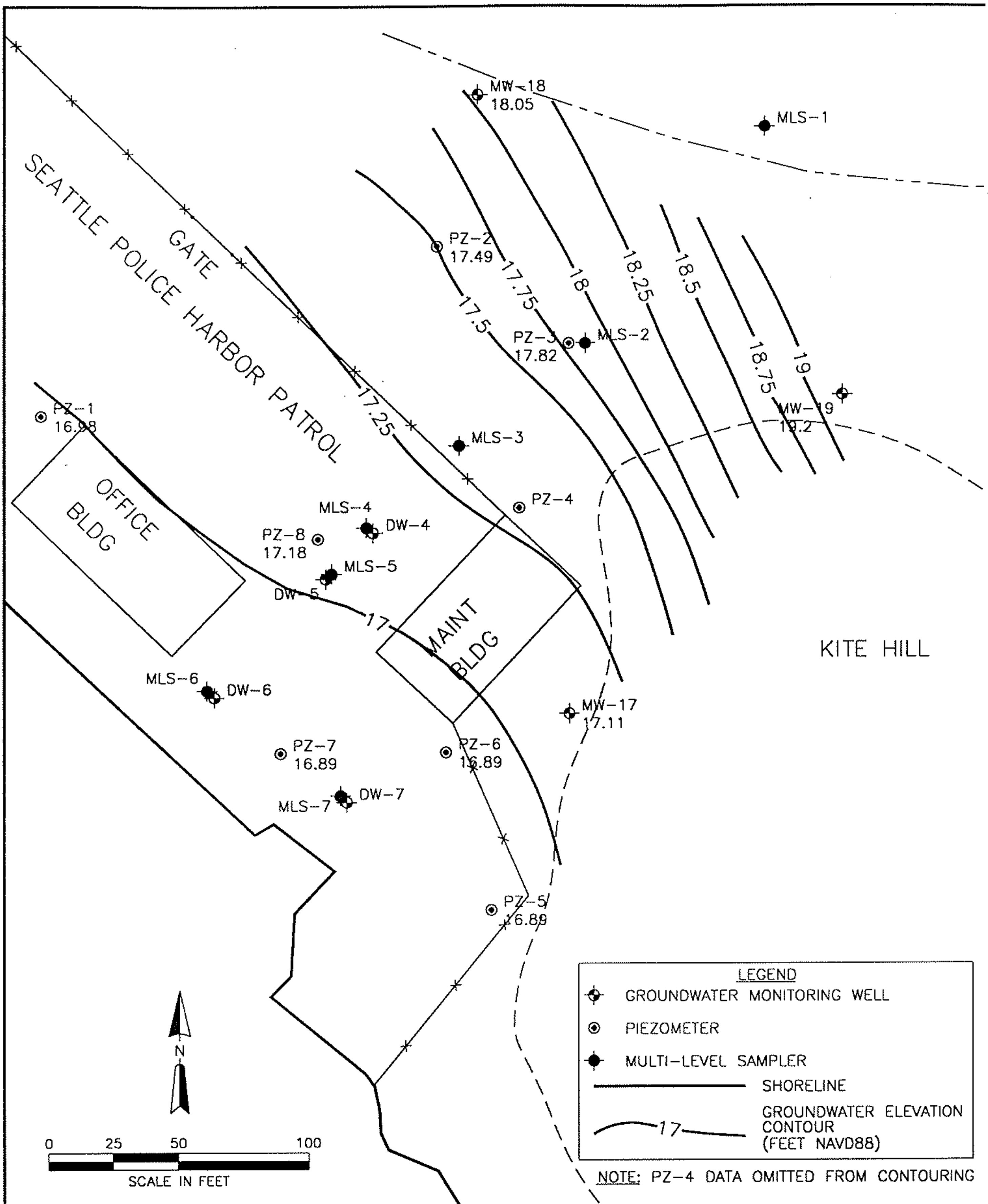
CUR. DATE: 4/16/98

CAD FILE 3434S018

JANUARY 5, 1998 GROUNDWATER ELEVATION CONTOURS

RETEC REMEDIATION TECHNOLOGIES INC

DRAWING NO. REV. 0



REF DWG	DESC.					
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NO	DRWN	DATE	REVISION	CHKD DATE	APPVD DATE	

5-3434-300

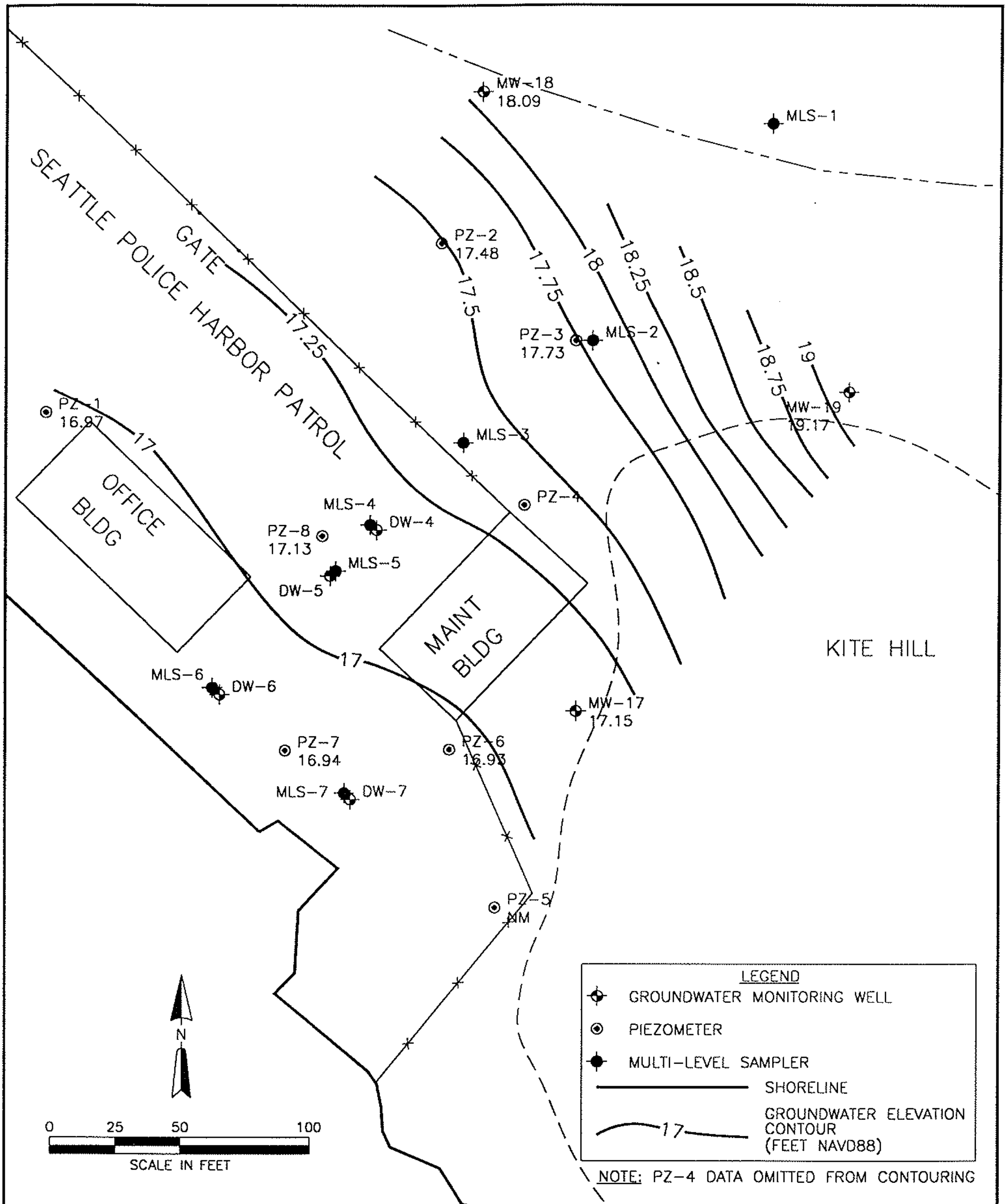
CUR. DATE: 4/16/98

CAD FILE 3434S020

FEBRUARY 12, 1998
GROUNDWATER ELEVATION
CONTOURS

RETEC REMEDIATION TECHNOLOGIES INC

DRAWING NO. REV. 0



REF DWG	DESC.					
0	N.S.	4/15/1998	DRAFT			
NO	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE

5-3434-300

CUR. DATE: 4/16/98

CAD FILE 3434S019

FEBRUARY 18, 1998
GROUNDWATER ELEVATION CONTOURS

RETEC
REMEDIATION TECHNOLOGIES INC

DRAWING NO. REV. 0

Appendix G

Groundwater Analytical Results

Table G-1 Groundwater Quality Data

Sample Location: Sample Date: Sample ID: Compound	Potential Cleanup Level 10 x MTCA Method B Surface Water Criteria	MLS-1-3 MLS-1-3-0298 02/17/98	MLS-1-2 MLS-1-2-0298 02/17/98	MLS-1-1 MLS-1-1-0298 02/17/98	MLS-2-3 MLS-2-3-0298 02/17/98	MLS-2-2 MLS-2-2-0298 02/17/98	MLS-2-1 MLS-2-1-0298 02/17/98	MLS-3-3 MLS-3-3-0298 02/17/98	MLS-3-2 MLS-3-2-0298 02/17/98	MLS-3-1 MLS-3-1-0298 02/17/98
2-Methylnaphthalene	0	< 0.001	< 0.001	< 0.001	**1.30**	**9.50**	**0.40**	**5.5**	**1.1**	**1.1**
Acenaphthene	6.43	< 0.001	< 0.001	**0.0095**	**0.14**	**2.40**	**0.066**	**1.6**	**0.096**	**0.11**
Acenaphthylene	0	< 0.001	< 0.001	**0.0011**	**0.13**	**0.61**	**0.038**	**1.1**	**0.077**	**0.13**
Anthracene	259	< 0.001	< 0.001	**0.0018**	**0.045**	**1.50**	**0.012**	**1.2**	**0.014**	**0.026**
Benzo(a)anthracene	0	< 0.001	< 0.001	< 0.001	**0.015**	**0.57**	**0.0032**	**0.53**	< 0.001	**0.0052**
Benzo(a)pyrene	—	< 0.001	< 0.001	< 0.001	**0.011**	**0.47**	**0.0026**	**0.41**	< 0.001	**0.0043**
Benzo(b)fluoranthene	—	< 0.001	< 0.001	< 0.001	< 0.01	**0.35**	**0.0015**	**0.21**	< 0.001	**0.002**
Benzo(g,h,i)perylene	—	< 0.001	< 0.001	< 0.001	< 0.01	**0.19**	**0.0012**	**0.17**	< 0.001	**0.0014**
Benzo(k)fluoranthene	—	< 0.001	< 0.001	< 0.001	**0.01 J**	**0.30**	**0.0019**	**0.16**	< 0.001	**0.0036**
Carbazole	—	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	—	< 0.001	< 0.001	< 0.001	**0.014**	**0.53**	**0.0032**	**0.57**	< 0.001	**0.0052**
Dibenz(a,h)anthracene	—	< 0.001	< 0.001	< 0.001	< 0.01	**0.073**	< 0.001	**0.081**	< 0.001	< 0.001
Dibenzo(a,h)anthracene	—	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	—	< 0.001	< 0.001	< 0.001	**0.068**	**0.71**	**0.024**	**0.92**	**0.044**	**0.052**
Fluoranthene	0.92	< 0.001	< 0.001	< 0.001	**0.041**	**1.50**	**0.0098**	**1.6**	**0.0041**	**0.015**
Fluorene	34.6	< 0.001	< 0.001	**0.0035**	**0.10**	**1.70**	**0.039**	**1.7**	**0.057**	**0.071**
Indeno(1,2,3-cd)pyrene	—	< 0.001	< 0.001	< 0.001	< 0.01	**0.21**	**0.0011**	**0.18**	< 0.001	**0.0016**
Naphthalene	98.8	**0.0013**	< 0.001	**0.073**	**12.0**	**31.0**	**2.50**	**37.0**	**10.0**	**12.0**
Pentachlorophenol	—	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	0	< 0.001	< 0.001	< 0.001	**0.18**	**5.80**	**0.056**	**3.9**	**0.05**	**0.11**
Pyrene	25.9	< 0.001	< 0.001	< 0.001	**0.053**	**1.80**	**0.013**	**1.8**	**0.0048**	**0.02**

NOTES:

Concentrations shown in mg/L.
NA - Not Analyzed
< - Below detection limit
J - Indicates an estimated concentration when the value is less than the calculated reporting limits.
M - Indicates an estimated concentration. Analyte has low spectral match.

Table G-1 Groundwater Quality Data (Continued)

Sample Location: Sample Date: Sample ID: Compound	Potential Cleanup Level 10 x MTCA Method B Surface-Water Criteria	MLS-4-5 MLS-4-5-0298 02/17/98	MLS-4-4 MLS-4-4-0298 02/17/98	MLS-4-3 MLS-4-3-0298 02/17/98	MLS-4-2 MLS-4-2-0298 02/17/98	DW-4 DW-4-0298 02/18/98	MLS-5-5 MLS-5-5-0298 02/17/98	MLS-5-4 MLS-5-4-0298 02/17/98	MLS-5-3 MLS-5-3-0298 02/17/98	MLS-5-2 MLS-5-2-0298 02/17/98	MLS-5-1 MLS-5-1-0298 02/17/98	MLS-5-1 MLS-5-6-0298 02/17/98
2-Methylnaphthalene	0	**0.47**	**1.0**	**1.1**	**1.1**	**1.1**	**0.10**	**1.1**	**1.1**	**1.1**	**0.92**	**1.0**
Acenaphthene	6.43	**0.017**	**0.11**	**0.10**	**0.10**	**0.12**	**0.052**	**0.12**	**0.14**	**0.12**	**0.11**	**0.11**
Acenaphthylene	0	< 0.005	**0.13**	**0.11**	**0.12**	**0.17**	**0.0072**	**0.13**	**0.1**	**0.11**	**0.13**	**0.12**
Anthracene	259	**0.02**	**0.016**	**0.017**	**0.017**	**0.027**	**0.0054**	**0.018**	**0.0098**	**0.012**	**0.01**	**0.0098**
Benzo(a)anthracene	0	**0.0062**	< 0.001	**0.0014**	**0.0011**	< 0.005	< 0.005	< 0.005	< 0.005	< 0.001	< 0.001	< 0.005
Benzo(a)pyrene	—	**0.0048 J**	< 0.001	< 0.001	**0.001**	< 0.005	< 0.005	< 0.005	< 0.005	< 0.001	< 0.001	< 0.005
Benzo(b)fluoranthene	—	< 0.005	< 0.001	< 0.001	< 0.001	< 0.005	< 0.005	< 0.005	< 0.005	< 0.001	< 0.001	< 0.005
Benzo(g,h,i)perylene	—	< 0.005	< 0.001	< 0.001	< 0.001	< 0.005	< 0.005	< 0.005	< 0.005	< 0.001	< 0.001	< 0.005
Benzo(k)fluoranthene	—	< 0.005	< 0.001	< 0.001	< 0.001	< 0.005	< 0.005	< 0.005	< 0.005	< 0.001	< 0.001	< 0.005
Carbazole	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	—	**0.0059**	< 0.001	**0.0013**	**0.0013**	< 0.005	< 0.005	< 0.005	< 0.005	< 0.001	< 0.001	< 0.005
Dibenz(a,h)anthracene	—	< 0.005	< 0.001	< 0.001	< 0.001	< 0.005	< 0.005	< 0.005	< 0.005	< 0.001	< 0.001	< 0.005
Dibenzo(a,h)anthracene	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	—	**0.034**	**0.066**	**0.065**	**0.047**	**0.065**	**0.011**	**0.066**	**0.064**	**0.051**	**0.049**	**0.054**
Fluoranthene	0.92	**0.019**	**0.0058**	**0.0077**	**0.0069**	**0.019**	**0.0077**	**0.0094**	< 0.005	**0.0038**	**0.0013**	< 0.005
Fluorene	34.6	**0.083**	**0.072**	**0.076**	**0.068**	**0.082**	**0.02**	**0.076**	**0.079**	**0.079**	**0.073**	**0.073**
Indeno(1,2,3-cd)pyrene	—	< 0.005	< 0.001	< 0.001	< 0.001	< 0.005	< 0.005	< 0.005	< 0.005	< 0.001	< 0.001	< 0.005
Naphthalene	98.8	**1.1**	**11.0**	**10.0**	**10.0**	**11.0**	**0.49**	**9.9**	**11.0**	**9.8**	**9.5**	**11.0**
Pentachlorophenol	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	0	**0.11**	**0.068**	**0.07**	**0.07**	**0.11**	**0.029**	**0.082**	**0.068**	**0.064**	**0.054**	**0.062**
Pyrene	25.9	**0.027**	**0.0072**	**0.0081**	**0.008**	**0.015**	**0.01**	**0.011**	< 0.005	**0.0041**	< 0.001	< 0.005

NOTES:

Concentrations shown in mg/L.
NA - Not Analyzed
< - Below detection limit
J - Indicates an estimated concentration when the value is less than the calculated reporting limits.
M - Indicates an estimated concentration. Analyte has low spectral match.

Table G-1 Groundwater Quality Data (Continued)

Sample Location: Sample Date: Sample ID: Compound	Potential Cleanup Level 10 x MTCA Method B Surface-Water Criteria	DW-5 DW-20-0298 02/18/98	DW-5 DW-5-0298 02/18/98	MLS-6-5 MLS-6-5-0498 04/15/98	MLS-6-5 MLS-6-5-298 02/17/98	MLS-6-4 MLS-6-4-0498 04/15/98	MLS-6-4 MLS-6-4-0298 02/17/98	MLS-6-3 MLS-6-3-0298 02/17/98	MLS-6-2 MLS-6-2-0498 04/15/98	MLS-6-2 MLS-6-2-0298 02/17/98	MLS-6-1 MLS-6-1-0498 04/15/98	MLS-6-1 MLS-6-1-0298 02/17/98
2-Methylnaphthalene	0	**1.2**	**1.2**	**0.0069**	< 0.001	< 0.0001	< 0.001	**0.0058**	**0.37**	**0.19**	**0.11**	**0.12**
Acenaphthene	6.43	**0.10**	**0.094**	< 0.001	< 0.001	**0.0023**	**0.0037**	**0.0042**	**0.15 E**	**0.16**	**0.021**	**0.024**
Acenaphthylene	0	**0.14**	**0.13**	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.0014	< 0.001	< 0.005	< 0.001	< 0.005
Anthracene	259	**0.017**	**0.015**	< 0.001	< 0.001	**0.0025**	< 0.001	**0.0025**	**0.004**	**0.0078**	< 0.001	< 0.005
Benzo(a)anthracene	0	< 0.005	< 0.005	< 0.001	< 0.001	< 0.0001	< 0.001	**0.0022**	< 0.001	< 0.005	< 0.001	< 0.005
Benzo(a)pyrene	—	< 0.005	< 0.005	< 0.001	< 0.001	< 0.0001	< 0.001	**0.0017**	< 0.001	< 0.005	< 0.001	< 0.005
Benzo(b)fluoranthene	—	< 0.005	< 0.005	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.0014	< 0.001	< 0.005	< 0.001	< 0.005
Benzo(g,h,i)perylene	—	< 0.005	< 0.005	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.0014	< 0.001	< 0.005	< 0.001	< 0.005
Benzo(k)fluoranthene	—	< 0.005	< 0.005	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.0014	< 0.001	< 0.005	< 0.001	< 0.005
Carbazole	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	—	< 0.005	< 0.005	< 0.001	< 0.001	< 0.0001	< 0.001	**0.0024**	< 0.001	< 0.005	< 0.001	< 0.005
Dibenz(a,h)anthracene	—	< 0.005	< 0.005	NA	< 0.001	NA	< 0.001	< 0.0014	NA	< 0.005	NA	< 0.005
Dibenzo(a,h)anthracene	—	NA	NA	< 0.001	NA	< 0.0001	NA	NA	< 0.001	NA	< 0.001	NA
Dibenzofuran	—	**0.055**	**0.05**	< 0.001	< 0.001	**0.0013**	< 0.001	< 0.0014	**0.021**	**0.025**	**0.0011**	< 0.005
Fluoranthene	0.92	**0.0061**	**0.0053**	< 0.001	< 0.001	**0.0064**	**0.0015**	**0.0053**	**0.0019**	< 0.005	< 0.001	< 0.005
Fluorene	34.6	**0.066**	**0.064**	< 0.001	< 0.001	**0.0012**	**0.0015**	**0.0027**	**0.005**	**0.055**	**0.0014**	< 0.005
Indeno(1,2,3-cd)pyrene	—	< 0.005	< 0.005	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.0014	< 0.001	< 0.005	< 0.001	< 0.005
Naphthalene	98.8	**12.0**	**12.0**	**0.072**	**0.0014**	**0.0022**	**0.0044**	**0.047**	**8.8**	**4.4**	**3.3**	**3.6**
Pentachlorophenol	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	0	**0.072**	**0.065**	< 0.001	< 0.001	**0.0016**	**0.0034**	**0.0093**	**0.034**	**0.051**	< 0.001	< 0.005
Pyrene	25.9	**0.0061**	**0.0059**	< 0.001	< 0.001	**0.0097**	**0.0022**	**0.0075**	**0.002**	< 0.005	< 0.001	< 0.005

NOTES:

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< - Below detection limit
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Table G-1 Groundwater Quality Data (Continued)

Sample Location: Sample Date: Sample ID: Compound	Potential Cleanup Level 10 x MTCA Method B Surface-Water Criteria	**DW6** **DW6-0498** **04/15/98**	**DW-6** **DW-6-0298** **02/18/98**	**MLS-7-5** **MLS-7-5-0498** **04/15/98**	**MLS-7-5** **MLS-7-5-0298** **02/17/98**	**MLS-7-4** **MLS-7-4-0498** **04/15/98**	**MLS-7-4** **MLS-7-4-0298** **02/17/98**	**MLS-7-3** **MLS-7-3-0498** **04/15/98**	**MLS-7-3** **MLS-7-3-298** **02/17/98**	**MLS-7-2** **MLS-7-2-0498** **04/15/98**	**MLS-7-2** **MLS-7-2-298** **02/17/98**	**MLS-7-1** **MLS-7-1-0498** **04/15/98**	**MLS-7-1** **MLS-7-1-298** **02/17/98**
2-Methylnaphthalene	0	**0.52**	**1.0**	**0.0011**	**0.0052**	**0.0027**	**0.006**	**0.73**	**1.2**	**0.19**	**0.17**	**0.23**	**0.19**
Acenaphthene	6.43	**0.098**	**0.12**	**0.0023**	**0.0068**	**0.0039**	**0.0071**	**0.17**	**0.28**	**0.19**	**0.23**	**0.20**	**0.28**
Acenaphthylene	0	**0.086**	**0.10**	< 0.0001	< 0.001	< 0.0001	< 0.001	**0.019**	**0.021**	**0.0087**	**0.011**	**0.0067**	**0.019**
Anthracene	259	**0.0061** M	**0.0076**	**0.0003**	**0.0019**	< 0.0001	< 0.001	**0.01**	**0.013**	**0.0088**	**0.011**	**0.0093**	**0.011**
Benzo(a)anthracene	0	< 0.001	< 0.005	**0.0016**	**0.0021**	< 0.0001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.005	< 0.001	< 0.005
Benzo(a)pyrene	—	< 0.001	< 0.005	**0.0014**	**0.0023**	< 0.0001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.005	< 0.001	< 0.005
Benzo(b)fluoranthene	—	< 0.001	< 0.005	< 0.0001	**0.0014**	< 0.0001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.005	< 0.001	< 0.005
Benzo(g,h,i)perylene	—	< 0.001	< 0.005	< 0.0001	**0.0017**	< 0.0001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.005	< 0.001	< 0.005
Benzo(k)fluoranthene	—	< 0.001	< 0.005	**0.0001**	**0.0018**	< 0.0001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.005	< 0.001	< 0.005
Carbazole	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	—	< 0.001	< 0.005	**0.0002**	**0.0024**	< 0.0001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.005	< 0.001	< 0.005
Dibenz(a,h)anthracene	—	NA	< 0.005	NA	< 0.001	NA	< 0.001	NA	< 0.005	NA	< 0.005	NA	< 0.005
Dibenzo(a,h)anthracene	—	< 0.001	NA	< 0.0001	NA	< 0.0001	NA	< 0.001	NA	< 0.001	NA	< 0.001	NA
Dibenzofuran	—	**0.049**	**0.046**	**0.0003**	< 0.001	< 0.0001	< 0.001	**0.038**	**0.044**	**0.037**	**0.046**	**0.036**	**0.048**
Fluoranthene	0.92	**0.001**	< 0.005	**0.001**	**0.0046**	< 0.0001	< 0.001	**0.0043**	< 0.005	**0.0017**	< 0.005	**0.0022**	< 0.005
Fluorene	34.6	**0.06**	**0.056**	**0.0015**	**0.003**	**0.0003**	**0.0011**	**0.086**	**0.078**	**0.087**	**0.084**	**0.077**	**0.083**
Indeno(1,2,3-cd)pyrene	—	< 0.001	< 0.005	< 0.0001	**0.0013**	< 0.0001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.005	< 0.001	< 0.005
Naphthalene	98.8	**15.0**	**12.0**	**0.008**	**0.03**	**0.01**	**0.027**	**14.0**	**12.0**	**16.0**	**13.0**	**14.0**	**14.0**
Pentachlorophenol	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	0	**0.036**	**0.042**	**0.0029**	**0.01**	**0.0005**	**0.0021**	**0.062**	**0.086**	**0.063**	**0.075**	**0.063**	**0.087**
Pyrene	25.9	**0.001**	< 0.005	**0.0011**	**0.007**	**0.0001**	< 0.001	**0.0047**	< 0.005	**0.0013**	< 0.005	**0.0022**	< 0.005

NOTES:

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Table G-1 Groundwater Quality Data (Continued)

Sample Location: / Sample Date: / Sample ID: / Compound	Potential Cleanup Level 10 x MTCA Method B Surface-Water Criteria	DW7 DW7-0498 04/15/98	DW-7 DW-7-0298 02/18/98	MW-13 MW13-0498 04/16/98	MW-14 MW-14-0298 02/18/98	MW-22 MW22-0498 04/16/98	MW-22 MW-22-0298 02/18/98	MW-22-D MW22-0498-DUP 04/16/98	MW-23 MW23-0498 04/16/98	MW-23 MW-23-0298 02/18/98	MW-24 MW24-0498 04/16/98	MW-24 MW-24-0298 02/18/98
2-Methylnaphthalene	0	**0.42**	**0.86**	< 0.0001	< 0.001	< 0.0001	**0.0017**	< 0.0001	< 0.0001	**0.0076**	< 0.0001	< 0.001
Acenaphthene	6.43	**0.11**	**0.12**	< 0.0001	**0.076**	**0.036**	**0.047**	**0.037**	**0.0031**	**0.026**	**0.075**	**0.078**
Acenaphthylene	0	**0.061**	**0.083**	**0.0024**	**0.0042**	**0.0022**	**0.0044**	**0.0023**	**0.0021**	**0.0039**	**0.0028**	**0.0035**
Anthracene	259	**0.0095 M**	**0.012**	**0.0036**	**0.0018**	**0.004**	**0.0061**	**0.0042**	< 0.0001	**0.0021**	**0.0052**	**0.0046**
Benzo(a)anthracene	0	< 0.001	< 0.005	**0.0013**	< 0.001	**0.0002**	< 0.001	**0.0001**	< 0.0001	< 0.001	< 0.0001	< 0.001
Benzo(a)pyrene	—	< 0.001	< 0.005	**0.002**	< 0.001	< 0.0001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.0001	< 0.001
Benzo(b)fluoranthene	—	< 0.001	< 0.005	**0.0016**	< 0.001	< 0.0001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.0001	< 0.001
Benzo(g,h,i)perylene	—	< 0.001	< 0.005	**0.0022**	< 0.001	< 0.0001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.0001	< 0.001
Benzo(k)fluoranthene	—	< 0.001	< 0.005	**0.001**	< 0.001	< 0.0001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.0001	< 0.001
Carbazole	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	—	< 0.001	< 0.005	**0.0013**	< 0.001	**0.0001**	< 0.001	**0.0001**	< 0.0001	< 0.001	< 0.0001	< 0.001
Dibenz(a,h)anthracene	—	NA	< 0.005	NA	< 0.001	NA	< 0.001	NA	NA	< 0.001	NA	< 0.001
Dibenzo(a,h)anthracene	—	< 0.001	NA	**0.0014**	NA	< 0.0001	NA	< 0.0001	< 0.0001	NA	< 0.0001	NA
Dibenzofuran	—	**0.05**	**0.048**	< 0.0001	**0.0019**	**0.0017**	**0.0042**	**0.0019**	< 0.0001	**0.0013**	**0.0043**	**0.0041**
Fluoranthene	0.92	**0.0028**	< 0.005	**0.0068**	**0.003**	**0.0028**	**0.0028**	**0.0022**	**0.0005**	**0.0021**	**0.0037**	**0.0028**
Fluorene	34.6	**0.060**	**0.063**	**0.0002**	**0.014**	**0.012**	**0.019**	**0.013**	**0.0010**	**0.0099**	**0.031**	**0.03**
Indeno(1,2,3-cd)pyrene	—	< 0.001	< 0.005	**0.0017**	< 0.0010	< 0.0001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.0001	< 0.001
Naphthalene	98.8	**15.0**	**11.0**	**0.0057**	**0.0017**	**0.0036**	**0.0017**	**0.0056**	**0.0003**	**0.0086**	**0.012**	**0.018**
Pentachlorophenol	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	0	**0.046**	**0.058**	**0.0084**	< 0.001	**0.0028**	**0.025**	**0.0061**	< 0.0001	**0.0086**	**0.0009**	**0.0014**
Pyrene	25.9	**0.0029**	< 0.005	**0.0092**	**0.0045**	**0.003**	**0.0038**	**0.0024**	**0.0007**	**0.0027**	**0.0039**	**0.0031**

NOTES:

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M - Indicates an estimated concentration. Analyte has low spectral match.

Table G-1 Groundwater Quality Data (Continued)

Compound / Sample Location: / Sample Date: / Sample ID:	Potential Cleanup Level 10 x MTCA Method B Surface-Water Criteria	MW-25 / MW25-0498 / 04/16/98	MW-25 / MW-25-0298 / 02/18/98	PZ-3 / PZ-3-1297 / 12/29/97	PZ-4 / PZ-4-1297 / 12/29/97	PZ-7 / PZ-7-1297 / 12/29/97
2-Methylnaphthalene	0	**0.0013**	**0.0085**	**12.0**	**1.40**	**0.99**
Acenaphthene	6.43	**0.049**	**0.063**	**2.20**	**0.53**	**0.24**
Acenaphthylene	0	**0.0054**	**0.0088**	**1.30**	**0.086**	**0.05**
Anthracene	259	< 0.001	< 0.005	**1.80**	**0.14**	**0.015**
Benzo(a)anthracene	0	< 0.001	< 0.005	**2.50**	**0.089**	**0.0034**
Benzo(a)pyrene	—	< 0.001	< 0.005	**2.20**	**0.084**	**0.0032**
Benzo(b)fluoranthene	—	< 0.001	< 0.005	**1.30**	**0.052**	**0.0017**
Benzo(g,h,i)perylene	—	< 0.001	< 0.005	**0.78**	**0.039**	**0.0019**
Benzo(k)fluoranthene	—	< 0.001	< 0.005	**1.60**	**0.043**	**0.0019**
Carbazole	—	NA	NA	**1.50**	**0.082**	**0.15**
Chrysene	—	< 0.001	< 0.005	**2.50**	**0.087**	**0.004**
Dibenz(a,h)anthracene	—	NA	< 0.005	**0.29**	**0.01**	< 0.001
Dibenzo(a,h)anthracene	—	< 0.001	NA	NA	NA	NA
Dibenzofuran	—	**0.0014**	< 0.005	**1.20**	**0.17**	**0.045**
Fluoranthene	0.92	**0.0011**	< 0.005	**2.30**	**0.22**	**0.022**
Fluorene	34.6	**0.01**	**0.014**	**2.50**	**0.44**	**0.061**
Indeno(1,2,3-cd)pyrene	—	< 0.001	< 0.005	**0.77**	**2.50**	**0.0018**
Naphthalene	98.8	**0.21**	**1.1 E**	**34.0**	**0.0013**	**6.90**
Pentachlorophenol	—	NA	NA	< 5.0	< 0.015	< 0.005
Phenanthrene	0	**0.0028**	**0.0081**	**6.90**	**0.46**	**0.120**
Pyrene	25.9	**0.0014**	< 0.005	**2.00**	**0.18**	**0.012**

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ATTACHMENT 2C-2
Floyd|Snider's WSA Shoreline Investigation Data Report

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1.0 Introduction

1.1 BACKGROUND

Gas Works Park is situated on the northern shore of Lake Union, a heavily developed urban lake located north of downtown Seattle, Washington (Figure A.1). Historical operations at the site have resulted in environmental contamination. The Gas Works Uplands have been investigated and remedial construction has been completed, as documented in a formal Consent Decree (CD) between the Washington State Department of Ecology (Ecology), Puget Sound Energy (PSE), and the City of Seattle (City) (State of Washington 1999).

This data report is part of the investigation and remediation of Lake Union sediments offshore from the Gas Works Uplands, which are being addressed in a separate scope of work. Ecology, the City, and PSE have entered into an Agreed Order (AO; State of Washington 2005) to conduct a remedial investigation and feasibility study (RI/FS) and associated planning for the Gas Works Sediment Area (GWSA). The GWSA is delineated by an Area of Investigation (AOI) line (Figure A.1). The AOI is the area where the RI/FS' will be focused. The AO further defines two study areas within the AOI line, the Western Study Area and the Eastern Study Area—as shown in Figure A.1. The Eastern Study Area (ESA) RI/FS process will be completed by PSE. The City is conducting the RI/FS process for the Western Study Area (WSA). This data report is focused on the Gas Works Sediment (GWS)-WSA.

Seattle Public Utilities (SPU) prepared a Current Situation Report and RI/FS Work Plan (Floyd|Snider 2005a) for the GWS-WSA, which was approved by Ecology on April 19, 2005 in a letter to Allison Geiselbrecht (Keeling 2005). GWS-WSA field investigations were then conducted in accordance with the approved RI/FS Work Plan. This data report is consistent with Task 3 of the AO Exhibit B, Statement of Work for the Western Study Area.

The City, under the lead of SPU, has prepared this data report to present the results of a shoreline investigation performed adjacent to the GWS-WSA, and, to fulfill obligations under the Washington State Model Toxics Control Act (MTCA). This document is consistent with requirements of MTCA (Chapter 173-340 WAC) and the Washington State Sediment Management Standards (SMS) [Chapter 173-204 WAC]. The shoreline investigation was performed in September and October 2006 in accordance with the GWS-WSA Shoreline Investigation Sampling and Analysis Plan (SAP; The Floyd|Snider Team 2006).

The investigation described in this data report is consistent with the existing CD and Cleanup Action Plan (CD/CAP) in effect for the Gas Works Park and Harbor Patrol properties (Uplands), which states that "full analysis of any Gas Works Park upland to sediment pathways…will be reserved for the next phase of cleanup analysis and action, under a separate decree or order" (State of Washington 1999). As specified in the Uplands CD/CAP, the investigation described in this data report supports the evaluation of risks to biota in the sediments and will be conducted under the AO for the GWSA (State of Washington 2005). Section 1.5 of Restrictive Covenant No. 20050505001726, which is in effect for the Uplands, requires that "any activity on the [Gas Works Park] Property that may result in the release or exposure to the environment of a hazardous substance that remains on the Property…is prohibited without prior written approval from Ecology" (City of Seattle 2005).

1.2 SITE CONDITIONS

An area of dense non-aqueous phase liquid (DNAPL)-impacted sediment is present in the GWS-WSA adjacent to the shoreline and extending approximately 300 feet offshore. Records regarding historical Uplands uses, however, do not clearly indicate there was an over-water structure or activity that would have resulted in significant "top-down" transport mechanism or source to account for the DNAPL observed in the sediments.

The spatial and vertical distribution of DNAPL in upland wells near the Harbor Patrol facility and in offshore sediments raised the concern of a continued shoreline source of DNAPL (historical and/or current). Due to the locations of previous shoreline borings and wells, a data gap existed regarding the potential presence of DNAPL in the shoreline bank area between Harbor Patrol and the western end of the prow/seawall. The potential that DNAPL could be present in this portion of the shoreline bank area is particularly relevant to the selection of a sediment remedial action. In part, this is due to the generally steep GWS-WSA shoreline slope.

The steep shoreline slope present on the west and shoreline structures, as well as facility operations inhibit shoreline access with sampling vessels to collect surface sediment grab samples and subsurface sediment core samples. Therefore, the abrupt shoreline slope, extent of shoreline data gaps, and lack of a known historical over-water DNAPL source were all characteristics of the GWS-WSA that warranted performance of this shoreline investigation to support the GWS-WSA RI/FS.

1.3 PURPOSE AND OBJECTIVES

The purpose of this shoreline investigation is to evaluate the upland-to-sediment pathway in the context of potential DNAPL migration from the Uplands to the sediments (and associated aquatic receptors). The information obtained will confirm or update the conceptual site model and support development of remedial alternatives proposed for the GWS-WSA. The results of this shoreline investigation will be presented and incorporated in the GWS-WSA remedial RI/FS.

The information obtained from this shoreline investigation will facilitate a well-informed decision by the City and Ecology regarding the preferred remedial alternative. The information obtained will help define the most cost-effective sediment remedy, from both short and long-term perspectives.

The objectives of the investigation include the following:

- Visually delineate the presence of DNAPL in the shoreline bank in areas with limited existing data coverage. This information will aid in evaluating the potential for ongoing DNAPL migration.
- Identify the petrophysical characteristics of the DNAPL (where DNAPL is present in soils and fill along the shoreline, and based on field conditions) in order to evaluate its potential mobility to the sediments.

- Evaluate the geologic conditions at the bank in areas with limited existing data coverage, including thickness and elevations of the fill and glacial units. This information will aid in evaluating the potential location and vertical extent of remedial action components that may be necessary at the bank.
- Measure groundwater flow characteristics, including vertical hydraulic gradients and hydraulic conductivities, at the shoreline for use in groundwater modeling to evaluate long-term protectiveness of GWS-WSA remedial alternatives.
- Evaluate DNAPL recoverability (if DNAPL is encountered) in temporary groundwater wells and evaluate the physical properties of DNAPL to assess potential mobility to the sediments.
- Identify the geotechnical characteristics of the bank materials for use in evaluating potential remedial action components for the bank area.

2.0 Soil Borings, Soil Samples, and Well Construction

The methods employed for drilling the soil borings, collecting soil samples, and constructing the wells departed from the methods proposed in Floyd|Snider's SAP. The following sections describe the scope of the investigation, the departures from the SAP, and the reasons for them.

2.1 SCOPE OF FIELD INVESTIGATION

A total of nine soil borings were advanced at five locations along the GWS-WSA shoreline. At each boring, soil was sampled at selected depths to obtain geologic information and support the visual identification of DNAPL. When encountered, DNAPL samples were obtained and analyzed for mobility characteristics. Soil samples were also selected for geotechnical testing (i.e., grain size and moisture content).

At three locations, one temporary shallow well and one temporary deep groundwater well were installed. These three well pairs were used to evaluate the general groundwater flow in, and the hydrogeologic properties of, the Gasworks Fill and Recessional Stratified Drift. The wells in each pair are within approximately 10 feet of each other. Groundwater quality sampling was not performed. These six temporary groundwater wells will be properly decommissioned upon completion of the field program.

The following two tables summarize the drilling program. David Evans and Associates, Inc. (Professional Surveys) conducted a survey to obtain the coordinates of boring locations and vertical elevations. Figure A.1 shows the boring and well locations. Boring logs and well completion drawings are shown in Attachment A.1.

Summary of Soil Borings

Location	Boring ID	Description
Northwestern portion of Harbor Patrol Facility, near shoreline.	TDW1	Deep soil boring completed as temporary well. Boring is 43.8 ft deep and the well screen is located between 37 and 42 ft bgs.
Northwestern portion of Harbor Patrol Facility, near shoreline.	TSW1	Shallow soil boring completed as temporary well. Boring is 10.5-ft deep and located near TDW1. Well screen is located between 5 and 10 ft bgs. Split spoon samples were only collected in the screen interval.
West side of Kite Hill, near shoreline.	TDW2	Deep soil boring completed as temporary well. Boring is 40.1 ft deep and well screen is located between 34 and 39 ft bgs.
West side of Kite Hill, near shoreline.	TSW2	Shallow soil boring completed as temporary well. Boring is 10.5 ft deep and located near TDW2. Well screen is located between 7 and 12 ft bgs. Split spoon samples were only collected in the screen interval.
West side of Kite Hill, near	TSB3	Soil boring is 31.1 ft deep and located near TDW2. This boring was drilled to sample potentially DNAPL-impacted soils at

Location	Boring ID	Description
shoreline.		Selected depths where DNAPL impacts were observed while drilling TDW2.
Southwest side of Kite Hill, near shoreline.	TSB1	Soil boring is 47.7 ft deep.
South side of Kite Hill, near shoreline.	TSB2	Soil boring is 49.2 ft deep.
South side of Kite Hill, near shoreline.	TDW3	Soil boring completed as temporary well. Boring is 40.8 ft deep and the well screen is located between 34.5 and 39.5-ft bgs.
South side of Kite Hill, near shoreline.	TSW3	Soil boring completed as temporary well. Boring is 11.5 ft deep and located near TDW3. Well screen is located between 6.5 and 11.5 ft bgs. Split spoon samples were only collected in the screen interval.

Soil Boring and Well Summary

I.D.	State Plane Coordinates (ft WA North)	Elevation of Ground Surface (ft USACE)	Elevation of Top PVC (ft USACE)	Total Depth (ft)	Screen Interval (ft bgs)
TDW1	**239,245.2 North 1,269,573.7 East**	24.8	24.51	43.8	37 to 42
TDW2	**238,940.3 North 1,269,7545.0 East**	24.7	24.50	40.1	34 to 39
TDW3	**238,769.8 North 1,269,998.3 East**	26.6	26.50	40.8	34.5 to 39.5
TSW1	**239,252.3 North 1,269,586.6 East**	25.6	25.35	10.5	5 to 10
TSW2	**238,955.4 North 1,269,762.8 East**	27.3	27.06	12.0	7 to 12
TSW3	**238,775.8 North 1,270,000.3 East**	27.3	26.99	11.5	7 to 11.5
TSB1	**238,867.5 North 1,269,836.9 East**	29.0	NA	47.7	NA
TSB2	**238,814.0 North 1,269,926.1 East**	31.4	NA	49.5	NA
TSB3	**238,938.3 North 1,269,758.6 East**	24.9	NA	31.1	NA

2.2 SOIL SAMPLE COLLECTION METHODS

Two different length 2-inch diameter split spoon samplers were used, 18- and 24-inches[1]. Soil samples were collected at intervals that coincided with the length of the split spoon sampler. Where the 18-inch split spoon sampler was used, the subsequent sample was collected from a depth 18 inches deeper, regardless of recovery. Where the 24-inch split spoon was used, the subsequent sample was collected from a depth 24 inches deeper. Therefore, soil samplers were continuously driven—except where refusal occurred. However, due to incomplete sample recovery, only a portion of the soil profile was actually collected for observation.

Most soil samples were collected using 2-inch diameter split spoons. In a few locations, a 2.5-inch diameter split spoon sampler (also called a Dames & Moore sampler) was used. The Dames & Moore sampler was mainly used to obtain larger samples of suspected glacial till. The sampler type used is indicated on the boring logs.

2.3 SAMPLING STRATEGY

The SAP indicates that a deep soil boring would first be drilled and sampled continuously to identify DNAPL-saturated soil. Then, a second boring would be drilled so laboratory samples of DNAPL-saturated soil could be collected. This procedure was changed because of problems associated with heaving sand and because the DNAPL content of the soil was less than anticipated.

The procedure used was to drill a deep soil boring until glacial till was encountered[2]. Soil samples were continuously collected using split spoon samplers. Where potentially heavy DNAPL stains were observed, samples were collected with 6-inch long brass rings inserted into the split spoon samplers. Selected “ring samples” were sealed, labeled, and shipped to PTS Laboratories[3,4]. The remaining ring samples were emptied out for observation. The heaviest DNAPL stains were observed in soil samples collected at TDW2. Consequently, Boring TSB3 was drilled to resample selected depth intervals using a Dames & Moore sampler with brass rings. However, heavy DNAPL stains were not observed in the target depth intervals even though TSB3 was located about 5 feet from TDW2.

Shallow soil borings were proposed at three locations (TSW1, TSW2, and TSW3) for the purpose of constructing shallow wells for hydrologic testing. Soil samples at these locations were collected in the well screen interval for observation only and not laboratory testing.

[1] The 2-inch diameter, 18-inch long, split spoon sampler is typically used for the standard penetration test (SPT).

[2] The deep soil borings are TDW1, TDW2, TDW3, TSB1, and TSB2.

[3] Void space in the ring samples, if present, was filled with pieces of plastic bags. The ends of the rings were sealed with plastic caps and taped shut using duct tape. The ring samples were labeled as to boring, depth, and orientation then stored on dry ice.

[4] Samples were continuously stored in a cooler with dry ice until shipped to the Laboratory (refer to Chain of Custodies included in Attachment A.2).

2.4 WELL CONSTRUCTION

This section describes actual well construction—if it differed from that proposed in the SAP. Refer to the boring logs in Attachment A.1 for well construction details.

Well screens are 5 feet long, rather than 10 feet as originally proposed. For the deep wells, the bottoms of the screens were placed slightly into the glacial till. For shallow wells the top of the screen was placed near the water table.

Sand packs were generally placed about 3 feet above the tops of the screens for deep wells and about 1 foot above the tops of the screens for shallow wells. Bentonite pellet seals were generally about 2 feet thick (over the sandpacks) in the deep wells and thick enough to extend to 1.5 feet below ground surface (bgs) for the shallow wells. The deep wells had an additional well seal that consisted of “Quick Grout” (a high solids bentonite grout) placed on top of the bentonite pellets using a tremie pipe. In comparison, the SAP proposed a cement-bentonite grout placed over a bentonite pellet seal using a tremie pipe. These changes in well construction were made to reduce the amount of time required for well construction and to minimize the potential for the bentonite pellets to bridge inside the auger, as happened in TDW1, the first well constructed.

Well TDW1 was not constructed according to plan due to a problem. Bentonite pellets bridged between the PVC well casing and the inside of the auger. The driller was unable to remove the bridge and had to remove the auger before the full seal could be installed. Consequently, TDW1 was constructed with a thin seal that consists of about 1 foot of bentonite pellets placed on the top of the sand pack. Between this seal and the water table, there is formation soil that collapsed around the PVC casing as the auger was removed. A bentonite seal was placed around the PVC casing above the water table.

2.5 FIELD OBSERVATIONS

The most important field observations recorded include the color, texture, and moisture content of the fill and soils encountered. Also included were the blow counts (i.e., the number of hammer strikes required to drive the sampler into the soil) and indications of possible DNAPL and/or hydrocarbon contamination (e.g., odor, sheen, stains). These observations are recorded on the boring logs (Attachment A.1).

Observations suggest that DNAPL is a minor phase in the samples collected for this investigation and does not appear to be a mobile, separate liquid phase. Field personnel did not observe soil samples that had enough DNAPL to flow out of the sample. However, sheens (locally with colors) and oil blebs were observed in some soil samples. In locations where DNAPL stains were relatively heavy, soil samples were submitted for petrophysical testing.

The location of the top of the Vashon Till was based on field observations. This unit was identified as a gray or dark gray, compact, very dense (high blow count), silty sand or sandy silt. When field personnel believed the Vashon Till was encountered, an additional sample was collected using the (larger) diameter Dames & Moore sampler. This provided a larger sample for observation. At most locations, a sample of the Vashon Till was submitted to the geotechnical laboratory for grain size analysis.

3.0 Laboratory Testing and Results

Selected soil samples were analyzed for petrophysical and geotechnical properties. The table below summarizes the testing accomplished. Appendices B and C contain copies of the laboratory reports and chain of custody forms.

3.1 PETROPHYSICAL LABORATORY TESTING

Petrophysical tests were performed by PTS Laboratories Inc., which is located in Santa Fe Springs, CA. Selected samples collected during hollow stem auger drilling were tested for pore fluid saturation and free product mobility. The following table summarizes the petrophysical testing accomplished and results obtained. The laboratory report is shown in Attachment A.2.

Summary of Samples Tested

Analysis	Location	Sample I.D.
Density, Total Porosity (API RP 40) Pore Fluid Saturations (ASTM D425M, Dean Stark)	TDW2	TDW2-15.5-16.0
	TDW2	TDW2-16.8-18.8
	TDW2	TDW2-21.5-22.0
	TSB2	TSB2-21.3-21.8

Summary of Petrophysical Test Results

Property	Range of Results
Bulk Density (g/cc)	1.61 – 1.80
Grain Density (g/cc)	2.69 – 2.73
Total Porosity (%Vb)	34.1 – 40.3
Water Saturation, before centrifuge (%Pv)	52.9 – 71.7
Water Saturation, after centrifuge (%Pv)	10.0 – 26.0
NAPL Saturation, before centrifuge (%Pv)	2.1 – 5.6
NAPL Saturation, after centrifuge (%Pv)	0.1 – 4.1

Notes:
cc Cubic centimeters.
g Grams.
Pv Pore volume.
The sum of the water and NAPL saturations (i.e., before centrifugation) does not equal 100% of the porosity. The difference is pore space filled with air. Because free DNAPL was not observed in the split spoon sampler and on the brass rings, it is likely the fluid lost from the sample was water that drained out of the brass rings while the drillers were retrieving the samplers. The lost water was simultaneously replaced with air.

3.2 GEOTECHNICAL LABORATORY TESTING

Geotechnical laboratory tests were performed by Analytical Resources Inc., which is located in Tukwila WA. Selected samples collected during hollow stem auger drilling were tested for grain size and moisture content. The following table summarizes the geotechnical testing accomplished. The laboratory report is shown in Attachment A.3.

Summary of Geotechnical Testing

Analysis	Location	Sample
Grain Size (ASTM D421/422)	TDW1	TDW1-9.0
	TDW1	TDW1-15.5
	TDW1	TDW1-27.5
	TDW2	TDW2-23.0
	TDW2	TDW2-39.5
	TDW3	TDW3-9.5
	TDW3	TDW3-29.9
	TDW3	TDW3-39.5
	TSB1	TSB1-15.0
	TSB1	TSB1-33.5
	TSB1	TSB1-47.0
	TSB2	TSB2-5.5
	TSB2	TSB2-17.5
	TSB2	TSB2-39.0
	TSB2	TSB2-49.0
Moisture Content (ASTM 2216)	TDW1	TDW1-43.2
	TSB2	TSB2-45.0
	TSB2	TSB2-49.0

The following table summarizes the results of the moisture content analyses.

Summary of Moisture Content Analyses

Sample ID	Stratigraphic Unit	Moisture Content (%)
TDW1-43.2	Vashon Till	17.6
TSB2-45.0	Recessional Stratified Drift	11.8
TSB2-49.0	Vashon Till	9.13

The following table summarizes the grain size analyses in terms of gravel, sand and silt plus clay. Hydrometer analysis was performed only on samples with potentially significant silt plus clay contents.

Summary of Grain Size Analyses

Sample ID	Stratigraphic Unit	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Silt + Clay (%)
TDW1-9.0	Recessional Stratified Drift	0.9	96.6	-	-	2.6
TDW1-15.5	Recessional Stratified Drift	38.8	55.8	-	-	5.4
TDW1-27.5	Recessional Stratified Drift	24.9	69.9	-	-	5.1
TDW2-23.0	Recessional Stratified Drift	37.4	59.8	-	-	2.8
TDW2-39.5	Vashon Till	25.7	48.7	21.7	3.9	25.6
TDW3-9.5	Gas Works Fill	19.9	58.9	14.0	7.3	21.3
TDW3-29.9	Recessional Stratified Drift	21.9	73.8	-	-	4.4
TDW3-39.5	Vashon Till	25.2	46.5	25.4	2.9	28.3
TSB1-15.0	Gas Works Fill	28.7	62.6	-	-	8.8
TSB1-33.5	Recessional Stratified Drift	10.8	84.5	-	-	4.7
TSB1-47.0	Vashon Till	14.2	50.0	31.7	4.1	35.8
TSB2-5.5	Gas Works Fill	32.1	58.2	5.3	4.3	9.6
TSB2-17.5	Gas Works Fill	24.8	64.3	-	-	10.8
TSB2-39.0	Recessional Stratified Drift	2.2	93.7	-	-	4.0
TSB2-49	Vashon Till	10.8	54.8	29.6	4.7	34.3

Notes:

- Indicates samples where silt plus clay contents were too low for hydrometer analyses.

4.0 Hydrogeological Test Results

Aspect Consulting performed hydrogeological tests for this investigation. Their technical memorandum is presented in Attachment A.4.

Aspect Consulting performed the following services for this investigation:

- Developed the six temporary monitoring wells constructed for this project.
- Performed slug tests (to estimate aquifer hydraulic conductivity) in the same six monitoring wells.
- Collected a comprehensive set of water level measurements across the Uplands and adjacent King County Metro site.
- Evaluated the data collected to estimate upland groundwater flow directions, horizontal and vertical hydraulic gradients, and groundwater velocities in the shoreline area.
- Compared the results of this shoreline investigation with previous results obtained from previous investigations.

4.1 WATER TABLE AQUIFER

Aspect concluded that the available information indicates that the Gas Works Fill and Recessional Stratified Drift form a single unconfined aquifer (a water table aquifer) that they refer to as the GWF/RSD hydrostratigraphic unit. However, this unit contains considerable small-scale stratification that can create localized semi-confined conditions.

In Attachment A.4, Figure 2 shows inferred groundwater flow directions for the upland based on their October 2006 groundwater level measurements. The groundwater contours represent the water table surface in the combined GWF/RSD hydrostratigraphic unit, but also in the Vashon Till (VT) unit where the GWF/RSD unit is absent in the vicinity of the Metro site (located northwest of the study area). According to Aspect, this interpretation is consistent with the previous hydrogeologic interpretation for the Metro site.

The water table surface generally flows south/southwest toward Lake Union. The water table surface gradient is low (up to 0.003 foot/foot) in the vicinity of the shoreline. Aspect noted a slight depression of about one foot in the groundwater levels in the vicinity of Wells RW-1, PZ-9, and PZ-10. They were unable to determine the cause of the anomaly and did not include the data from these three wells in the contours shown on Figure 2.

4.2 VERTICAL GRADIENTS

Aspect estimated vertical groundwater gradients in the GWF/RSD (i.e., water table) aquifer in the vicinity of the shoreline. These estimates were made from measurements from the six wells constructed for this investigation. One set of measurements was made in October 2006 and a second set was made in November 2006. In general, there appear to be small upward vertical gradients up to approximately 0.0007 foot/foot.

These vertical gradients estimated for the shoreline area are at least an order of magnitude less than the horizontal gradients estimated for this area. These results indicate groundwater flow is predominantly horizontal in the shoreline area.

4.3 HYDRAULIC CONDUCTIVITY

Aspect developed a set of estimates of hydraulic conductivity for the GWF/RSD aquifer based on the slug tests they performed and a pumping test performed in the vicinity of Harbor Patrol in 1998. Aspect's "best estimate" of hydraulic conductivity of this unit is 16 feet/day (6×10^{-3} cm/sec). They developed this estimate by evaluating the shoreline shallow and deep slug test results as well as the earlier pumping test result.

4.4 GROUNDWATER VELOCITY

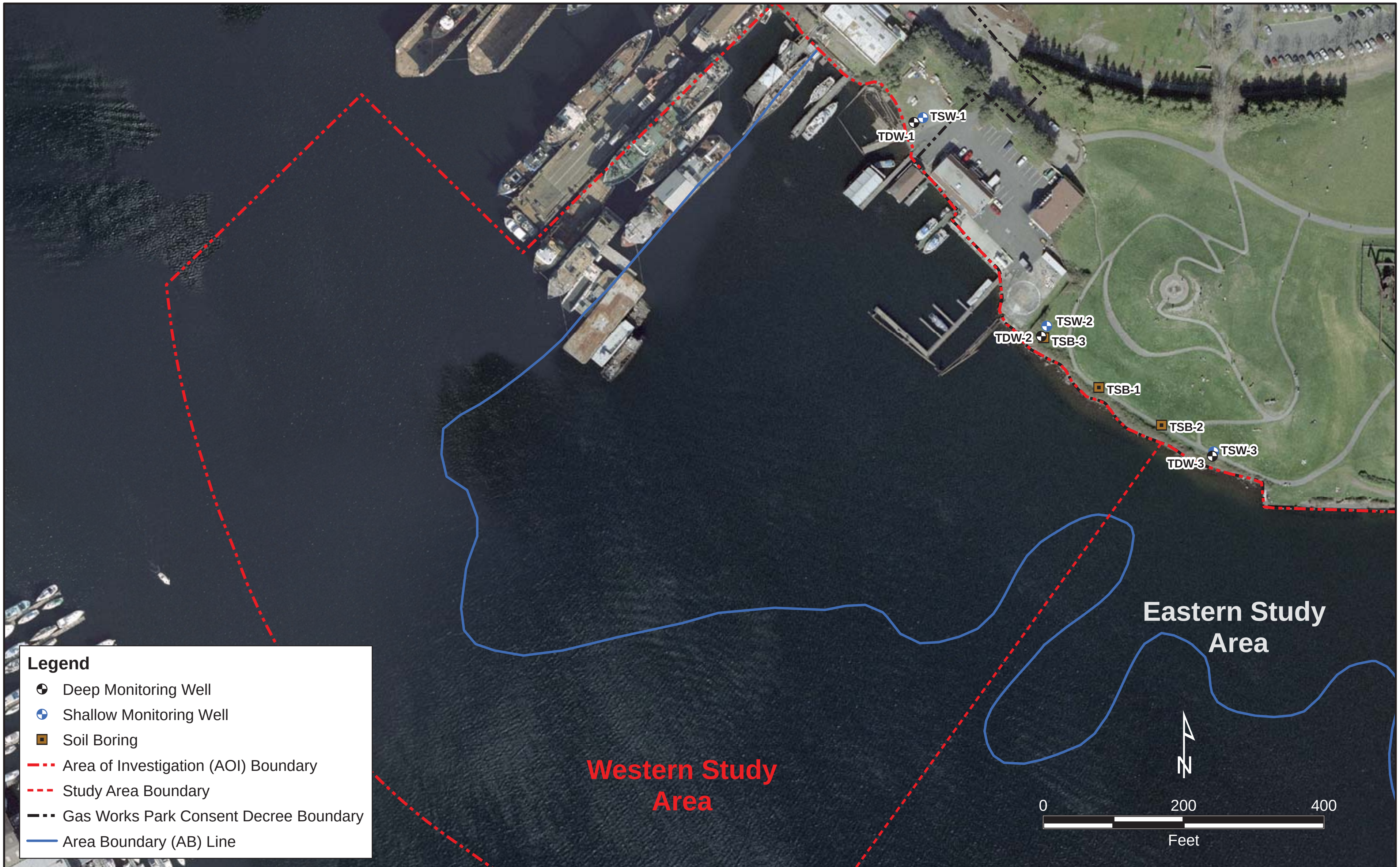
Aspect estimated the average linear groundwater velocity in the GWF/RSD aquifer to be about 0.16 feet/day in the vicinity of the shoreline. The velocity varies locally due to differences in hydraulic gradient.

Gas Works Sediment
Western Study Area

Remedial Investigation/Feasibility Study

Appendix A
Shoreline Investigation Data Report

Figures



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Shoreline Investigation Data Report
Gas Works Sediment Western Study Area
City of Seattle

DRAFT

Figure A.1
Site Map with 2006 Soil Boring and Monitoring Well Locations

F:\projects\COS-GWSA\GIS\RIFS Report\Figure A.1 (Site Map with 2006 FS SBs and MWs 8.5 x 11).mxd

ECOLOGY REVIEW DRAFT May 25, 2007

Gas Works Sediment
Western Study Area

Remedial Investigation/Feasibility Study

Appendix A
Shoreline Investigation Data Report

Attachments

RELATIVE DENSITY / CONSISTENCY

SAND / GRAVEL			SILT / CLAY		
Density	SPT N-values	Approx. Relative Density (%)	Consistency	SPT N-values	Approx. Undrained Shear Strength (psf)
Very Loose	<4	<15	Very Soft	<2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Med. Dense	10 to 30	35 - 65	Med. Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	>50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	>30	>4000

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		GROUP DESCRIPTIONS	
Gravel 50% or more of the coarse fraction retained on the #4 sieve. Use dual symbols (eg. GP-GM) for 5% to 12% fines.	GRAVEL (<5% fines)	GW	Well-graded GRAVEL
		GP	Poorly-graded GRAVEL
	GRAVEL (>12% fines)	GM	Silty GRAVEL
		GC	Clayey GRAVEL
Sand 50% or more of the coarse fraction passing the #4 sieve. Use dual symbols (eg. SP-SM) for 5% to 12% fines.	SAND (<5% fines)	SW	Well-graded SAND
		SP	Poorly-graded SAND
	SAND (>12% fines)	SM	Silty SAND
		SC	Clayey SAND
Silt and Clay 50%or more passing #200 sieve	Liquid Limit < 50	ML	SILT
		CL	Lean CLAY
		OL	Organic SILT or CLAY
	Liquid Limit > 50	MH	Elastic SILT
		CH	Fat CLAY
		OH	Organic SILT or CLAY
Highly Organic Soils		PT	PEAT

Notes:

1. Soil exploration logs contain material descriptions based on visual observation and field tests using a system modified from the Uniform Soil Classification System (USCS). Where necessary laboratory tests have been conducted (as noted in the "Other Tests" column), unit descriptions may include a classification. Please refer to the discussions in the report text for a more complete description of the subsurface conditions.

2. The graphic symbols given above are not inclusive of all symbols that may appear on the borehole logs. Other symbols may be used where field observations indicated mixed soil constituents or dual constituent materials.

DESCRIPTIONS OF SOIL STRUCTURES

- **Layered:** Units of material distinguished by color and/or composition from material units above and below
- **Laminated:** Layers of soil typically 0.05 to 1mm thick, max. 1 cm
- **Lens:** Layer of soil that pinches out laterally
- **Interlayered:** Alternating layers of differing soil material
- **Pocket:** Erratic, discontinuous deposit of limited extent
- **Homogeneous:** Soil with uniform color and composition throughout
- **Fissured:** Breaks along defined planes
- **Slickensided:** Fracture planes that are polished or glossy
- **Blocky:** Angular soil lumps that resist breakdown
- **Disrupted:** Soil that is broken and mixed
- **Scattered:** Less than one per foot
- **Numerous:** More than one per foot
- **BCN:** Angle between bedding plane and a plane normal to core axis

COMPONENT DEFINITIONS

COMPONENT	SIZE / SIEVE RANGE	COMPONENT	SIZE / SIEVE RANGE
Boulder:	> 12 inches	Sand	
Cobbles:	3 to 12 inches	Coarse Sand:	#4 to #10 sieve (4.5 to 2.0 mm)
Gravel		Medium Sand:	#10 to #40 sieve (2.0 to 0.42 mm)
Coarse Gravel:	3 to 3/4 inches	Fine Sand:	#40 to #200 sieve (0.42 to 0.074 mm)
Fine Gravel:	3/4 inches to #4 sieve	Silt	0.074 to 0.002 mm
		Clay	<0.002 mm

TEST SYMBOLS

for In Situ and Laboratory Tests listed in "Other Tests" column.

CBR	California Bearing Ratio
Comp	Compaction Tests
Con	Consolidation
DD	Dry Density
DS	Direct Shear
%F	Fines Content
GS	Grain Size
Perm	Permeability
PP	Pocket Penetrometer
R	R-value
SG	Specific Gravity
TV	Torvane
TXC	Triaxial Compression
UCC	Unconfined Compression

SYMBOLS

Sample/In Situ test types and intervals

- 2-inch OD Split Spoon, SPT (140-lb. hammer, 30" drop)
- 3.25-inch OD Spilt Spoon (300-lb hammer, 30" drop)
- Non-standard penetration test (see boring log for details)
- Thin wall (Shelby) tube
- Grab
- Rock core
- Vane Shear

MONITORING WELL

- Groundwater Level at time of drilling (ATD)
- Static Groundwater Level
- Cement / Concrete Seal
- Bentonite grout / seal
- Silica sand backfill
- Slotted tip
- Slough
- Bottom of Boring

MOISTURE CONTENT

Dry	Dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

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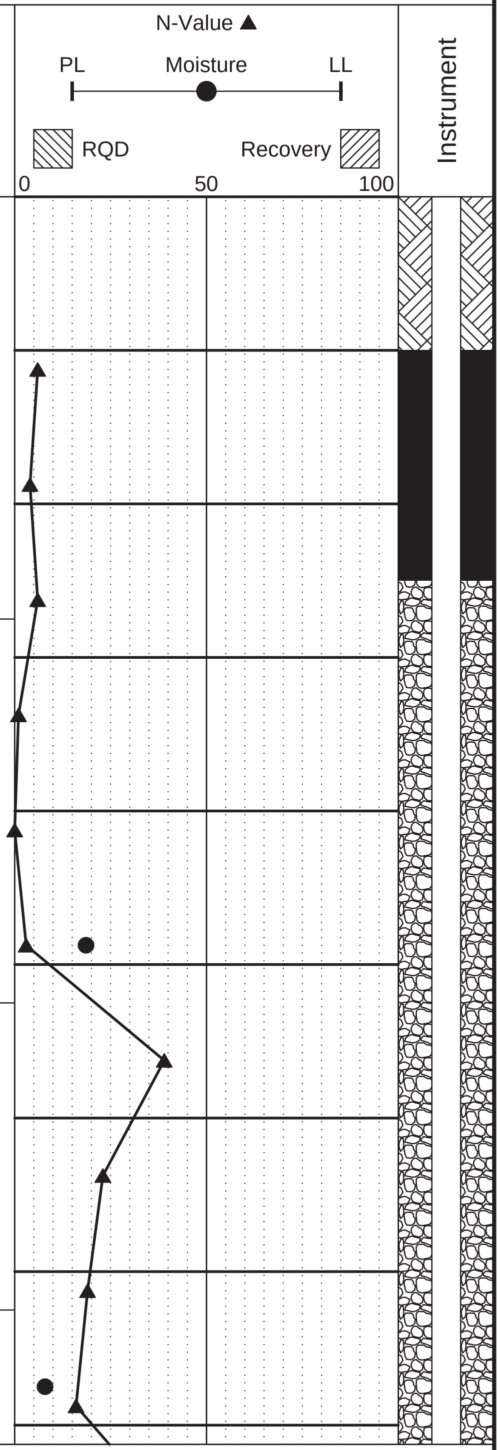
Terms and Symbols for Boring and Test Pit Logs

Figure 1

Project:	Gas Works Sediment Cleanup	Surface Elevation:	24.8 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	24.51 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 239245.21, Easting: 1269573.75	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						Loose, dark brown, gray and black, mottled, slightly silty, slightly gravelly, SAND; moist to wet; poorly graded to well graded, slight iron-oxide staining, no oil odor or sheen; (Gas Works Fill) SP-SM/SP.
2	S-1		4, 3, 3			
4	S-2		1, 1, 3			
	S-3		2, 3, 3			
6	S-4		1, 0, 1			Very loose, dark gray, SAND, trace of silt and gravel; wet; scattered thin silt and peat seams, faint odor, no oil sheen or staining; (Recessional Stratified Drift) SP.
8	S-5		1, 0, 0			
10	S-6		0, 1, 2	TDW1-9.0		--Faint unknown odor between 9 and 10 feet. --Silty peat seam at 9.5 feet.
	S-7		7, 16, 23			Dense to medium dense, dark grayish brown, trace of gravel to slightly gravelly, SAND, trace of silt; wet; bedded, no oil sheen or staining; (Recessional Stratified Drift) SP.
12	S-8		9, 10, 13			
14	S-9		6, 10, 9			
16	S-10		4, 8	TDW1-15.5		Medium dense and dense, dark gray, clean to slightly silty, gravelly, SAND to SAND, trace of gravel and silt; wet; no oil odor sheen or staining; (Recessional Stratified Drift) SP/SP-SM.



Completion Depth:	43.8ft
Date Borehole Started:	9/19/06
Date Borehole Completed:	9/21/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

LOG OF TEST BORING TDW-1

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Figure 2

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	24.8 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	24.51 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 239245.21, Easting: 1269573.75	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
	S-11		8, 7, 11, 31			Medium dense and dense, dark gray, clean to slightly silty, gravelly, SAND to SAND, trace of gravel and silt; wet; no oil odor sheen or staining; (Recessional Stratified Drift) SP/SP-SM. *(Continued)*
18	S-12		7, 14, 12			
20	S-13		1, 4, 6			
	S-14		6, 9, 21			
22	S-15		3, 13, 10			
24	S-16		10, 13, 20			
26	S-17		10, 21, 50/5			Very dense, dark gray, slightly gravelly to gravelly, SAND, trace of silt; wet; bedded, scattered slightly silty seams, scattered gravel lenses, no oil sheen or odor; (Recessional Stratified Drift) SP/SP-SM.
	S-18		15, 49, 50/3	TDW1-27.5		
28	S-19		15, 50/5			
30	S-20		6, 24, 50/3			
32	S-21		13, 50/5			

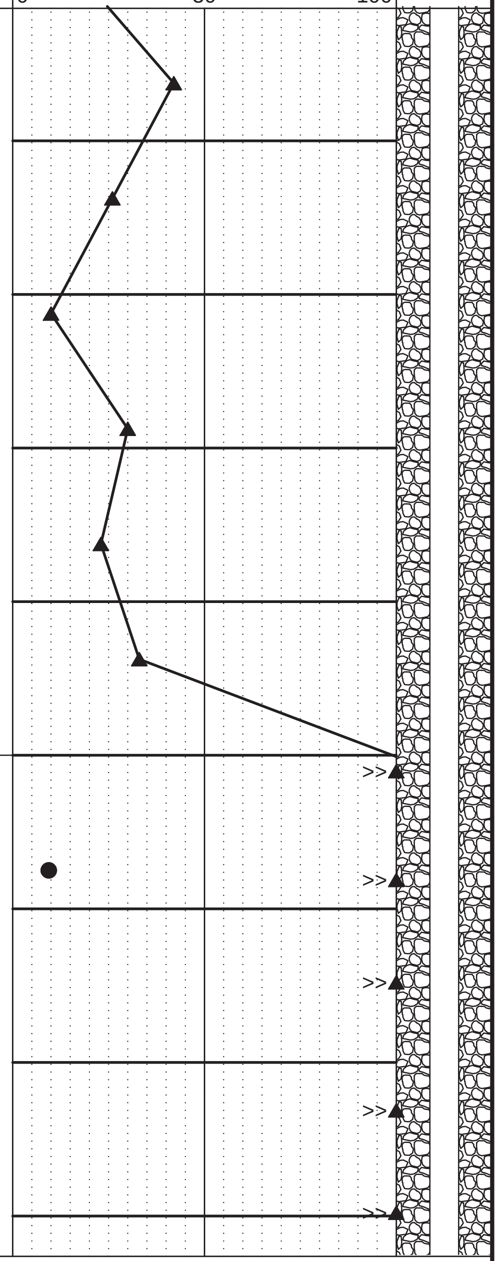
N-Value ▲

PL — Moisture ● — LL

RQD — Recovery

0 — 50 — 100

Instrument



Completion Depth:	43.8ft
Date Borehole Started:	9/19/06
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Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

LOG OF TEST BORING TDW-1

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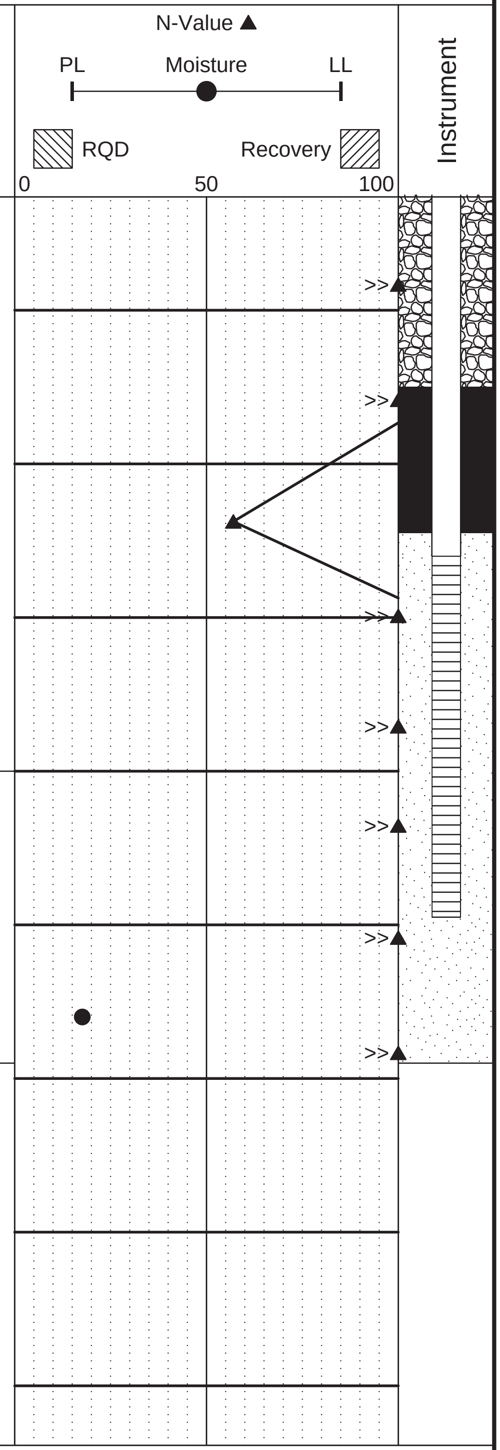
Figure 2

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	24.8 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	24.51 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 239245.21, Easting: 1269573.75	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Blows / 6 in.	Other Tests	MATERIAL DESCRIPTION
	S-22	16 / 34 / 50/4		Very dense, dark gray, slightly gravelly to gravelly, SAND, trace of silt; wet; bedded, scattered slightly silty seams, scattered gravel lenses, no oil sheen or odor; (Recessional Stratified Drift) SP/SP-SM. *(Continued)* --Driller reports groundwater heave between 33 and 39 feet..
34	S-23	13 / 30 / 50/4		
36	S-24	12 / 23 / 34		
38	S-25	22 / 50/5.5		--Slightly silty seam at 37.5 feet.
	S-26	17 / 50/4		
40	S-27	50/5		Very dense, light gray and gray, silty, gravelly SAND; moist; locally trace of clay, no oil sheen; (Vashon Till) SM.
42	S-28	150/4		--8-inch-thick, hard, sandy, silty clay seam at 42.3 feet.
	S-29	100/4	TDW1-43.2	
44				Bottom of boring at 43.8 feet below ground surface.
46				
48				



Completion Depth:	43.8ft	Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.	
Date Borehole Started:	9/19/06		
Date Borehole Completed:	9/21/06		
Logged By:	J. Lamanna		
Drilling Company:	Boart Longyear		

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LOG OF TEST BORING TDW-1

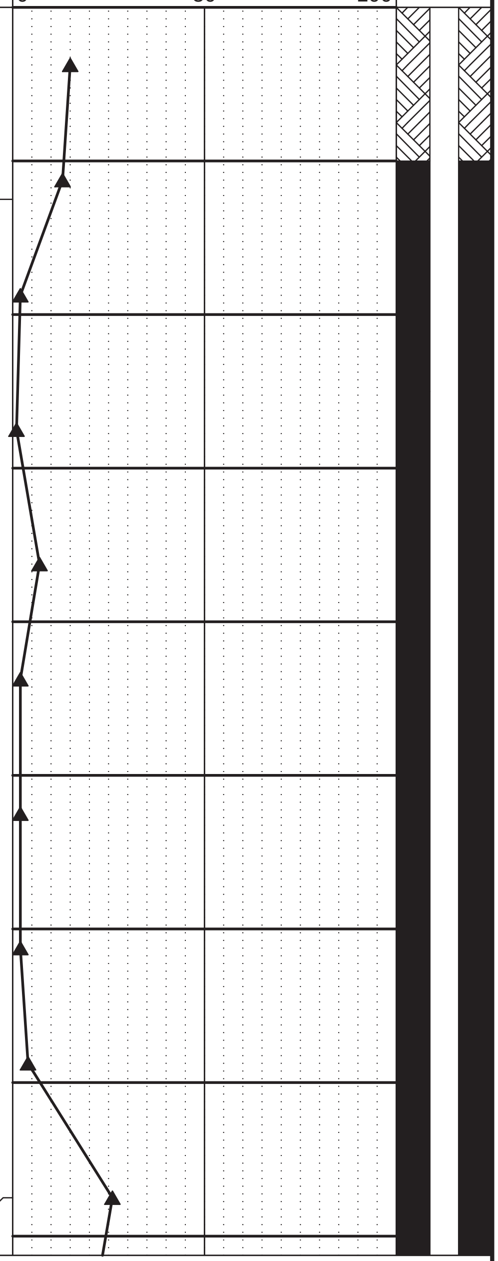
Figure 2

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	24.7 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	24.50 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238940.34, Easting: 1269754.99	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0	S-1		5, 8, 7			Medium dense, brown, slightly silty, gravelly SAND; dry; abundant coal fragments and roots; (Gas Works Fill) SP-SM.
2	S-2		4, 8, 5			Very loose to loose, brown to black, intermixed, slightly silty, slightly gravelly to gravelly SAND and gravelly SAND, trace of silt; moist to wet; scattered brick, wood, metal, and ceramic fragments; (Gas Works FIll) SP/SW-SM.
4	S-3		2, 1, 1			
	S-4		1, 0, 1			
6	S-5		7, 0, 3			--Naphthalene-like odor noted below 6.3 feet.
8	S-6		4, 1, 2			
10	S-7		0, 1, 1			
12	S-8		1, 1, 2			
14	S-9		1, 1, 1			
	S-10		2, 2, 1			
16			6, 20	TDW2-15.5		--Oil sheen with color, black oil blebs, and naphthalene-like odor at 15 feet.

N-Value ▲ | PL — Moisture — LL | RQD | Recovery | 0 50 100 | Instrument



		Remarks
Completion Depth:	40.0ft	Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.
Date Borehole Started:	9/28/06	
Date Borehole Completed:	9/29/06	
Logged By:	J. Lamanna	
Drilling Company:	Boart Longyear	

LOG OF TEST BORING TDW-2

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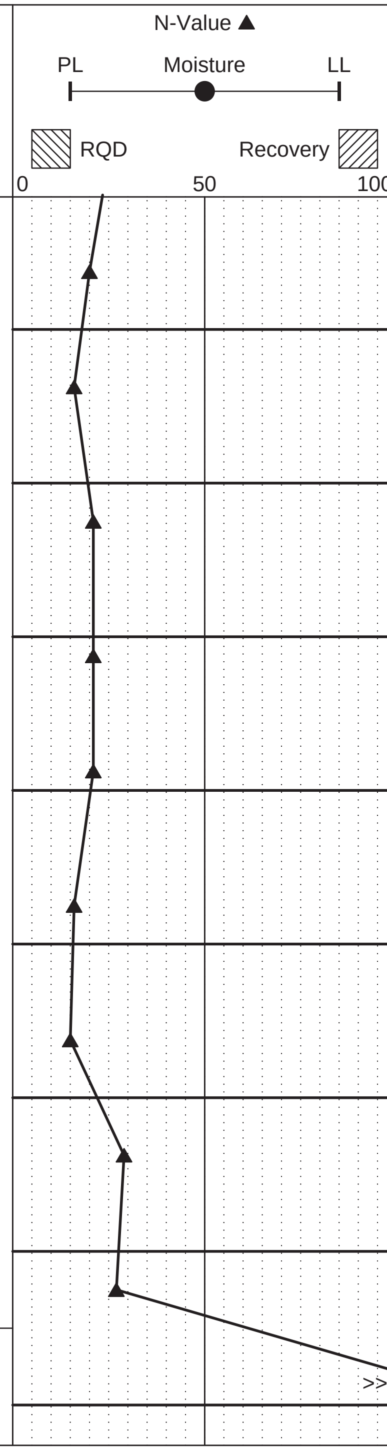
Figure 3

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	24.7 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	24.50 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238940.34, Easting: 1269754.99	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Blows / 6 in.	Other Tests	MATERIAL DESCRIPTION
		31		Medium dense, gray and dark gray, interbedded fine SAND, trace of silt, and slightly gravelly to gravelly, SAND, trace of silt; wet; naphthalene-like odor, oil sheen and oil staining; (Recessional Stratified Drift) SP. *(Continued)*
	S-11	6, 8, 12	TDW2-16.8	--Questionable N-values between 16.5 and 19 feet because driller was distracted.
18	S-12	7, 6, 10		
20	S-13	6, 8, 13, 16		
22	S-14	6, 8, 13	TDW2-21.5	--Driller notes groundwater heave and geologist notes oil-stained slough in samples below 22 feet.
	S-15	3, 9, 12	TDW2-23.0	--Oil staining and oil sheen in slough between 23.0 and 34.5 feet.
24				
	S-16	4, 4, 12, 16		
26				
	S-17	8, 6, 9		--Very heavy oil staining in slough between 27 and 28 feet.
28	S-18	9, 10, 19		-Geologist notes heavy oil stains and sheen on slough in sample at 29.5 feet, and a 3/8-inch-thick sand bed with dark brown oil stains at 29.7 feet.
30	S-19	4, 9, 18	TDW2-30.6	--Wood fragment at 30 feet.
	S-20	36, 50/5		Very dense, gray-brown, gravelly SAND to SAND, trace of silt; wet; significant groundwater heave noted, oil staining in sample slough; (Recessional Stratified Drift) SP.
32				



Instrument

Completion Depth:	40.0ft
Date Borehole Started:	9/28/06
Date Borehole Completed:	9/29/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

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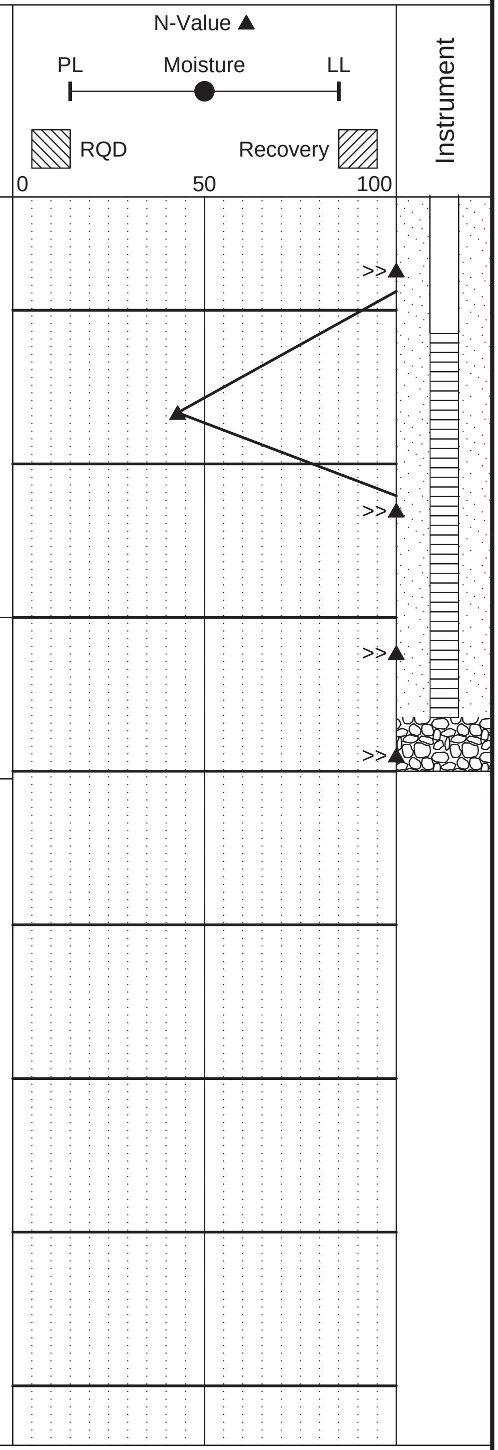
LOG OF TEST BORING TDW-2

Figure 3

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	24.7 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	24.50 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238940.34, Easting: 1269754.99	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
	S-21		25 50/5.5			Very dense, gray-brown, gravelly SAND to SAND, trace of silt; wet; significant groundwater heave noted, oil staining in sample slough; (Recessional Stratified Drift) SP. *(Continued)*
34						
	S-22		2 11 32 50/2			
36	S-23		50/2.5			
38	S-24		28 50/5			Very dense, gray, silty, gravelly SAND; moist; no oil staining; (Vashon Till) SM.
40	S-25		86 14/1	TDW2-39.5		
						Bottom of boring at 40.1 feet below ground surface.
42						
44						
46						
48						



Completion Depth: 40.0ft
Date Borehole Started: 9/28/06
Date Borehole Completed: 9/29/06
Logged By: J. Lamanna
Drilling Company: Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

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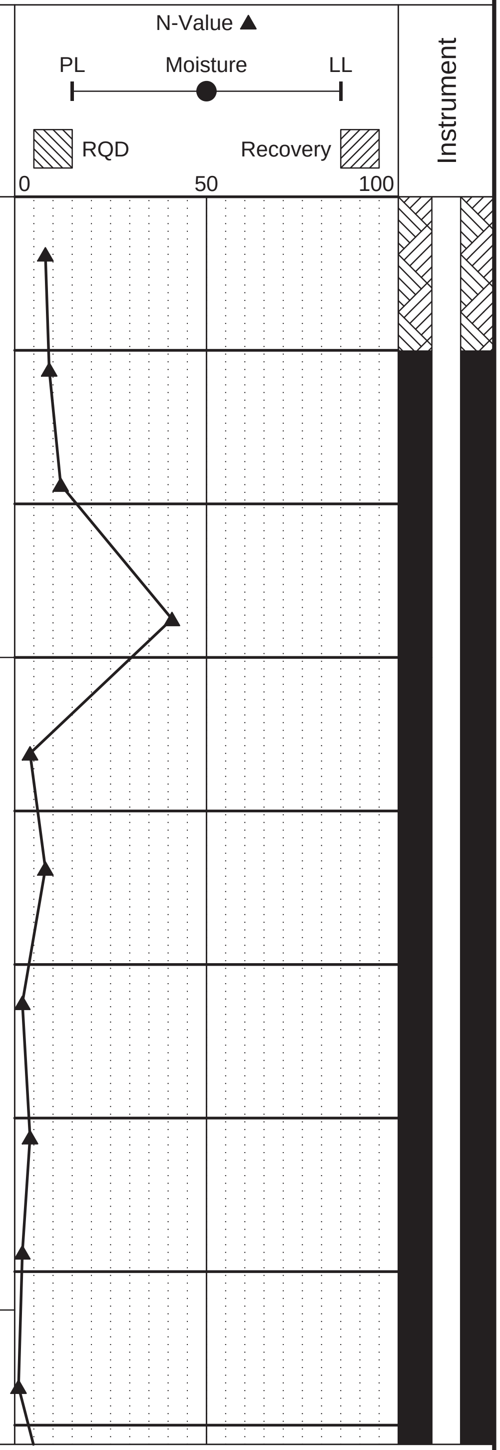
LOG OF TEST BORING TDW-2

Figure 3

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	26.6 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	26.50 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238769.82, Easting: 1269998.28	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0	S-1		3, 3, 5			Loose to dense, dark brown and black, slightly silty, gravelly SAND; moist to wet; scattered root, concrete, wood, brick, and slag fragments; no oil odor or staining; (Gas Works Fill) SP-SM.
2	S-2		6, 5, 4			
4	S-3		3, 4, 8			
	S-4		3, 7, 34	TDW3-4.5	▽	
6	S-5		12, 2, 2	TDW3-6.5		Loose to very loose, very dark brown to black, slightly silty to silty, gravelly SAND; wet; scattered wood, ceramic, and brick fragments; chemical odor with slight sheen; (Gas Works FIll) SP-SM.
8	S-6		2, 6, 5			
10	S-7		3, 2, 1, 1	TDW3-9.5, 10.0		
12	S-8		2, 0, 2	TDW3-11.5, 12.0, 12.0R		
14	S-9		2, 1, 1			--Soil appears to be a little oily, but not saturated and with a naphthelene-like odor at 13 feet.
	S-10		1, 1, 1, 0	TDW3-14.5, 15.5		Very loose to loose, very dark brown to black, organic-rich, silty SAND; wet; abundant wood and plant fragments; (Gas Works Fill/Old Mudline Horizon) SM/OL.
16						



Completion Depth:	40.8ft
Date Borehole Started:	9/26/06
Date Borehole Completed:	9/27/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

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LOG OF TEST BORING TDW-3

Figure 4

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	26.6 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	26.50 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238769.82, Easting: 1269998.28	Sampling Method:	SPT w/ Auto Hammer

Sample No.	Blows / 6 in.	Other Tests
S-11	2, 1, 1, 9	TDW3-17.0
S-12	5, 12, 14	
S-13	4, 8, 9, 13	
S-14	5, 9, 14	
S-15	7, 10, 9	
S-16	5, 11, 13, 18	
S-17	5, 11, 11	
S-18	3, 5, 7	
S-19	2, 5, 10, 18	TDW3-29.9
S-20	5, 17	

Depth, (ft): 18, 20, 22, 24, 26, 28, 30, 32

MATERIAL DESCRIPTION

Very loose to loose, very dark brown to black, organic-rich, silty SAND; wet; abundant wood and plant fragments; (Gas Works Fill/Old Mudline Horizon) SM/OL. *(Continued)*

Medium dense to dense, dark gray, slightly gravelly to gravelly, fine to medium SAND, trace of silt; wet; bedded, no oil staining or sheen; (Recessional Stratified Drift) SP.

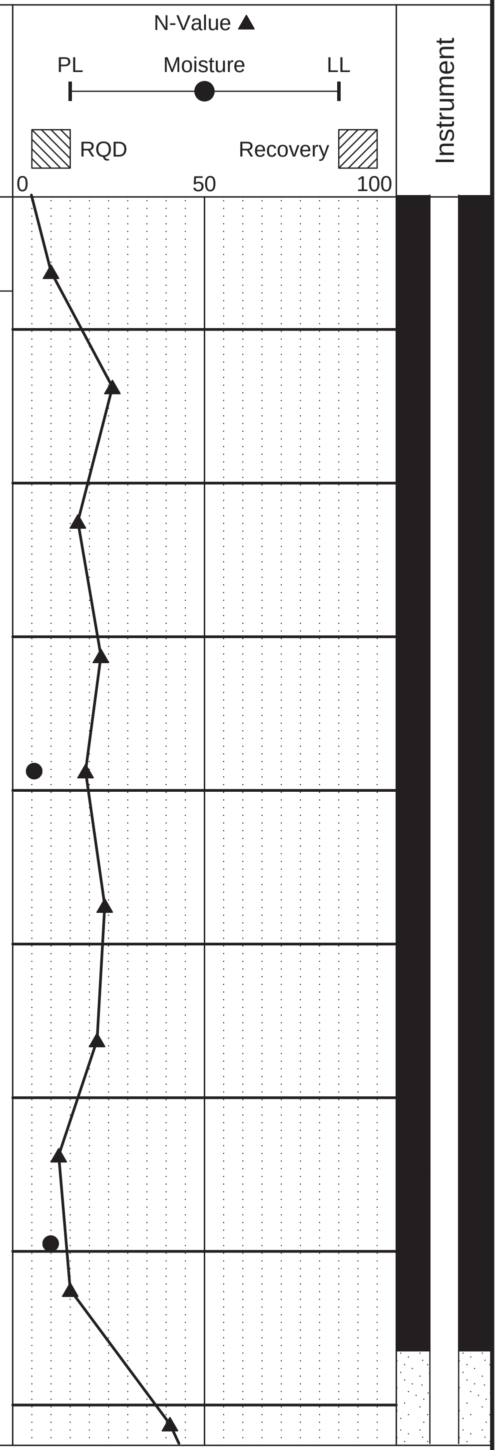
--Naphthalene-like odor between 17.5 and 31 feet.

--Grades to silty fine SAND, trace of gravel between 22.5 and 27.5 feet.

--Scattered sandy silt seams between 24.5 and 26 feet.

--Grades to clean, slightly gravelly SAND below 27.5 feet. Driller notes groundwater heave.

--No naphthalene-like odor noted below 31 feet.



Completion Depth:	40.8ft	Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.
Date Borehole Started:	9/26/06	
Date Borehole Completed:	9/27/06	
Logged By:	J. Lamanna	
Drilling Company:	Boart Longyear	

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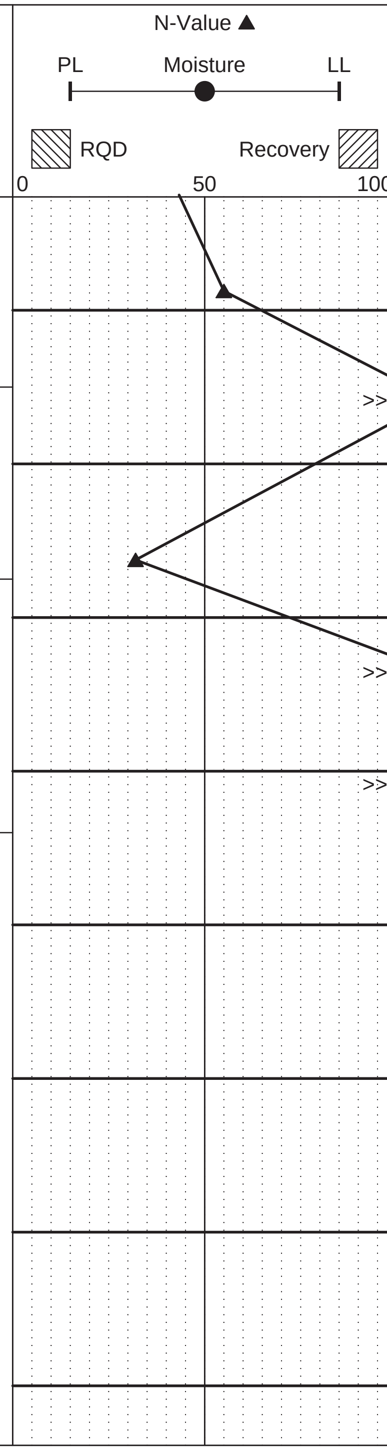
LOG OF TEST BORING TDW-3

Figure 4

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	26.6 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	26.50 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238769.82, Easting: 1269998.28	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
			24			Medium dense to dense, dark gray, slightly gravelly to gravelly, fine to medium SAND, trace of silt; wet; bedded, no oil staining or sheen; (Recessional Stratified Drift) SP. *(Continued)*
34	S-21		3 13 42			
	S-22		11 50 50/4			Very dense to dense, gray silty fine SAND; moist; (Vashon Recessional Outwash) SM.
36						
	S-23		8 12 20			Very dense, gray, silty, gravelly SAND; moist to wet; no oil staining or sheen; (Vashon Till?) SM.
38	S-24		5 39 50/5			
40	S-25		20 50 50/4	TDW3-39.5		
						Bottom of boring at 40.8 feet below ground surface.
42						
44						
46						
48						



Instrument

Completion Depth:	40.8ft
Date Borehole Started:	9/26/06
Date Borehole Completed:	9/27/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

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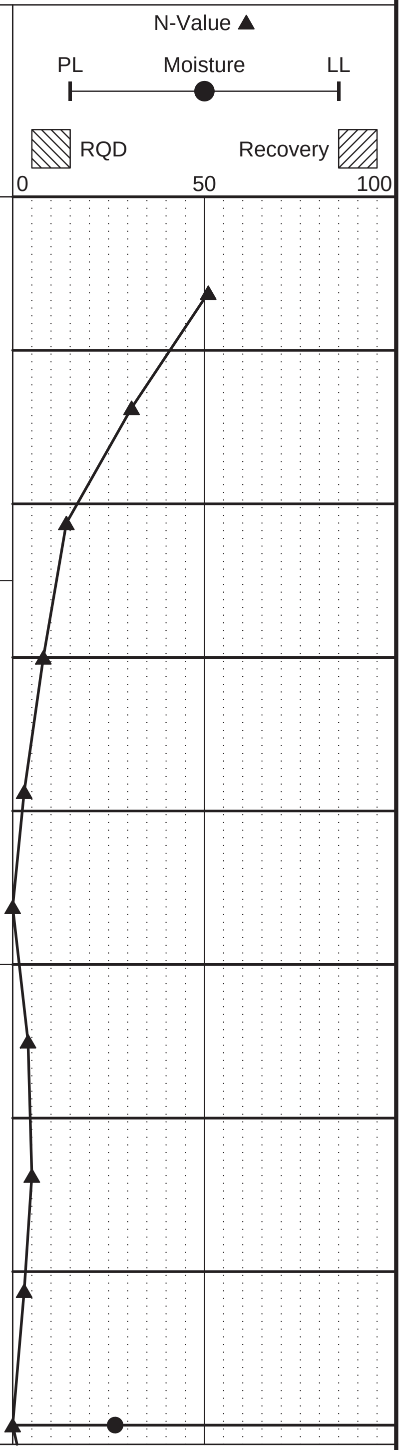
LOG OF TEST BORING TDW-3

Figure 4

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	29.0 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238867.49, Easting: 1269836.89	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0					SM	Very dense to medium dense, brown and very dark brown, slightly gravelly to gravelly, silty SAND; moist; Scattered concrete fragments, variable color, earthy odor; (Gas Works Fill) SM.
	S-1	SPT	2, 35, 16			
2	S-2	SPT	10, 14, 17			
4	S-3	SPT	4, 9, 5			
5					SM	Loose to very loose, brown and dark gray-brown, slightly gravelly, silty SAND; moist to wet; earthy odor; (Gas Works Fill) SM.
6	S-4	SPT	0, 3, 5, 3			
8	S-5	SPT	0, 2, 1		▽	
	S-6	SPT	1, 0, 0			
10	S-7	SPT	1, 2, 2, 2		SP-SM/SM	Very loose to medium dense, dark gray and black, clean to slightly silty, slightly gravelly to gravelly SAND; wet; scattered concrete, slag, ceramic, glass, wood, metal, and brick fragments; (Gas Works Fill) SP-SM/SM.
12	S-8	SPT	1, 2, 3			--No oil stains or sheen.
14	S-9	SPT	3, 2, 1			--Oily, naphthelene-like odor between 15 and 30 feet.
16	S-10	SPT	1, 0	TSB1-15.0		



		Remarks
Completion Depth:	47.7ft	Remarks: Standard Penetrations Test (SPT) sampler *AND* Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.
Date Borehole Started:	9/25/06	
Date Borehole Completed:	9/25/06	
Logged By:	J. Lamanna	
Drilling Company:	Boart Longyear	

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LOG OF TEST BORING TSB-1

Figure 5

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	29.0 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238867.49, Easting: 1269836.89	Sampling Method:	SPT w/ Auto Hammer

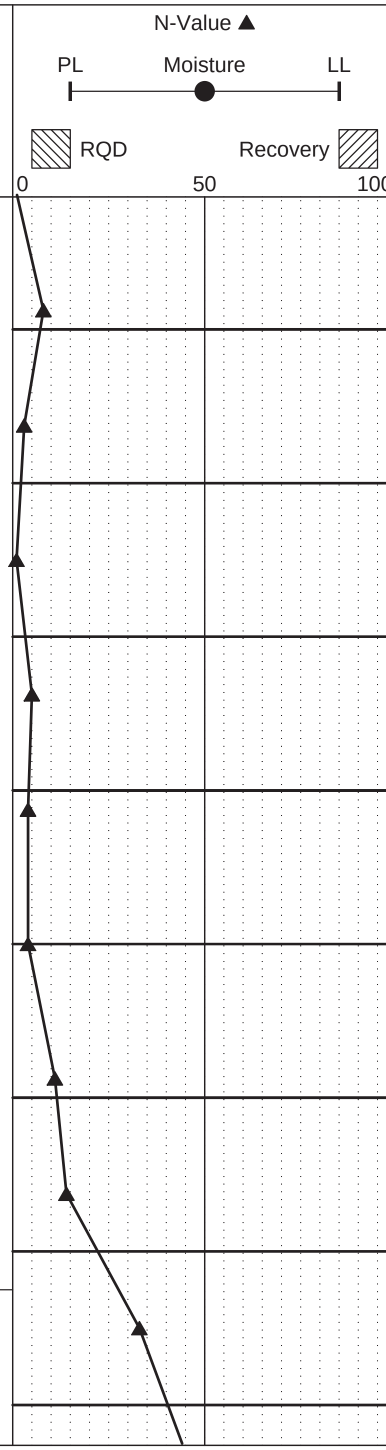
Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol
			0, 2		
18	S-11		1, 2, 6		
	S-12		1, 2, 1		
20 – 22	S-13		1, 1, 0, 3		
	S-14		1, 2, 3		
24	S-15		3, 2, 2		
26	S-16		2, 2, 2, 2		
28	S-17		3, 3, 8		
	S-18		10, 5, 9		
30 – 32	S-19		6, 16, 17, 20		
32			12		

MATERIAL DESCRIPTION

Very loose to medium dense, dark gray and black, clean to slightly silty, slightly gravelly to gravelly SAND; wet; scattered concrete, slag, ceramic, glass, wood, metal, and brick fragments; (Gas Works Fill) SP-SM/SM. *(Continued)*

--Slight sheen (no color) between 20 and 29 feet.

Dense and medium dense, dark gray and very dark gray, slightly gravelly to gravelly, fine to medium SAND, trace of silt; wet; locally sandy gravel at top, slight naphthelene-like odor, no oil sheen or stains; (Recessional Stratified Drift) SP.



Completion Depth:	47.7ft
Date Borehole Started:	9/25/06
Date Borehole Completed:	9/25/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler *AND* Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

LOG OF TEST BORING TSB-1

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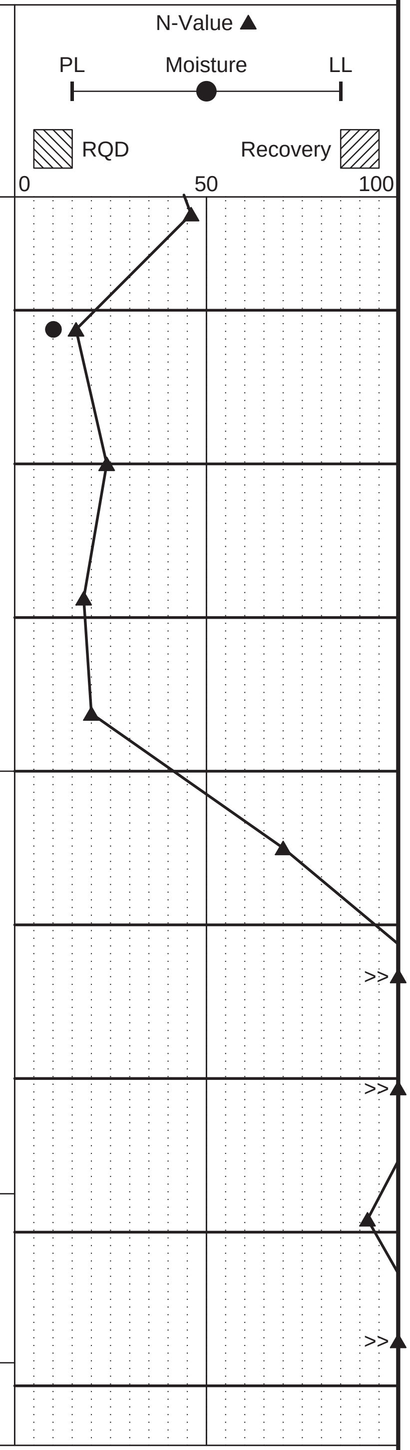
Figure 5

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	29.0 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238867.49, Easting: 1269836.89	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
	S-20		17, 29		SP	Dense and medium dense, dark gray and very dark gray, slightly gravelly to gravelly, fine to medium SAND, trace of silt; wet; locally sandy gravel at top, slight naphthelene-like odor, no oil sheen or stains; (Recessional Stratified Drift) SP. *(Continued)*
34	S-21		5, 7, 9	TSB1-33.5		
36	S-22		6, 9, 15, 17			
38	S-23		6, 6, 12			
	S-24		4, 8, 12			
40					SP	Very dense, gray, slightly gravelly to gravelly, SAND, trace of silt; wet; possible naphthelene-like odor, no oil stains or sheen; (Recessional Stratified Drift) SP.
	S-25		13, 36, 34, 35			
42	S-26		22, 33, 55/4			
44	S-27		3, 41, 55/3			
					SM	Very dense, gray, slightly gravelly, silty SAND; moist; no naphthelene-like odor; (Vashon Till) SM.
46	S-28		10, 42, 50, 56/2			
	S-29		50, 50/4	TSB1-47.0		
48						Bottom of boring at 47.7 feet below ground surface.



Completion Depth:	47.7ft
Date Borehole Started:	9/25/06
Date Borehole Completed:	9/25/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler *AND* Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

LOG OF TEST BORING TSB-1

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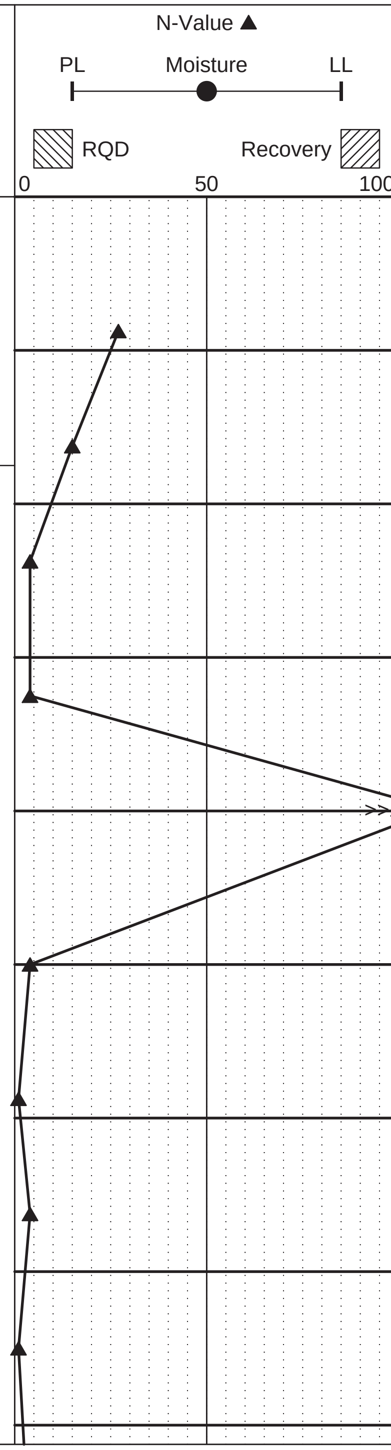
Figure 5

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	31.4 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238814.03, Easting: 1269926.06	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						Medium dense, dark brown to gray-brown, slightly silty to silty, gravelly SAND; moist; scattered crushed rock and wood chips; (Gas Works Fill) SM/SP-SM.
2	S-1		13, 15, 12			
	S-2		10, 8, 7			
4	S-3		3, 2, 2			Very loose, dark brown to black, slightly silty to silty, gravelly SAND; moist to wet; scattered concrete, glass, ceramic, brick, metal, and slag fragments; (Gas Works Fill) SP-SM/SM. --Oily odor but no oil sheen or oil staining between 3.5 and 8.3 feet.
6	S-4		1, 2, 2, 4	TSB2-5.5		
8	S-5		4, 50/5.5	TSB2-7.5		--Sample S-5 was pounded on concrete.
10	S-6		3, 2, 2, 1			
12	S-7		1, 0, 1			
	S-8		1, 2, 2			
14	S-9		2, 0, 1, 1			
16						



Completion Depth:	49.5ft
Date Borehole Started:	9/21/06
Date Borehole Completed:	9/21/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

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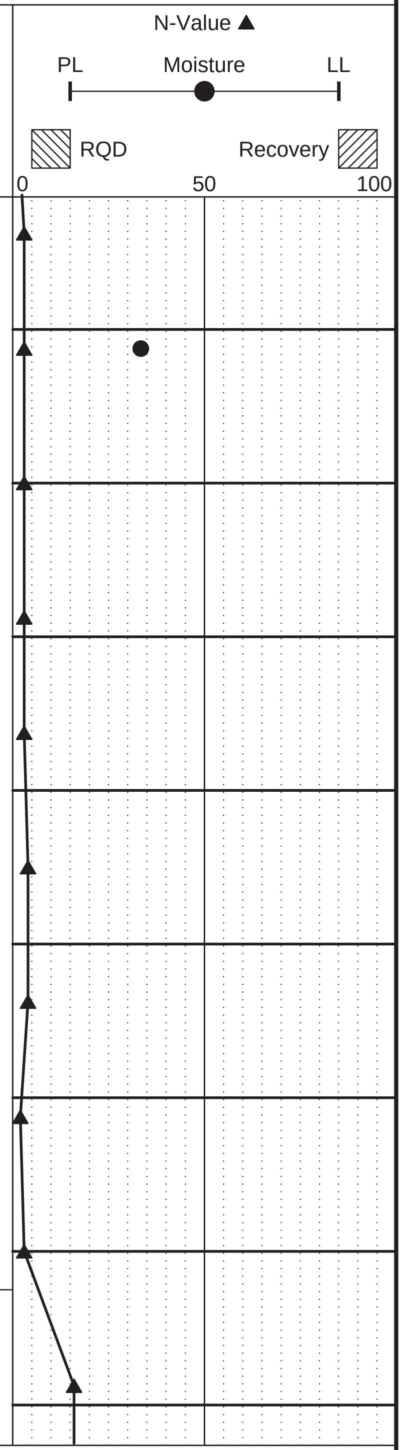
LOG OF TEST BORING TSB-2

Figure 6

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	31.4 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238814.03, Easting: 1269926.06	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Blows / 6 in.	Other Tests	MATERIAL DESCRIPTION
	S-10	0, 1, 2		--Oily odor, oil sheen and staining from 16 to 30.5 feet. Oil content variable and apparently less than saturated. Very loose, dark brown to black, slightly silty to silty, gravelly SAND; moist to wet; scattered concrete, glass, ceramic, brick, metal, and slag fragments; (Gas Works Fill) SP-SM/SM. *(Continued)*
18	S-11	1, 1, 2	TSB2-17.5	
20	S-12	1, 1, 2, 1		
22	S-13	2, 1, 2	TSB2-21.3	
	S-14	2, 2, 1	TSB2-22.5	
24	S-15	2, 3, 1, 2	TSB2-25.7	
26	S-16	1, 2, 2		
28	S-17	2, 1, 1		
30	S-18	2, 2, 1, 8		Medium dense to dense, dark gray, slightly gravelly to gravelly SAND, trace of silt; wet; slight oil odor and sheen in upper 2 feet of unit; (Recessional Stratified Drift) SP. --Wood fragment at 31.5 feet.
32	S-19	3, 5, 11		



Completion Depth:	49.5ft
Date Borehole Started:	9/21/06
Date Borehole Completed:	9/21/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

LOG OF TEST BORING TSB-2

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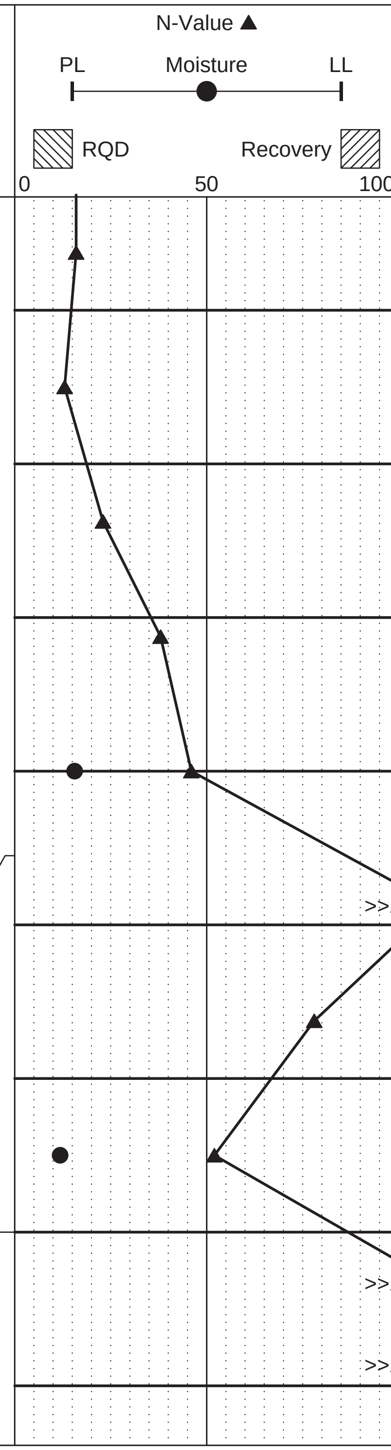
Figure 6

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	31.4 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238814.03, Easting: 1269926.06	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
	S-20		4, 8, 8			Medium dense to dense, dark gray, slightly gravelly to gravelly SAND, trace of silt; wet; slight oil odor and sheen in upper 2 feet of unit; (Recessional Stratified Drift) SP. *(Continued)* --Oily odor below 32 feet. No oil sheen or staining.
34	S-21		3, 7, 6			
36	S-22		14, 5, 9			
38	S-23		14, 3, 15			
40	S-24		23, 6, 20	TSB2-39.0		
	S-25		26, 32, 5			--Wood fragment at 41 feet.
42	S-25		39, 50/4			Very dense, gray, slightly gravelly, silty SAND grading to slightly gravelly, sandy SILT; wet; slight oily odor above 44 feet; (Recessional Stratified Drift) SM/ML.
44	S-26		8, 30, 48			--No oily odor or sheen noted below 44 feet.
	S-27		10, 15, 37			
46	S-28		36, 20, 46, 50/4			Very dense, gray, slightly gravelly, silty SAND; moist; no oil odor; (Vashon Till) SM.
48	S-29		50/5.5			



Completion Depth:	49.5ft	Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.	
Date Borehole Started:	9/21/06		
Date Borehole Completed:	9/21/06		
Logged By:	J. Lamanna		
Drilling Company:	Boart Longyear		

LOG OF TEST BORING TSB-2

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Figure 6

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	31.4 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238814.03, Easting: 1269926.06	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION	N-Value ▲ / PL Moisture LL / RQD Recovery (0 50 100)
	S-30		100/6	TSB2-49.0		Very dense, gray, slightly gravelly, silty SAND; moist; no oil odor; (Vashon Till) SM. *(Continued)*	>>
						Bottom of boring at 49.5 feet below ground surface.	
50							
52							
54							
56							
58							
60							
62							
64							

Completion Depth:	49.5ft
Date Borehole Started:	9/21/06
Date Borehole Completed:	9/21/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler ***AND*** Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

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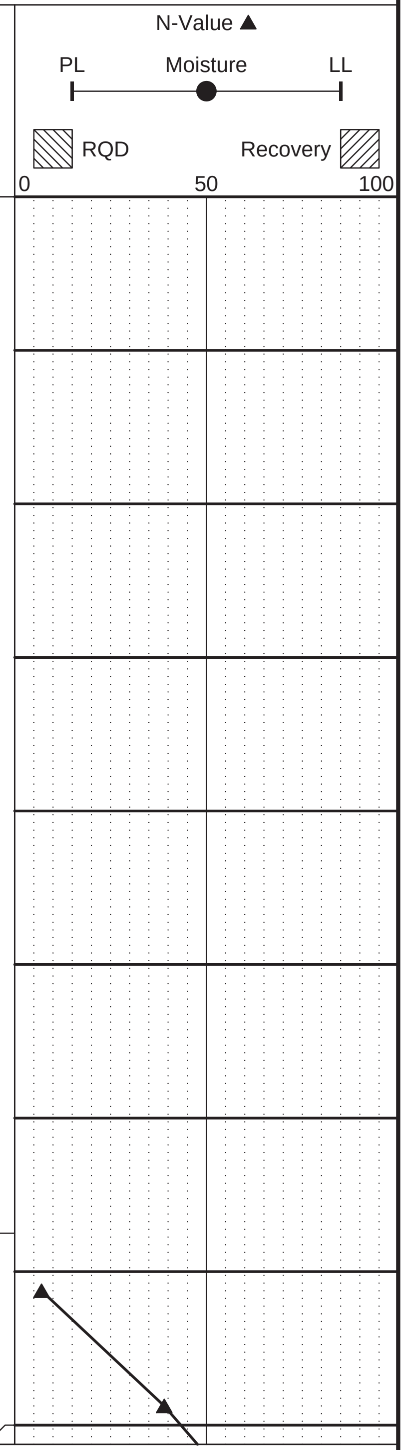
LOG OF TEST BORING TSB-2

Figure 6

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	24.9 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238938.34, Easting: 1269758.61	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						Borehole advanced from ground surface to a depth of 13.5 feet without sampling. Therefore, no soil description is presented for the soil interval between 0 and 13.5 feet.
2						-TSB3 is located near TDW2, which was sampled in this depth interval.
4						
6						
8						
10						
12						
14	S-1		3 3 4			Very loose to loose, dark gray, slightly silty to silty, slightly gravelly to gravelly, SAND; wet; scattered reeds and wood (organic-rich); scattered glass fragments; naphthalene-like odor, no free oil; (Gas Works Fill/Old Mudline Horizon) SP-SM/SM.
16	S-2		4 8			--Oil stains and colored sheen in soil at the 16.0-foot contact--does not appear to be saturated with oil.



Completion Depth:	31.1ft
Date Borehole Started:	10/2/06
Date Borehole Completed:	10/2/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

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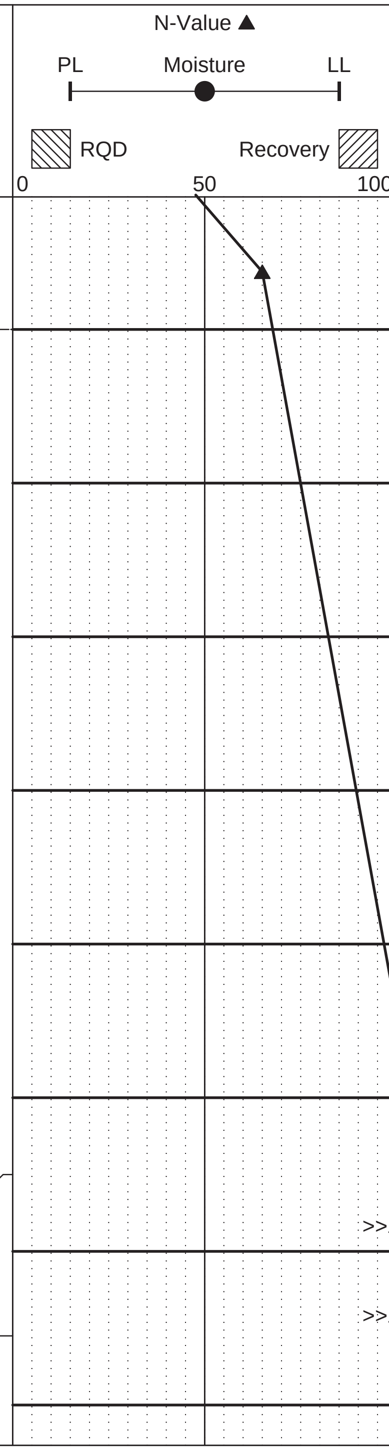
LOG OF TEST BORING TSB-3

Figure 7

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	24.9 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238938.34, Easting: 1269758.61	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
16.5–18	S-3		31, 8, 31, 34	TSB3-16.5		Medium dense, dark gray, slightly gravelly to gravelly, SAND, trace of silt; wet; (Recessional Stratified Drift) SP-SM. *(Continued)*
18–29						Borehole advanced from a depth of 18 feet to 29 feet without sampling. Therefore, no soil description is presented for the soil interval between 18 and 29 feet. -TSB3 is located about 5 feet from TDW2, which was sampled in this depth interval. --Driller notes significant groundwater heave during sampling of samples S-4 and S-5.
29–31.1	S-4		9, 34, 50/4	TSB3-16.5R		Medium dense, gray, slightly gravelly to gravelly, SAND, trace of silt; wet; strong naphthalene-like odor, no sheen or oil drops; (Recessional Stratified Drift) SP.
	S-5		50, 50/2			
31.1						Bottom of boring at 31.1 feet below ground surface.



Completion Depth:	31.1ft
Date Borehole Started:	10/2/06
Date Borehole Completed:	10/2/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Dames and Moore Sampler (D&M) driven with 140-lb. safety hammer. Therefore, samples obtained with a D&M sampler indicate non-standard N-values.

LOG OF TEST BORING TSB-3

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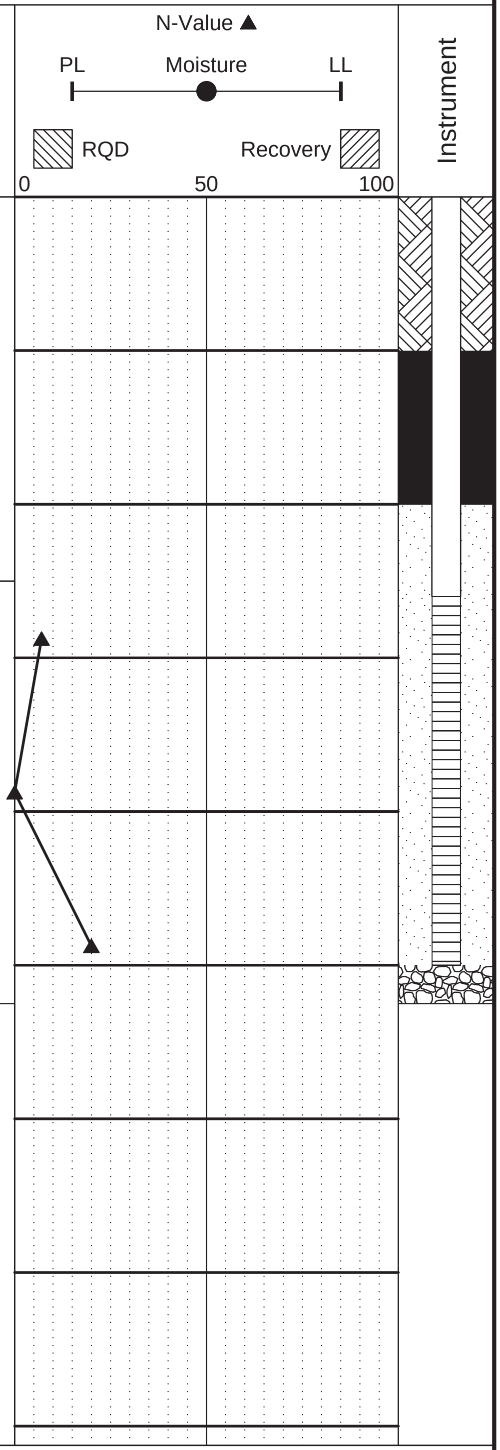
Figure 7

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	25.6 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	25.35 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 239252.34, Easting: 1269586.6	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						Borehole advanced from ground surface to a depth of 5 feet without sampling. Therefore, no soil description is presented for the soil interval between 0 and 5 feet.
2						-TSW1 is located near TDW1, which was sampled in this depth interval.
4						
5–6	S-1		2, 2, 5	TSW2-5.0		Very loose to medium dense, dark yellow-brown and dark gray-brown, slightly silty SAND to slightly gravelly to gravelly, SAND, trace of silt; wet; scattered wood chips, no oil odor or sheen; (Gas Works Fill) SP.
7–8	S-2		1, 0, 0	TSW2-7.0		
9–10	S-3		6, 11, 9	TSW2-9.0		
10.5						Bottom of boring at 10.5 feet below ground surface.
12						
14						
16						



Completion Depth:	10.5ft
Date Borehole Started:	9/21/06
Date Borehole Completed:	9/21/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler driven with 140-lb. safety hammer.

LOG OF TEST BORING TSW-1

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Figure 8

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	27.3 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	27.06 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238955.42, Easting: 1269762.77	Sampling Method:	SPT w/ Auto Hammer

N-Value ▲ — PL, Moisture, LL — RQD, Recovery — 0, 50, 100 — Instrument

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						Borehole advanced from ground surface to a depth of 5.5 feet without sampling. Therefore, no soil description is presented for the soil interval between 0 and 5.5 feet.
2						-TSW2 is located near TDW2, which was sampled in this interval.
4						
6	S-1		1 0 0 0			Very loose, yellow, brown, gray to black, slightly silty SAND, trace of gravel to gravelly, silty SAND; wet; scattered brick fragments and burnt wood, no oil odor or sheen; (Gas Works Fill) SP-SM/SM.
8	S-2		1 0	No Rec.		
10	S-3		0 1 0 0			
12						Bottom of boring at 12.0 feet below ground surface.
14						
16						

Completion Depth:	11.5ft
Date Borehole Started:	10/2/06
Date Borehole Completed:	10/2/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler driven with 140-lb. safety hammer.

LOG OF TEST BORING TSW-2

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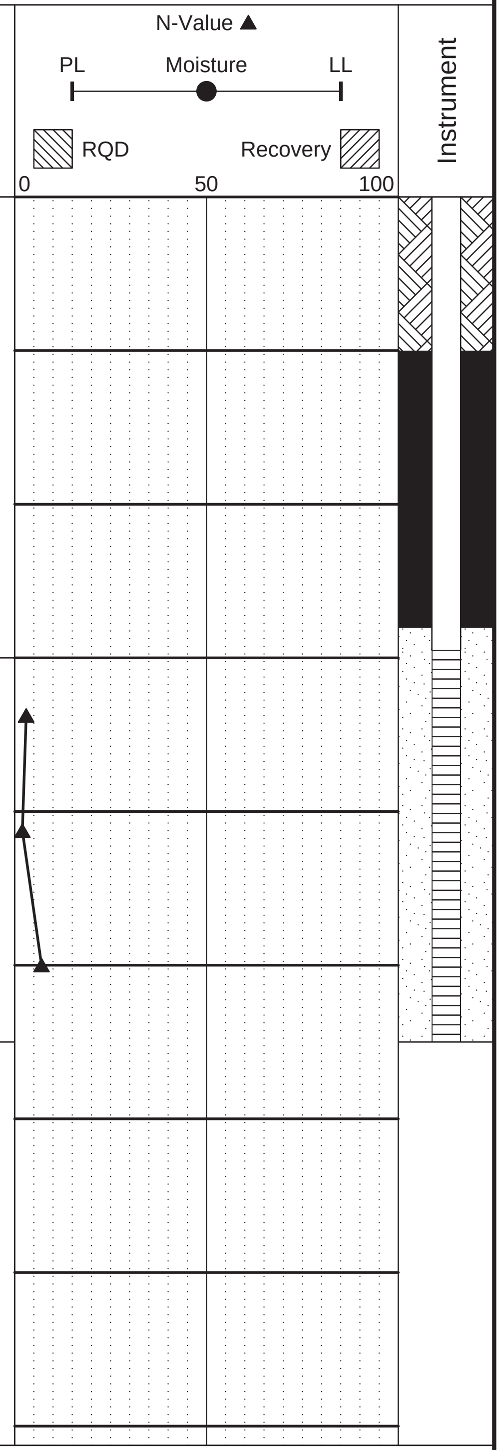
Figure 9

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Gas Works Sediment Cleanup	Surface Elevation:	27.3 ft. (USACE)
Job Number:	06-091	Top of Casing Elev.:	26.99 ft. (USACE)
Location:	Gas Works Park, Seattle Washington	Drilling Method:	HSA
Coordinates:	Northing: 238775.84, Easting: 1270000.34	Sampling Method:	SPT w/ Auto Hammer

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						Borehole advanced from ground surface to a depth of 6 feet without sampling. Therefore, no soil description is presented for the soil interval between 0 and 6 feet.
2						-TSW3 is located near TDW3, which was sampled in this depth interval.
4						
6	S-1		2, 2, 1			Very loose to loose, strong brown, dark brown to dark gray, slightly silty to silty, slightly gravelly to gravelly SAND; moist to wet; scattered slag and ceramic fragments, no oil odor or sheen; (Gas Works Fill) SP-SM/SP.
8	S-2		1, 1, 1			
10	S-3		1, 3, 4, 4			
						Bottom of boring at 11.5 feet below ground surface.
12						
14						
16						



Completion Depth:	11.9ft
Date Borehole Started:	9/27/06
Date Borehole Completed:	9/27/06
Logged By:	J. Lamanna
Drilling Company:	Boart Longyear

Remarks: Standard Penetrations Test (SPT) sampler driven with 140-lb. safety hammer.

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LOG OF TEST BORING TSW-3

Figure 10

The stratification lines represent approximate boundaries. The transition may be gradual.

PTS Laboratories
ENVIRONMENTAL SERVICES

36834

CHAIN OF COUSTODY RECORD

COMPANY: FLOYD SNIDER

ADDRESS: 601 UNION ST #600 CITY: SEATTLE WA ZIP CODE: 98101

PROJECT MANAGER: JANE FISHER 206-292-2078

PROJECT NAME: GASWORKS PARK PHONE NUMBER: 206-682-7867

PROJECT NUMBER: COS - GWSA-3040 FAX NUMBER:

SITE LOCATION: SEATTLE

SAMPLER SIGNATURE: [signature]

PO#: COS-GWSA

TURNAROUND TIME: 24 HOURS ☐ 48 HOURS ☐ 72 HOURS ☐ 5 DAYS ☐ NORMAL ☒ (2 WEEKS)

OTHER: ____

SAMPLE INTEGRITY (CHECK): INTACT ____ ON ICE ____

PTS QUOTE NO.:

PTS FILE:

ANALYSIS REQUEST

SAMPLE ID NUMBER	DATE	TIME	DEPTH, FT	NUMBER OF SAMPLES	SOIL PROPERTIES PACKAGE	HYDRAULIC CONDUCTIVITY PACKAGE	PORE FLUID SATURATIONS PACKAGE ×	TCEQ/TNRCC PROPERTIES PACKAGE	CAPILLARITY PACKAGE	FLUID PROPERTIES PACKAGE	PHOTOLOG: CORE PHOTOGRAPHY	MOISTURE CONTENT, ASTM D2216	POROSITY: TOTAL, API RP40	POROSITY: EFFECTIVE, ASTM D425M	SPECIFIC GRAVITY, ASTM D854	BULK DENSITY (DRY), API RP40 or ASTM D2937	AIR PERMEABILITY, API RP40	HYDRAULIC CONDUCTIVITY, EPA9100, API RP40, D5084	GRAIN SIZE DISTRIBUTION, ASTM D422/4464M	TOC: WALKLEY-BLACK	ATTERBERG LIMITS, ASTM D4318	PORE FLUID SAT'N API RP40	FREE PRODUCT MOBILITY ASTM D425M / API RP40			COMMENTS
✓ TSB2-21.3-21.8	9/22	1010	21.3																			X	X			
✓ TSB2-22.5-23.0	9/22	1020	22.5																							
✓ TSB2-25.7-26.2	9/22	1047	26.0																							
✓ TDW3-9.5-10.0	9/26	1306	9.5																							
✓ TDW3-11.5-12.0	↓	1316	11.5																							
✓ TDW3-14.5-15.0	↓	1345	14.5																							
✓ TDW3-17.0-17.5	↓	1353	17.0																							
✓ TDW2-15.5-16.0	9/28	1207	15.5																			X	X			
✓ TDW2-16.8-17.3	↓	1219	16.8																			X	X			
✓ TDW2-18.3-18.8	↓	1231	18.3																			X	X			
✓ TDW2-21.5-22.0	9/28	1330	21.5																							

1. RELINQUISHED BY	2. RECEIVED BY	3. RELINQUISHED BY	4. RECEIVED BY
[signature]	[signature]		
COMPANY: FLOYD SNIDER	COMPANY: PTS LABS	COMPANY:	COMPANY:
DATE: OCT 3, 2006 TIME: 1109	DATE: 10/4/06 TIME: 11:24	DATE: TIME:	DATE: TIME:

PTS File No: 36834
Client: Floyd Snider

PTS Laboratories

FREE PRODUCT MOBILITY: INITIAL AND RESIDUAL SATURATIONS

PROJECT NAME: Gasworks Park
PROJECT NO: COS-GWSA-304D

		METHODS:	API RP 40		API RP 40	ASTM D425M, DEAN-STARK			
						PORE FLUID SATURATIONS, % Pv			
		SAMPLE	DENSITY		TOTAL	Initial Fluid Saturations		After Centrifuge at 1000xG	
SAMPLE ID.	DEPTH, ft.	ORIENTATION (1)	BULK, g/cc	GRAIN, g/cc	POROSITY, %Vb	WATER (Swi) SATURATION	NAPL (Soi) SATURATION	WATER (Srw) SATURATION	NAPL (Sor) SATURATION
TSB2-21.3-21.8	21.5	V	1.61	2.69	40.3	71.7	5.6	26.0	2.4
TDW2-15.5-16.0	15.9	V	1.80	2.73	34.2	71.4	5.2	14.0	4.1
TDW2-16.8-17.3	17.1	V	1.70	2.72	37.5	66.2	2.1	11.5	0.1
TDW2-18.3-18.8	18.5	V	1.80	2.73	34.1	52.9	4.4	10.0	1.2

N/A = Not Analyzed. Vb = Bulk Volume, Pv = Pore Volume. (1) H = horizontal, V = vertical
Soi = Initial NAPL Saturation as received prior to centrifuging at 1000xG, Swi = Initial Water Saturation as received prior to centrifuging at 1000xG
Sor = Residual NAPL Saturation after centrifuging at 1000xG, Srw = Residual Water Saturation after centrifuging at 1000xG
Water =0.9996 g/cc, NAPL = 1.100 g/cc.

Analytical Resources, Incorporated
Analytical Chemists and Consultants

October 23, 2006

Ms. Jane Fisher
Floyd/Snider
Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101-2341

RE: Project: Gas Works Shoreline Investigation

ARI Job No: JZ51

Dear Jane:

Please find enclosed original results for the above referenced project.

A case narrative from the geotechnical laboratory is included.

An electronic copy of the reports and all associated raw data will remain on file with ARI. If you have any questions or require additional information, please contact me at your convenience.

Sincerely,

ANALYTICAL RESOURCES, INC.

Sincerely,

ANALYTICAL RESOURCES, INC.

Elysabeth for Dosli

Susan Dunnihoo
Client Service Manager
sue@arilabs.com
206/695-6207

Enclosures

Chain of Custody Record & Laboratory Analysis Request

Analytical Resources, Incorporated
Analytical Chemists and Consultants
4611 South 134th Place, Suite 100
Tukwila, WA 98168
206-695-6200 206-695-6201 (fax)

ARI Assigned Number: JZ51	Turn-around Requested: TWO WEEK
ARI Client Company: FLOYD SNIDER	Phone: 206-292-2078
Client Contact: JANE FISHER	
Client Project Name: GASWORKS PARK SHORELINE INVESTIGATION	
Client Project #: COS-GWSA	Samplers: LAMANNA
Page: 1 of 3	
Date: Oct 3, 2006	Ice Present? Y/N -1
No. of Coolers: 2	Cooler Temps: 4.0, Amb

Analysis Requested

Sample ID	Date	Time	Matrix	No. Containers	GRAIN SIZE ASTM D421/422	MOISTURE CONTENT ASTM-2216						HOLD	Notes/Comments
TDW1-9.0	9/19/06		S	1-16oz	X								
TDW1-15.5	↓		S	↓	X								
TDW1-27.5	↓		S	↓	X								
TDW1-43.2	9/20/06		S	1-4oz		X							
TSW1-5.0	9/21/06		S	2-4oz								X	
TSW1-9.0	9/21/06		S	1-4oz								X	
TSB2-7.5	9/21/06		↓	1-4oz								X	
TSB2-22.5	9/22/06		↓	1-4oz								X	
TSB2-49.0	9/22/06		↓	1-4oz		X							
TSW1-7.0	9/21/06		↓	1-4oz								X	

Comments/Special Instructions	Relinquished by:	Received by:	Relinquished by:	Received by:
	(Signature) [signature]	(Signature) Bob Congleton	(Signature)	(Signature)
	Printed Name: JOHN LAMANNA	Printed Name: BOB CONGLETON	Printed Name:	Printed Name:
	Company: FLOYD SNIDER	Company: ARI	Company:	Company:
	Date & Time: Oct 3, 2006 1253	Date & Time: 10/3/06 1253	Date & Time:	Date & Time:

Limits of Liability: *ARI will perform all requested services in accordance with appropriate methodology following ARI Standard Operating Procedures and the ARI Quality Assurance Program. This program meets standards for the industry. The total liability of ARI, its officers, agents, employees, or successors, arising out of or in connection with the requested services, shall not exceed the Invoiced amount for said services. The acceptance by the client of a proposal for services by ARI release ARI from any liability in excess thereof, not withstanding any provision to the contrary in any contract, purchase order or co-signed agreement between ARI and the Client.*

Sample Retention Policy: All samples submitted to ARI will be appropriately discarded no sooner than 90 days after receipt or 60 days after submission of hardcopy data, whichever is longer, unless alternate retention schedules have been established by work-order or contract.

Chain of Custody Record & Laboratory Analysis Request

ARI Assigned Number: JZ51	Turn-around Requested: TWO WEEK	Page: 2 of 3
ARI Client Company: FLOYD SNIDER	Phone: 206-292-2078	Date: Oct 3 2006 / Ice Present? Y-1 N-1
Client Contact: JANE FISHER		No. of Coolers: 2 / Cooler Temps: 4.0, AMB
Client Project Name: GASWORKS PARK SHORELINE INVESTIG		
Client Project #: COS-GWSA	Samplers: LAMANNA	

Analytical Resources, Incorporated
Analytical Chemists and Consultants
4611 South 134th Place, Suite 100
Tukwila, WA 98168
206-695-6200 206-695-6201 (fax)

Sample ID	Date	Time	Matrix	No. Containers	GRAIN SIZE ASTM D421/422	MOISTURE CONTENT ASTM-2216						HOLD	Notes/Comments
TSB2-5.5	9/22/06		S	1-16oz	X								
TSB2-17.5	9/22/06		S	1-16oz	X								
TSB2-39.0	9/22/06		S	1-16oz	X								
TSB2-45.0	9/22/06		S	1-4oz		X							
TSB2-49.0	9/22/06		S	1-4oz 1-16oz	X	X							
TSB1-15.0	9/25/06		S	1-16oz	X								
TSB1-33.5	9/25/06		S	1-16oz	X								
TSB1-47.0	9/25/06		S	1-16oz	X								
TDW3-4.5	9/26/06	1256	S	1-4oz								X	
TDW3-6.5	"	1255	S	1-4oz								X	

Comments/Special Instructions	Relinquished by:	Received by:	Relinquished by:	Received by:
	(Signature) [signature]	(Signature) B C Congleton	(Signature)	(Signature)
	Printed Name: JOHN LAMANNA	Printed Name: BOB CONGLETON	Printed Name:	Printed Name:
	Company: FLOYD SNIDER	Company: ARI	Company:	Company:
	Date & Time: OCT 3, 2006 1253	Date & Time: 10/3/06 1253	Date & Time:	Date & Time:

Limits of Liability: ARI will perform all requested services in accordance with appropriate methodology following ARI Standard Operating Procedures and the ARI Quality Assurance Program. This program meets standards for the industry. The total liability of ARI, its officers, agents, employees, or successors, arising out of or in connection with the requested services, shall not exceed the Invoiced amount for said services. The acceptance by the client of a proposal for services by ARI release ARI from any liability in excess thereof, not withstanding any provision to the contrary in any contract, purchase order or co-signed agreement between ARI and the Client.

Sample Retention Policy: All samples submitted to ARI will be appropriately discarded no sooner than 90 days after receipt or 60 days after submission of hardcopy data, whichever is longer, unless alternate retention schedules have been established by work-order or contract.

Chain of Custody Record & Laboratory Analysis Request

Analytical Resources, Incorporated
Analytical Chemists and Consultants
4611 South 134th Place, Suite 100
Tukwila, WA 98168
206-695-6200 206-695-6201 (fax)

ARI Assigned Number:	JZ51
Turn-around Requested:	TWO WEEK
Page:	3 of 3
ARI Client Company:	FLOYD SNIDER
Phone:	206-292-2078
Date:	OCT 3, 2006
Ice Present?	Y-1 N-1
Client Contact:	JANE FISHER
No. of Coolers:	2
Cooler Temps:	4.0, AMB
Client Project Name:	GASWORKS PARK SEDIMENT INVESTIGATION
Client Project #:	COS-GWSA
Samplers:	LAMANNA

Sample ID	Date 2006	Time	Matrix	No. Containers	GRAIN SIZE ASTM D421/422	MOISTURE CONTENT ASTM-2216						HOLD	Notes/Comments
TDW3-9.5	9/26		S	1-16oz	X								
TDW3-12.0	9/26	1319	S	1-4oz								X	"SPLITS"
TDW3-12.0-R	9/26	1322	S	1-8oz								X	
TDW3-29.9	9/26		S	1-16oz	X								
TDW3-39.5	9/26		S	1-16oz	X								
TDW2-23.0	9/28		S	1-16oz	X								
TDW2-30.6	9/28	1416	S	1-4oz								X	
TDW2-39.5	9/29	1050	S	1-16oz	X								
TSB3-16.5-18	10/2	1250	S	1-4oz								X	"SPLITS"
TSB3-16.5-18R	10/2	1250	S	1-8oz								X	

Comments/Special Instructions	Relinquished by:	Received by:	Relinquished by:	Received by:
	(Signature) [signature]	(Signature) Bob Congleton	(Signature)	(Signature)
	Printed Name: JOHN LAMANNA	Printed Name: BOB CONGLETON	Printed Name:	Printed Name:
	Company: FLOYD SNIDER	Company: ARI	Company:	Company:
	Date & Time: OCT 3, 2006 1253	Date & Time: 10/03/06 1253	Date & Time:	Date & Time:

Limits of Liability: *ARI will perform all requested services in accordance with appropriate methodology following ARI Standard Operating Procedures and the ARI Quality Assurance Program. This program meets standards for the industry. The total liability of ARI, its officers, agents, employees, or successors, arising out of or in connection with the requested services, shall not exceed the Invoiced amount for said services. The acceptance by the client of a proposal for services by ARI release ARI from any liability in excess thereof, not withstanding any provision to the contrary in any contract, purchase order or co-signed agreement between ARI and the Client.*

Sample Retention Policy: All samples submitted to ARI will be appropriately discarded no sooner than 90 days after receipt or 60 days after submission of hardcopy data, whichever is longer, unless alternate retention schedules have been established by work-order or contract.

Cooler Receipt Form

ANALYTICAL RESOURCES INCORPORATED

ARI Client: FSI Project Name: ______

COC NO.: ______ Delivered By: HAND

Tracking NO.: ______ Date: ______

ARI Job No.: ______ Lims NO.: ______

Preliminary Examination Phase:

1. Were intact, properly signed and dated custody seals attached To the outside of the cooler? .... YES (NO)
2. Were custody papers included with the cooler .... (YES) NO
3. Were custody papers properly filled out (ink, signed etc.)? .... (YES) NO
4. Complete custody forms and attach all shipping documents .... OK (NA)

Cooler Accepted BY: Bob Congle Date: 10/3/06 Time: 1253

Log-IN Phase:

5. Was a temperature blank include in the cooler? .... YES (NO)
6. Record Cooler Temperature....... 4.0, AMB °C
7. What kind of packing material was used? .... ICE / —
8. Was sufficient ice used (if appropriate)? .... (YES) (NO) —
9. Were all bottles sealed in separate plastic bags? .... YES (NO)
10. Did all bottles arrive in good condition (unbroken)? .... (YES) NO
11. Were all bottle labels complete and legible? .... (YES) NO
12. Did all bottle labels and tags agree with custody papers? .... (YES) NO
13. Were all bottles used correct for the requested analyses? .... (YES) NO
14. Do any of the analyses (bottles) require preservative? (If so, Preservation checklist must be attached) .... YES (NO)
15. Were all VOA vials free of air bubbles? .... ~~YES~~ ~~NO~~
16. Was sufficient amount of sample sent in each bottle? .... (YES) NO
17. Notify Project Manager of any discrepancies or concerns....... (OK) NA

Cooler Opened By: BC Date: 10/3/06 Time 1253

Explain any discrepancies or negative responses:

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Client: Floyd, Snider	ARI Project No.: JZ51
Client Project: Gasworks Park Shoreline Invest.	Client Project No.: COS-GWSA

Case Narrative

1. Seventeen samples were received on October 3, 2006, and were in good condition.
2. Fifteen samples were tested for grain size distribution according to ASTM Method D422.
3. Nine samples appeared to contain less than 15% fines and the sieve portion of the procedure was performed, but not the hydrometer portion. The remaining six samples were prepared according to ASTM Method D421, dry prep method, and run for sieve and hydrometer analysis according ASTM Method D422.
4. Three samples were submitted for moisture content determination according to ASTM Method D2216.
5. There were no perceived anomalies to the samples or testing.
6. The data is provided in summary tables and plots.

Released by: [signature] Date: 10/21/06
Title: Lead Technician

4611 South 134th Place, Suite 100 • Tukwila WA 98168 • **206-695-6200** • **206-695-6201** fax

ANALYTICAL RESOURCES INCORPORATED

GEOTECHNICAL ANALYSIS DATA SHEET
Moisture Content by Method ASTM D2216

Data Release Authorized:
Reported: 10/21/06
Date Received: 10/03/06

QC Report No: JZ51-Floyd, Snider
Project: GASWORKS PARK SHORELINE INVEST.
COS-GWSA

Client/ ARI ID	Date Sampled	Matrix	Analysis Date	Result
TDW1-43.2 JZ51D 06-18554	09/20/06	Soil	10/21/06 12:00	17.61
TSB2-45.0 JZ51M 06-18563	09/22/06	Soil	10/21/06 12:00	11.82
TSB2-49.0 JZ51N 06-18564	09/22/06	Soil	10/21/06 12:00	9.13

Reported in Percent

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Floyd, Snider
COS-GWSA

Percent Finer Than Indicated Size, By ASTM D422

Sample ID	Depth (ft)	Moisture Content (%)	3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
TDW1-9.0	NA	18.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.1	96.4	92.2	75.3	40.9	13.9	2.6
TDW1-15.5	NA	7.9	100.0	100.0	100.0	100.0	87.8	78.2	72.4	61.2	52.1	45.6	35.9	20.6	11.1	5.4
TDW1-27.5	NA	9.4	100.0	100.0	100.0	100.0	100.0	90.5	85.4	75.1	62.0	50.0	34.8	16.7	8.4	5.1
TSB2-17.5	NA	33.4	100.0	100.0	100.0	100.0	100.0	100.0	95.0	75.2	62.7	52.4	42.5	30.6	20.5	10.8
TSB2-39.0	NA	15.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.8	93.5	85.2	55.8	18.7	7.3	4.0
TSB1-15.0	NA	26.7	100.0	100.0	100.0	100.0	100.0	97.4	86.1	71.3	56.1	42.9	29.0	17.7	12.6	8.8
TSB1-33.5	NA	10.1	100.0	100.0	100.0	100.0	100.0	96.0	96.0	89.2	73.7	61.3	46.2	24.4	10.2	4.7
TDW3-29.9	NA	9.9	100.0	100.0	100.0	100.0	100.0	91.2	84.9	78.2	69.8	61.0	43.4	22.3	9.7	4.4
TDW2-23.0	NA	5.6	100.0	100.0	100.0	100.0	92.6	75.9	72.7	62.6	55.7	49.7	36.9	17.0	6.1	2.8

ANALYTICAL RESOURCES INCORPORATED

Floyd, Snider
COS-GWSA

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	2"	1"	3/4"	1/2"	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
TSB2-5.5	100.0	100.0	100.0	94.6	86.1	67.9	54.5	41.0	27.8	16.8	10.8	9.7	8.9	7.5	6.8	6.4	5.7	4.3	2.5
TSB2-49	100.0	100.0	100.0	97.5	92.3	89.2	84.6	80.4	73.4	60.2	46.9	34.3	24.0	19.3	15.0	12.0	9.0	4.7	1.7
TSB1-47.0	100.0	100.0	92.9	91.4	91.4	85.8	81.7	77.7	71.2	59.7	47.9	35.8	25.2	20.0	15.9	12.3	9.8	4.1	1.0
TDW3-9.5	100.0	100.0	100.0	94.6	88.9	80.1	66.0	53.3	42.7	33.1	25.9	21.2	19.3	16.8	14.2	11.6	9.0	7.3	3.4
TDW3-39.5	100.0	100.0	94.6	82.2	80.8	74.8	70.3	66.5	60.4	49.6	38.9	28.2	19.3	15.2	11.9	9.5	7.0	2.9	0.8
TDW2-39.5	100.0	100.0	95.0	81.2	78.6	74.3	69.6	64.6	57.5	45.9	35.5	25.7	20.3	16.0	12.6	10.0	8.2	3.9	1.3

Testing performed according to ASTM D421/D422

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Floyd, Snider
COS-GWSA

Percent Retained in Each Size Fraction, By ASTM D422

Sieve Size (microns)	3-2"	2-1.5"	1.5-1"	1-3/4"	3/4-1/2"	1/2-3/8"	3/8-#4	4750-2000	2000-850	850-425	425-250	250-150	150-75	<75
TDW1-9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	2.8	4.1	17.0	34.4	27.0	11.3	2.6
TDW1-15.5	0.0	0.0	0.0	12.2	9.6	5.8	11.2	9.1	6.6	9.7	15.2	9.5	5.7	5.4
TDW1-27.5	0.0	0.0	0.0	0.0	9.5	5.1	10.3	13.1	11.9	15.3	18.0	8.3	3.3	5.1
TSB2-17.5	0.0	0.0	0.0	0.0	0.0	5.0	19.8	12.5	10.3	9.9	11.9	10.1	9.6	10.8
TSB2-39.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	4.2	8.3	29.4	37.1	11.4	3.3	4.0
TSB1-15.0	0.0	0.0	0.0	0.0	2.6	11.3	14.8	15.2	13.2	14.0	11.3	5.1	3.8	8.8
TSB1-33.5	0.0	0.0	0.0	0.0	4.0	0.0	6.8	15.5	12.4	15.1	21.8	14.2	5.5	4.7
TDW3-29.9	0.0	0.0	0.0	0.0	8.8	6.4	6.7	8.4	8.8	17.6	21.0	12.6	5.4	4.4
TDW2-23.0	0.0	0.0	0.0	7.4	16.6	3.2	10.2	6.9	6.0	12.8	19.9	10.9	3.3	2.8

ANALYTICAL RESOURCES INCORPORATED

Floyd, Snider
COS-GWSA

Percent Retained in Each Size Fraction

Description	% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay
Particle Size (microns)	> 4750	4750-2000	2000-425	425-75	75-32	32-22	22-13	13-9	9-7	7-3.2	<3.2
TSB2-5.5	32.1	13.3	26.7	18.2	0.7	1.4	0.7	0.4	0.7	1.4	4.3
TSB2-49	10.8	4.6	11.2	39.0	10.3	4.7	4.3	3.0	3.0	4.3	4.7
TSB1-47.0	14.2	4.1	10.5	35.4	10.6	5.1	4.1	3.6	2.6	5.7	4.1
TDW3-9.5	19.9	14.1	23.3	21.5	1.9	2.6	2.6	2.6	2.6	1.7	7.3
TDW3-39.5	25.2	4.4	9.9	32.2	8.9	4.1	3.3	2.5	2.5	4.1	2.9
TDW2-39.5	25.7	4.8	12.1	31.8	5.3	4.3	3.5	2.6	1.7	4.3	3.9

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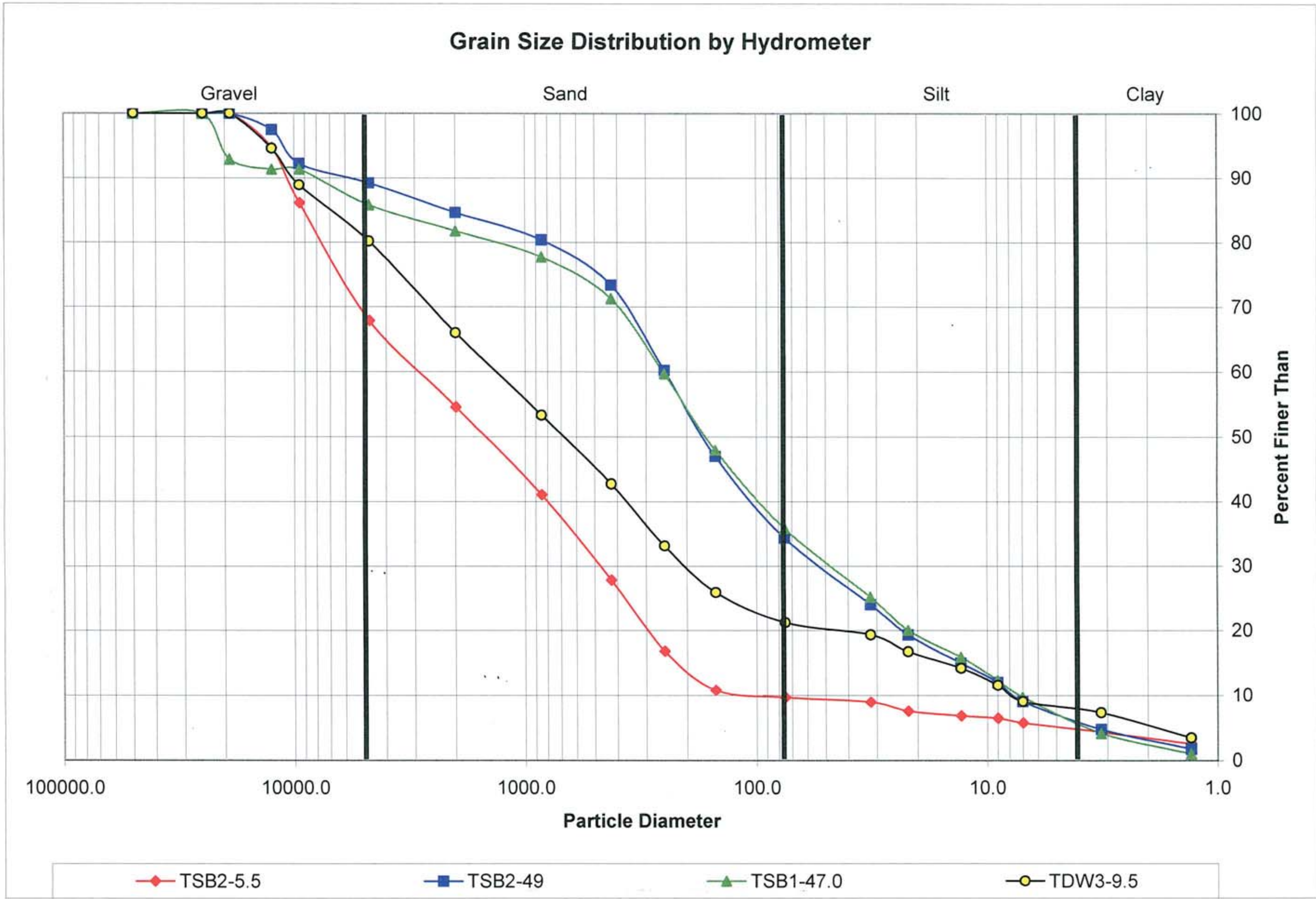

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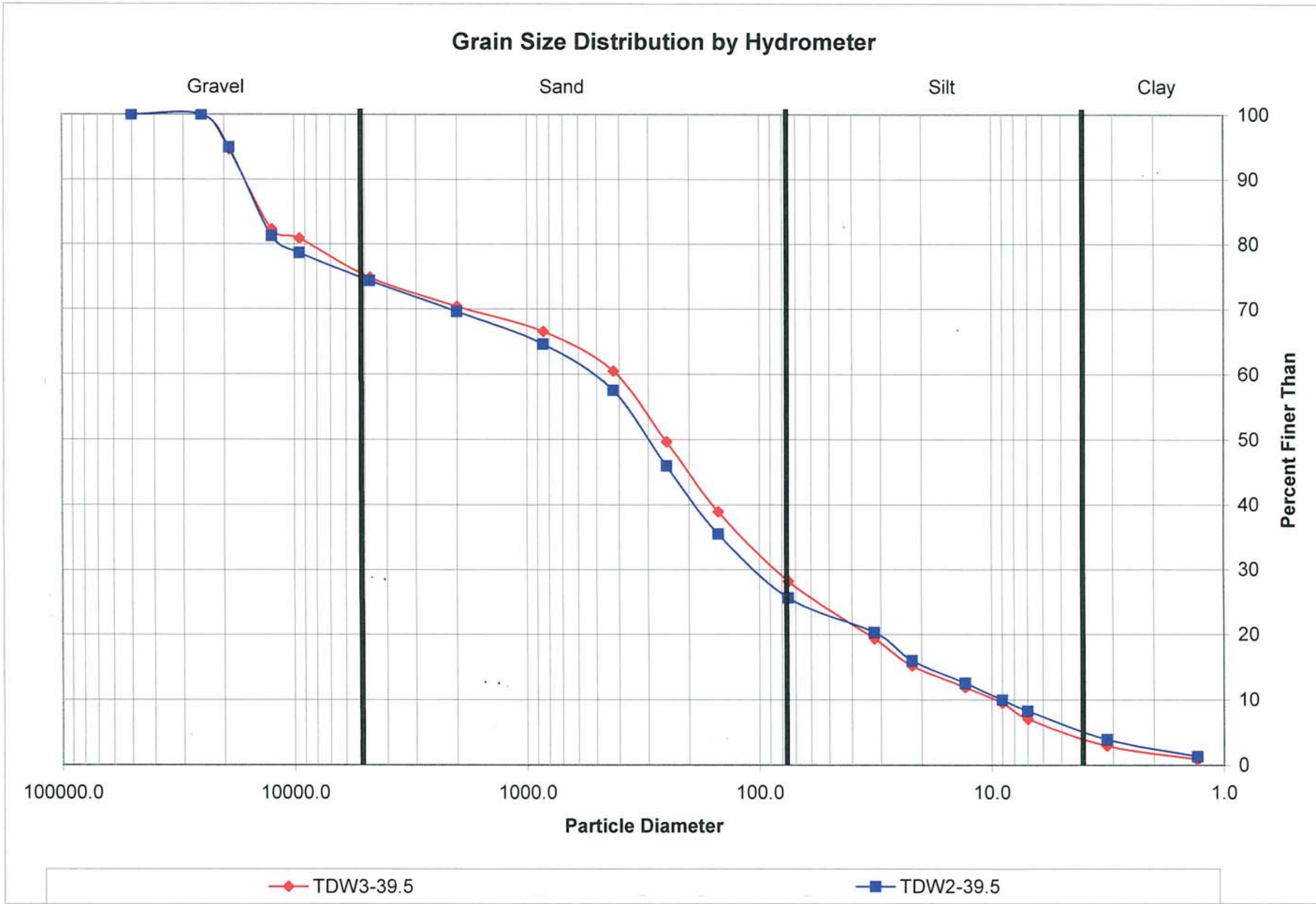

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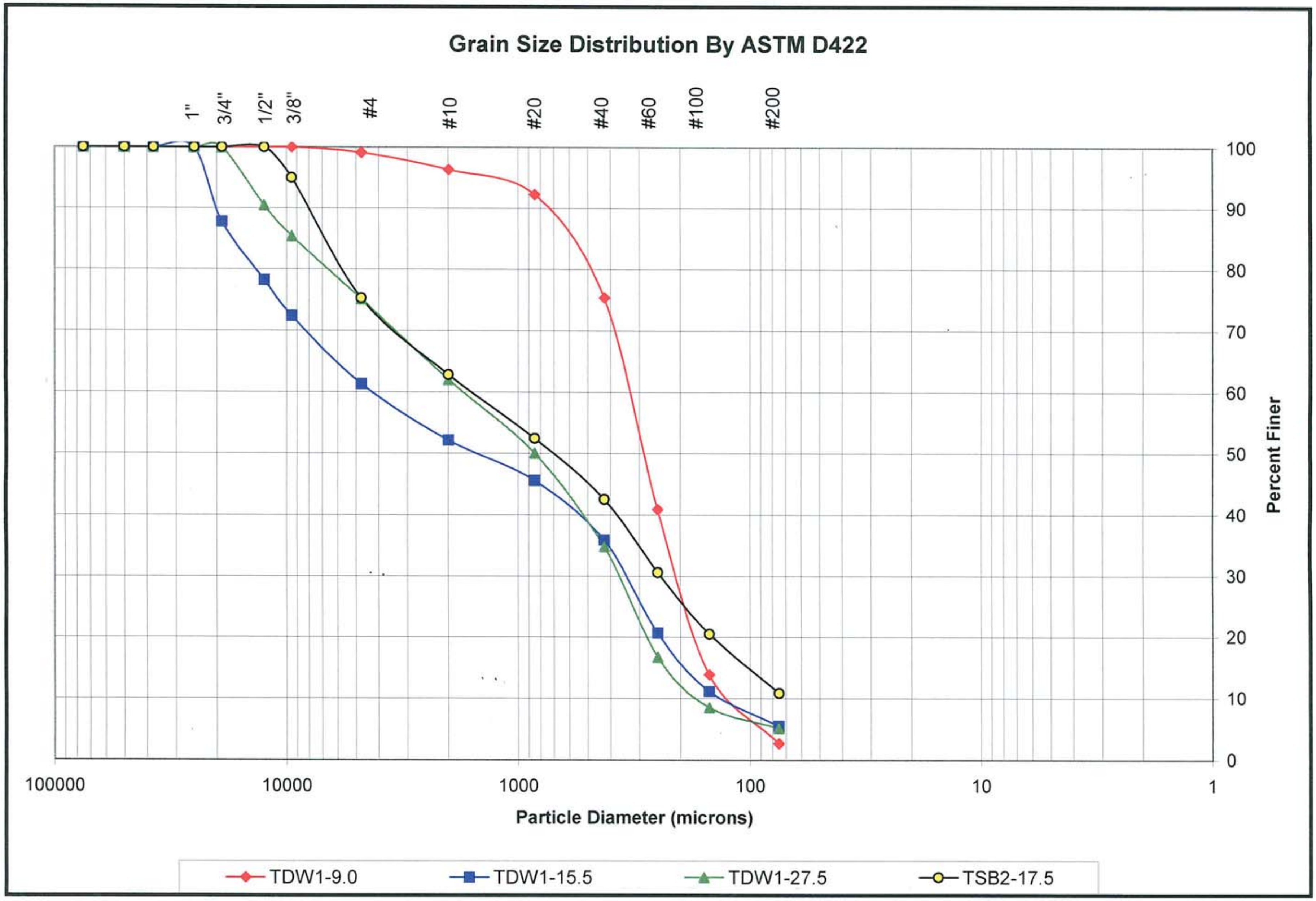

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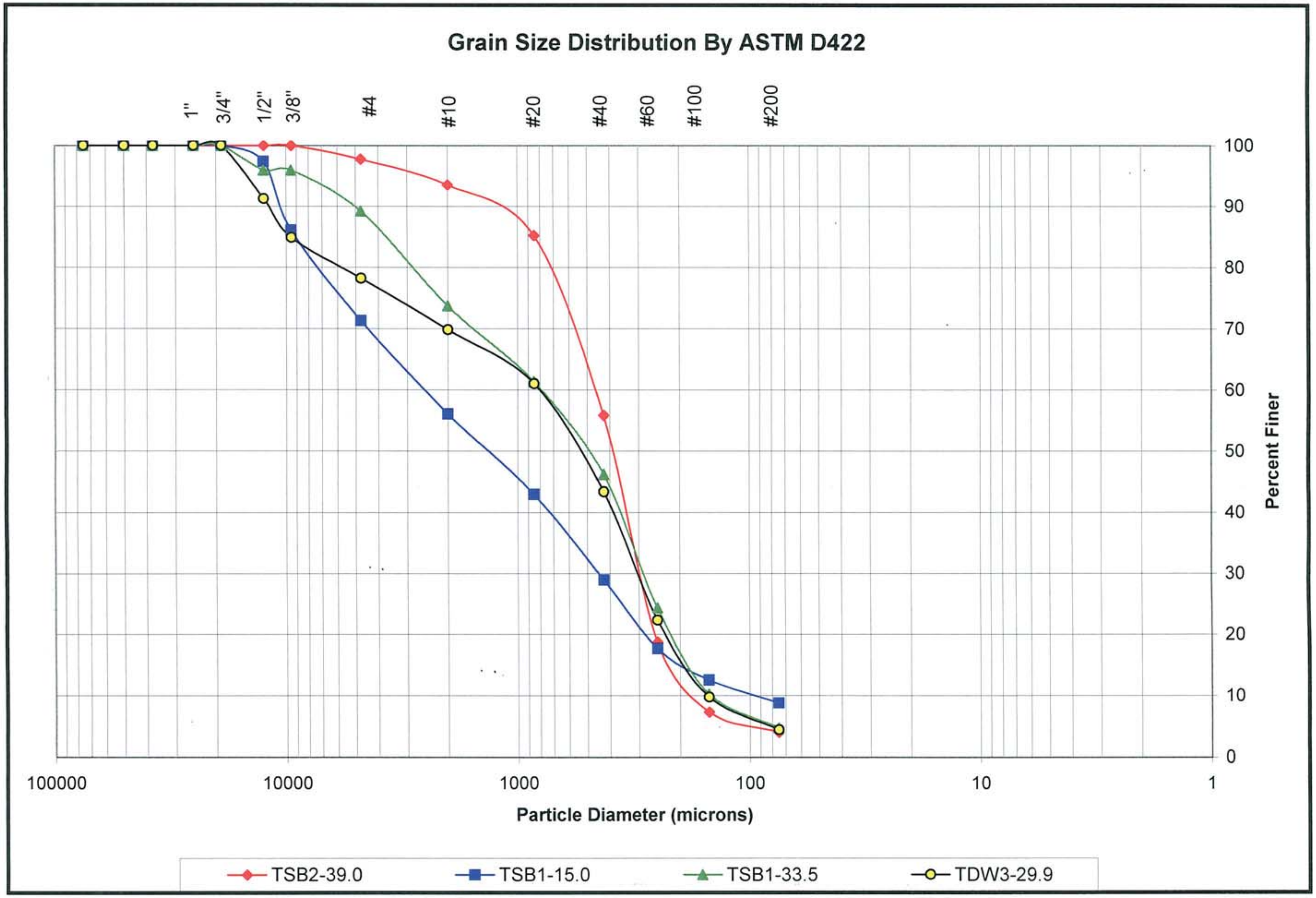

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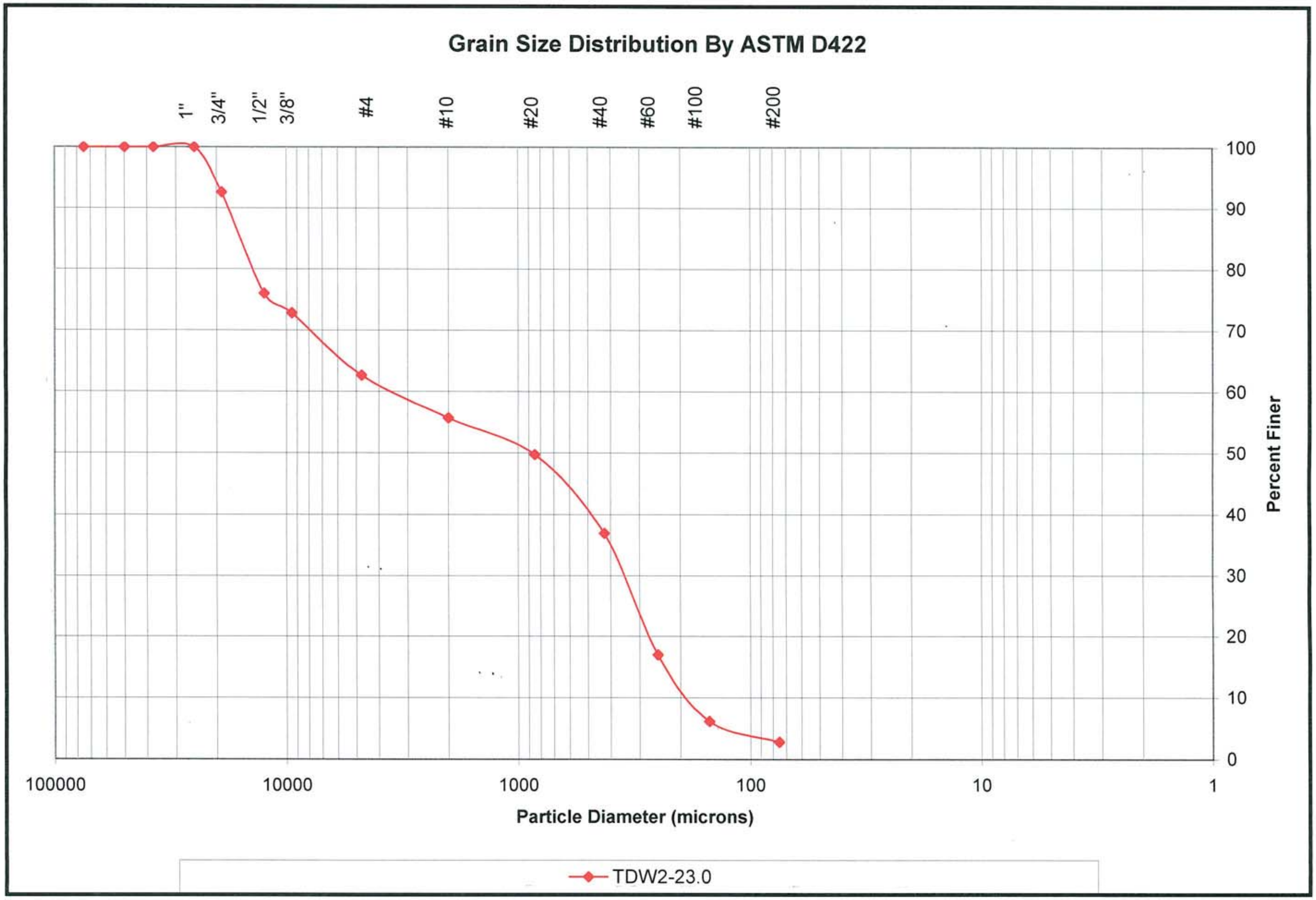

MEMORANDUM

Project No.: 060102-001-03

May 10, 2007

To: Allison Geiselbrecht, PhD, Floyd|Snider

From: Jeremy Shaha, Tyson Carlson, LHG, and Steve Germiat, LHG

Re: **Hydrogeologic Results from Shoreline Investigation**
Gas Works Sediment Western Study Area
Seattle, Washington

Introduction

This memorandum summarizes the results of the hydrogeologic work completed as part of the shoreline investigation to support the Gas Works Sediment Western Study Area (GWS-WSA) remedial investigation/feasibility study (RI/FS). The work performed under the hydrogeologic investigation task includes:

- Development of six temporary groundwater monitoring wells along the shoreline of the study area, including measurement for presence of non-aqueous phase liquid (NAPL) in the wells;
- Slug testing of the six temporary wells to estimate aquifer hydraulic conductivity;
- Collection of a comprehensive set of water level measurements across the western and eastern study areas;
- Evaluation of the data collected to estimate upland groundwater flow directions, horizontal and vertical hydraulic gradients, and groundwater velocities along the shoreline; and
- Compare data collected in this shoreline investigation with previous hydrogeologic information for the area.

This collective hydrogeologic information helps refine the conceptual site model which is the basis for constructing a numerical groundwater flow model that will be used in evaluation of remedial alternatives for the GWS-WSA.

Temporary Monitoring Well Development

Six temporary monitoring wells (TSW-1, TDW-1, TSW-2, TDW-2, TSW-3 and TDW-3) were installed by Floyd|Snider along the shoreline of the GWS-WSA site between September 19 and October 2, 2006 (Figure 1). We developed these temporary monitoring wells on October 3, 2006, to remove sediment accumulated in the sand pack and bottom of the well during installation, and help improve the well's hydraulic connection with the surrounding aquifer.

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www.aspectconsulting.com

The temporary monitoring wells were developed with surging and pumping techniques using a 12-volt well development pump. The saturated screen interval was gently surged with the pump for short periods of time before the pump was lowered to the bottom of the well to remove accumulated sediment. This process was repeated several times until the overall turbidity of the groundwater removed from the well had significantly decreased, stabilizing at less than 50 NTU, and sediment no longer accumulated at the bottom of the well.

NAPL was not observed visually, nor indicated by an oil-water interface probe, in any of the six temporary monitoring wells during development. A chemical odor was noted in water from wells TSW-1, TDW-2, and TSW-3 during development. In addition, no evidence of NAPL was indicated in the six temporary wells using an oil-water interface probe during a second round of water level measurements collected approximately a month later.

All groundwater from development of the temporary monitoring wells was stored in labeled, 55-gallon drums located within the Harbor Patrol property, awaiting proper disposal.

Field parameters, including temperature, specific conductance, pH and turbidity were monitored during the development of the temporary monitoring wells. Table 1 summarizes the field parameter data at the end of development with comments regarding observations.

Groundwater Flow Direction and Gradients

Groundwater level measurements were collected from accessible upland monitoring wells located on the Gas Works Park property, Seattle Harbor Patrol property, King County Metro property, and adjacent public access areas on October 4, 2006. Monitoring well top-of-casing elevations were compiled from multiple sources and converted to the Army Corps of Engineers' Locks vertical datum (3.25 feet below the NAVD88 datum) for evaluation[1]. A summary of the groundwater level measurements, including relevant monitoring well completion information and measuring point elevations, is provided in Table 2. Because of uncertainty in the well elevations on the Metro property, the groundwater elevation data for those wells are presented to 0.1 foot, not 0.01 foot in Table 2.

In the project area, the sequence of upland stratigraphic units from youngest to oldest (shallow to deep) is: Gas Works Fill (GWF), Recessional Stratified Drift (RSD), Vashon Glacial Till (VT), and Advanced Stratified Drift (ASD). Offshore, the GWF is absent and is replaced by lake sediments to overlie the RSD. The lake sediment units are differentiated into (from youngest to oldest) the Upper Recent Deposits (RD_U), Lower Recent Deposits (RD_L), and, in some explorations, a Glaciolacustrine Clay (GC). Within GWS-WSA, the Vashon Glacial Till (VT) appears to pinch out offshore – on average, within 70 to 100 feet of the shoreline. South of the pinch out, the RSD directly overlies the ASD.

All of the accessible monitoring wells are screened within the GWF and/or RSD geologic units. There is no continuous low-permeability layer (aquitard) separating these two geologic

[1] The Corps' Locks datum is 3.25 feet below the NAVD88 datum, therefore elevations relative to the Locks datum are 3.25 feet higher than those relative to the NAVD88 datum (i.e., elevation per Locks datum = elevation per NAVD88 datum + 3.25 feet).

units in the upland; consequently, they together represent a single hydrostratigraphic unit for the purposes of this investigation. The available information indicates that the GWF/RSD hydrostratigraphic unit is a single unconfined aquifer (water table aquifer); however, the unit contains small-scale stratification which can create localized semi-confined conditions.

Figure 2 illustrates the contoured water table elevations and inferred groundwater flow directions for the upland, based on the October 2006 groundwater level measurements. The contours represent the water table surface in the combined GWF/RSD hydrostratigraphic unit, but also in the VT unit where the GWF/RSD unit is absent, namely, in the Metro site area north of approximately Northlake Way. We infer that there is a continuous water table surface between the two units as evidenced by the water table elevation data. This interpretation is consistent with previous hydrogeologic interpretations for the Metro site (AGI cross section A-A' included in Foster Wheeler 1998).

Based on the interpretation presented in Figure 2, groundwater flow upland of the GWS-WSA is generally to the south/southwest, towards Lake Union. The water table surface across the upland area roughly mimics topography, sloping steeply in the topographically higher area north of Northlake Way and flattening as it approaches the lake shoreline. The highest observed horizontal gradient occurs within the glacial till unit north of the Metro South Yard property (0.07 feet/foot), although this interpretation is largely influenced by a single data point (Metro well MW-16). By contrast, the upland horizontal gradient within the Gas Works Park property is lower (0.01 feet/foot).

Of greatest interest for the GWS-WSA is the shoreline area of the Metro South Yard property, Harbor Patrol property, and the western Gas Works Park property. In this broad shoreline area, shoreward of the 21-foot water table elevation contour (Figure 2), the water table surface is relatively flat, varying by less than approximately 0.8 feet. The horizontal hydraulic gradients in this area are correspondingly lowest (0.003 feet/foot or less). The lake elevation at the time of the October 4, 2006, water level measurements (20.4 feet) was obtained from the Army Corps of Engineers' web site.

An anomaly in the October 2006 water level data is a slight depression in groundwater levels (approximately 1-foot) indicated in the vicinity of wells RW-1, PZ-9, and PZ-10, northeast of the Harbor Patrol property. The reason for the low water table elevations at these wells (Table 2) could not be determined; therefore, these data were not included in the water table elevation contours on Figure 2. RETEC (1998) also measured groundwater elevations below lake level in Harbor Patrol property monitoring wells during each of their nine rounds of water level measurements (December 1997 through May 1998).

RETEC (1998) calculated horizontal gradients across the WSA using data from the nine rounds of water level measurements. That information indicates a steeper horizontal gradient to the north which becomes flatter near the lake shoreline – consistent with the results from this study. The data do not show a consistent seasonal change in horizontal gradient over the 6 months, but RETEC notes that the highest gradient in the unpaved area north of Harbor Patrol property was measured in February 1998, approximately 2 weeks after the wettest period of the study. No such gradient difference was noted within the paved Harbor Patrol area or in the western Gas Works Park property.

The average of the nine horizontal gradient values calculated by RETEC (1998) for the Harbor Patrol Area in 1997-1998 is 0.003 feet/foot, consistent with that observed near the WSA shoreline based on the October 2006 data collected in this investigation. RETEC (1998) used a gradient of 0.003 feet/foot in their groundwater transport modeling for the Harbor Patrol property.

Vertical Gradients

Vertical gradients occur within the GWF/RSD unit, and between the GWF/RSD unit and the deeper ASD unit. Estimates of both are described below.

Within GWF/RSD Unit

Vertical hydraulic gradients within the GWF/RSD unit along the GWS-WSA shoreline are calculated from groundwater level measurements collected from the three temporary monitoring well pairs installed for the shoreline investigation. Table 3 presents the calculated vertical gradients for the well pairs, in addition to relevant groundwater level data and well completion information.

Based on the October 2006 measurements, there is a very small water level elevation difference between the shallow and deep wells in each pair (0.02 feet or less; Table 3). The data indicate a relatively small upward gradient (-4×10^{-4} to -7×10^{-4} feet/foot) within the unit along the GWS-WSA shoreline (negative values represent upward gradients; positive values represent downward gradients). A second set of water level measurements collected on November 3, 2006, indicate the same small difference (0.02 foot or less) in groundwater elevations, except that a very small downward gradient is indicated at the TSW-3/TDW-3 well pair (Table 3). However, that value is based on a measured water level difference of only 0.01 foot, which is within the range of measurement error. As stated above, no evidence of NAPL was indicated in the six temporary wells during either round of water level measurements collected using an oil-water interface probe (Table 3).

RETEC (1998) calculated vertical gradients within Harbor Patrol property using four rounds of water level data collected from four pairs of wells between February 1998 and May 1998. Those measurements indicate vertical gradients that are an order of magnitude larger in magnitude than those measured from the three temporary well pairs in this study. The 1998 data are variable in direction of the vertical gradient, with two well pairs (DW-6/PZ-7 and DW-7/PZ-7) indicating downward gradients in all four measurements; one well pair (DW-5/PZ-8) indicating upward gradients in all measurements; and one well pair (DW-4/PZ-8) indicating upward and then downward gradients during the four measurements. This variability may be a result, in part, of the wells in each pair being farther apart (20 to 35 feet) than the pairs of temporary wells used in this study.

During the four sets of measurements between February and May 1998, groundwater elevations rose in all of the wells. During this time, progressively smaller upward gradients were observed from the two PZ-7 well pairs, and vertical gradients changed from upward to downward at the DW-4/PZ-8 well pair. These data suggest a progression toward a smaller component of upward flow, or to downward flow, as recharge to the GWF/RSD continues.

In short, the vertical gradients based on the data from this study are an order of magnitude less than the estimated horizontal gradients in this area. The data indicate that groundwater flow in the GWF/RSD unit along the GWS-WSA shoreline is predominantly horizontal with only a small component of vertical (predominantly upward) flow. We expect that the component of upward flow becomes larger farther offshore, approaching discharge at the mudline.

Between GWF/RSD Unit and Deeper ASD Unit

Historical groundwater level data collected from monitoring wells MW-3 and MW-3D are used to estimate a vertical gradient between the GWF/RSD and the deeper ASD unit. These hydrostratigraphic units are hydraulically separated from each other in the uplands and nearshore area by the intervening lower permeability VT unit. Well MW-3D, formerly located next to well MW-3 (Figure 1), is the only monitoring well in the area screened in the ASD; however, it no longer exists. The only synchronous water level data available for wells MW-3 and MW-3D are 1986 and 1987, as presented on the USGS and Tetra Tech well logs for the wells. The well elevation and depth-to-water data are presented to a precision of 0.01 foot on the logs and are considered generally reliable. The November 1986 groundwater elevation in the ASD well MW-3D was more than 10 feet lower than that in the GWF/RSD well MW-3, a surprisingly large difference. The data were generally confirmed by Tetra Tech’s April 1987 measurements in which the ASD water level elevation was approximately 8.8 feet lower than the elevation in the GWF/RSD.

These data indicate a large downward vertical gradient of approximately 0.2 feet/foot between the GWF/RSD unit and the ASD unit in this upgradient area (Table 3). A downward gradient at this location is not unexpected, but the gradient’s large magnitude seems unusual for two units without great vertical separation. The magnitude of the gradient indicates that the intervening VT unit is an effective hydraulic barrier (aquitard). The USGS report (Turney and Goerlitz 1989) notes that, despite this downward gradient at a location 750 feet inland from the shoreline, upward flow of groundwater into the lake from both units is expected.

Hydraulic Conductivity (K) Estimates for GWF/RSD Unit

K Estimates from Slug Testing of Temporary Wells

In order to determine the magnitude and variability of hydraulic conductivity (K) in the GWF/RSD unit along the shoreline of Lake Union, slug tests were performed in the six temporary monitoring wells installed for this shoreline investigation. The slug tests were performed using various length solid PVC slug rods and the resultant changes in water levels were monitored with a down-hole pressure transducer.

Prior to performing the actual slug test, the static water level of the well was measured and a pressure transducer was set near the bottom of the well to measure baseline water levels.

Once a stable baseline water level had been recorded, a slug rod was quickly lowered below the static water level in the well. A 3-foot slug rod was used in the shallow wells (TSW-1, TSW-2 and TSW-3), and a 5-foot slug rod was used in the deep wells (TDW-1, TDW-2 and TDW-3). The initial displacement in the water level (falling-head data) was recorded with the pressure transducer and water levels were monitored until they returned to within 0.1-foot of the pre-slug water level. Once groundwater levels recovered to within tolerance, the slug rod was quickly removed from the water column in the well, and the resulting increase in the groundwater level (rising-head data) was monitored until the water level was again within tolerance of the pre-slug static water level. Attachment A presents the raw slug test data collected from the six temporary monitoring wells (Figures A-1 through A-6).

Analysis of the slug test data was performed using both the Hvorslev (1951) and Bouwer and Rice (1976) Slug Test Methods for unconfined aquifers using AQTESOLV™ software. The initial AQTESOLV™ solution was also checked using the Hvorslev (1951) Slug Test Method in a graphical solution. Based on the difficulty of instantaneously lowering the slug below the static water level and the oscillatory nature of the falling-head data, only the rising-head data were used to estimate the hydraulic conductivity of the aquifer immediately adjacent to the temporary monitoring wells.

In order to calculate the hydraulic conductivity values in AQTESOLV™, several assumptions had to be made concerning well construction details. For example, for deep monitoring wells completed at the bottom of the GWF/RSD unit (TDW-1, TDW-2, and TDW-3), the lower portion of the screen interval is completed across the contact between the GWF/RSD and VT units – thus, reducing the effective screen length of the well. Table 4 lists the assumptions and hydraulic parameters used to determine the hydraulic conductivity values in AQTESOLV™.

Table 4 provides hydraulic conductivity values for the temporary monitoring wells estimated using the different analysis methods. A best-estimate hydraulic conductivity value for the aquifer immediately surrounding each monitoring well was calculated as the average result from the two analytical slug test solutions. Detailed AQTESOLV solutions for both the Hvorslev (1951) and Bouwer and Rice (1976) analyses are provided in Attachment A (Figures A-7 through A-18).

The slug test results indicate that the upper portion of the GWF/RSD unit, namely the GWF, generally has a slightly higher hydraulic conductivity than the RSD forming the lower portion of the hydrostratigraphic unit. Hydraulic conductivity estimates for the shallow wells TSW-1, TSW-2 and TSW-3 ranged between 40 and 160 ft/day, with an average (geometric mean) of 80 ft/day (3 x 10^{-2} cm/sec). Hydraulic conductivity estimates for the deep wells TDW-1, TDW-2 and TDW-3 ranged between 10 and 60 ft/day, with an average of 30 ft/day (1 x 10^{-2} cm/sec).

K Estimate from Previous Study

RETEC (1998) performed a step-drawdown and a 50-hour constant rate pumping test to determine hydraulic properties of the RSD. The pumping test was conducted in well RW-1 (Figure 1), and drawdown response was monitored in several nearby monitoring wells. Well

RW-1 was screened within a 3- to 4-foot thickness of silty/clayey sand, and the pumping rate for the constant rate test was approximately 0.25 gpm.

Results were calculated using data sets from the pumping and monitoring wells and several analytical solutions, yielding an average transmissivity value of 43 ft^2/day and a storativity value of 0.0028 (dimensionless). Assuming an effective aquifer thickness of 8.8 feet, the hydraulic conductivity estimates ranged from about 2 to 10 feet/day, with an average value of 5 ft/day (2×10^{-3} cm/sec; Table 4).

Best Estimate of K

The advantage of a long-tem constant rate pumping test over slug testing of individual wells is that the pumping test is representative of aquifer properties over a larger scale, whereas the influence of slug testing is limited to a small volume of aquifer immediately around the well. However, in this case, the aquifer conditions at RW-1 (silty/clayey sand) are different than the conditions observed at the three deep temporary well borings (predominantly non-silty sand), and the RW-1 pumping test results are not necessarily representative of aquifer conditions along the WSA shoreline. Therefore, it is appropriate for the GWS-WSA to incorporate the slug test K estimates from the more permeable portion of the aquifer along the shoreline in determining a best estimate K for the GWF/RSD unit. We place somewhat greater confidence in the slug test estimates from the deep temporary wells than those from the shallow temporary wells. The shallow wells are screened near the water table, and only had approximately 5 feet of saturation in them at the time of slug testing; therefore, a smaller initial water level displacement could be achieved than in the deep wells which had a longer water column. The greater initial aquifer stress achieved in testing the deep wells provides greater confidence in those test results.

Consequently, we develop a best estimate K value for the GWF/RSD by weighting the K estimates from the various test methods based our confidence in the estimates. Based on professional judgment, we assign relative weighting factors of 1, 3, and 10 to the average K estimates from the shallow well slug tests, the deep well slug tests, and the 50-hour pumping test, respectively. Based on this approach, the best estimated K value for GWF/RSD unit is 16 feet/day (6×10^{-3} cm/sec) (Table 4).

Groundwater Velocity and Flux Estimates

Average Linear Groundwater Velocity

The average linear groundwater velocity in the GWF/RSD unit along the shoreline is estimated by applying Darcy's Law of the form:

$$v = K * i / n$$

where:
v = Average linear groundwater velocity in feet/day;
K = Best estimate hydraulic conductivity in feet/day;
i = Horizontal hydraulic gradient in feet/foot; and
n = Effective porosity (dimensionless).

The assumed parameter values for the GWF/RSD unit are as follows:

- Hydraulic conductivity (K) = 16 feet/day (6 x 10^{-3} cm/sec) as described above;
- Horizontal hydraulic gradient (i) = 0.003 feet/foot, which is a representative average for the shoreline area as described above. Vertical gradients in the GWF/RSD unit near the shoreline are small and not considered in this estimate; and
- Effective porosity (n) = 0.27, which was calculated from the empirical relationship between bulk density and total porosity (assuming a particle density of 2.65 g/cm^3), then reduced by a nominal five percent to yield effective porosity. Effective porosity excludes isolated pores space that is not available to fluid flow. This approach was similar to the methods used in RETEC's groundwater modeling of the GWS-ESA (S.S. Papadopoulos & Associates 2006).

Using these assumptions, average linear groundwater velocity in GWF/RSD unit at the shoreline is estimated to be 0.16 ft/day. Because the upland horizontal hydraulic gradient varies somewhat near the shoreline of the GWS-WSA, the groundwater velocity also varies somewhat. Based on the groundwater elevation contours collected for this shoreline investigation (Figure 2), the upland gradient along the shoreline ranges by less than a factor of 2 (0.0020 to 0.0038 feet/foot), resulting in estimated velocities ranging from approximately 0.12 to 0.22 ft/day at each of the temporary monitoring well pairs. This is the estimated velocity that groundwater travels on the pore scale, also termed seepage velocity.

This groundwater velocity at the shoreline may be different than the velocity discharging from the soft sediment into the lake, since the soft sediment (RD_U/RD_L) K and effective porosity are expected to be different than that in the GWF/RSD unit. There are no hydraulic parameter measurements for the soft sediment, and these will be estimated as part of the groundwater flow modeling effort for the project.

References

Bouwer, H., and R.C. Rice, 1976. *A Slug Test for Determining Hydraulic Conductivity in Unconfined Aquifers with Completely or Partially Penetrating Wells*. Water Resources Research v. 12, no. 3. pp. 423-428.

Foster Wheeler 1998. *Estimate of Sustainable Yield and Slug Test Data, Former Chevron Bulk Terminal 100-1327 and Current King County (METRO) Terminal, Seattle, Washington*. June 30, 1998.

Hvorslev, M. J., 1951. *Time Lag and Soil Permeability in Groundwater Observations. U.S. Army Corps Engineers*, Waterways Experimental Station Bulletin 36, Vicksburg, Mississippi.

S.S. Papadopoulos & Associates, Inc., 2006. *North Lake Union Groundwater Modeling Memorandum*. Letter from Michael J. Riley to Dan Baker. March 23, 2006.

Remediation Technologies, Inc. (RETEC), 1998. *Fate and Transport Assessment of Polyclyclic Aromatic Hydrocarbons from Tar: Gas Works Park MGP Site*. Funded by EPRI, Palo Alto, California, and Puget Sound Energy, Seattle, Washington. 1998.

Turney, G.L. and D.F. Goerlitz 1989. *Ground-Water Contamination at an Inactive Coal and Oil Gasification Plant Site, Gas Works Park, Seattle, Washington*. USGS Water-Resource Investigation Report 88-4224. 1989.

Attachments

Table 1 – Water Quality Parameters Collected During Well Development
Table 2 – Summary of Groundwater Level Measurements and Well Construction Details
Table 3 – Vertical Groundwater Gradients
Table 4 – Hydraulic Conductivity (K) Estimates for GWF/RSD Unit
Figure 1 – Groundwater Monitoring Well Location Map
Figure 2 – Water Table Elevation Contour Map
Attachment A – Slug Test Data Figures

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Table 1 - Water Quality Parameters Collected During Well Development

Gas Works Sediment Western Study Area
Seattle, Washington

Well	Temperature in degrees Celcius	Specific Electrical Conductance in uS	pH	Turbidity in NTU	Starting Depth to Sediment[a]	Final Depth to Sediment[a]	Total Water Volume Removed in Gallons	Comments
TSW-1	17.8	176	6.3	6	9.6	9.8	50	Chemical odor.
TDW-1	13.4	659	6.1	30	42.1	42.2	60	
TSW-2	15.8	1139	7.2	34	11.8	11.9	25	
TDW-2	13.4	1415	7.5	36	39.6	40.0	85	Slight chemical odor.
TSW-3	17.5	1263	6.8	5	11.5	11.5	40	Slight chemical odor.
TDW-3	14.0	865	6.6	6	39.4	39.4	65	

Notes:

[a] All depths are reported in feet below top of casing.

No evidence of non-aqueous phase liquid (NAPL) observed during well development.

Table 2 - Summary of Groundwater Level Measurements and Well Construction Details

Gas Works Sediment Western Study Area - Seattle, Washington

Well ID	Well Log Information				Well Information (USACE Datum)						Screen and Groundwater Elevation in Feet (USACE)				
	Ground Surface Elevation	Stickup	Measuring Point Elevation	Listed Vertical Datum	ATD Water Level Depth	Screen Interval Depth		Unit of Screen Interval[e]	Ground Surface Elevation	Measuring Point Elevation	Screen Interval Elevation			10/4/06 Depth to Water in Feet	10/4/06 Groundwater Elevation in Feet (USACE)
						Top	Bottom				Top	Bottom	Mid		
Harbor Patrol Property															
CMP-01	21.41	-	21.64	MSL	2	6.5	21.5	GWF/SD[f]	24.7	24.89	18.4	3.4	10.9	4.47	20.42
DW-04	22.10	-	21.76	NAVD88	4	32.0	37.0	GWF/SD[f]	25.4	25.01	-7.0	-12.0	-9.5	18.16	6.85
DW-05	21.92	-	21.59	NAVD88	7	24.0	29.0	GWF/SD[f]	25.2	24.84	0.8	-4.2	-1.7	4.55	20.29
DW-06	21.39	-	21.04	NAVD88	4	37.0	42.0	GWF/SD[f]	24.6	24.29	-12.7	-17.7	-15.2	4.02	20.27
DW-7	21.80	-	21.46	NAVD88	5	37.5	42.5	GWF/SD[f]	25.1	24.71	-12.8	-17.8	-15.3	4.45	20.26
PZ-01	21.55	-	21.55	NAVD88	-	3.0	13.0	GWF/SD	24.8	24.80	21.8	11.8	16.8	4.55	20.25
PZ-04	30.48	-	30.30	NAVD88	-	10.0	30.0	GWF/SD	33.7	33.55	23.6	3.6	13.6	nm	nm
PZ-05	24.49	-	24.28	NAVD88	7.72	3.0	18.0	GWF/SD	27.7	27.53	24.5	9.5	17.0	nm	nm
PZ-06	23.91	-	23.55	NAVD88	7.03	5.0	20.0	-	27.2	26.80	21.8	6.8	14.3	nm	nm
PZ-07	21.28	-	21.12	NAVD88	-	5.0	20.0	GWF/SD	24.5	24.37	19.4	4.4	11.9	nm	nm
PZ-08	21.92	-	21.73	NAVD88	-	5.0	20.0	-	25.2	24.98	20.0	5.0	12.5	4.71	20.27
DNR Waterway No. 20 Property															
TDW-1	*21.60*	-0.31	21.29	NAVD88	4.2	37.5	42.5	GWF/SD[f]	24.9	24.54	-12.7	-17.7	-15.2	4.02	20.52
TSW-1	*22.40*	-0.27	22.13	NAVD88	4.5	5.3	10.3	GWF/SD	25.7	25.38	20.4	15.4	17.9	4.85	20.53
Gas Works Park Property															
TDW-2	*21.50*	-0.22	21.28	NAVD88	4.5	35.3	40.3	GWF/SD[f]	24.8	24.53	-10.5	-15.5	-13.0	4.09	20.44
TSW-2	*24.10*	-0.26	23.84	NAVD88	7	7.0	12.0	GWF/SD	27.4	27.09	20.4	15.4	17.9	6.69	20.40
TDW-3	*23.40*	-0.12	23.28	NAVD88	5.5	34.8	39.8	GWF/SD[f]	26.7	26.53	-8.1	-13.1	-10.6	6.12	20.41
TSW-3	*24.10*	-0.33	23.77	NAVD88	7	7.0	12.0	GWF/SD	27.4	27.02	20.4	15.4	17.9	6.61	20.41
MW-03	32.12	-0.44	31.68	NAVD88	4.95	1.5	11.0	GWF/SD	35.4	34.93	33.4	23.9	28.7	8.60	26.33
MW-03D	32.21	-0.44	31.77	NGVD	13.81	54.6	57.6	ASD	39.0	38.59	-16.0	-19.0	-17.5	nm	nm
MW-05	29.21	-0.48	28.73	NGVD	12.34	8.3	18.3	GWF/SD[f]	36.0	35.55	27.3	17.3	22.3	nm	nm
MW-06	27.16	-0.42	26.74	NGVD	1.60	1.9	9.9	GWF/SD	34.0	33.56	31.7	23.7	27.7	nm	nm
MW-07	29.32	-0.47	28.85	NGVD	9.60	7.1	17.1	GWF/SD[f]	36.1	35.67	28.6	18.6	23.6	nm	nm
MW-08	29.88	-0.53	29.35	NGVD	7.96	8.0	18.0	VT	36.7	36.17	28.2	18.2	23.2	nm	nm
MW-09	31.06	-0.33	30.73	NAVD88	7.74	10.8	20.8	VT	34.3	33.98	23.2	13.2	18.2	nm	nm
MW-10	29.14	-0.42	28.72	NAVD88	9.0	5.3	15.3	GWF/SD	32.4	31.97	26.7	16.7	21.7	10.79	21.18
MW-11	31.51	-0.35	31.16	NGVD	11.90	2.0	3.0	GWF/SD	38.3	37.98	36.0	35.0	35.5	nm	nm
MW-13	25.81	-0.33	25.48	NGVD	10.45	7.0	17.0	GWF/SD	32.6	32.30	25.3	15.3	20.3	11.60	20.70
MW-14	20.20	-0.36	19.84	NGVD	4.75	3.0	10.0	GWF/SD	27.0	26.66	23.7	16.7	20.2	5.62	21.04
MW-15	31.05	-0.35	30.70	NGVD	15.33	8.0	18.0	GWF/SD[f]	37.9	37.52	29.5	19.5	24.5	16.63	20.89
MW-16	16.56	-0.48	16.08	NGVD	0.05	2.5	10.5	GWF/SD	23.4	22.90	20.4	12.4	16.4	nm	nm
MW-17	-	-	29.32	NAVD88	10.88	6.5	16.5	GWF/SD	32.9	32.57				12.34	20.23
MW-18	-	-	-	-	-	-	-	-	-	-	-	-	-	16.86	nm
MW-19	-	-	-	-	-	-	-	-	-	-	-	-	-	17.28	nm
MW-22	20.70	-	20.40	NAVD88	3	24.0	34.0	GWF/SD[f]	24.0	23.65	-0.4	-10.4	-5.4	3.40	20.25
MW-23	19.96	-	19.51	NAVD88	5	22.0	32.0	GWF/SD[f]	23.2	22.76	0.8	-9.2	-4.2	2.49	20.27
MW-24	20.67	-	20.34	NAVD88	3	5.0	15.0	GWF/SD	23.9	23.59	18.6	8.6	13.6	3.35	20.24
MW-25	19.72	-	19.39	NAVD88	5	5.0	15.0	GWF/SD	23.0	22.64	17.6	7.6	12.6	2.39	20.25
PZ-02	30.95	-	30.95	NAVD88	-	5.0	20.0	-	34.2	34.20	29.2	14.2	21.7	nm	nm
PZ-03	31.03	-	30.83	NAVD88	-	5.0	20.0	GWF/SD	34.3	34.08	29.1	14.1	21.6	13.75	20.33
PZ-09	33.51	-	33.09	NAVD88	19	12.5	22.5	GWF/SD[f]	36.8	36.34	23.8	13.8	18.8	17.09	19.25
PZ-10	33.72	-	32.83	NAVD88	13.5	12.5	22.5	GWF/SD[f]	37.0	36.08	23.6	13.6	18.6	17.19	18.89
RW-01	33.66	-	33.31	NAVD88	19	12.5	22.5	GWF/SD[f]	36.9	36.56	24.1	14.1	19.1	17.22	19.34
OBS-2	-	-	22.70	NAVD88	-	-	-	-	-	25.95	-	-	-	5.44	20.51
OBS-3	-	-	25.87	NAVD88	-	-	-	-	-	29.12	-	-	-	7.84	21.28
Metro Property (south yard)															
AGI-2	21.6[a]	-0.4[b]	21.2[b]	City of Seattle	12.5	8.0	23.0	GWF/SD	34.6	34.15	26.2	11.2	18.7	13.30	20.9
MLU-1	20.9[a]	2.2	23.05[a]	City of Seattle	11.9	10.0	20.0	GWF/SD	33.9	36.00	26.0	16.0	21.0	15.50	20.5
MLU-3	21[a]	-0.39	20.61[a]	City of Seattle	12.4	11.0	21.0	GWF/SD	34.0	33.56	22.6	12.6	17.6	13.25[d]	20.3
MW-04	21.4[a]	2.9	24.3[a]	City of Seattle	14	9.7	19.7	GWF/SD	34.4	37.65	27.6	17.6	22.6	16.58[d]	20.7
MW-08A	-	-	-	-	13.05	10.0	25.0	GWF/SD	-	33.57[c]	23.6	8.6	16.1	12.98[d]	20.6
MW-25	-	-	-	-	11	5.0	20.0	GWF/SD	-	34.14[c]	29.1	14.1	21.6	13.57[d]	20.6
MW-26	-	-	-	-	11	5.0	20.0	GWF/SD	-	33.84[c]	28.8	13.8	21.3	13.27[d]	20.6
(In/Next to Roads) Near Metro Property															
MW-09	27.30	-0.4[b]	26.9[b]	City of Seattle	17	11.9	21.9	GWF/SD	40.3	39.89	28.0	18.0	23.0	15.20	24.7
MW-11	23.90	-0.4[b]	23.5[b]	City of Seattle	12.5	6.0	15.5	GWF/SD[f]	36.9	36.45	30.5	21.0	25.7	10.74	25.7
MW-14	22.2[a]	-0.4[b]	21.8[b]	City of Seattle	13	9.2	19.2	GWF/SD	35.2	34.75	25.6	15.6	20.6	14.17	20.6
MW-15	22.1[a]	-0.4[b]	21.7[b]	City of Seattle	14.5	9.4	19.4	GWF/SD	35.1	34.65	25.3	15.3	20.3	14.11	20.5
MW-16	43.90	-0.4[b]	43.5[b]	City of Seattle	17	9.5	24.1	VT	56.9	56.49	47.0	32.4	39.7	18.52	38.0
MW-19	-	-	-	-	11.5	9.0	19.0	GWF/SD[f]	-	34.07[c]	25.1	15.1	20.1	13.48	20.6
MW-20	-	-	-	-	-	13.0	23.0	?	-	-	-	-	-	14.17	nm
MW-21	-	-	-	-	12	5.0	23.0	GWF/SD[f]	-	34.49[c]	29.5	11.5	20.5	13.82	20.7
MW-22	-	-	-	-	14	5.0	23.0	?	-	35.73[c]	30.7	12.7	21.7	15.21	20.5
Lake Elevation															20.4

Notes:

Elevation Conversions for Different Vertical Datums:

USACE = NGVD29 + 6.82

USACE = COS + 12.95

Ground Surface and Measuring Point Elevations

[a] Well elevation information based on well logs.

[b] Assumed stick-down of 0.4 ft

[c] Measuring point elevation based on SAIC's arbitrary benchmark. Converted to Locks Datum based on an average conversion factor based on elevations from well logs for other Metro wells.

[d] Water level measured on October 6, 2006.

[e] Unit of screen interval abbreviations are:

GWF/SD = Gas Works Fill/Stratified Drift unit

VT = Vashon Till unit

ASD = Advance Stratified Drift unit

[f] Screen interval extends into VT unit, but the head is considered representative of the GWF/SD unit.

Table 3 - Vertical Groundwater Gradients

Gas Works Sediment Western Study Area
Seattle, Washington

			Screen Depths										
Well Name	Ground Surface Elevation[a]	Top of PVC Casing Elevation[a]	Top of Screen	Bottom of Screen	Effective Bottom of Screen[b]	Effective Midpoint of Screen	Screen Midpoint Elevation[a]	Groundwater Depth	Groundwater Elevation[a]	Vertical Gradient[c]	Groundwater Depth	Groundwater Elevation[a]	Vertical Gradient[c]
Within Gas Works Fill/Stratified Drift Hydrostratigraphic Unit								**10/3/06 Measurements**			**11/6/06 Measurements**		
TSW-1	25.65	25.38	5.3	10.3	10.3	7.8	**17.9**	4.86	**20.52**	**-0.0006**	4.68	**20.70**	**-0.0006**
TDW-1	24.85	24.54	37.5	42.5	40.0	38.8	**-13.9**	4.00	**20.54**		3.82	**20.72**	
TSW-2	27.35	27.09	7.0	12.0	12.0	9.5	**17.9**	6.62	**20.47**	**-0.0007**	6.58	**20.51**	**-0.0007**
TDW-2	24.75	24.53	35.3	40.3	38.0	36.6	**-11.9**	4.04	**20.49**		4.00	**20.53**	
TSW-3	27.35	27.02	7.0	12.0	12.0	9.5	**17.9**	6.58	**20.44**	**-0.0004**	6.54	**20.48**	**0.0004**
TDW-3	26.65	26.53	34.8	39.8	37.8	36.3	**-9.6**	6.08	**20.45**		6.06	**20.47**	
Between Gas Works Fill/Recessional Stratified Drift (GWF/RSD) Unit and Advance Stratified Drift (ASD) Unit								**11/3/86 Measurements**			**4/23/87 Measurements**		
MW-3	38.94	38.50	1.6	10.6	10.6	6.1	**32.8**	4.71	**33.79**	**0.2**	4.95	**33.55**	**0.2**
MW-3D	39.03	38.59	54.6	57.6	57.6	56.1	**-17.1**	14.67	**23.92**		13.81	**24.78**	

Notes:

[a] All screen depths are in feet below ground surface. All groundwater depths are in feet below TOC. All elevations are in feet relative to USACE Locks datum.

[b] The effective bottom of the screen is the bottom of the Gas Works Fill/Stratified Drift Unit for screen intervals extending into the Vashon Till Unit.

[c] Negative values represent upward gradients; positive values represent downward gradients.

No evidence of non-aqueous phase liquid (NAPL) observed in the six temporary wells during either round of water level measurements.

Table 4 - Hydraulic Conductivity (K) Estimates for GWF/RSD Unit
Gas Works Sediment Western Study Area - Seattle, Washington

Estimates from Slug Testing Temporary Wells

Well Information					AQTESOLV Parameters									K Estimates by Different Methods			Final K Estimates	
Well	Screen Length (ft)	Effective Screen Length[a] (ft)	Total Depth (ft)	Static Water Level (ft)	Static Water Column Height (H); ft	Initial Displacement s(0); ft	Aquifer Saturated Thickness (D); ft	Kv/Kh	Casing Radius r(c); ft	Effective Radius r(w); ft	Outer Radius of Well Skin r(sk); ft	Effective Porosity of Filter Pack Envelope (n)	AQTESOLV Solution (Bouwer-Rice; ft/day)	AQTESOLV Solution (Hvorslev; ft/day)	Graphical Solution (Hvorslev; ft/day)	**Estimated K (ft/day)**	**Estimated K (cm/sec)**
Shallow Wells																	
TSW-1	5	5	9.8	4.9	4.9	1.6	37.4	0.1	0.08	0.3	0.3	0.5	140	180	-	160	6.E-02
TSW-2	5	5	11.9	6.7	5.2	1.2	33.3	0.1	0.08	0.3	0.3	0.5	40	40	-	40	1.E-02
TSW-3	5	5	11.5	6.6	4.9	0.6	32.8	0.1	0.08	0.3	0.3	0.5	80	100	-	90	3.E-02
												Geometric mean of shallow well estimates:				*80*	*3.E-02*
Deep Wells																	
TDW-1	5	2.5	42.2	4.0	38.2	2.9	35.7	0.1	0.08	0.3	0.3	0.5	10	10	7	10	4.E-03
TDW-2	5	2.7	40.0	4.1	35.9	2.6	33.6	0.1	0.08	0.3	0.3	0.5	60	50	-	60	2.E-02
TDW-3	5	3	39.4	6.1	33.3	2.0	31.2	0.1	0.08	0.3	0.3	0.5	50	50	-	50	2.E-02
												Geometric mean of deep well estimates:				*30*	*1.E-02*

Notes:

[a] The effective screen length assumes the bottom of the Gas Works Fill/Stratified Drift Unit is the bottom of the screen interval for screen intervals extending into the Vashon Till Unit.

Estimate from 50-Hour Pumping Test of Well RW-1 (RETEC 1998)

Estimated K (ft/day)	Estimated K (cm/sec)
5	*2.E-03*

Weighted Best Estimate Value

		Resultant Best Estimate K (ft/day)	Resultant Best Estimate K (cm/sec)
Weighting factor for collective slug test estimates from shallow wells:	1		
Weighting factor for collective slug test estimates from deep wells:	3	**16**	**6.E-03**
Weighting factor for 50-hr pump test estimate:	10		

Aspect consulting
IN-DEPTH PERSPECTIVE

179 Madrone Lane North
Bainbridge Island, WA 98110
(206) 780-9370

811 First Avenue #480
Seattle, WA 98104
(206)-328-7443

Groundwater Monitoring Well Location Map

Gas Works Sediment Western Study Area RIFS

Seattle, WA

DATE: May 2007	PROJECT NO. 060102
DESIGNED BY: ACM	
DRAWN BY: ACM	FIGURE NO. 1
REVISED BY: ACM	

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IN-DEPTH PERSPECTIVE
179 Madrone Lane North, Bainbridge Island, WA 98110, (206) 780-9370
811 First Avenue #480, Seattle, WA 98104, (206)-328-7443

Water Table Elevation Contour Map
Gas Works Sediment Western Study Area RIFS
Seattle, WA

DATE: May 2007	PROJECT NO. 060102
DESIGNED BY: SJG	
DRAWN BY: ACM	FIGURE NO. 2
REVISED BY: ACM	

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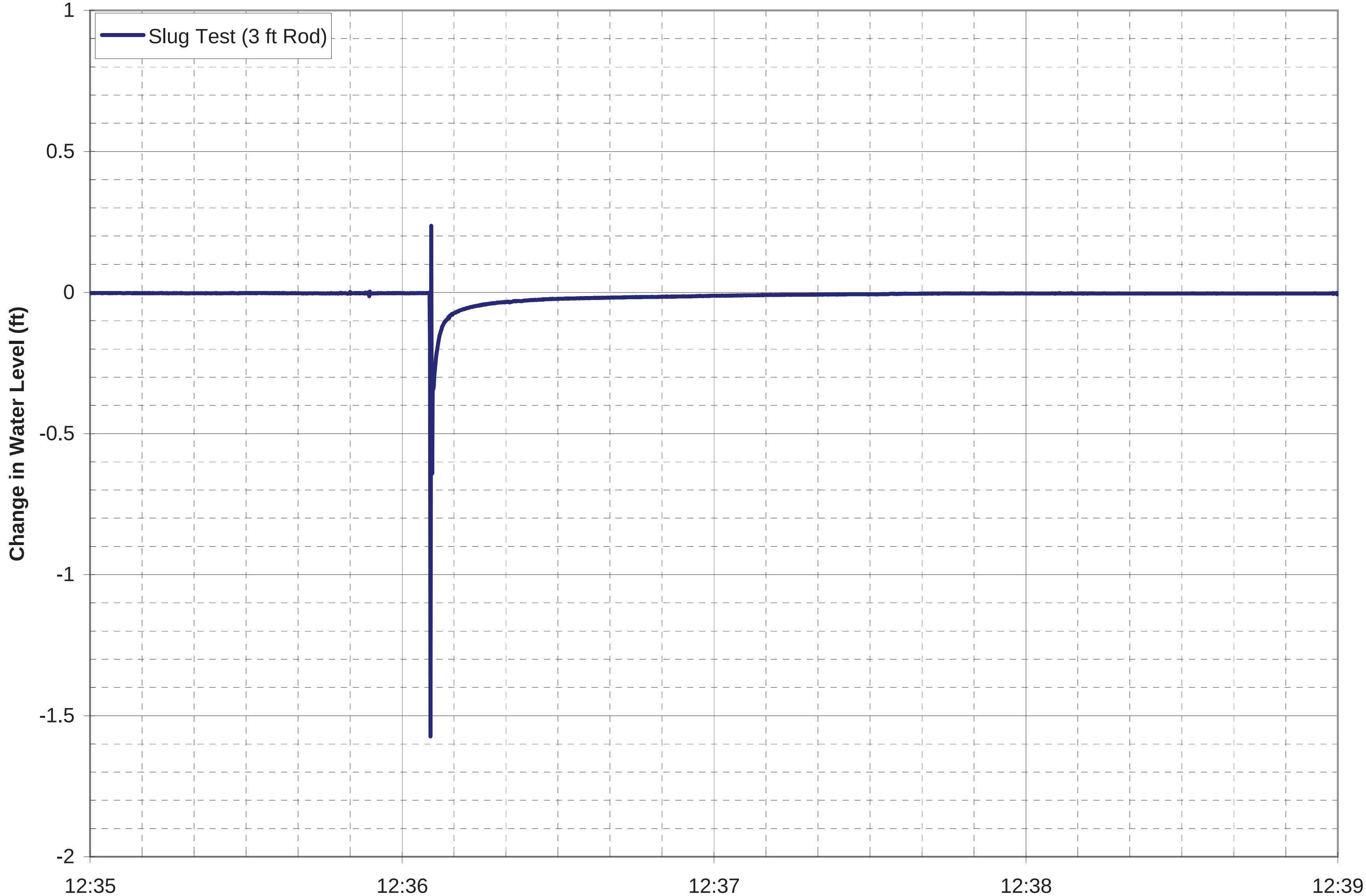
ATTACHMENT A

Slug Test Data Figures



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V:\060102 Gas Works Park Groundwater\Hydro Results memo\Figs A1 - A6.xls

Figure A-1
TSW-1 Slug Test Results
Gas Works Sediment Western Study Area

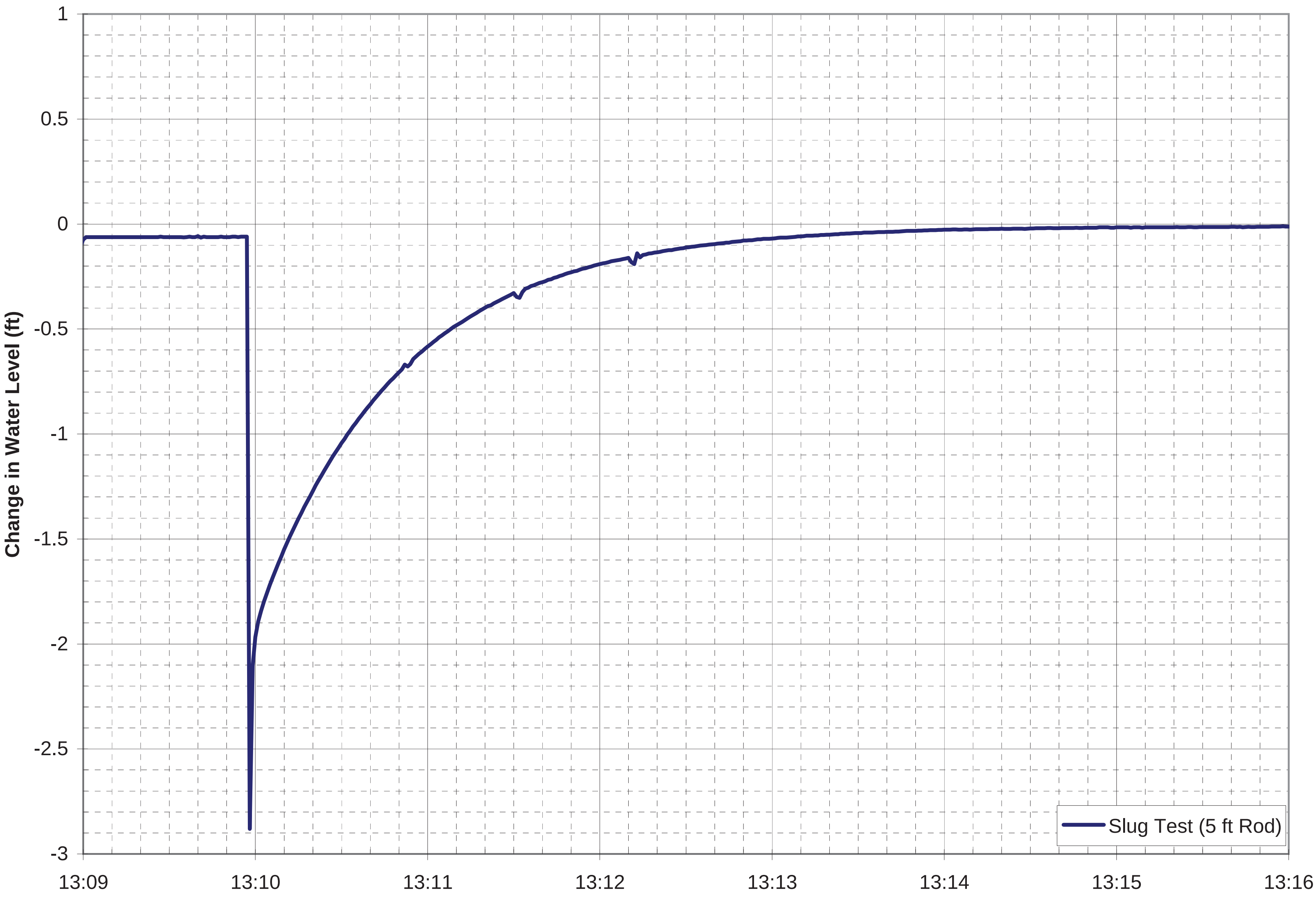

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Figure A-2
TDW-1 Slug Test Results
Gas Works Sediment Western Study Area

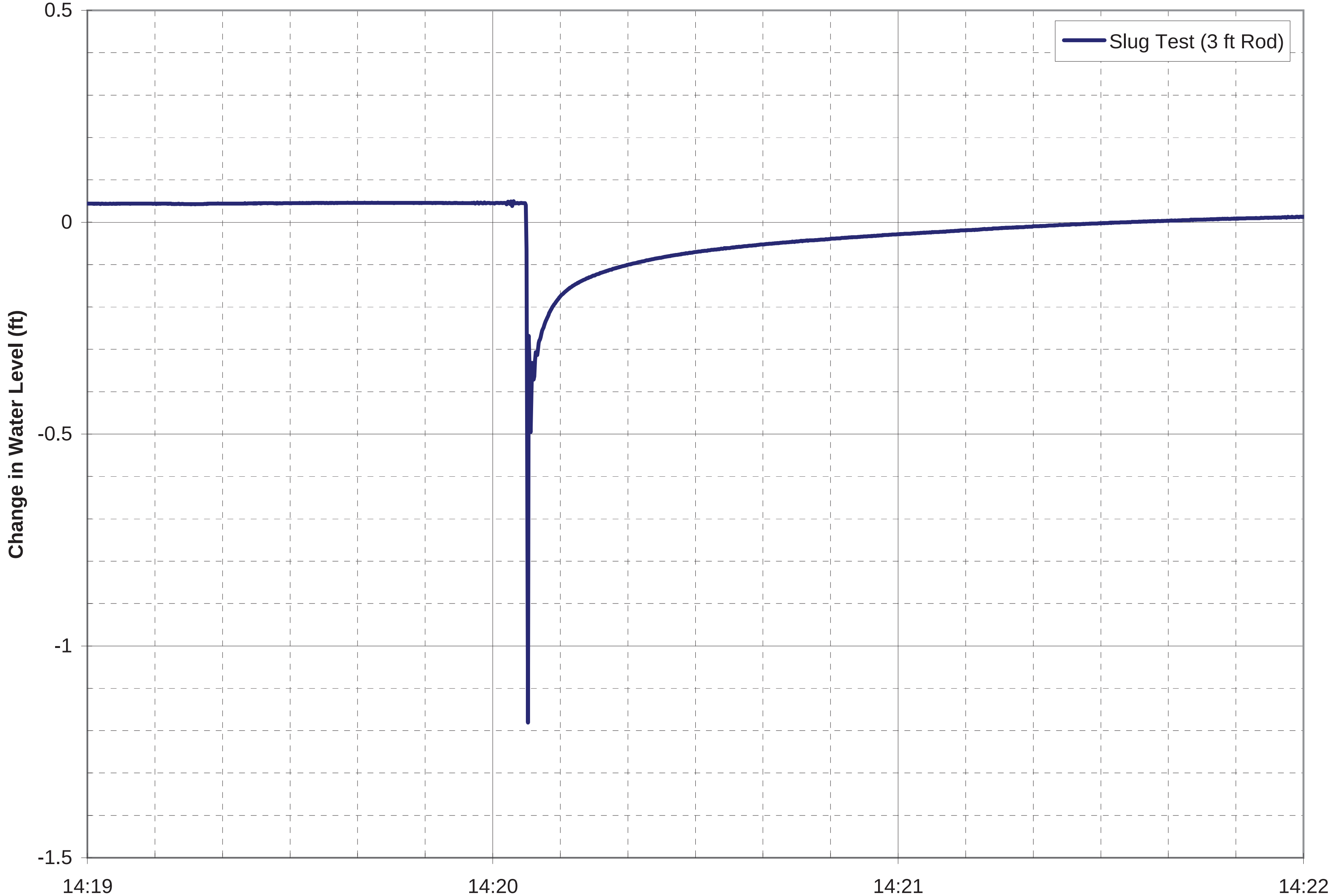

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Figure A-3
TSW-2 Slug Test Results
Gas Works Sediment Western Study Area

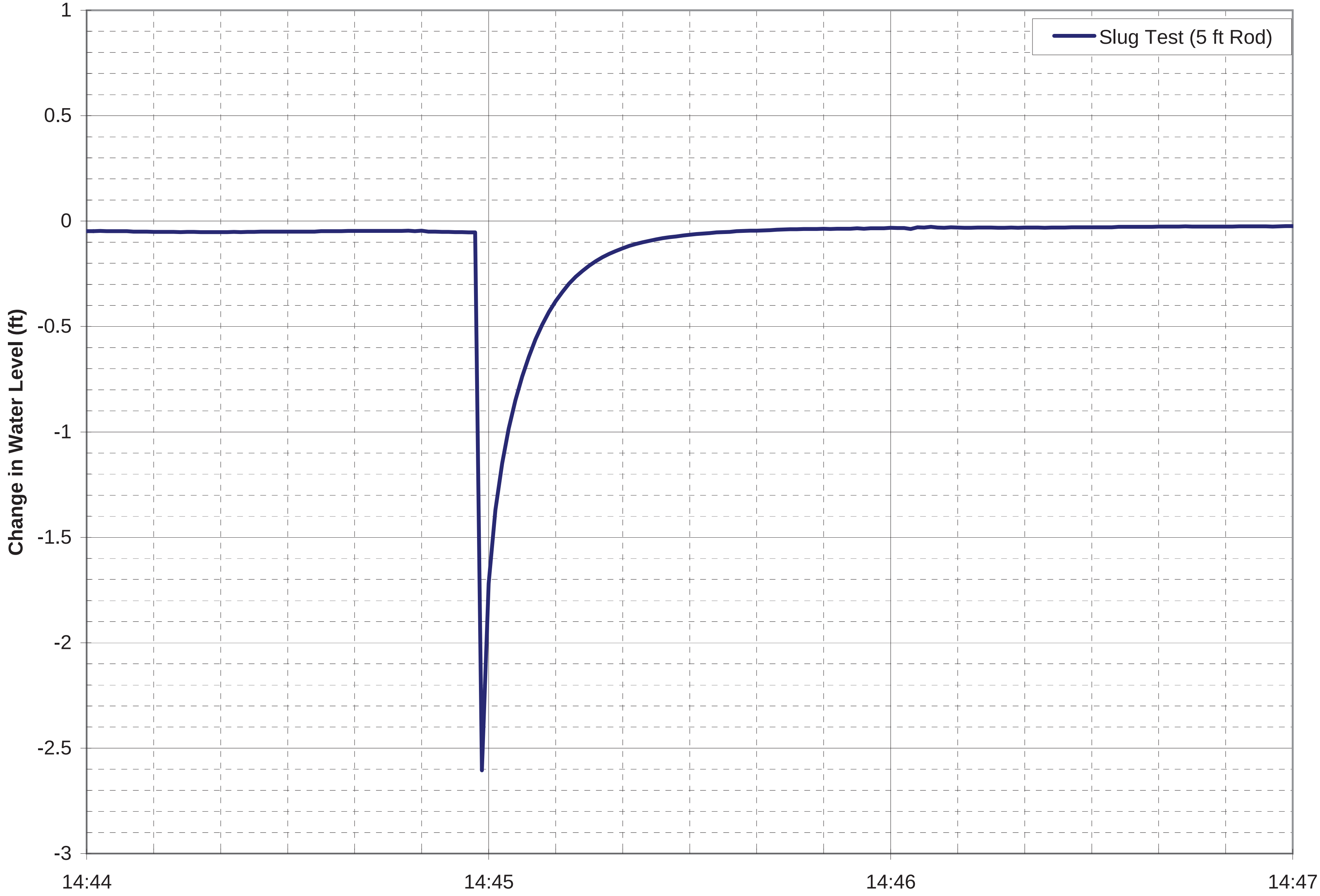

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Figure A-4
TDW-2 Slug Test Results
Gas Works Sediment Western Study Area

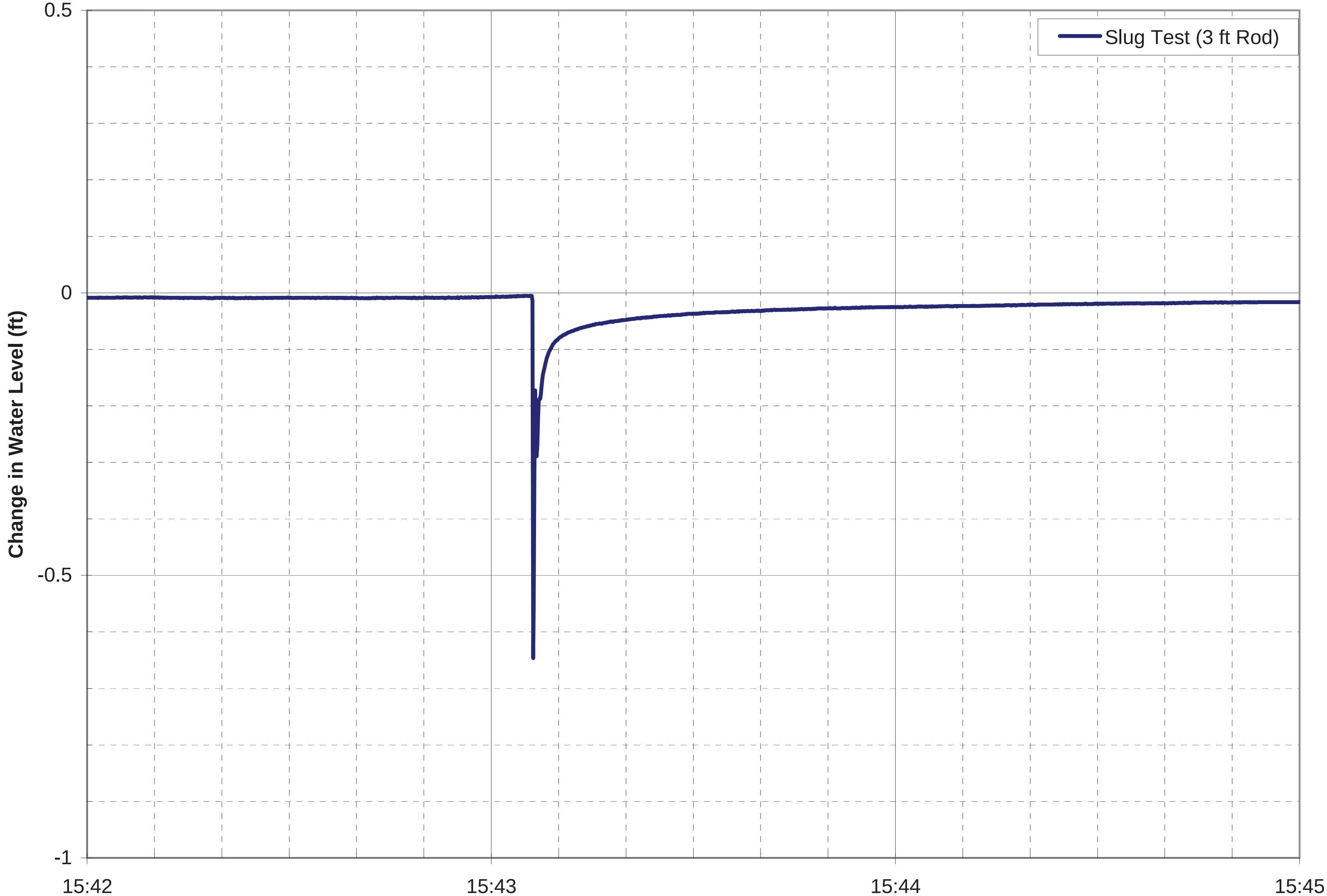

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Figure A-5
TSW-3 Slug Test Results
Gas Works Sediment Western Study Area

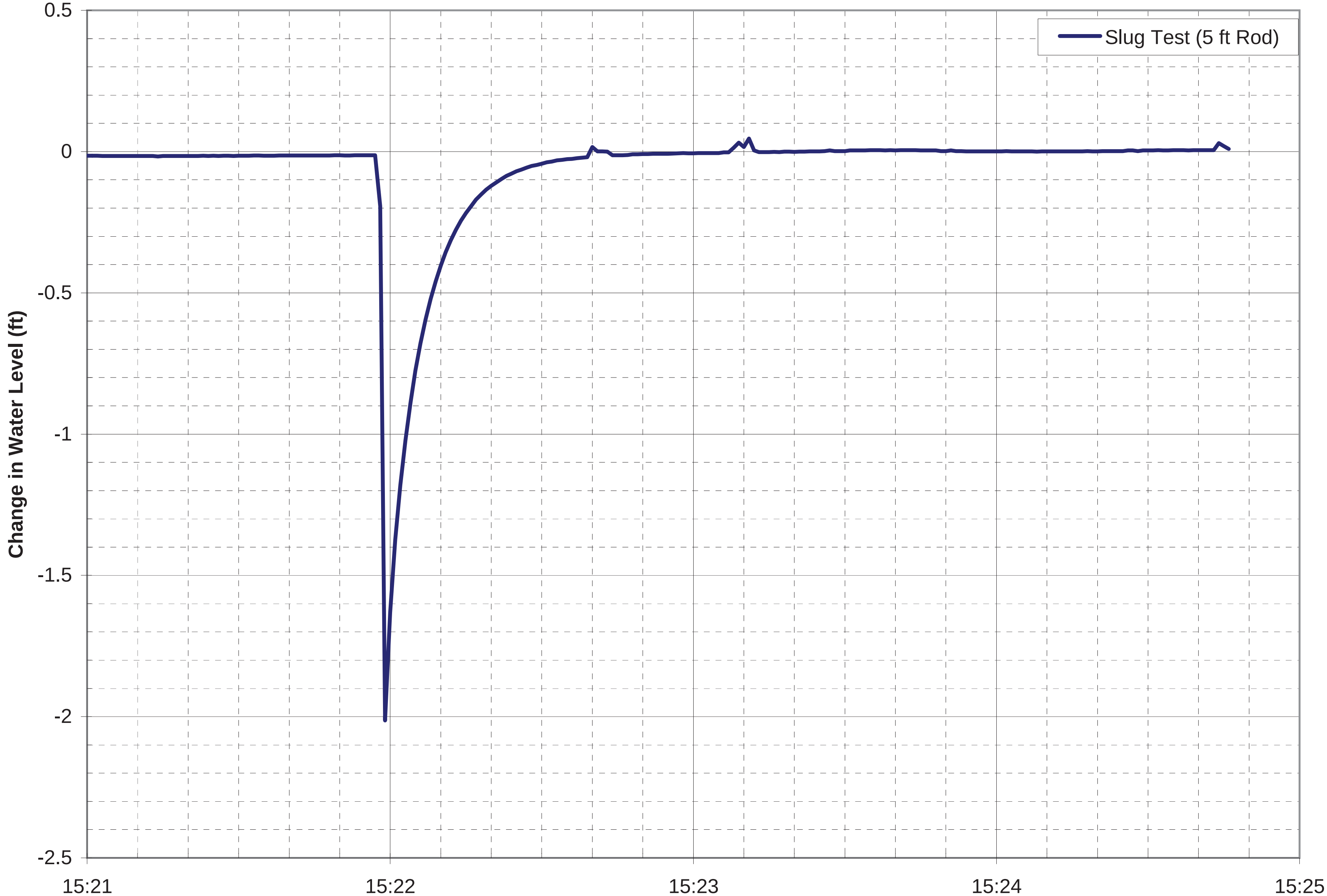

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Figure A-6
TDW-3 Slug Test Results
Gas Works Sediment Western Study Area

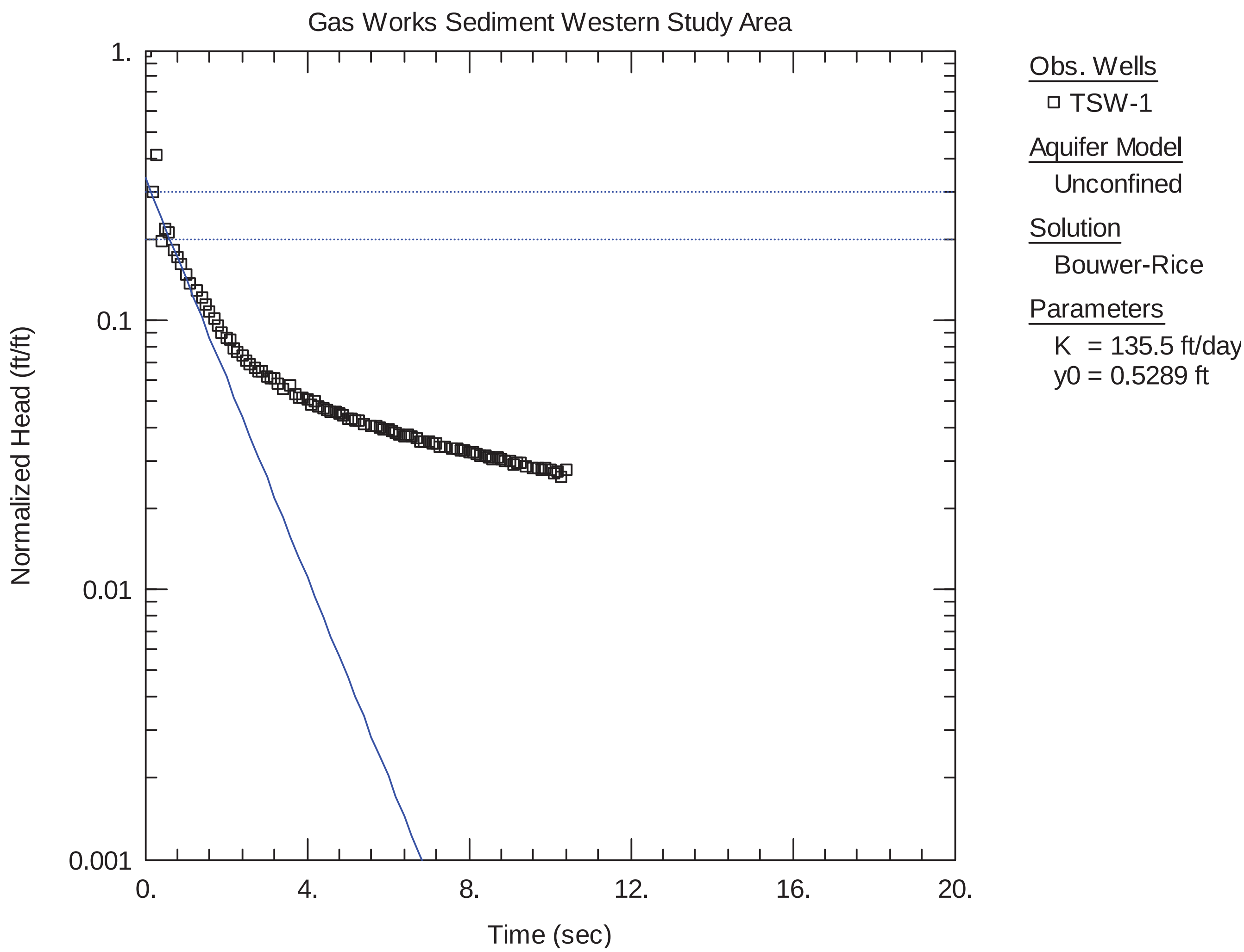

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Figure A-7

TSW-1 Bouwer-Rice Analysis

Gas Works Sediment Western Study Area, Seattle, WA

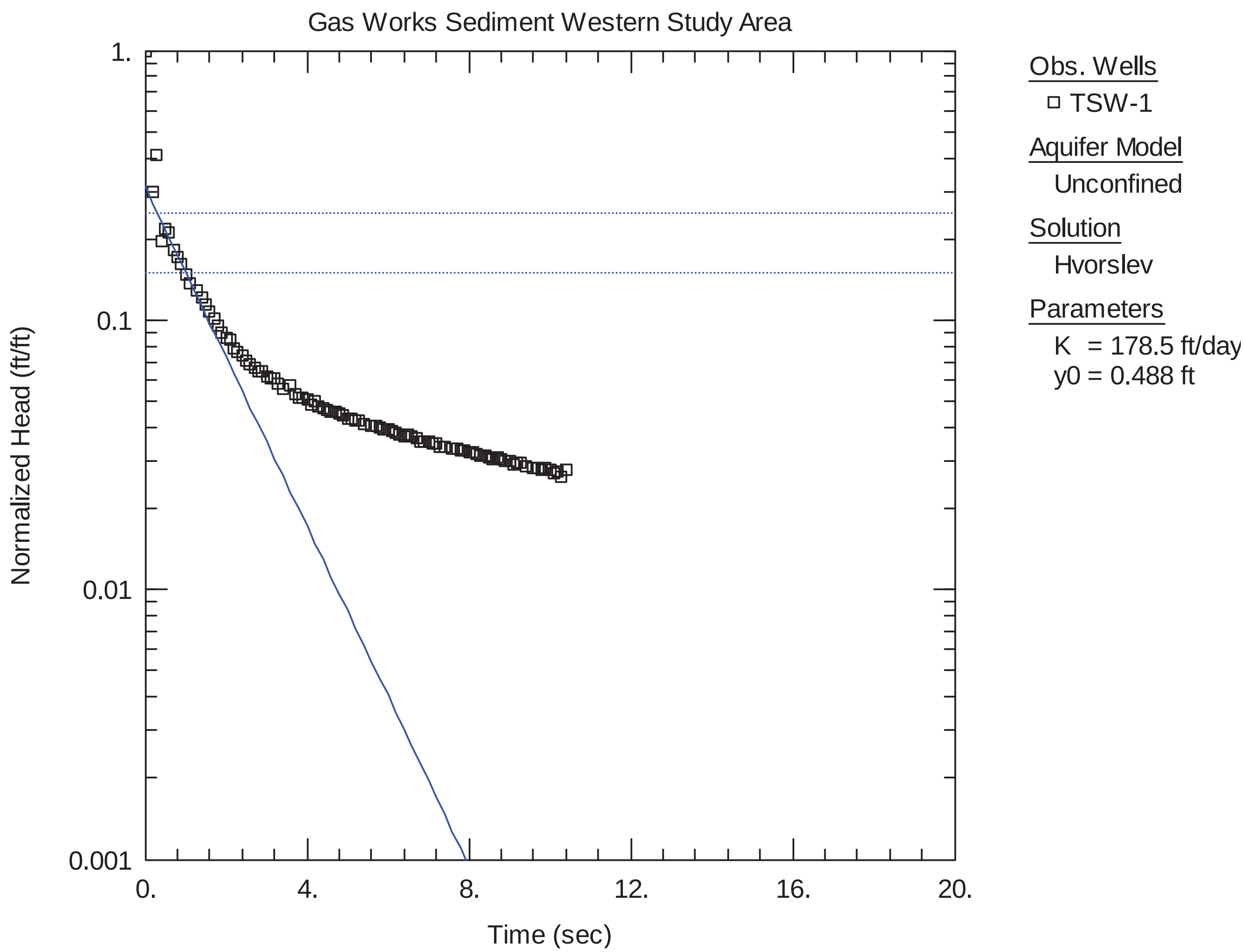

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Figure A-8

TSW-1 Hvorslev Analysis

Gas Works Sediment Western Study Area, Seattle, WA

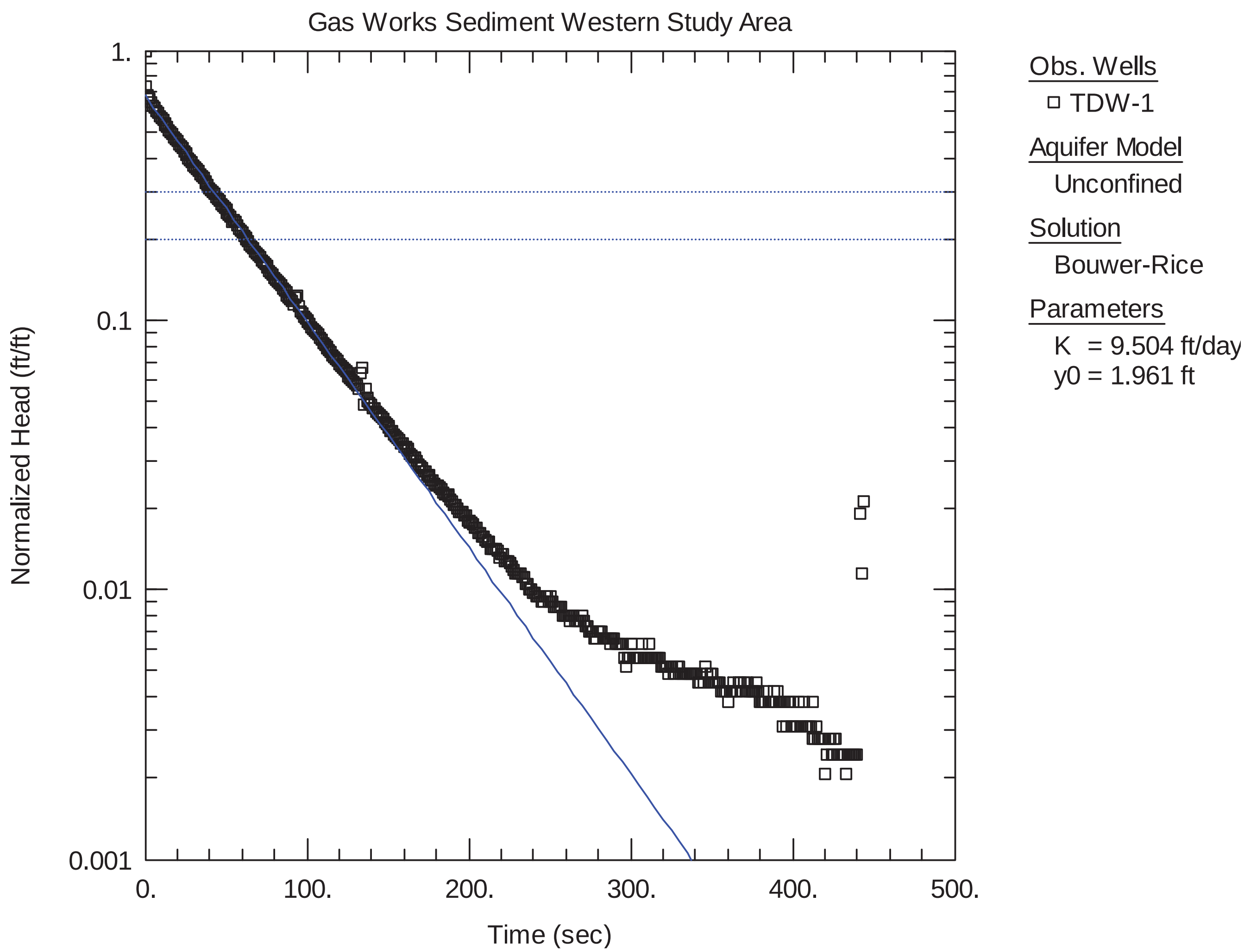

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Figure A-9

TDW-1 Bouwer-Rice Analysis

Gas Works Sediment Western Study Area, Seattle, WA

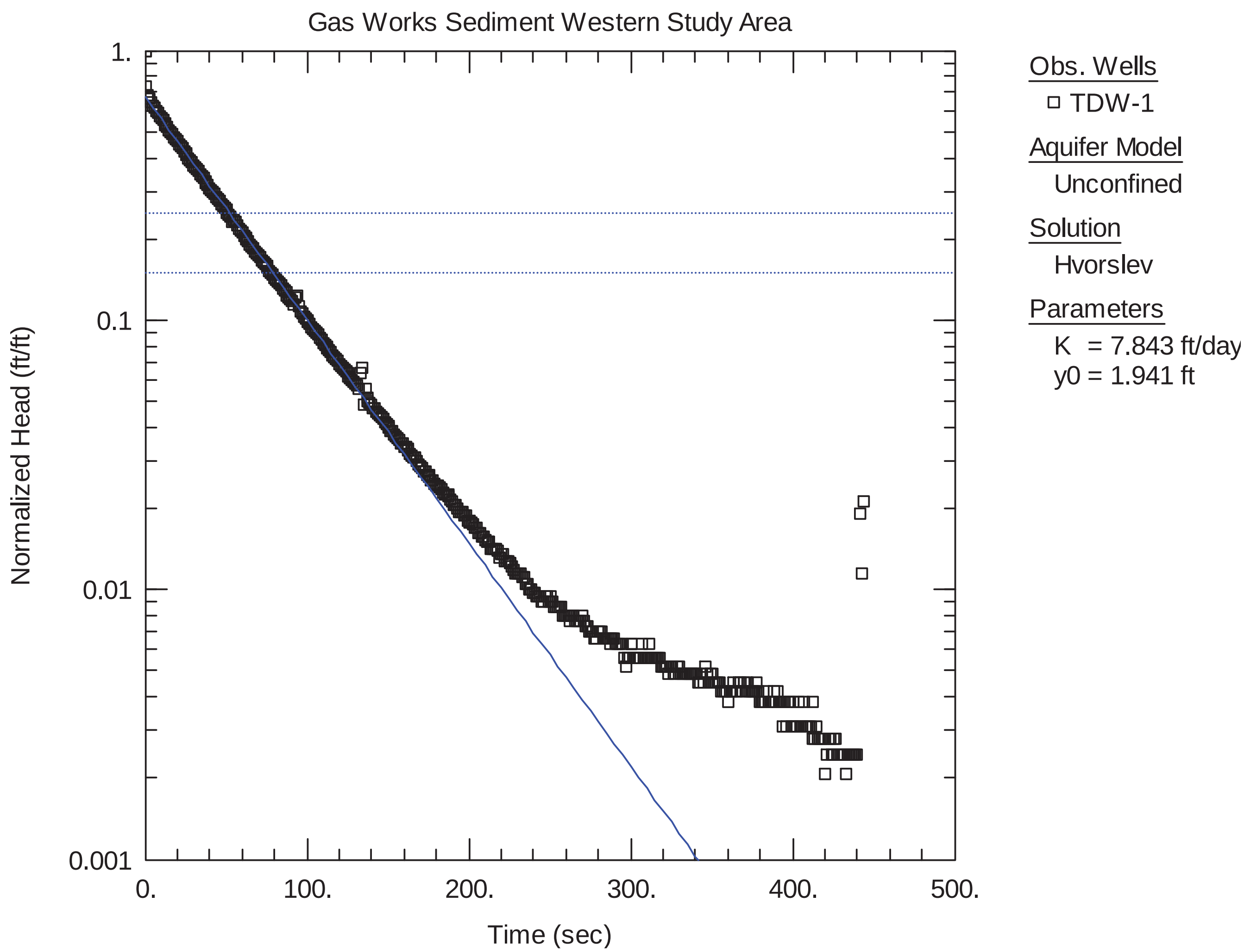

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Figure A-10

TDW-1 Hvorslev Analysis

Gas Works Sediment Western Study Area, Seattle, WA

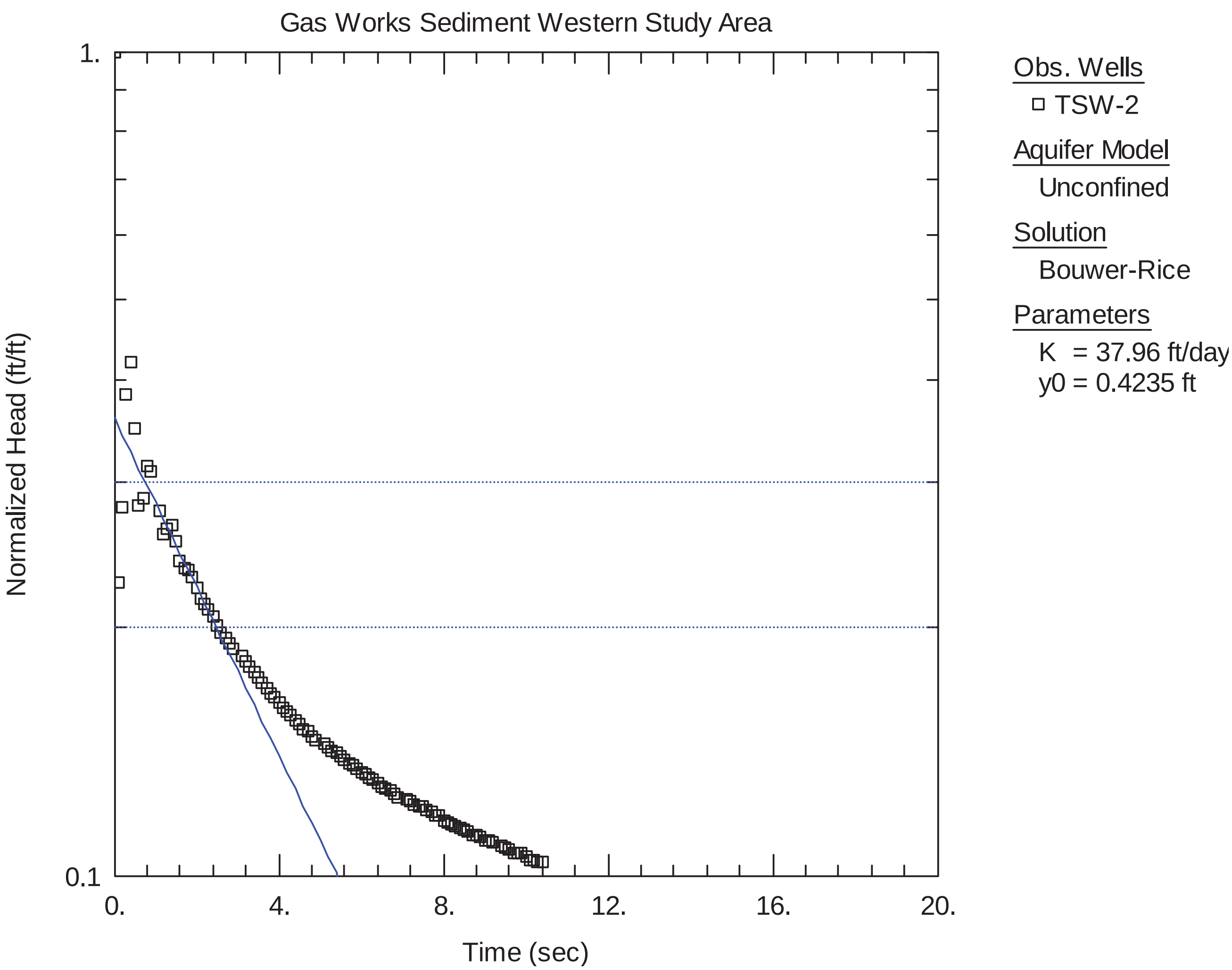

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Figure A-11

TSW-2 Bouwer-Rice Analysis

Gas Works Sediment Western Study Area, Seattle, WA

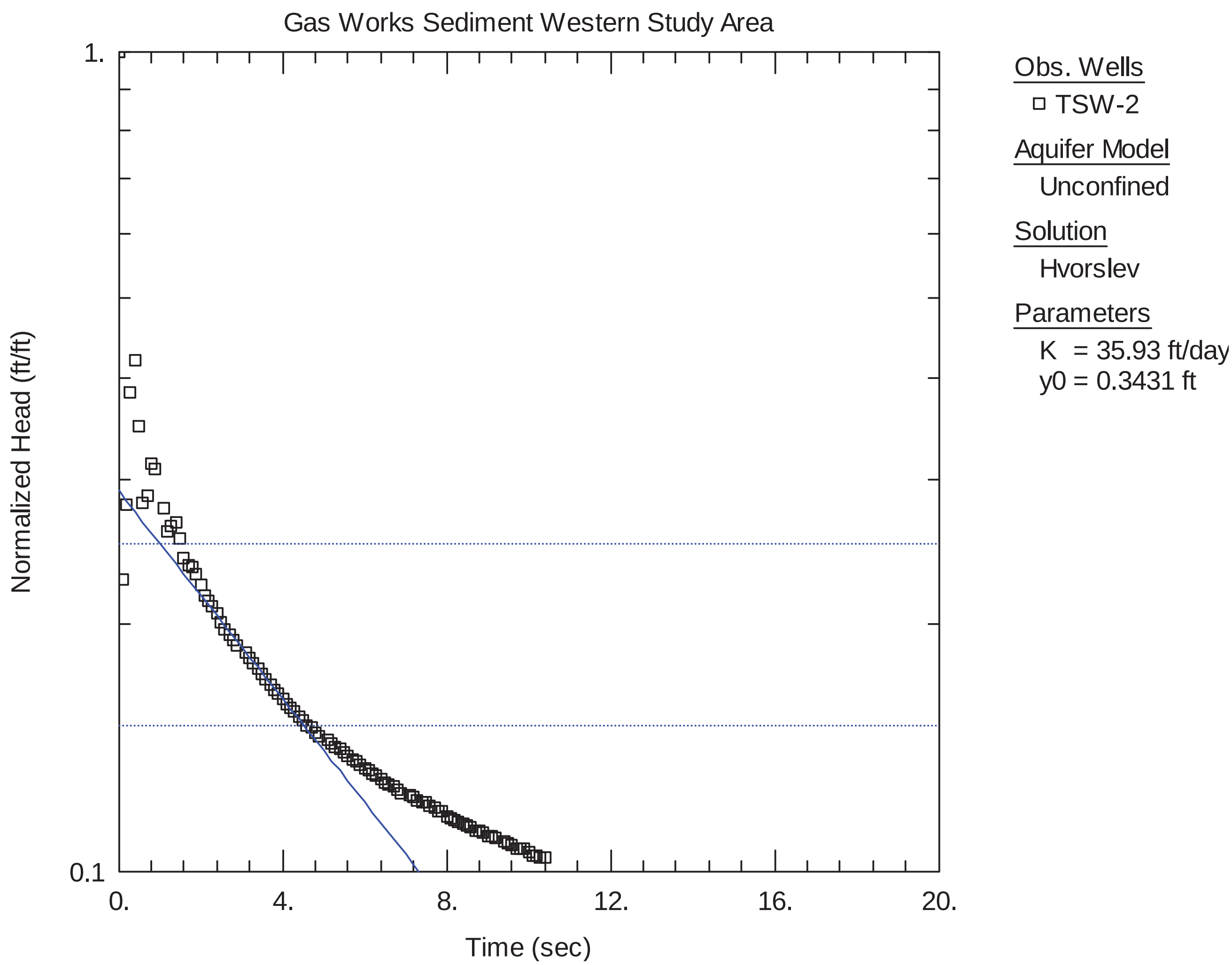

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Figure A-12
TSW-2 Hvorslev Analysis
Gas Works Sediment Western Study Area, Seattle, WA

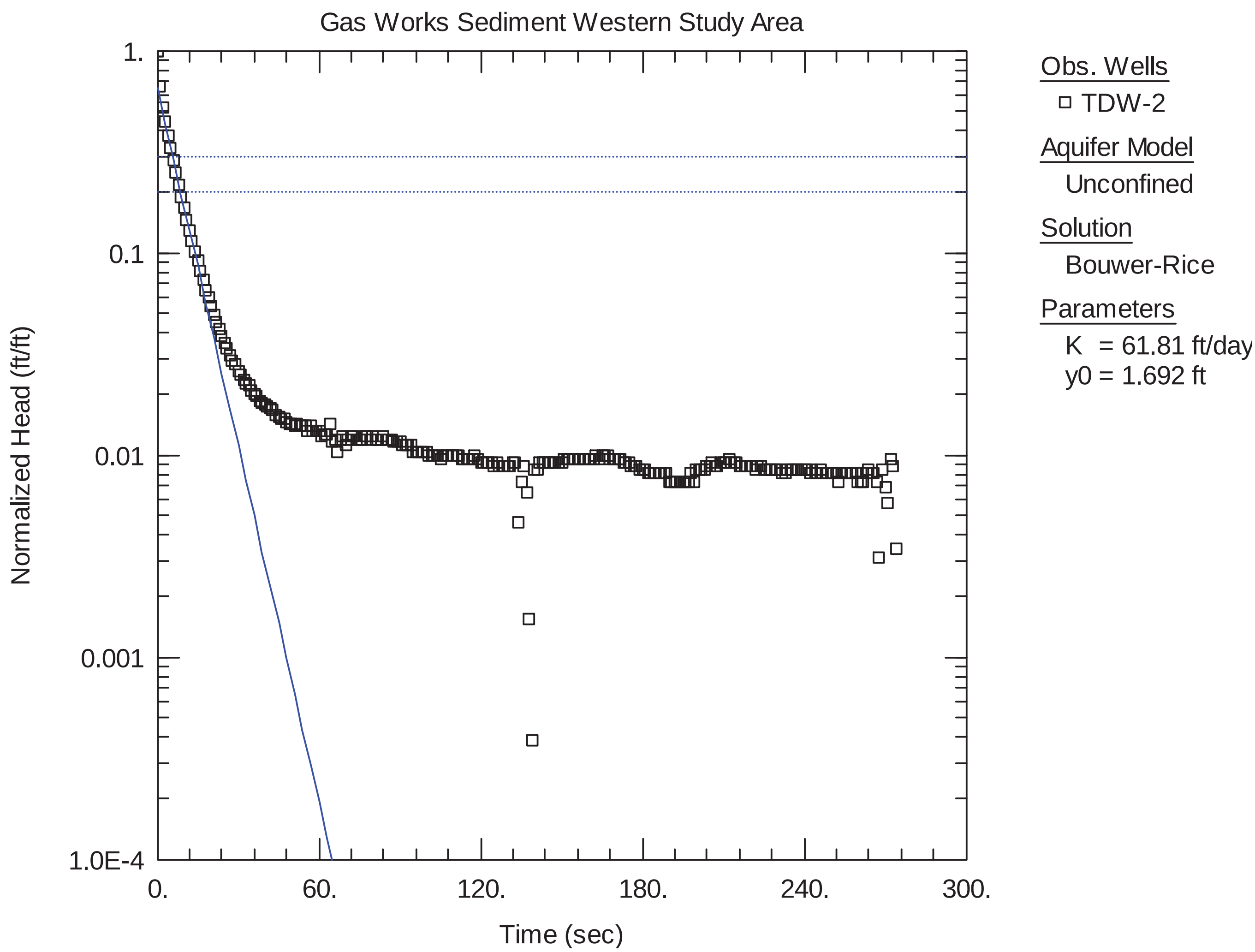

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Figure A-13

TDW-2 Bouwer-Rice Analysis

Gas Works Sediment Western Study Area, Seattle, WA

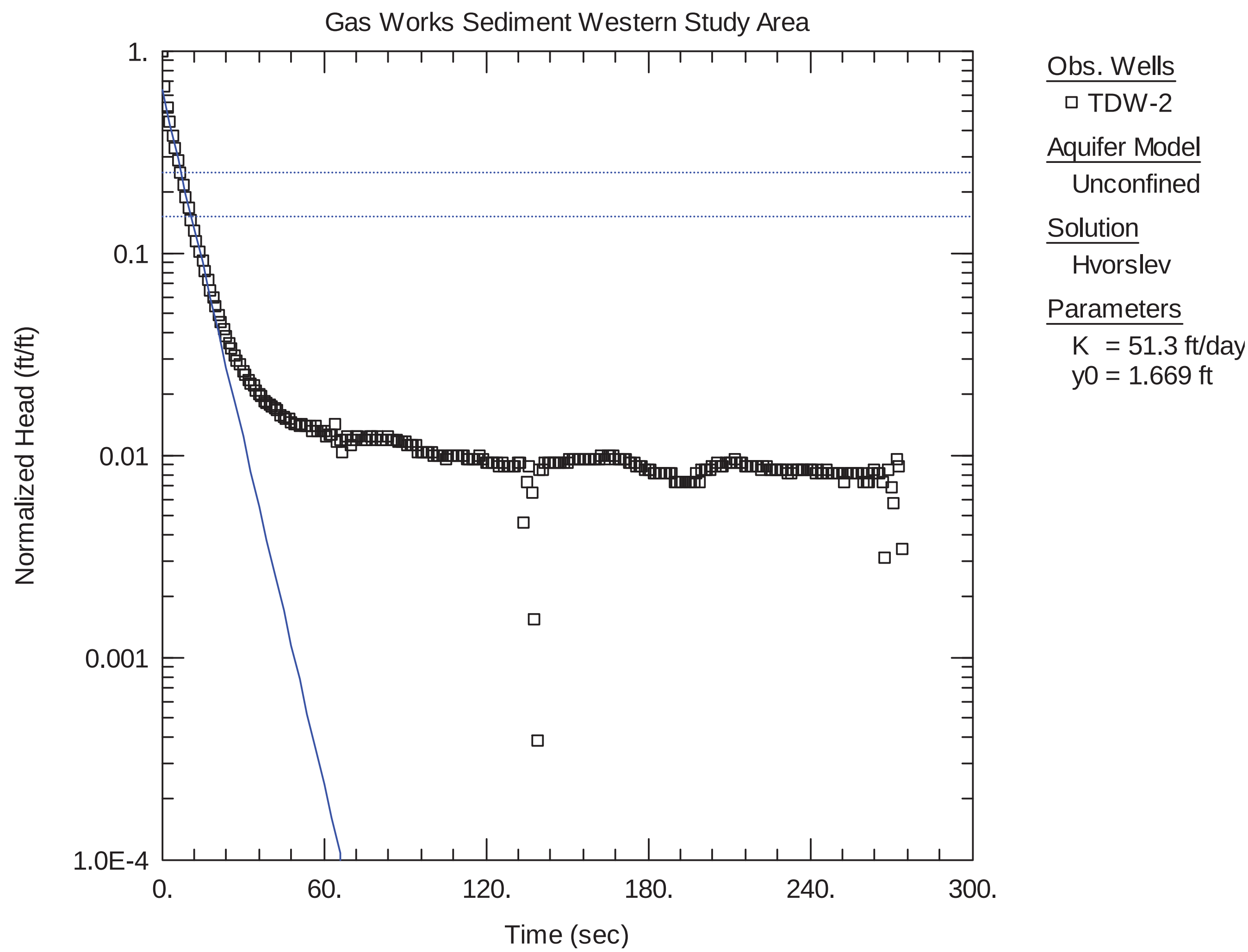

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Figure A-14

TDW-2 Hvorslev Analysis

Gas Works Sediment Western Study Area, Seattle, WA

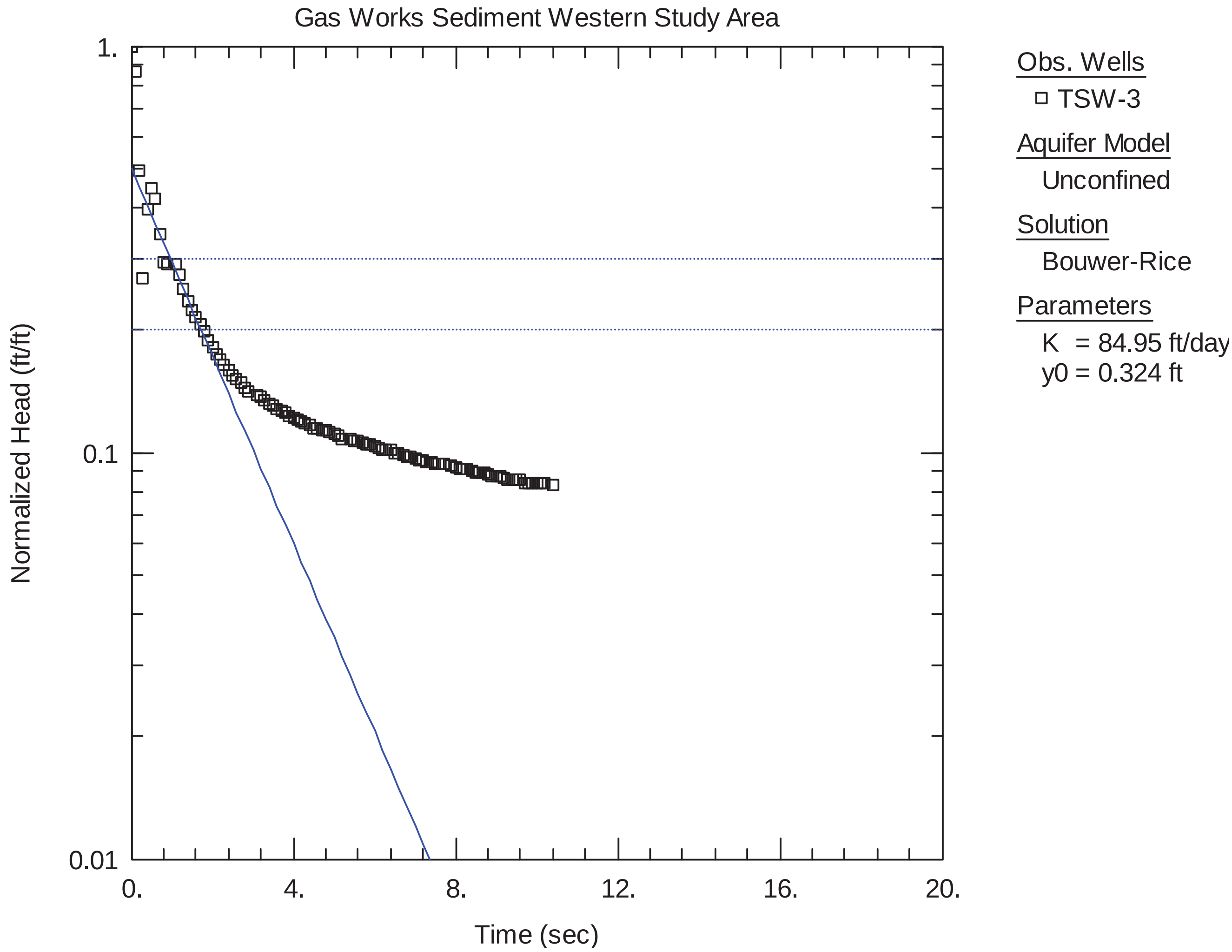

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Figure A-15

TSW-3 Bouwer-Rice Analysis

Gas Works Sediment Western Study Area, Seattle, WA

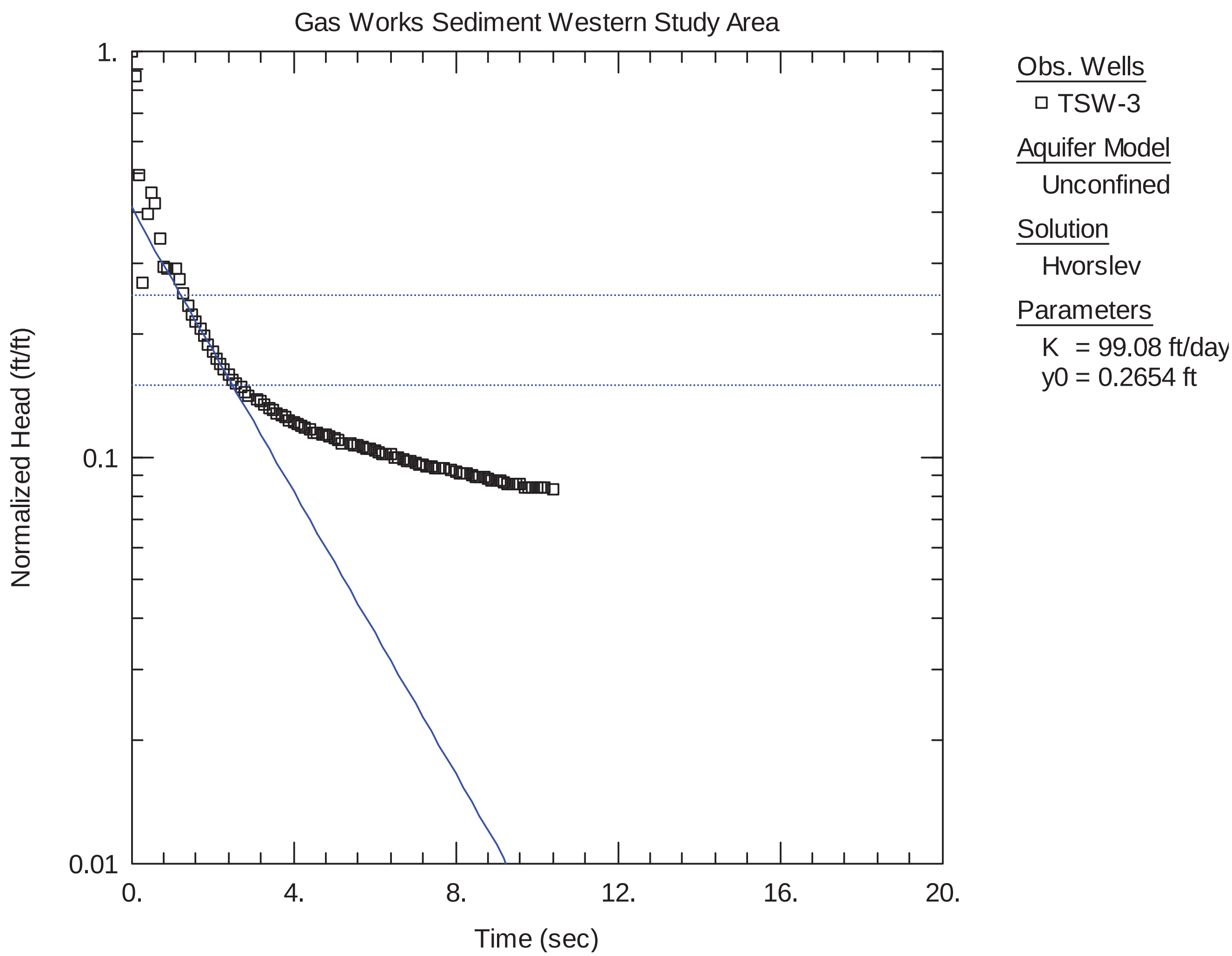

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Figure A-16

TSW-3 Hvorslev Analysis

Gas Works Sediment Western Study Area, Seattle, WA

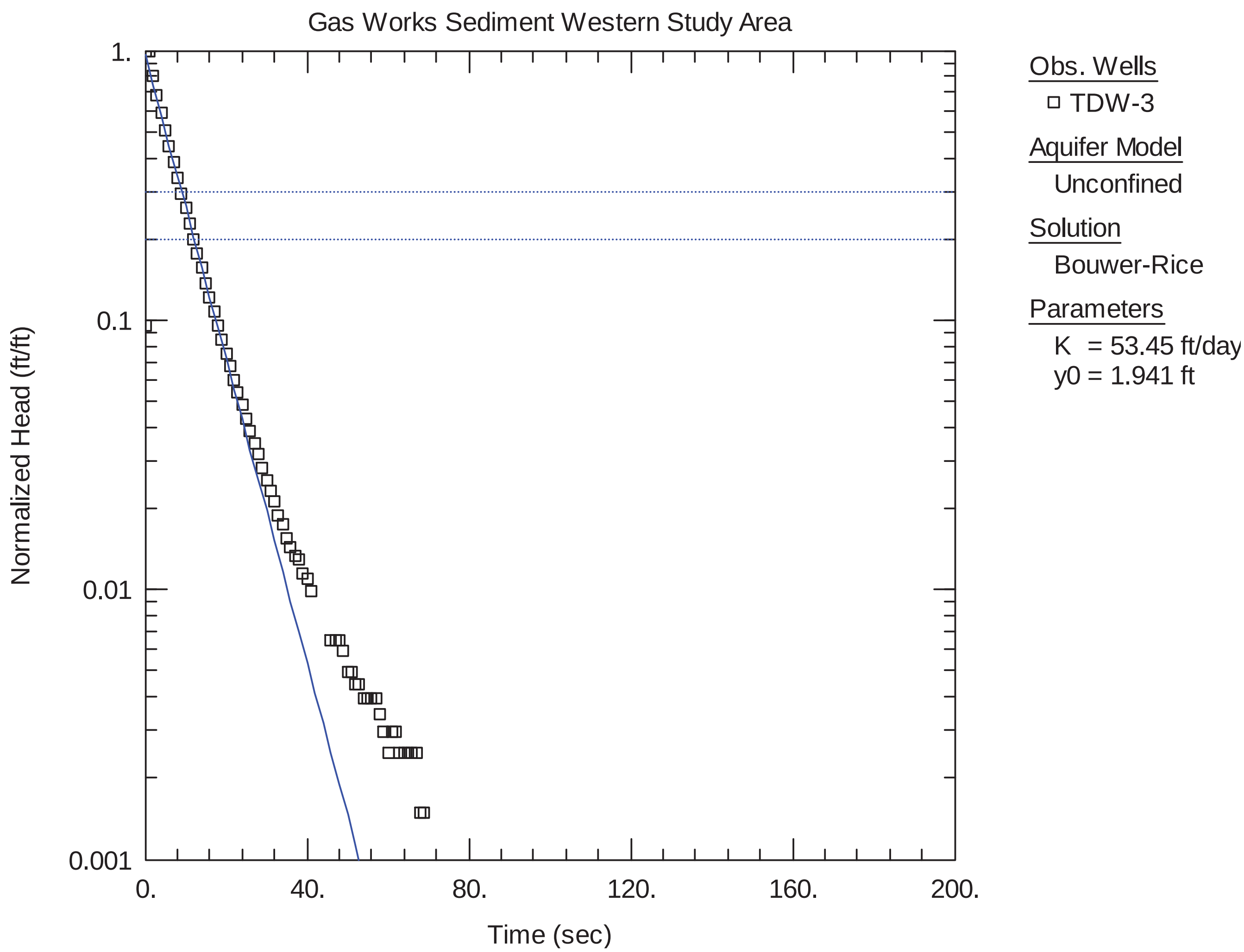

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Figure A-17

TDW-3 Bouwer-Rice Analysis

Gas Works Sediment Western Study Area, Seattle, WA

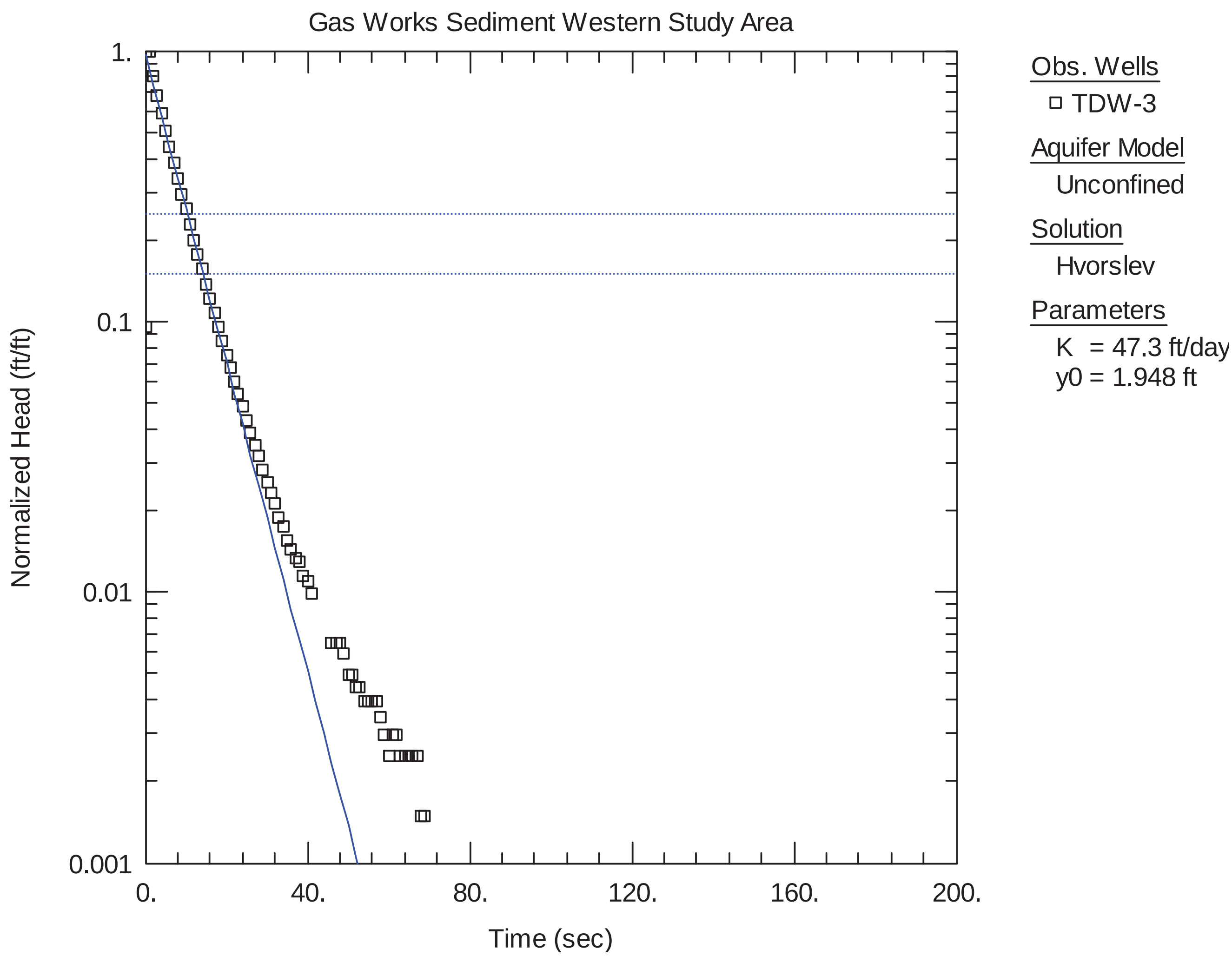

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Figure A-18

TDW-3 Hvorlev Analysis

Gas Works Sediment Western Study Area, Seattle, WA

ATTACHMENT 2C-3
2004 and 2005 Sediment Chemical Data Packages

ATTACHMENT 2C-3
2004 AND 2005 SEDIMENT CHEMICAL DATA PACKAGES

In 2004-2005, RETEC collected sediment grab (0 to 10 centimeters [cm]) and core samples for the Phase 3 sediment investigation in the Eastern Study Area (ESA). In 2005, Floyd|Snider collected sediment grab (0 to 10 cm) and core samples for the sediment investigation in the Western Study Area (WSA). The studies were conducted to refine the horizontal and vertical extent of the chemical concentrations in the ESA and WSA, respectively, and further investigate potential contaminant sources, sediment physical properties and transport pathways to facilitated development of remedial alternatives to address impacted sediment.

This attachment includes the following Phase 3 ESA chemical data packages.

- HL18, HL41
- HL42, HL69, HM02, HM06
- HM11
- HM46
- HM60, HM61, HM62, HM63
- HM80, HM81, HM82, HM83
- HM84, HM97, HN15
- HN00, HN01, HN14
- HO56, HO57
- HO58, HO59
- HP38
- HP74
- HP93, HQ21
- HQ02, HQ53, HR98
- HQ10
- HQ34, HQ44, HQ60
- HQ65
- HQ73
- HR71
- HR83, HS12
- HS21
- HT08
- HU78
- HY74
- HY88, HY90
- HZ01, HZ34, HZ34
- IM75

The ESA and WSA chemical data packages will be included in a future draft of the RI.