APPENDIX A
NOTICE OF INTENT TO REMEDIATE, REPORT NOTIFICATIONS, AND PROOFS

Remedial Investigation Report
Area of Interest 1
Philadelphia Refinery Complex
Philadelphia, Pennsylvania
Philadelphia Refinery Operations,
a series of Evergreen Resources Group, LLC
3144 Passyunk Avenue, Philadelphia, Pennsylvania

Philadelphia Refinery

Sunoco Inc.
3144 Passyunk Avenue
Philadelphia PA 19145-5299
215 339 2000

October 12, 2006

Mr. Robert Day-Lewis
Pennsylvania DEP
2 East Main Street
Norristown, PA 19401

Mr. Steve O'Neil
Pennsylvania DEP
2 East Main Street
Norristown, PA 19401

Re: Sunoco Inc. (R&M) Philadelphia Refinery
Philadelphia, Philadelphia County

Dear Mr. Day-Lewis and Mr. O'Neil:

In accordance with the Land Recycling and Environmental Remediation Standards Act (Act 2), enclosed are two copies of a Notice of Intent to Remediate (NIR) for the Sunoco Inc. (R&M) Philadelphia Refinery. This NIR covers remediation being done as part of the 2003 Consent Order and Agreement (CO&A) at Point Breeze, Girard Point and Schuylkill River Tank Farm. Remediation at Belmont Terminal, which is part of the CO&A, is not part of this NIR since this site is not subject to RCRA Corrective Action. Sunoco is considering submitting a separate NIR for this area under the Act 2 program only.

This NIR is being submitted with the intent to enter the Sunoco Philadelphia Refinery into the One Cleanup Program with PaDEP and the USEPA. All remediation work at the Philadelphia refinery will be completed under the 2003 Consent Order & Agreement (CO&A), however, RCRA Corrective Action measures will be addressed concurrently with work performed under the CO&A and within the Act 2 program.

Please call me at 610-859-1881 or email me at jroppenheim@sunocoinc.com with any questions or comments.

Best Regards,

James Oppenheim, PE
Sr. Environmental Consultant

Cc: Sunoco Legal Dept.
Philadelphia Refinery Environmental Central File
David Burke, PADEP
Walter Payne, PADEP
Hon Lee, USEPA Region III
Colleen Costello, Langan

Will remediation be to a site-specific standard ☒ or as a special industrial area ☐? If so, the municipality or municipalities must be provided 30-day comment period. Remediator/Property Owner/Consultant. For each of these recipients of the approval of the final report, complete form below.

Remediator

Contact Person: James R. Oppenheim

Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Remediation Project Manager

Phone Number: (610) 859-1881

Company Name: Sunoco, Inc. (R&M)

Address (street, city, state, zip): 100 Green St., Marcus Hook, PA 19061

Email Address: jroppenheim@sunocoinc.com

Property Owner

Contact Person: Scott Baker

Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Environmental Manager

Phone Number: (215) 339-2074

Company Name: Sunoco, Inc. (R&M)

Address (street, city, state, zip): 3144 Passyunk Ave. Philadelphia, PA 19145

Email Address: sabaker@sunocoinc.com

Consultant

Contact Person: Colleen Costello

Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Consultant

Phone Number: (215) 864-0640

Company Name: Langan Engineering and Environmental Services

Address (street, city, state, zip): 30 South 17th St., Suite 1500, Philadelphia, PA 19103

Email Address: ccostello@langan.com

Preparer of Notice of Intent to Remediate:

Name: James Oppenheim

Title: Project Manager

Address: 100 Green Street
Marcus Hook, PA 19061

Telephone: (610) 859-1881

Email Address: jroppenheim@sunocoinc.com

Email Image File of Site Map showing property lines and general area of site(s) to be remediated to: (landrecycling@state.pa.us)

Philadelphia Refinery

Sunoco Inc.
3144 Passyunk Avenue
Philadelphia PA 19145-5299
215 339 2000

October 12, 2006

Manager
Philadelphia Department of Public Health
Environmental Health Services
321 University Avenue
Philadelphia, PA 19104

Re: Sunoco, Inc. (R&M) Philadelphia Refinery
Philadelphia, Philadelphia County

Dear Sir/Madam:

The Land Recycling and Environmental Remediation Standards Act (Act 2) requires that a Notice of Intent to Remediate (NIR) be provided to the municipality in which the site is located when a site is being remediated to a site-specific Standard. The municipality is afforded a 30-day comment period. In accordance with this provision of the Act, Sunoco, Inc. (R&M) is formally notifying you of its intent to remediate the subject site under Act 2. A copy of the NIR, which will be sent to the Pennsylvania Department of Environmental Protection (PaDEP), is enclosed. This notice will also be published in the Pennsylvania Bulletin, and a summary of the notice appeared in the Philadelphia Daily News on October 16, 2006.

Publication of this notice in the Philadelphia Daily News initiates the 30-day public and municipal comment period. During the next thirty days, your municipality may request to become involved in the development of the remediation plans for the site. If the municipality wishes to become involved in this project, please send your comments to Sunoco to my attention.

Please call me at (610) 859-1881 if you have any questions concerning the proposed remediation.

Best Regards,

James R. Oppenheim, P.E.
Senior Environmental Consultant

Cc: Sunoco Legal Dept.
Philadelphia Refinery Environmental Central File
Steve O'Neil, PaDEP
Colleen Costello, Langan

Will remediation be to a site-specific standard ☒ or as a special industrial area ☐? If so, the municipality or municipalities must be provided 30-day comment period.
Remediator/Property Owner/Consultant. For each of these recipients of the approval of the final report, complete form below.

Remediator

Contact Person: James R. Oppenheim

Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Remediation Project Manager

Phone Number: (610) 859-1881

Company Name: Sunoco, Inc. (R&M)

Address (street, city, state, zip): 100 Green St., Marcus Hook, PA 19061

Email Address: jroppenheim@sunocoinc.com

Property Owner

Contact Person: Scott Baker

Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Environmental Manager

Phone Number: (215) 339-2074

Company Name: Sunoco, Inc. (R&M)

Address (street, city, state, zip): 3144 Passyunk Ave. Philadelphia, PA 19145

Email Address: sabaker@sunocoinc.com

Consultant

Contact Person: Colleen Costello

Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Consultant

Phone Number: (215) 864-0640

Company Name: Langan Engineering and Environmental Services

Address (street, city, state, zip): 30 South 17th St., Suite 1500, Philadelphia, PA 19103

Email Address: ccostello@langan.com

Preparer of Notice of Intent to Remediate:

Name: James Oppenheim

Title: Project Manager

Address: 100 Green Street
Marcus Hook, PA 19061

Telephone: (610) 859-1881

Email Address: jroppenheim@sunocoinc.com

Email Image File of Site Map showing property lines and general area of site(s) to be remediated to: (landrecycling@state.pa.us)

Proof of Publication in The Philadelphia Daily News
Under Act. No 587, Approved May 16, 1929

STATE OF PENNSYLVANIA
COUNTY OF PHILADELPHIA

Anna Dickerson being duly sworn, deposes and says that **The Philadelphia Daily News** is a newspaper published daily, except Sunday, at Philadelphia, Pennsylvania, and was established in said city in 1925, since which date said newspaper has been regularly issued in said County, and that a copy of the printed notice of publication is attached hereto exactly as the same was printed and published in the regular editions and issues of the said newspaper on the following dates:

October 16, 2006

Affiant further deposes and says that he is an employee of the publisher of said newspaper and has been authorized to verify the foregoing statement and that he is not interested in the subject matter of the aforesaid notice of publication, and that all allegations in the foregoing statement as to time, place and character of publication are true.

Anna Dickerson

Sworn to and subscribed before me this 16th day of October, 2006

Mary Anne Logan
Notary Public

My Commission Expires:

NOTARIAL SEAL
Mary Anne Logan, Notary Public
City of Philadelphia, Phila. County
My Commission Expires March 30, 2009

Copy of Notice of Publication

Newspaper Notice of Intent to Remediate to an Environmental Standard.
(Sections 302(e)(1)(ii), 303(h)(1)(ii), 304(n)(1)(i), and 305(c)(1))

Pursuant to the Land Recycling and Environmental Remediation Standards Act (Act), the act of May 19, 1995, P.L. 4, No. 1995-2., notice is hereby given that Sunoco Inc.(R&M) has submitted to the Pennsylvania Department of Environmental Protection a Notice of Intent to Remediate a site located at 3144 Passyunk Ave., Philadelphia, Philadelphia County, Pennsylvania. This Notice of Intent to Remediate states that the site is a petroleum refinery. It has been determined that petroleum compounds have impacted soil and groundwater at the site. Sunoco Inc. (R&M) has indicated that proposed remediation measures will include source reduction and engineered boundary controls. The proposed future use of the property is industrial for continued operation as a petroleum refinery.

Sunoco Inc. (R&M) plans to use the site-specific remediation standard at the site. The Act provides for a 30-day public comment period for site-specific standard remediation. The 30-day comment period is initiated with the publication of this notice. Until November 16, 2006, the City of Philadelphia may submit a request to Sunoco Inc. (R&M) to be involved in the development of the remediation and reuse plans for the site. The City of Philadelphia may also submit a request to Sunoco Inc. (R&M) during this 30-day comment period to develop and implement a public involvement plan. Copies of these requests and of any comments should also be submitted to the Department of Environmental Protection at 2 East Main Street, Norristown, PA 19401 to the attention of Mr. Walter Payne. All correspondence with Sunoco Inc. (R&M) should be addressed to the Public Relations Dept., Sunoco Inc. (R&M) at 3144 Passyunk Ave, Philadelphia, PA, 19145.

LEGAL NOTICES

Newspaper Notice of Intent to Remediate
to an Environmental Standard.
(Sections 302(e)(1)(ii), 303(h)(1)(ii),
304(n)(1)(i), and 305(c)(1))

Pursuant to the Land Recycling and Environmental Remediation Standards Act (Act), the act of May 19, 1995, P.L. 4, No. 1995-2., notice is hereby given that Sunoco Inc.(R&M) has submitted to the Pennsylvania Department of Environmental Protection a Notice of Intent to Remediate a site located at 3144 Passyunk Ave., Philadelphia, Philadelphia County, Pennsylvania. This Notice of Intent to Remediate states that the site is a petroleum refinery. It has been determined that petroleum compounds have impacted soil and groundwater at the site. Sunoco Inc. (R&M) has indicated that proposed remediation measures will include source reduction and engineered boundary controls. The proposed future use of the property is industrial for continued operation as a petroleum refinery.

Sunoco Inc. (R&M) plans to use the site-specific remediation standard at the site. The Act provides for a 30-day public comment period for site-specific standard remediation. The 30-day comment period is initiated with the publication of this notice. Until November 16, 2006, the City of Philadelphia may submit a request to Sunoco Inc. (R&M) to be involved in the development of the remediation and reuse plans for the site. The City of Philadelphia may also submit a request to Sunoco Inc. (R&M) during this 30-day comment period to develop and implement a public involvement plan. Copies of these requests and of any comments should also be submitted to the Department of Environmental Protection at 2 East Main Street, Norristown, PA 19401 to the attention of Mr. Walter Payne. All correspondence with Sunoco Inc. (R&M) should be addressed to the Public Relations Dept., Sunoco Inc. (R&M) at 3144 Passyunk Ave, Philadelphia, PA, 19145.

Appeared in: ***Philadelphia Inquirer & Philadelphia Daily News*** on Monday, 10/16/2006

Back

Evergreen Resources Management
2 Righter Parkway, Suite 200
Wilmington, DE 19803

November 17, 2014

Mr. C. David Brown, Ph. D., PG
Department of Environmental Protection
2 East Main Street
Norristown, PA 19401

RE: Philadelphia Energy Solutions Refining & Marketing LLC (PES) Philadelphia Refinery Complex
3144 West Passyunk Avenue, Philadelphia, Philadelphia County, Pennsylvania

Dear Mr. Brown:

In accordance with the Land Recycling and Environmental Remediation Standards Act (Act 2), enclosed is the revised Notice of Intent to Remediate (NIR) for the Philadelphia Refinery Complex (site). The original NIR for the site was submitted on October 12, 2006. The purpose of this revision is to update owner and remediator information for the facility. This revision also includes a site location map depicting a change to property boundaries, most notably the exclusion of Belmont Terminal, which was covered under a separate NIR submission on October 6, 2014. It should be noted that the Belmont Terminal was not included in the original October 12, 2006 NIR, therefore, its exclusion from the revised NIR is not a change.

On August 14, 2012, Sunoco, Inc. (R&M) (Sunoco) entered into a Consent Order and Agreement with Philadelphia Energy Solutions Refining & Marketing LLC (PES) and the Pennsylvania Department of Environmental Protection (PADEP) for the Philadelphia Refinery Complex. As part of this buyer-seller agreement, Sunoco retained responsibility of remediation activities for environmental conditions existing at the time of the transfer, and PES is responsible for environmental conditions following the purchase agreement. On September 8, 2012, Sunoco conveyed the Philadelphia Refinery to PES. Effective December 30, 2013, “Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC” (Evergreen) assumed Sunoco legacy remediation liabilities with respect to the Philadelphia Refinery Complex. Evergreen will continue to manage the remediation work at the facility under the One Cleanup Program with the PADEP and United States Environmental Protection Agency (USEPA) and in accordance with 2012 Consent Order & Agreement.

Please call me at (302) 477-0192 with any questions or comments.

Best Regards,

James Oppenheim, PE
Vice President

cc: Evergreen File
Charles Barksdale, Philadelphia Energy Solutions Refining and Marketing, LLC
Jennifer Menges, Stantec Consulting Services Inc.

For DEP Use Only
PF #____________
Rem ID #__________

8000-FM-CRLG0010 Rev. 9/2010

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
COMMUNITY REVITALIZATION AND LOCAL GOVERNMENT SUPPORT

NOTICE OF INTENT TO REMEDIATE

Act 1995-2 requires four general information items to be included in the NIR: the general location, listing of contaminants, intended use of property, and proposed remediation measures. In addition, indicate the standard(s) to be obtained (if known) and attach a scaled site map (if available).

Property Name Philadelphia Energy Solutions Refining & Marketing LLC (PES) Philadelphia Refinery Complex

Former Name(s) / AKA Sunoco Inc. (R&M) Philadelphia Refinery

Address / Location 3144 Passyunk Avenue

City Philadelphia Zip Code 19145

Municipality(s)City of Philadelphia County(ies) Philadelphia

Latitude 39 º (deg). 55 ‘ (min) 13.976 “ (sec) Longitude 75 º (deg). 11 ‘ (min) 52.429 “ (sec)

Horizontal Collection Method Geographic Information Systems

Horizontal Reference Datum NAD 1983 Reference Point Visitor Entrance

☒ Wish to participate in the DEP/EPA MOA. Contact Troy Conrad at tconrad@state.pa.us for details.

EPA ID#, if known PAD049791098

DEP ID#(s), if known Multiple
(i.e., eFACTS site ID#, storage tank facility ID#, water quality permit #, watershed permit, air quality permit #, etc.)

Date Release Occurred (if known) ____________

Provide a brief description of the site contamination in plain language (e.g. fuel oil spill, historical chemical industrial area contamination), the names of any know primary contaminants to be addressed, and the intended future use of the property.

The site contamination consists of impacts to soil and groundwater associated with historic petrochemical refining operations. The primary consistuents of concern in soil and groundwater are lead, 1,2-dichloroethane, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, cumene, ethylbenzene, methyl tertiary butyl ether, toluene, total xylenes, ethylene dibromide, anthracene, benzo(a)anthracene, benzo(g,h,i)perylene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluorene, naphthalene, phenanthrene, and pyrene. The future use of the facility is to remain industrial.

Provide a general description of proposed remediation measures.

Evergreen is submitting this Notice of Intent to Remediate (NIR) in order update an NIR previously submitted on October 6, 2006 which formally entered the property into the PA Act 2 Program. In November 2011, the facility was formally entered into the PA One Cleanup Program with the USEPA and PADEP. The purpose of this NIR revision is to update the facility ownership and remediator information. The facility has been divided into 11 Areas of Interest (AOIs). These areas consist of the Point Breeze Processing Area North Yard (AOI 8) and South Yards (AOI 1 through AOI 4); the Girard Point South Tank Field (AOI 5) and Processing Area (AOI 6 and AOI 7); the Schuylkill River Tank Farm (AOI 9); the West Yard (AOI 10); and the deep aquifer (AOI 11). Each AOI will be characterized in accordance with PA Act 2, and remedial measures will be developed to address the risk of exposure identified during the characterization activities.

Remediation Standard(s) planned (if known at this time):

☐ Unknown at this time ☐ Soil ☐ Groundwater
☐ Background ☐ Soil ☐ Groundwater
Contaminants:

☐ Statewide Health - Residential ☐ Soil ☐ Groundwater
Contaminants:

☐ Statewide Health – Non-Residential ☐ Soil ☐ Groundwater
Contaminants:

☒ Site Specific ☒ Soil ☒ Groundwater
Contaminants:

☐ Special Industrial Area* ☐ Soil ☐ Groundwater
Contaminants:

*NOTE: Specific standard or Special Industrial Area require a 30-day municipal comment period

Remediator / Property Owner / Consultant. Complete the form below for *each* recipient obtaining a release of liability upon approval of the final report. Attach additional sheets as necessary.

Remediator

Contact Person/Title Jim Oppenheim, PE/Vice President eFACTS Client ID* 314958
Relationship to Site Remediator Client Type* Limited Liability Company
(e.g. owner, remediator, participant in cleanup, consultant, etc.)
Phone Number (302) 477-0192 Email Address JROPPENHEIM@evergreenresmgt.com
Company Name Evergreen Resources Management Operations EIN or Federal ID # 46-4184955
Address (street, city, state, zip) 2 Righter Parkway, Suite 200, Wilmington, DE 19803

Property Owner

Contact Person/Title Charles Barksdale Jr./Site Environmental Director eFACTS Client ID* 298341
Relationship to Site Owner Client Type* Limited Liability Company
(e.g. owner, remediator, participant in cleanup, consultant, etc.)
Phone Number 215-339-2074 Email Address charles.barksdale@pes-companies.com
Company Name Philadelphia Energy Solutions Refining and Marketing, LLC EIN or Federal ID # 61-168974
Address (street, city, state, zip) 3144 Passyunk Ave, Philadelphia, PA 19145

Consultant

Contact Person/Title Jennifer Menges/Principal Consultant, LRS eFACTS Client ID* N/A
Relationship to Site Consultant Client Type* N/A
(e.g. owner, remediator, participant in cleanup, consultant, etc.)
Phone Number (610) 840-2540 Email Address Jennifer.Menges@stantec.com
Company Name Stantec EIN or Federal ID # N/A
Address (street, city, state, zip) 1060 Andrew Drive, Suite 140, West Chester, PA 19380

*Include eFACTS Client ID (if known) – “Client Types” below:

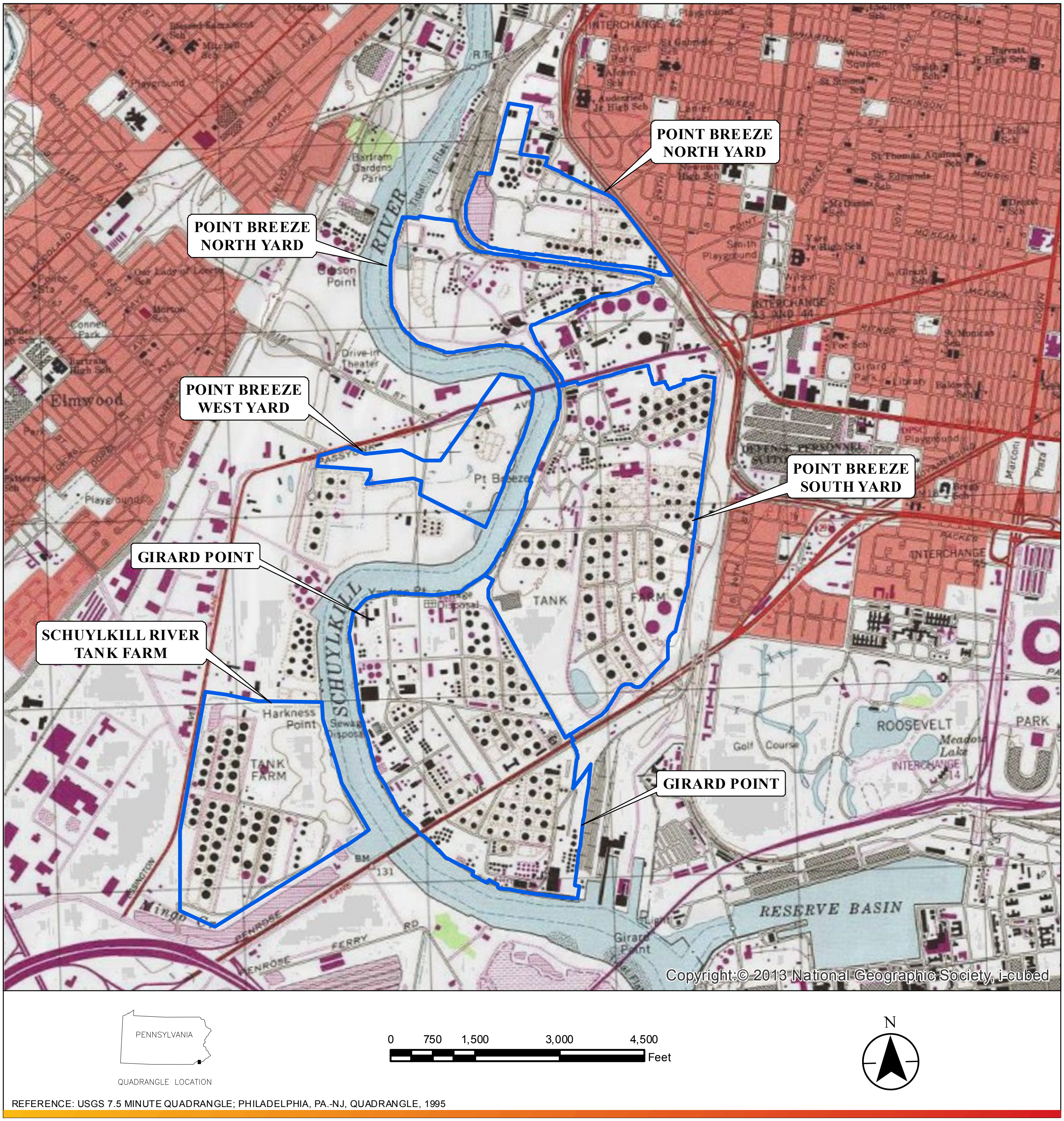
Association/Organization
Authority
County
Estate/Trust
Federal Agency
Individual
Limited Liability company
Limited Liability Partnership
Municipality
Non-Pennsylvania Government
Other (Non-Government)
Pennsylvania Corporation
Partnership-General
Partnership-Limited
School District
Sole Proprietorship
State Agency

Preparer of Notice of Intent to Remediate

Name Jim Oppenheim, PE Title Vice President
Phone Number (302) 477-0192 Email Address JROPPENHEIM@evergreenresmgt.com
Company Name Evergreen Resources Management eFACTS Client ID

Operations

Address (street, city, state, zip) 2 Righter Parkway, Suite 200, Wilmington, DE 19803



REFERENCE: USGS 7.5 MINUTE QUADRANGLE; PHILADELPHIA, PA.-NJ, QUADRANGLE, 1995

Stantec Consulting Services Inc.
1060 Andrew Drive, Suite 140
West Chester, Pennsylvania 19380
Tel. 610-840-2500
Fax. 610-840-2501
www.stantec.com

DRAWN BY: GWC
CHECKED BY: JKD
APPROVED BY: JLM
DATE: 11/11/2014

Prepared For:

EVERGREEN RESOURCES
MANAGEMENT OPERATIONS
PHILADELPHIA REFINERY COMPLEX
3144 PASSYUNK AVENUE
PHILADELPHIA, PA. 19145

Figure Title:

Philadelphia Refinery Complex
Site Location Map

Figure No.:

1

Evergreen Resources Management
2 Righter Parkway, Suite 200
Wilmington, DE 19803

November 17, 2014

Leigh Anne Rainford, MPH
Sanitarian Supervisor
Philadelphia Department of Public Health
Environmental Engineering Section
321 University Avenue
Philadelphia, PA 19104

RE: Philadelphia Energy Solutions Refining & Marketing LLC (PES) Philadelphia Refinery Complex
3144 West Passyunk Avenue Philadelphia, Philadelphia County

Dear Ms. Rainford:

The Land Recycling and Environmental Remediation Standards Act (Act 2) requires that a Notice of Intent to Remediate (NIR) a site be provided to the municipality in which the site is located. This notification is to inform the City of Philadelphia of the submission of an update to the original October 12, 2006 NIR. The purpose of the revised NIR is to update the facility owner and remediator information. On September 8, 2012, Sunoco Inc., (R&M) (Sunoco) conveyed the Philadelphia Refinery to Philadelphia Energy Solutions Refining & Marketing LLC (PES). As part of the transaction, Sunoco retained responsibility for remediation activities for environmental conditions existing at the time of the transfer. Effective December 30, 2013, "Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC" (Evergreen) assumed Sunoco legacy remediation liabilities with respect to the Philadelphia Refinery Complex. A copy of the revised NIR is enclosed for your reference.

Please call me at (302) 477-0192 if you have any questions concerning the proposed remediation.

Best Regards,

James Oppenheim, PE
Vice President

cc: Evergreen File
C. David Brown, PADEP
Charles Barksdale, Philadelphia Energy Solutions Refining and Marketing, LLC
Jennifer Menges, Stantec Consulting Services Inc.

Stantec

July 27, 2016

Attention: Leigh Anne Rainsford, MPH
Sanitarian Supervisor
Philadelphia Department of Public Health
Environmental Engineering Section
321 University Avenue
Philadelphia, PA 19104

Reference: Remedial Investigation Report, Area of Interest 1
Philadelphia Energy Solutions Refining & Marketing LLC (PES) Philadelphia Refinery Complex, 3144 West Passyunk Avenue, Philadelphia, Philadelphia County, PA

Dear Ms. Rainsford,

Notice is hereby given that Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC (remediator) is in the process of submitting a Remedial Investigation Report to the Pennsylvania Department of Environmental Protection for Area of Interest 1 located within the Philadelphia Energy Solutions Refining and Marketing LLC (PES) facility, City of Philadelphia, Philadelphia County, Pennsylvania. The report is being submitted in accordance with the site-specific remediation standards.

This notice is made under the provision of the Land Recycling and Environmental Standards Act, the Act of May 19, 1995, P.L. #4, No. 2.

Regards,

STANTEC CONSULTING SERVICES INC.

DeBoer

Jenny DeBoer
Geologist
Phone: (610)-840-2545
Fax: (610)-840-2501
jenny.deboer@stantec.com

cc. Jim Oppenheim, Evergreen
Tiffani Doerr, Evergreen
Charles Barksdale, PES
Jennifer Menges, Stantec

SENDER: *COMPLETE THIS SECTION*

- ■ Complete items 1, 2, and 3.
- ■ Print your name and address on the reverse so that we can return the card to you.
- ■ Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Leigh Anne Rainsford, MPH
Sanitarian Supervisor
Philadelphia Department of Public Health
Environmental Engineering Section
321 University Avenue
Philadelphia, PA 19104

9590 9403 0969 5223 1603 10

2. Article Number *(Transfer from service label)*

7012 1010 0002 5103 5224

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)*

C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

19104 KEY DESK MOT
JUL 29 2016
USPS

3. Service Type
- ☐ Adult Signature
- ☐ Adult Signature Restricted Delivery
- ☒ Certified Mail®
- ☐ Certified Mail Restricted Delivery
- ☐ Collect on Delivery
- ☐ Collect on Delivery Restricted Delivery
- ☐ Insured Mail
- ☐ Insured Mail Restricted Delivery (over $500)
- ☐ Priority Mail Express®
- ☐ Registered Mail™
- ☐ Registered Mail Restricted Delivery
- ☒ Return Receipt for Merchandise
- ☐ Signature Confirmation™
- ☐ Signature Confirmation Restricted Delivery

PS Form 3811, July 2015 PSN 7530-02-000-9053

Domestic Return Receipt

Stantec

July 27, 2016

Via electronic mail: ads@phillynews.com

Attention: Mary Anne Logan
Legal Advertising Department – Daily News
P.O. Box 8263 – 4th Floor
Philadelphia, PA 19101

Reference: Remedial Investigation Report, Area of Interest 1
Philadelphia Energy Solutions Refining & Marketing LLC (PES) Philadelphia Refinery Complex
3144 West Passyunk Avenue, Philadelphia, Philadelphia County, PA

Dear Ms. Logan,

On behalf of Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC (Evergreen), Stantec Consulting Services Inc. requests that the following Public Notice be published in the Philadelphia Daily News under the legal notices section.

Notification of Submittal of a Remedial Investigation Report
Notice is hereby given that Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC (remediator) is in the process of submitting a Remedial Investigation Report to the Pennsylvania Department of Environmental Protection, Southeast Regional Office for Area of Interest 1 located at the Philadelphia Energy Solutions Refining and Marketing LLC (PES) facility, Philadelphia, Philadelphia County, PA. The report is being submitted in accordance with the site-specific remediation standards. This notice is made under the provision of the Land Recycling and Environmental Remediation Standards Act, the Act of May 19, 1995, P.L. #4, No. 2.

Please publish the notice as soon as possible and email the proof of publication to me at jenny.deboer@stantec.com. Please also mail the hard copy of the proof of publication to my attention at the following address:

Stantec Consulting Services Inc.
Attn: Jenny DeBoer
1060 Andrew Drive, Suite 140
West Chester, PA 19380

Reference: Remedial Investigation Report, Area of Interest 1
Philadelphia Energy Solutions Refining & Marketing LLC (PES) Philadelphia Refinery Complex

Should you have any questions or comments regarding the request, please contact me at (610) 840-2545.

Regards,

STANTEC CONSULTING SERVICES INC.

DeBoer

Jenny DeBoer
Geologist
Phone: (610)-840-2545
Fax: (610)-840-2501
jenny.deboer@stantec.com

cc. Jim Oppenheim, Evergreen
Tiffani Doerr, Evergreen
Charles Barksdale, PES
Jennifer Menges, Stantec

Proof of Publication in The Philadelphia Daily News
Under Act. No 587, Approved May 16, 1929

STATE OF PENNSYLVANIA
COUNTY OF PHILADELPHIA

Cindy Jakubowski being duly sworn, deposes and says that **The Philadelphia Daily News** is a newspaper published daily, except Sunday, at Philadelphia, Pennsylvania, and was established in said city in 1925, since which date said newspaper has been regularly issued in said County, and that a copy of the printed notice of publication is attached hereto exactly as the same was printed and published in the regular editions and issues of the said newspaper on the following dates:

July 29, 2016

Affiant further deposes and says that she is an employee of the publisher of said newspaper and has been authorized to verify the foregoing statement and that she is not interested in the subject matter of the aforesaid notice of publication, and that all allegations in the foregoing statement as to time, place and character of publication are true.

Cindy Jakubowski

Sworn to and subscribed before me this 29th day of July, 2016.

Mary Anne Logan
Notary Public

My Commission Expires:

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
MARY ANNE LOGAN, Notary Public
City of Philadelphia, Phila. County
My Commission Expires March 30, 2017

Copy of Notice of Publication

Notification of Submittal of a Remedial Investigation Report

Notice is hereby given that Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC (remediator) is in the process of submitting a Remedial Investigation Report to the Pennsylvania Department of Environmental Protection, Southeast Regional Office for Area of Interest 1 located at the Philadelphia Energy Solutions Refining and Marketing LLC (PES) facility, Philadelphia, Philadelphia County, PA. The report is being submitted in accordance with the site-specific remediation standards. This notice is made under the provision of the Land Recycling and Environmental Remediation Standards Act, the Act of May 19, 1995, P.L. #4, No. 2.

APPENDIX B
QUALITY ASSURANCE/QUALITY CONTROL PLAN AND FIELD PROCEDURES MANUAL

Remedial Investigation Report
Area of Interest 1
Philadelphia Refinery Complex
Philadelphia, Pennsylvania
Philadelphia Refinery Operations,
a series of Evergreen Resources Group, LLC
3144 Passyunk Avenue, Philadelphia, Pennsylvania

Stantec

Quality Assurance/ Quality Control Plan and Field Procedures Manual

Sunoco Partners Marcus Hook Industrial Complex and Philadelphia
Energy Solutions (PES) Philadelphia Refinery Complex

Evergreen Resources Management Operations
May 20, 2016

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1.0 INTRODUCTION

This Quality Assurance/Quality Control Plan and Field Procedures Manual (QA/QC Plan) outlines the procedures developed to ensure the collection and analysis of quality data for investigations completed under the United States Environmental Protection Agency (USEPA) Resource Conservation and Recovery Act (RCRA), Pennsylvania Department of Environmental Protection (PADEP) Act 2, and Pennsylvania and Delaware's Tank programs at the Sunoco Partners Marketing and Terminals, LP (Sunoco Partners) Marcus Hook Industrial Complex (MHIC) and the Philadelphia Energy Solutions Refining and Marketing, LLC (PES) Philadelphia Refinery Complex (PRC) on behalf of Evergreen Resources Management Operations (Evergreen). This document shall be used in conjunction with the site-specific work plans developed for each site and Standard Operating Procedures (SOPs) for field work as incorporated as Appendix A of this QA/QC Plan.

The QA/QC Plan is a planning document that provides a "blueprint" for obtaining the type and quality of data needed to support environmental decision making. The QA/QC Plan integrates relevant technical and quality aspects of a project and documents quality assurance and quality control.

The selection criteria and evaluation specified in this document will be used for validating the data in accordance with the USEPA Guidance on Environmental Data Verification and Data Validation (USEPA 240-R-02-004), dated November 2002 (EPA QA/G-8), USEPA Contract Laboratory Program National Functional Guidelines (NFGs) for Superfund Organic Methods Data Review (USEPA 540-R-08-01), dated June 2008 (SOM02.2) and USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review (USEPA 540-R-10-011), dated January 2010 (ISM02.2). Qualifiers assigned to the data will be consistent with the data qualifiers specified in the NFGs and the USEPA Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (USEPA 540-R-08-01), collectively referred to herein as validation guidance.

2.0 QUALITY CONTROL REQUIREMENTS

The field and laboratory QC requirements for the characterization and remediation activities are discussed in the following subsections. Specific QC checks and acceptance criteria are provided in the referenced analytical methods.

2.1 Field Sampling Quality Control

The field QC requirements include analyzing reference standards for field instrument calibration and for routine calibration verifications. All initial and continuing calibration procedures will be implemented by trained personnel following the manufacturer's instructions to ensure the equipment is functioning within the specified tolerances. The calibration and maintenance history of the project-specific field instrumentation will be maintained in an active field logbook.

Field QC samples for this project include field duplicate samples to assess the overall precision of the sampling and analysis event, equipment rinse blanks to ensure proper cleaning of non-dedicated equipment is conducted between samples to avoid potential cross contamination (also generally referred to as field blanks), and trip blank samples to monitor cross contamination of water samples by volatile organic compounds (VOCs) during sample transport.

The frequency of collection of equipment rinse blanks will be one per sampling event. Field duplicate samples will only be prepared for groundwater samples, not for soil sampling events, at a collection frequency of 1 in 20 samples. One trip blank will be included for every shipment of samples to an analytical laboratory, at a minimum frequency of one trip blank per sample shipment which contains samples for VOCs analyses.

2.2 Analytical Quality Control

The laboratory QC requirements for the analyses may include evaluating chemical/thermal preservation, holding times, handling requirements, method blanks, instrument performance checks, initial calibration standards, calibration verification standards, internal standards, surrogate compound spikes, interference check samples, serial dilution samples, matrix spike/matrix spike duplicate (MS/MSD) samples, and laboratory control samples (LCS). The acceptance criteria for the above identified requirements will be generated by the laboratory and included in the laboratory reports, along with the other laboratory QC requirements.

3.0 DATA VERIFICATION, VALIDATION, AND USABILITY

All field and laboratory data will be reviewed, verified, and/or validated. These terms are defined as follows:

- Data review is the in-house examination to ensure that the data have been recorded, transmitted, and processed correctly.
- Data verification is the process for evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, and/or contractual requirements.
- Data validation is an analyte-specific and sample-specific process that extends the evaluation of data beyond method, procedure, or contractual compliance (i.e., data verification) to determine the quality of a specific data set relative to the end use.

Field data and logbooks will be reviewed to ensure that the requirements of the sampling program, including the number of samples and locations, sampling, and sample handling procedures, were fulfilled.

Data verification, validation, and usability assessments performed on a percentage of lab packages to ensure that the data are scientifically defensible, properly documented, of known quality, and meet the project objectives, are described in the following sections. Data determined to be unusable may require corrective action be taken. Data use limitations will be identified in the data validation and usability assessment (VUA) report, which will be generated as required for characterization or final reporting to the agencies.

3.1 Data Review, Verification, and Validation Requirements

Data review, verification, and validation of the analytical data will be performed by each consultant completing the field activities. The exception to this scenario will be Aquaterra Technologies, Inc. (Aquaterra), in which case Aquaterra will review/verify the data and the consultant company working with Aquaterra will subsequently validate the samples.

Field information will be reviewed to ensure that all field measurements were conducted in accordance with the requirements of the site-specific work plan and this QA/QC Plan including applicable SOPs. Field measurements obtained using procedures inconsistent with the requirements of these documents will be evaluated and may require that additional samples are collected or the use of the data be restricted.

Stage 1 Verification and Validation Checks

One hundred percent of the sample results will go through a Stage 1 verification and validation. As part of the data management process, each consultant will complete verification and validation based on the validation guidance. Data verification and validation will consist of the following items based on the guidance stated.

Stage 1 verification and validation of the laboratory analytical data package consists of checks for the compliance of sample receipt conditions, sample characteristics (e.g., percent moisture), and analytical results (with associated information). It is recommended that the following minimum baseline checks (as relevant) be performed on the laboratory analytical data package received for a Stage 1 validation label:

1. Documentation identifies the laboratory receiving and conducting analyses, and includes documentation for all samples submitted by the project or requester for analyses.
2. Requested analytical methods were performed and the analysis dates are present.
3. Requested target analyte results are reported along with the original laboratory data qualifiers and data qualifier definitions for each reported result.
4. Requested target analyte result units are reported.
5. Requested reporting limits for all samples are present and results at and below the requested (required) reporting limits are clearly identified (including sample detection limits if required).
6. Sampling dates (including times if needed), date and time of laboratory receipt of samples, and sample conditions upon receipt at the laboratory (including preservation, pH and temperature) are documented.
7. Sample results are evaluated by comparing sample conditions upon receipt at the laboratory (e.g., preservation checks) and sample characteristics (e.g., percent moisture) to the validation guidance.

Stage 2 Verification and Validation Checks

A minimum of 10 percent of the samples will be flagged for VUA. When a laboratory work order is selected, the entire work order will undergo Stage 2 validation. Laboratory work orders or sample delivery groups (SDGs) that are selected for VUA will undergo validation based on the NFGs.

The selection of samples that will undergo VUA process is designed to meet the needs of the site investigation, characterization, remediation, and closure programs, such as tank closures. Sampling that falls outside these programs will not undergo the VUA process. This includes samples that are collected for permit compliance, such as RCRA and effluent wastewater, as well as product samples, onsite soil reuse samples, and waste characterization samples.

Ten percent of samples will be selected based on the following additional conditions:

1. Sample package selected will contain a field duplicate sample.
2. Sample package selected will contain an equipment rinse blank.
3. Sample package selected will be representative of the contracted analytical laboratories, sample media, parameters, time, and project goals.

QC samples that are collected in the field will provide the best information for completing the VUA reports. The conditions for selection of samples are designed to provide the most useful information regarding sample analysis. Therefore, field duplicate samples have been identified as a priority condition. However, field duplicate samples will only be prepared for groundwater samples, not for soil sampling events. This is due to the known, inherent heterogeneity of soil at the sites. For program efficiency, entire SDGs will be selected for submission in the VUA process. Individual samples should not be selected and processed unless there is an overriding reason to do so, such as a point of compliance sample result that when compared to the historic data set appears to be anomalous.

Stage 2 data validation includes a review of the following QC data deliverables:

1. Technical holding times
2. Method blanks
3. Surrogate spikes
4. MS/MSD results
5. LCS results
6. Field duplicates

7. Trip and equipment rinse blank samples

Stage 2B Verification and Validation Checks

Stage 2B verification and validation will be completed on inorganic analytical data and will contain the following (in addition to Stage 1 verification):

1. Requested methods (handling, preparation, cleanup, and analytical) are performed.
2. Method dates (including dates, times and duration of analysis for radiation counting measurements and other methods, if needed) for handling (e.g., Toxicity Characteristic Leaching Procedure), preparation, cleanup and analysis are present, as appropriate.
3. Sample-related QC data and QC acceptance criteria (e.g., method blanks, surrogate recoveries, deuterated monitoring compounds (DMC) recoveries, laboratory control sample (LCS) recoveries, duplicate analyses, matrix spike and matrix spike duplicate recoveries, serial dilutions, post digestion spikes, standard reference materials) are provided and linked to the reported field samples (including the field quality control samples such as trip and equipment blanks).
4. Requested spike analytes or compounds (e.g., surrogate, DMCs, LCS spikes, post digestion spikes) have been added, as appropriate.
5. Sample holding times (from sampling date to preparation and preparation to analysis) are evaluated.
6. Frequency of QC samples is checked for appropriateness (e.g., one LCS per twenty samples in a preparation batch).
7. Sample results are evaluated by comparing holding times and sample-related QC data to the requirements in the data validation guidance.
8. Initial calibration data (e.g., initial calibration standards, initial calibration verification [ICV] standards, initial calibration blanks [ICBs]) are provided for all requested analytes and linked to field samples reported. For each initial calibration, the calibration type used is present along with the initial calibration equation used including any weighting factor(s) applied and the associated correlation coefficients, as appropriate. Recalculations of the standard concentrations using the initial calibration curve are present, along with their associated percent recoveries, as appropriate (e.g., if required by the project, method, or contract). For the ICV standard, the associated percent recovery (or percent difference, as appropriate) is present.
9. Appropriate number and concentration of initial calibration standards are present.

10. Continuing calibration data (e.g., continuing calibration verification [CCV] standards and continuing calibration blanks [CCBs]) are provided for all requested analytes and linked to field samples reported, as appropriate. For the CCV standard(s), the associated percent recoveries (or percent differences, as appropriate) are present.
11. Reported samples are bracketed by CCV standards and CCBs standards as appropriate.
12. Method specific instrument performance checks are present as appropriate (e.g., tunes for mass spectrometry methods, DDT/Endrin breakdown checks for pesticides and aroclors, instrument blanks and interference checks for ICP methods).
13. Frequency of instrument QC samples is checked for appropriateness (e.g., gas chromatography-mass spectroscopy [GC-MS] tunes have been run every 12 hours).
14. Sample results are evaluated by comparing instrument-related QC data to the requirements in the data validation guidance.

Stage 3 Verification and Validation Checks

Stage 3 verification and validation will be completed on organic analytical data and will contain the following (in addition to Stage 2B):

1. Instrument response data (e.g., GC peak areas, ICP corrected intensities) are reported for requested analytes, surrogates, internal standards, and DMCs for all requested field samples, matrix spikes, matrix spike duplicates, LCS, and method blanks as well as calibration data and instrument QC checks (e.g., tunes, DDT/Endrin breakdowns, interelement correction factors, and Florisil cartridge checks).
2. Reported target analyte instrument responses are associated with appropriate internal standard analyte(s) for each (or selected) analyte(s) (for methods using internal standard for calibration).
3. Fit and appropriateness of the initial calibration curve used or required (e.g., mean calibration factor, regression analysis [linear or non-linear, with or without weighting factors, with or without forcing]) is checked with recalculation of the initial calibration curve for each (or selected) analyte(s) from the instrument response.
4. Comparison of instrument response to the minimum response requirements for each (or selected) analyte(s).
5. Recalculation of each (or selected) opening and closing CCV (and CCB) response from the peak data reported for each (or selected) analyte(s) from the instrument response, as appropriate.

6. Compliance check of recalculated opening and/or closing CCV (and CCB) response to recalculated initial calibration response for each (or selected) analyte(s).
7. Recalculation of percent ratios for each (or selected) tune from the instrument response, as appropriate.
8. Compliance check of recalculated percent ratio for each (or selected) tune from the instrument response.
9. Recalculation of each (or selected) instrument performance check (e.g., DDT/Endrin breakdown for pesticide analysis, instrument blanks, interference checks) from the instrument response.
10. Recalculation and compliance check of retention time windows (for chromatographic methods) for each (or selected) analyte(s) from the laboratory reported retention times.
11. Recalculation of reported results for each reported (or selected) target analyte(s) from the instrument response.
12. Recalculation of each (or selected) reported spike recovery (surrogate recoveries, DMC recoveries, LCS recoveries, duplicate analyses, matrix spike and matrix spike duplicate recoveries, serial dilutions, post digestion spikes, standard reference materials etc.) from the instrument response.
13. Each (or selected) sample result(s) and spike recovery(ies) are evaluated by comparing the recalculated numbers to the laboratory reported numbers according to the requirements in the data validation guidance.

Stage 4 Verification and Validation Checks

Additional data validation may be completed for selected sites and/or sampling events, up to EPA Level 4 data review, which will require a laboratory data package inclusive of raw data. Stage 4 verification and validation includes all of the elements of the previous stages of validation and the following:

1. Evaluation of instrument performance checks (GC/MS)
2. Initial and continuing calibration checks (organic and inorganic analyses)
3. Review of internal standards (GC/MS)
4. Instrument blanks (inorganics)
5. Interference check samples (metals)
6. Recalculations of sample results and reporting limits

3.2 Validation Codes

Consultant specific validation codes will be added to the database. This will allow quick identification of the consultant that has performed the verification and/or VUA. Stantec may append additional codes for data management purposes to the codes provided in dt_result table approval_code field. Valid codes are as follows:

Langan:

- LAN1 – Historical data collected by Langan Level 1 Validation (Verification)
- LAN-VER – Langan performed verification
- LAN-USB – Langan performed usability

GHD:

- GHD-VER – GHD performed verification
- GHD-USB – GHD performed usability

Stantec:

- STN-VER – Stantec performed verification
- STN-USB – Stantec performed usability

This methodology creates a means for consultants to perform verification and usability on data collected by another consultant.

3.3 Data Updates in the Electronic Data Deliverables

All consultants will request EQuIS 4 file format Electronic Data Deliverables (EDDs) for data management from the analytical laboratories. In order to facilitate the data updates in the database, the following methodology will be used.

1. The consultant chemist / chemist team will open the .RES file for the EDD that has been selected to be validated for usability. The file can be opened using Excel, Access, Notepad, or similar tool. Although, it is a best practice to open the file in a way to preserve the textual nature of the EDD, it is not necessary.
2. The chemist will use the result_comment field in the .RES file to enter the qualifiers associated with the record and add a semicolon as a delimiter (;) followed by the reason code for the qualification.

3. The .RES file is to be saved with a .USB extension at the end of the file. This file is to be separate from the original .RES file provided and should not be used to over write the original .RES file that was sent with the EDD. This will result in the laboratory work order undergoing VUA having five files instead of four for the EDD. For example:
    - 1234.SMP
    - 1234.TST
    - 1234.BCH
    - 1234.RES
    - 1234.RES.USB
4. Stantec will use the fifth file to update the database with the appropriate qualifiers and codes in validator_qualifiers and approval_a through approval_d fields in dt_result table in the database.
5. Stantec will also change the validated y/n field in dt_result table in the database for the particular EDD.

3.4 Validation Qualifiers

The following qualifiers should be used during the validation/usability process. These are based on the NFGs, validation guidance, and commonly used qualifiers.

Data Qualifiers and Definitions

U	The analyte was analyzed for, but was not detected above the level of the reported sample quantitation limit.
J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
J+	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample, potentially biased high.
J-	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample, potentially biased low.
UJ	The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
NJ	The analyte has been "tentatively identified" or "presumptively identified" as present and the associated numerical value is the estimated concentration in the sample.

R	The data are unusable. The sample results are rejected due to serious deficiencies in meeting QC criteria. The analyte may or may not be present in the sample.
B	The analyte was detected in the method, field, and/or trip blank. This qualifier is not pursuant to the NFGs.

If additional qualifiers are required, please forward the suggestions to the Stantec Data Management Team and they will be added to the list of approved codes.

Submitting Data and Validation Codes for Inclusion in the Database

EDDs will be submitted to the database using the SharePoint portal intake forms. The appropriate qualifiers and codes that have been added to the result_comment field in the .RES.USB file will be included in the submission.

Reason Codes

Following is a list of reason codes available for validation. If additional codes are required, please forward the suggestions to the Stantec Data Management Team and they will be added to the list of approved codes.

Reason Code	Reason Description
General Use	
EC	Result exceeds the calibration range.
HT	Holding time requirement was not met
MB	Method blank or preparation blank contamination
LCS	Laboratory control sample evaluation criteria not met
FB	Field blank contamination
RB	Rinsate blank contamination
SQL	The analysis meets all qualitative identification criteria, but the measured concentration is less than the reporting limit.
FD	Field duplicate evaluation criteria not met
TvP	Total to Partial criteria not met
RL	Reporting limit exceeds decision criteria (for non-detects)
Inorganic Methods	
ICV	Initial calibration verification evaluation criteria not met
CCV	Continuing calibration verification evaluation criteria not met
CCB	Continuing calibration blank contamination
PB	Preparation Blank
ICS	Interference check sample evaluation criteria not met
D	Laboratory duplicate or spike duplicate precision evaluation criteria not met
MS	Matrix spike recovery outside acceptance range
PDS	Post-digestion spike recovery outside acceptance range
MSA	Method of standard additions correction coefficient _0.995
DL	Serial dilution results did not meet evaluation criteria
Organic Methods	
TUNE	Instrument performance (tuning) criteria not met
ICAL	Initial calibration evaluation criteria not met
CCAL	Continuing calibration evaluation criteria not met
SUR	Surrogate recovery outside acceptance range
MS/SD	Matrix spike/matrix spike duplicate precision criteria not met
MS	Matrix spike recovery outside acceptance range
IS	Internal standard evaluation criteria not met
LM	The PFK lock mass SICPs indicate that ion suppression evident
ID	Target compound identification criteria not met
Results Reported for Analytes Analyzed Multiple Times	
NSR	Not selected for reporting because the result was qualified as unusable
NSDL	Not selected for reporting because diluted resulted was selected for reporting
NSQ	Not selected for reporting because result was lesser quality based on data validation
NSO	Not selected for reporting because of other reason
Bias Codes	
H	Bias in sample result likely to be high
L	Bias in sample result likely to be low
I	Bias in sample result is indeterminate

3.4 Verification and Validation Summary

Verification of sample collection procedures will consist of reviewing sample collection documentation for compliance with the requirements of the site-specific work plan and this QA/QC Plan. If alternate sampling procedures were used, the acceptability of the procedure will be evaluated to determine the effect on the usability of the data. Data usability will not be affected if the procedure used is determined to be an acceptable alternative that fulfills the measurement performance criteria in this QA/QC Plan.

The results of the data verification and validation procedure will identify data that do not meet the measurement performance criteria of this QA/QC Plan. Data verification and validation will determine whether the data are acceptable, of limited usability (qualified as estimated), or rejected. Data qualified as estimated will be reviewed and a discussion of the usability of estimated data will be included in the VUA report.

Data determined to be unusable may require corrective action to be taken. Potential types of corrective action may include resampling by the field team or reanalysis of samples by the laboratory. The corrective actions taken are dependent upon the ability to mobilize the field team and whether or not the data are critical for project data quality objectives to be achieved. Data use limitations will be identified in VUA report, which will be generated as required for characterization or final reporting to the agencies. Each consultant will be responsible for their own VUA reports.

Revision History

Revision	Description	Prepared By	Date
1.0	Initial creation of document as SOP for VUA	Stantec (Gus Sukkurwala/Jennifer Menges/Andrew Bradley)	5/31/2015
2.0	Incorporation into QA/QC Plan	GHD (Colleen Costello)	3/21/2016
3.0	Inclusion of Field Procedures. Edits from Langan (Emily Strake & Kevin McKeever)	Stantec (Jennifer Menges)	5/13/2016

APPENDIX A
EVERGREEN FIELD PROCEDURES MANUAL

Evergreen
Field Procedures Manual

Sunoco Partners Marcus Hook Industrial Complex and Philadelphia Energy Solutions (PES) Philadelphia Refinery Complex

Evergreen Resources Management Operations

May 20, 2016

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1.0 INTRODUCTION

This Field Procedures Manual outlines the standard operating procedures developed to ensure the collection and analysis of quality data for investigations completed under the United States Environmental Protection Agency (USEPA) Resource Conservation and Recovery Act (RCRA) program, Pennsylvania Department of Environmental Protection (PADEP) Act 2 program and Pennsylvania and Delaware's Tank programs at the Sunoco Partners Marketing and Terminals, LP (Sunoco Partners) Marcus Hook Industrial Complex (MHIC) and the Philadelphia Energy Solutions Refining and Marketing, LLC (PES) Philadelphia Refinery Complex (PRC) on behalf of Evergreen Resources Management Operations (Evergreen). The MHIC and PRC are herein referred to as facility or site.

Evergreen’s consultants collect data in pursuit of site characterization and remediation that will meet the expectations of the appropriate regulatory agencies. This document shall be used in conjunction with the site-specific work plans developed for each site and the QA/QC Plan of which this manual was incorporated as Appendix A.

1.1 Training Qualifications

All field personnel involved in field work at MHIC and the PRC shall have completed and where applicable, be current with OSHA 40-hour HAZWOPER training, annual OSHA 8-hour HAZWOPER refresher, Process Safety Management (PSM) training, site-specific safety module training for current facility badges (including fire watch and hole watch, if required), TWIC Card, annual drug screening, and annual respirator fit testing. All field personnel new to the facility should be provided with onsite health and safety (H&S) orientation by an experienced member of the project team. The onsite orientation should include review of the facility’s emergency action plan and training on Evergreen and site-specific H&S requirements. Appropriately qualified personnel should perform field work, based on the work scope and experience level required by the task to be executed.

1.2 Health and Safety Requirements

All consultants performing work at the referenced sites on behalf of Evergreen shall comply with the *Evergreen Resources Management Operations Health and Safety Requirements* dated June 1, 2014. This includes contractors, sub-contractors, and third party companies performing work for Evergreen at MHIC and the PES PRC. Each consultant must also have their own site-specific health and safety plan (HASP) submitted to and approved by Evergreen prior to performing any work. A site-specific HASP must be reviewed and signed by all field personnel prior to commencement of field activities.

1.3 PPE Requirements

The minimum standard PPE at the facilities includes fire resistant clothing (FRC; coveralls may be Nomex or other FRC, 6 ounce minimum, orange in color) with the name of the company displayed on the back of the garment, hard hat, sturdy safety-toe boots, safety glasses, long-gauntlet leather gloves, and personal H_2S monitors. Nitrile gloves for chemical protection and hearing protection may also be required depending on the location and type of work. Workers are to be trained on these PPE requirements before being permitted onsite. An appropriate respirator may be required if site-specific air monitoring action levels are met, in accordance with the site-specific HASP. If a worker has a particular sensitivity or concern, a respirator may be worn regardless of OSHA action levels. During winter weather conditions, slip prevention footwear such as crampons or overshoes should be worn for traction. Task-specific PPE will be further identified in following sections.

1.4 Site Controls

Safety cones and/or caution tape should be used in high traffic areas. The "Buddy System" may also be employed in high traffic areas, in areas where other contractors are working, and in remote areas. Additional task-specific site controls will be detailed in following sections.

1.5 Equipment and Decontamination

Numerous practices are employed throughout the processes of site investigation and sampling to assure the integrity of the resulting data. The risk in use of non-dedicated equipment at multiple sampling locations lies in the potential for cross-contamination. While the threat of cross-contamination is always present, it can be minimized through the implementation of a consistent decontamination program during sensitive site measurement and data collection activities.

All site equipment to be used in multiple locations (non-dedicated) for sampling of soil, sediment, and/or groundwater will be decontaminated immediately prior to initial use and between uses at each location according to the following steps:

- Remove particulates with a sorbent pad or towel and/or initial rinse with clean potable tap water;
- Wash equipment with clean sponge, soft cloth, or scrub brush as necessary in a solution of tap water/laboratory grade detergent (Alconox®, Liquinox®, or equivalent);
- Rinse with tap water;
- Rinse with deionized or distilled water; and
- Air dry for as long as possible.

Rinse water generated during decontamination procedures will be treated onsite by passing the water through a bucket or tube filled with activated carbon prior to discharge to the ground surface. Additional decontamination procedures may be appropriate depending on the task, and will be identified in the following sections, as applicable.

1.6 Documentation

All site activities and conditions for characterization activities should be recorded by field personnel in a field computer (e.g., YUMA) using the EQuIS Data Gathering Engine (EDGE) application, or if necessary, a field book may be used. The entry shall include at a minimum, the date, time, weather conditions, location, personnel present onsite, field readings, sampling methodology, as well as additional comments or observations. Task specific observations which should also be recorded will be identified in the following applicable sections.

2.0 LIQUID LEVEL ACQUISITION (WELL GAUGING) PROCEDURES

2.1 Potential Hazards

Traffic, pinch points, chemical (airborne and physical contact), and biological are all likely hazards to be encountered as well as slip/trip/fall potential during onsite well gauging activities. Additional hazards may be mentioned in the site-specific HASP and/or the daily job safety analysis (JSA).

2.2 Materials and Equipment Necessary for Task Completion

Optical oil/water interface probe with a graduated measuring tape to 0.01 foot accuracy, decontamination supplies (laboratory-grade detergent, deionized or distilled water, appropriate containers, scrub brush, and sorbent pads or paper towels), socket set, flathead screwdriver (or pry bar or manhole cover lifter), clear bailers with string for confirmation of light non-aqueous phase liquids (LNAPL), if necessary, and air monitoring instruments (optional, based on previous site visits).

2.3 Methodology

This task involves the deployment of an optical oil/water interface probe with a graduated measuring tape to 0.01 foot accuracy into a well (in most cases), recording the measurement, and decontaminating the probe. The recorded field measurements may then be utilized for one of several applications including: well sampling, water table gradient mapping, LNAPL occurrence, LNAPL thickness, and/or gradient mapping, and various testing procedures. Wells should be gauged in order of least to most contaminated, based on existing sampling data or LNAPL occurrence, to minimize the potential for cross-contamination between wells. If LNAPL is detected in a well that does not typically have LNAPL, it should be confirmed with a clear bailer.

The proper procedure for liquid level acquisition is as follows:

1) Decontaminate the optical oil/water interface probe with a graduated measuring tape to 0.01 foot accuracy prior to initial deployment, and again after each well measurement to prevent cross-contamination between wells.

2) If warranted, mark off a work area surrounding the well(s) to be gauged with safety cones and/or caution tape in order to protect personnel from auto traffic; the "Buddy System" may also be employed.

3) Where applicable, lift the manhole cover off of the well head (a screwdriver, pry bar, or manhole cover lifter may be used to lift the cover depending on the size of the manhole) or open protective well casing (stickup) and remove the well plug, if present.

4) Most wells should contain a mark or notch in the top edge of the casing from which normalized readings are to be measured (reference point elevation). Slowly lower the optical oil/water interface probe with a graduated measuring tape to 0.01 foot accuracy into the well until the instrument signals contact with liquid. Note whether or not the instrument’s tone is indicative of the presence of free-phase LNAPL (commonly a solid tone), or water (commonly an oscillating or beeping tone). If LNAPL is present, record the depth at which LNAPL was first indicated to the nearest hundredth of a foot, as measured from the top of well casing mark/notch. Slowly lower the probe through the LNAPL until the instrument’s tone changes to indicate the presence of water. Record the depth at which water was first indicated to the nearest hundredth of a foot. A clear bailer may be used to verify the existence or approximate amount and appearance of LNAPL. If no LNAPL is apparent, record the depth to water.

5) Retract the probe from the well and secure the well appropriately.

6) Note the date and time of measurement for gauging and record all measurements and observations in the field computer or, if necessary, in a field book for subsequent electronic data entry.

7) Decontaminate the probe in accordance with the decontamination procedure outlined in Section 1.5.

8) Clean up the work area, remove gauging equipment, and remove any traffic control devices.

3.0 GROUNDWATER MONITORING PROCEDURES

3.1 Potential Hazards

Traffic, pinch points, chemical (airborne and physical contact), and biological are all likely hazards to be encountered as well as slip/trip/fall potential during onsite well gauging activities. Additional hazards may be mentioned in the site-specific HASP and/or the daily JSA.

3.2 Materials and Equipment Necessary for Task Completion

A list of equipment required to access, gauge, purge, and sample site monitoring wells is presented below. Also listed are materials necessary to store, label, preserve, and transport groundwater samples.

- Current site map detailing well locations;
- Field book and/or field computer for recording site data;
- Graduated, optical oil/water interface probe;
- Keys and tools to provide well access;
- Appropriate, laboratory prepared sample containers and labels;
- Appropriate well purging apparatus as determined by volume of groundwater to be purged and compounds to be analyzed;
- Water quality meter for monitoring indicator field parameters (DO, pH, specific conductance, redox potential, and turbidity if available);
- Dedicated polyethylene bottom-loading bailer or well pump and disposable tubing for groundwater sample collection;
- Clean nylon or polypropylene bailer cord;
- Disposable nitrile sampling gloves;
- Decontamination supplies;
- Calibrated five-gallon bucket and watch or stopwatch to determine discharge rate during purging;
- Blank chain-of-custody forms; and

- Cooler(s) and ice for sample preservation.

3.3 Methodology for Three Well Volume Sampling

Prior to site visitation for the groundwater sampling event, the following data will be reviewed to ensure proper preparation for field activities:

- Most recent liquid level data from all wells;
- Most recent analytical data from all wells to determine gauging and sampling sequence; and
- Well construction characteristics.

Each monitoring well to be sampled will be gauged to obtain liquid level data immediately prior to initiation of the sampling process (refer to well gauging procedures above). Liquid level data should be recorded in a field computer or if necessary, a field book. Should free-phase LNAPL be detected by the gauging process, routine groundwater sampling will not be conducted at that location. If groundwater sampling under LNAPL is warranted, refer to the sub-LNAPL sampling section and methodology in Section 3.6.

Groundwater sampling will be initiated by purging from the well a minimum of three well volumes, except in cases where the well is pumped dry, as referenced below. Well purging is performed to remove stagnant water and to draw representative water from the aquifer into the well for subsequent sampling and analysis. In extreme cases where a well is pumped dry and/or shows little recharge capacity, the well should be evacuated once prior to sampling. Wellbore storage volume should be estimated using as-built information stored in the field computer or as indicated on the well log, and the depth to water measurement obtained immediately prior to sampling.

Water quality should be monitored and readings recorded in the field computer or field book while purging, typically through use of a multi-parameter water quality meter with a flow through cell or cord for down-well measurements. Water quality readings should be recorded a minimum of three times (pre-purge, during purge, and post-purge/sample collection) or four times (pre-purge and following each well volume). The parameters to be monitored and recorded are dissolved oxygen, pH, specific conductance, redox potential, temperature, and turbidity if available.

Well purging can be performed with various equipment including: a dedicated bailer for hand bailing low volumes of water; a surface mounted electric centrifugal pump with dedicated polyethylene tubing; and/or submersible pump (particularly when the depth to water is greater than 20 feet) with dedicated polyethylene tubing. During pumping, the intake will be placed directly below the static water surface and slowly lowered during the purging process. This procedure may not be necessary in low-yielding wells but is important in high-yielding, permeable strata where an intake initially placed deep in a well may draw laterally and have little influence in exchanging water from shallower depths within the well bore.

Flow rate during well purging will be approximated by the bucket and stop watch method. The duration of pumping required to remove three well volumes will be calculated directly from this flow rate. All fluids removed during purging will be treated onsite with activated carbon or in accordance with an approved work plan.

The sequence of obtaining groundwater samples will be based upon available historical site data for existing wells and photoionization detector (PID) readings for newly installed wells. Monitoring wells will be sampled in order of those having the lowest to highest concentration of constituents of concern (or PID readings for new wells), based upon the most recent available set of laboratory analyses, to reduce the potential for cross-contamination. For general monitoring events, groundwater samples will not be obtained for analysis from any well containing measurable free product. If groundwater sampling under LNAPL is warranted, refer to the sub-LNAPL sampling section and methodology in Section 3.6.

The following sequence of procedures will be implemented for the collection of groundwater samples from monitoring wells.

1) Establish a clean work area where sampling equipment will not come in contact with the ground or any potentially contaminated surfaces.
2) Use a dedicated polyethylene sampling bailer for each well.
3) Use a clean pair of nitrile gloves.

4) Attach an appropriate length of unused, clean nylon or polypropylene cord to the designated sampling bailer.
5) Select appropriate laboratory-provided sample containers.
6) Slowly lower sampling bailer into well until water surface is encountered; continue to lower the sampling bailer into the standing water column to one foot below the water surface.
7) Retrieve bailer at a steady rate to avoid excess agitation.
8) Visually inspect bailed sample to ensure that no free product or organic detritus has been collected.
9) Uncap first designated sample vial and fill from bailer as rapidly as possible but minimizing agitation; secure septum and lid.
10) Inspect sealed sample for entrapped air; if air is present, remove the lid and gently top off sample in vial, seal and inspect. Repeat until no air is apparent.
11) Repeat Steps 9 and 10 for the remaining sample vials based on the laboratory and/or regulatory protocol.
12) Complete and attach labels to sample containers noting sample collector, date, time, and location of sample; record same data in field computer or field book.
13) Place samples in ice-filled cooler in such a manner as to avoid breakage. Samples will be maintained at a temperature of approximately 4°C.
14) Dispose of gloves, bailer, and bailer cord as solid waste and move to next sample location.

3.4 Methodology for Low-Flow Purging and Sampling

For wells that will be purged and sampled via low-flow methodology, the USEPA Region III Bulletin QAD023: *Procedure for Low-Flow Purging and Sampling of Groundwater Monitoring Wells* will be followed. The following data will be reviewed for each well in order to set the pump intake for the low-flow sampling:

- Soil boring lithologic log;
- Well construction log showing the screened interval;
- Identification of the most permeable zone screened by the well;
- Approximate depth to static water;

- Proposed pump intake setting; and
- Technical rationale for the pump intake setting, preferably across from the most impacted/contaminated subsurface interval.

Adjustable rate, submersible, bladder pumps in conjunction with polyethylene tubing for purging and sampling will be used. An alternate set up could include a stainless steel submersible pump, such as a Hurricane® pump or a Monsoon® pump with dedicated polyethylene tubing. The tubing diameter will be between 3/16-inch and ½-inch inner diameter and the length of the tubing extended outside of the well should be minimized. Flow-through cells will be used to monitor groundwater quality parameters during sampling. Monitoring well information, equipment specifications, water level measurements, parameter readings, and other pertinent information will be recorded during well purging and sampling.

The following sequence of procedures will be implemented for the collection of groundwater samples from monitoring wells by the low-flow methodology.

1) PID Screening of Well: A PID measurement may be collected at the rim of the well immediately after the well cap is removed and recorded in the field computer or field book, if historic data is not available.

2) Depth to Water Measurement: A depth to water measurement will be collected and recorded. To avoid disturbing accumulated sediment and to prevent the inadvertent mixing of stagnant water, measuring the total depth of the well should be done at the completion of sampling.

3) Low Stress Purging Startup: Water pumping will commence at a rate of 100 to 400 milliliters per minute (mL/min). This pumping should cause very little drawdown in the well (less than 0.2-0.3 feet) and the water level should stabilize. Water level measurements are made frequently, and flow rate will be recorded in mL/min on the sampling form or field computer.

4) Low Stress Purging and Sampling: The water level and pumping rate will be monitored and recorded every five minutes during purging, and any pumping rate adjustments will be recorded. During the early phase of purging, emphasis will be placed on minimizing and stabilizing pumping stress, and recording any necessary adjustments. Adjustments, when necessary, will be made in the first 15 minutes of purging. If necessary, pumping rates will

be reduced to the minimum capabilities of the pump to avoid well dewatering. If the minimal drawdown exceeds 0.3 feet, but the water level stabilizes above the pump intake setting, purging will continue until indicator field parameters stabilize, as detailed in Step 5 below. If the water level drops below the pump intake setting at the absolute minimum purge rate, the pump will remain in place and the water level will be allowed to recover repeatedly until there will be sufficient water volume in the well to permit the collection of samples.

5) Indicator Field Parameter Monitoring: During well purging, indicator field parameters (DO, pH, specific conductance, redox potential, and turbidity if available) will be monitored every five minutes (or less frequently, if appropriate). Purging will be considered complete and sampling can commence when all the indicator field parameters have stabilized. Stabilization will be achieved when three consecutive readings, taken at five minute intervals (or less frequently, if appropriate), are within the following limits:
    - DO (±10 percent);
    - turbidity (±10 percent);
    - specific conductance (±3 percent);
    - pH (± 0.1 unit); and
    - redox potential ([Eh] ±10 mv).

   Temperature and depth to water will be also monitored during purging. Should any of the parameter-specific components of the water quality meter fail during monitoring, the sampling team will attempt to locate a replacement multi-meter or individual criteria meter. If none are available, the sampling team will continue recording the parameters that are operational, and proceed with the sampling. Any other field observations relating to sample quality, such as odor, foaming, effervescence, and sheens, will also be recorded in the field computer or on the sampling form.

6) Collection of Ground Water Samples: Water samples for laboratory analyses will be collected prior to the flow-through cell by either using a bypass assembly or by temporarily disconnecting the flow-through cell. All sample containers will be filled by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. During purging and sampling, the tubing should remain filled with water in order to minimize possible changes in water chemistry upon contact with the atmosphere. Methods employed to ensure that the outlet tubing will be filled include adjusting the tubing angle upward to

completely fill the tubing and restricting the diameter of the tubing near the outlet of the tubing.

The order in which samples will be collected is as follows:

- Volatile organics;
- Gas sensitive (e.g., Fe^{+2}, CH_4, H_2S/HS);
- Base neutrals or PAHs;
- Total petroleum hydrocarbons;
- Total metals;
- Dissolved metals;
- Cyanide;
- Sulfate and chloride;
- Nitrate and ammonia;
- Preserved inorganic;
- Non-preserved inorganic; and
- Bacteria.

After the appropriate laboratory-provided glassware is filled and labeled, the samples shall be placed in an ice-filled cooler and maintained at approximate 4°C for submittal to the laboratory. Upon completion of sampling at the well, decontaminate non-dedicated equipment in accordance with the decontamination procedure outlined in Section 1.5, and dispose of all dedicated equipment (gloves, tubing, etc.) as solid waste before moving to the next location.

3.5 Methodology for Passive (No-Purge) Sampling for Groundwater Collection

There are many passive groundwater sampling devices that allow for accurate sample collection without purging. Each device has specific uses and conditions for which they are more applicable. This methodology presents details for the use of HydraSleeve samplers.

The HydraSleeve is a disposable, single use device for the collection of representative groundwater samples for laboratory analysis of physical and chemical parameters.

HydraSleeves are placed within the screened interval (or other defined interval) of the well and activated after an equilibrium period. When used according to the manufacturer's instruction, the HydraSleeve will collect a groundwater sample without purging, thus causing no drawdown, agitation, or water column mixing. The HydraSleeve collects a sample from the screened interval only, and excludes water (or other fluids) from other parts of the well by use of check valve that seals when the sampler is full. The HydraSleeve takes advantage of the continuous natural movement of groundwater, which produces an equilibrium condition between the water in a well screen and the adjacent formation. HydraSleeves produce reliable data from low yield wells where other sample methods cannot due to well screen dewatering and associated alteration in water chemistry.

The HydraSleeve consists of the following components:

1) A long (usually 3 to 5 feet), flexible, lay-flat polyethylene sample sleeve, which is sealed at the bottom, and is equipped with a reed valve at the top allowing water to enter the HydraSleeve only during active sample retrieval.
2) A reusable, stainless steel weight attached with a clip to the bottom of the sleeve. The weight is used to carry the sample sleeve down the well to the specified depth (usually the bottom of the well screen). An optional top weight is also available to compress the sleeve in wells with short well screens.
3) A tether line attached to a spring clip at the top of the sample sleeve to deploy the device within the well and later retrieve it for sample collection.
4) A discharge tube is supplied with the device, which is used to puncture the wall of the sleeve after it is recovered to allow direct filling of sample bottles.

Deployment

Upon retrieval, the HydraSleeve is designed to effectively collect a "core" of water from within the well screen, which is equivalent in length and diameter to the sample sleeve. The upward motion opens the valve at the top, which then allows the device to fill with water. The Hydrasleeve should be installed with the top of the sample sleeve as close to the desired sample interval as possible. This will allow the sampler to fill and the check valve to close before the top of the device is pulled past the top of the sample interval.

To assemble and deploy the HydraSleeve:

1) Remove the Hydrasleeve from its package and hold it by the top, pinching the top at the holes.
2) Attach the spring clip and tether in the holes.
3) Slide the clip and bottom weight assembly into the holes at the bottom of the sleeve.
4) Lower the Hydrasleeve by the tether to the bottom or to the specified depth and secure the tether at the wellhead (Note: do not pull the HydraSleeve upward at any time during deployment, as this could cause the check valve to open and water to fill the sleeve inadvertently).

Sample Collection

Although the HydraSleeve only displaces approximately 100 milliliters (ml) of water during deployment, the well should be allowed to stabilize prior to sample collection so that natural flow conditions and contaminant distribution can return to equilibrium conditions. In certain jurisdictions, regulatory directives may prescribe a minimum equilibration period. When used for periodic monitoring programs, such as quarterly or semi-annual sampling, the HydraSleeve can be installed and remain in the well until the next sampling event, thus providing ample time for the well to equilibrate.

To collect a sample:

1) Be sure the tether is secured to the top of the well.
2) In one smooth motion, pull the tether upward at a rate of approximately 1 foot per second. The weight of the sampler will be felt when the valve closes. Continue pulling upward until the HydraSleeve is clear of the well.
3) Discard the water trapped at the top of the HydraSleeve above the reed valve.
4) Hold the HydraSleeve at the reed valve, and puncture the sleeve with the discharge tube just below the reed valve.
5) Decant the water into sample containers.
6) Discard the HydraSleeve as solid waste and process the excess water through activated carbon prior to discharge to the ground surface.

The weight and clips should be decontaminated prior to deploying a replacement HydraSleeve in the well. Tethers can be dedicated to individual wells or decontaminated and reused.

3.6 Methodology for Sub-LNAPL Sampling

The following section describes the methodology used for obtaining groundwater samples from the water column beneath LNAPL. Wells for sub-LNAPL sampling are not purged of three well volumes prior to sampling. This will prevent the potential of drawing LNAPL into the sample and to be representative of steady-state groundwater conditions beneath the LNAPL.

The following data will be reviewed for each well in order determine the appropriate equipment necessary:

- Well construction log showing diameter and total depth of the well;
- Approximate depth to LNAPL; and
- Approximate depth to static water.

A list of equipment for sub-LNAPL sampling is presented below:

- Field book or field computer for recording site data;
- Optical oil/water interface probe with a graduated measuring tape to 0.01 foot accuracy;
- Keys and tools to provide well access;
- Peristaltic pump;
- Polyethylene tubing specifications of 0.25-inch outer diameter x 0.17-inch inner diameter is preferable as this small diameter assists in achieving lower flow rates;
- Silicone tubing of appropriate diameter to operate peristaltic pump;
- Polyvinyl chloride (PVC) drop tube (1.5-inch or other appropriate diameter);
- PVC rod (0.5-inch or other appropriate diameter);
- PVC end cap for drop tube;
- Tether for end cap;
- Clamps for securing drop tube to well casing;
- Appropriate sample containers and labels;

- Decontamination supplies;
- Blank chain-of-custody forms; and
- Cooler and ice for sample preservation.

The following sequence of procedures will be implemented for the collection of sub-LNAPL groundwater samples.

1) Determine LNAPL Thickness: Use an optical oil/water interface probe with a graduated measuring tape to 0.01 foot accuracy to collect depth to LNAPL and depth to water measurements.
2) Installing Sampling Equipment: Deploy a 1.5-inch (or other appropriate diameter) PVC pipe (drop tube), with an attached end cap, through the LNAPL layer in the well. The end cap should be tethered to the drop tube so it is not lost in the well when removed and in a way that allows the drop tube to be sealed during installation. Lower the drop tube until the bottom of the tube is approximately two feet into the water column below the bottom of the LNAPL. Secure the drop tube to the well, and allow the system to equilibrate, approximately one half hour. The end cap is then removed by inserting a 0.5-inch (or other appropriate diameter) PVC rod into the drop tube and pushing on the cap until the lid is removed. The cap will be removed along with the tube upon completion of sampling.
3) Collection of Groundwater Samples: Lower polyethylene tubing through the 1.5-inch drop tube into the water column. Connect the polyethylene tubing to silicon tubing and engage the peristaltic pump for groundwater retrieval. Set the flow rate to the lowest pumping rate that can be sustained so that the LNAPL is not drawn into the tubing. Begin collecting groundwater in the sample container and continue until enough volume is obtained for all bottleware required by the laboratory for the requested analyses.

3.7 Decontamination Requirements

Of particular significance to the procedures of groundwater measurement and sampling is the limitation, whenever possible, of materials inserted into a well bore and, even more importantly, of materials transferred from well to well.

Many items can be discarded between well sampling and/or gauging locations without significantly impacting project costs. Dedicated sampling equipment which can be discarded between well sampling locations, will be used whenever possible to preclude decontamination requirements. Sampling equipment included in this category are polyethylene bailers, bailer cord, nitrile gloves, and sampling tubing. However, other monitoring and sampling equipment, such as oil/water interface probes and submersible sampling pumps, must be reused from well to well.

All site equipment to be used in multiple locations (non-dedicated) for gauging and/or sampling of groundwater will be decontaminated immediately prior to initial use and between uses at each location according to the following steps:

- Remove particulates with a sorbent pad or towel and/or initial rinse with clean potable tap water;
- Wash equipment with clean sponge, soft cloth, or scrub brush as necessary in a solution of tap water/laboratory grade detergent (Alconox®, Liquinox®, or equivalent);
- Rinse with tap water;
- Rinse with deionized or distilled water; and
- Air dry for as long as possible.

Rinse water generated during decontamination procedures will be treated onsite by passing the water through a bucket filled with activated carbon prior to disposal.

3.8 Documentation

All site activities and conditions at the time of purging and groundwater sampling should be recorded by field personnel in a field computer via the EDGE application or, if necessary, a field book may be used. The entry shall include the date, time, weather conditions, location (well name), personnel present onsite, PID readings, sampling methodology, purge rate, purge volume, and the aforementioned groundwater indicator parameters. A field qualifier “SL” shall be applied to each sub-LNAPL sample entry to denote sample collection as sub-LNAPL. Additional comments or observations (e.g., well damage, nearby pumping, LNAPL sheen) should also be recorded.

4.0 SOIL SAMPLING & WELL INSTALLATION PROCEDURES

4.1 Site Controls

Prior to hand augering, hydroexcavation, utilizing a backhoe, or deploying any drilling apparatus to the site, an underground utility line protection request must be made (i.e., Pennsylvania One Call) for mark-out of known subsurface utilities and associated laterals proximal to the drilling location. Site plans, if available, should be reviewed to document and avoid the location of onsite utilities.

After review of all known mapped and marked utilities, a site reconnaissance will be performed to document the location of utility meters and storm sewer drains. In addition, the location of overhead utilities must be documented. After completing the subsurface and overhead utility review, the area to drill may be considered clear of utilities, or the location may be adjusted to a nearby location, which must also be cleared.

Lastly, any drilling activities must be preceeded by clearing of the borehole, prior to advancement of augers or split spoons. To ensure the safety of workers, the borehole will be cleared by hand, hydroexcavator, or backhoe to a depth of approximately 8 feet below ground surface.

4.2 Potential Hazards

Traffic, pinch points, chemical (airborne and physical contact), and biological are all likely hazards to be encountered during soil sampling and well installation, as well as slip/trip/fall potential. Drilling is considered a high risk activity which requires facility approval prior to implementation. Additional hazards are identified in the site-specific HASP and/or the daily JSA.

4.3 Materials and Equipment Necessary for Task Completion

A list of equipment required to oversee test boring advancement and, where applicable, sample soil is presented below. Also listed are materials necessary to store, label, preserve, and transport soil samples.

- Current site map detailing well locations;
- Field computer and/or field book for recording site data;

- Appropriate, laboratory prepared sample containers and labels;
- PID;
- Single-use, disposable plastic scoops or stainless steel scoop for collecting soil samples;
- Single-use, disposable, laboratory-supplied syringes for soil sample collection (if applicable);
- Scale for weighing samples (e.g., methanol kits, if necessary);
- Disposable nitrile sampling gloves;
- Measuring tape (for measuring core recovery);
- Munsell soil color chart/book (recommended);
- Decontamination equipment (if applicable);
- Blank chain-of-custody forms; and
- Cooler(s) and ice for sample preservation.

4.4 Decontamination Requirements

All down-hole drilling equipment must be steam cleaned prior to drilling at each soil boring or well location. All soil sampling equipment must be cleaned with detergent and rinsed with deionized or distilled water prior to deployment into the borehole. All well construction materials (i.e. PVC well casing, PVC well screen, sand pack, bentonite) should be clean and dedicated to each borehole.

4.5 Methodology for Soil Boring Installation

4.5.1. Borehole Advancement

During test drilling activities, a borehole is advanced into the subsurface via a rotary or direct-push drilling technique. Various types of drilling methods could be deployed at these facilities to advance the borehole and gain access to the subsurface for characterization and sampling. A description of the most commonly utilized drilling methods is included below:

4.5.1.1 Hollow Stem Auger

A hollow, steel pipe (available diameters vary) with welded, exterior steel “flights” is used to convey subsurface material to the surface when rotated clockwise. A bit at the bottom of the lead auger cuts into the subsurface material, and the rotation conveys the loosened material (cuttings) up the flights, allowing the hole to be advanced (cuttings may not always return to the surface, such as when drilling in soft, saturated materials). The hollow center of the auger allows the driller to access the subsurface for soil sample collection and, where applicable, well installation during borehole advancement. During borehole advancement, a center stem of steel rods connected to an auger plug prevent soil cuttings from entering the drill column. Once a desired drilling depth is reached, the center plug and rods can be pulled out, leaving the auger stem in place to prevent borehole collapse. A split-spoon sampler can be threaded onto the rods in place of the plug and driven via a hammer to obtain a sample (Standard Penetration Test), or if terminal depth has been reached a monitoring well could be installed through the augers.

4.5.1.2 Air and Mud Rotary

Rotary drilling methods are similar to hollow stem auger drilling, however specialized drilling bits at the bottom of rods are used to cut into the subsurface material using compressed air, vibration, and/or pressurized drilling mud. Compressed air or mud is forced through the drilling rods via an air compressor or pump, and escapes through small holes in the drill bit. The circulation of drilling mud, or air combined with introduced water or formation water, conveys the soil cuttings to the surface (while also cooling the drilling bit and preventing borehole collapse).

4.5.1.3 Geoprobe®

A direct-push drilling method, Geoprobe® sampling utilizes a hydraulic hammer to drive steel rods into the subsurface for soil sampling. This method advances a core barrel lined with a plastic Macro-Core® sleeve into the soil column for continuous soil core collection.

4.5.1.4 Hand Auger

A stainless steel or aluminum hand auger is physically advanced to a desired soil sampling depth through rotation of the auger and head.

4.5.2 Soil Sampling

Soil samples will be obtained for lithologic logging and where appropriate, for laboratory analysis with one of three different sampling devices: Split barrel spoon sampler, hand auger, or Geoprobe® soil sampler. For either method, the sampling devices are lowered through the hollow-stem augers or open borehole to allow sampling of undisturbed sediments below the bit or drive shoe. Soil samples will be collected at regular intervals for subsurface characterization and selection of appropriate well screen interval(s). Soils which appear to be visually impacted or from intervals which exhibit the highest deflections on the screening device (PID or similar) will be sampled for laboratory analysis in accordance with an approved sampling plan.

4.5.2.1. Split barrel spoon sampler (split spoon)

The split spoon sampler will be driven into the soil column in accordance with ASTM Standard Method D1586 (Reference A6, Appendix E). Soil sampling by split spoon is characterized by drilling a borehole with a hollow-stem auger to the desired sampling depth (the standard calls for one sample per five foot depth interval). The split spoon sampler is attached to the drilling rods after removal of the auger plug. The drill operator will drive the sampler into the undisturbed soil by repeatedly striking the drilling rods with a 140 pound safety hammer over a 30 inch drop. Field personnel will record the number of blows required to drive the split spoon sampler for each successive six-inch interval. After the sampler has been filled, the driller will remove the rods and sampler from the borehole and should provide the intact sampler to field personnel for opening (the drive shoe and head can be loosened). Field personnel should split the spoon, scan with PID, measure sample recovery, thoroughly describe the soil lithology, note visual observations and odors, note degree of saturation, and where applicable collect soil sample(s) utilizing a stainless steel or disposable scoop. An approved, retractable knife may be used to trim the top and edges of the sample, and once prepared the sample should be containerized in appropriate sample containers.

4.5.2.2. Geoprobe®

The Geoprobe® operator will advance the drilling rods into the subsurface using a truck or track-mounted drill with a hydraulic hammer. A dedicated Geoprobe® Macro-Core® liner is inserted into the core barrel to collect continuous core samples, usually one per 4 foot interval. The Geoprobe® operator will remove the soil filled liner from the core barrel, cut the liner, and provide field personnel with the intact cores. After retrieval of the sample, the liner may be removed by field personnel and the soil core should be scanned with a PID and logged, including documentation of core recovery, soil lithology, visual observations and odors, and degree of saturation. Where applicable, field staff should remove the soil sample utilizing a stainless steel or disposable scoop and containerize in an appropriate sample container.

4.5.2.3. Hand Auger

The self-powered hand auger allows for soil from the desired interval to be collected directly through removal of the soil sample that is collected in the auger head for every six inches of advancement.

4.6 Methodology for Leaded Tank Bottoms Soil Sampling

Leaded tank bottom material is described as containing materials distinguished by distinctive rust/red to black, metallic, mostly oxidized scale materials, sometimes in a matrix of petroleum wax sludge. The approach for identifying leaded tank bottom materials is summarized below:

- If materials are encountered within the previously designated leaded tank bottom areas, matching the physical description given above for leaded tank bottoms, then samples should be collected for lead analysis.
- If total lead results are above the site-specific standard (SSS) for lead of 2,240 milligrams per kilogram (mg/kg) then samples should be analyzed for lead via Toxicity Characteristic Leaching Procedure (TCLP), EPA Test Method 1311.
- Delineated areas that exhibit soils that physically resemble leaded tank bottoms, exhibit lead concentrations greater than 2,240 mg/kg, and exceed 5 milligrams per liter (mg/l) for lead in the TCLP leachate (which is characteristically hazardous for lead) will retain the leaded tank bottom designation. If no soils are encountered that meet all three of these criteria, then the area will no longer be classified as a leaded tank bottom area.

4.7 Methodology for Monitoring Well or Recovery Well Installation

4.7.1 Well Construction

After drilling to a desired terminal depth via any of the drilling methods referenced above, permanent monitoring wells can be installed to allow access to groundwater for future monitoring and groundwater sampling. In general, monitoring wells are constructed of pipe with a slotted interval(s) (screen) through which groundwater can flow into the well from a desired water-bearing stratum. In most cases, PVC materials are utilized for monitoring well construction.

- For applications where LNAPL thickness measurement is necessary, the screened interval should extend above the presumed highest groundwater level.
- For applications where the shallowest groundwater interval is to be monitored (e.g., water-table aquifer), a single well casing is installed.
- For applications where multiple water bearing strata will be penetrated and where deep groundwater conditions are selected for monitoring, a double-cased well may be installed to prevent the vertical migration of contaminants to the deeper water bearing zone from shallower zone(s).

Each well construction type and considerations for field staff regarding how many casings are needed have been provided below.

4.7.1.1 Single Casing Construction

The most commonly installed monitoring well at the facilities have single casings and are constructed of PVC. To determine the length of screen used, seasonal groundwater table or tidal fluctuations should be considered to allow the water table to intercept the well screen throughout the year. Field personnel should advise the driller on the required well diameter, total well depth, screen interval, screen length, and slot size based on available subsurface information prior to drilling. Once the borehole is completed and the drilling crew has been advised on the desired construction, the drilling crew will thread the well screen onto an end cap at the wellhead and will lower the well into the borehole, adding lengths of casing until the terminal depth is reached.

While the well is held near the center of the borehole, the annular space between the well screen and formation is carefully backfilled with a sand filter pack, which consists of clean, sorted quartz sand sized to the formation grain size (typically #1 or #2 sand). The sand pack establishes continuity with the formation and acts as a filter to prevent soil from entering the well (the well screen slot size should be sized according to the formation median grain size to mitigate sediment intrusion, however is most commonly available from suppliers as 0.01 or 0.02-inch diameter slot size).

The sand pack should extend one to two feet above the top of well screen, and care must be taken by the driller to not bridge the sand or overshoot the top of sand target depth (particularly when installing wells through the auger stem). Above the sand pack, a seal (grout) is installed in the annular space between the well casing and the soil. The seal is comprised of hydrated bentonite, sometimes amended with pellets or a grout consisting of hydrated Portland cement, bentonite powder, or a blend of the two. A conventional grout blend is 95% Portland cement and 5% bentonite powder. The purpose of the seal is to prevent surface water from infiltrating the well screen. It is installed from the top of the sand to one to two feet below ground surface.

In circumstances where the top of well sand terminates below the water table (e.g., deeper groundwater or submerged screen), grout should be mixed into a slurry at the ground surface and pumped via tremmie pipe or hose to prevent bridging. Above the well seal, the annular space can be backfilled with granular bentonite or concrete. A cement cap or well pad is placed at the surface to further mitigate potential infiltration of surface water. A locking, steel protective casing (stand pipe) or a locking, flush-mounted curb box should be installed to protect the well.

4.7.1.2 Double Casing Construction

Construction of a double cased well is similar to that of a single case well; however, to prevent groundwater infiltration from shallower water bearing zones, a second casing is installed through a surface casing. This type of construction requires drilling two different diameter boreholes.

During drilling through the shallower groundwater bearing zone(s), a larger diameter borehole is drilled and should be sized according to the desired well and/or outer casing diameter. This may require reaming of the borehole depending on the conditions and drilling equipment. An outer (surface) casing is installed and the annulus is grouted. After the outer casing is installed and the grout has set, the borehole is advanced through the surface casing with a smaller diameter drill stem and bit. When the desired terminal depth is reached, a monitoring well is installed through the inner casing using the above-referenced single casing construction procedure (the annular space between the outer and inner casings above the well filter sand should be pressure grouted).

4.7.2 Handling of Soil Cuttings

Soil cuttings generated during drilling will be containerized or stockpiled on plastic until sampling and analytical data can be obtained. Soil cutting final placement (onsite soil reuse or offsite disposal) will be performed in accordance with Pennsylvania Department of Environmental Protection (PADEP) approved onsite soil reuse plans for each facility.

4.7.3 Well Development

After installation, monitoring wells will be developed to remove residual soil from within the well and filter media and to establish communication between the well and formation. Pump and surge methodology, either through use of a ditch pump or air compressor connected to black polyethylene pipe and surge block, should be utilized to successively agitate relatively clear groundwater from the well. Surging should begin from the bottom of the screened interval and continue iteratively to the top of the well screen in approximately 2 to 4-foot intervals (i.e., pump and surge each 2 to 4 foot interval of well screen several times until relatively clear discharge water is maintained, then move up to the next screen interval until all of the screen has been developed).

Alternately, a submersible pump may be used to pump water from the screened interval of shallow wells, with the screen of the well surged to evacuate silt that remains in the sand pack. The well should be alternately surged and purged until groundwater flowing from the well appears relatively free of sediments. A vacuum truck may be used for development for wells that contains product. Well development water should be managed/treated in accordance with the site-specific work plan.

4.8 Documentation

All site activities and conditions at the time of soil sampling, well installation, and well development should be recorded by field personnel in a field computer via the EDGE application or, if necessary, a field book may be used. The entry shall include the date, time, weather conditions, location (well or boring name), personnel present onsite, and the aforementioned lithologic data and well construction information. The entry shall include detailed data required to create representative soil boring lithologic logs and well as-built logs (if a well is constructed). This data should include but not be limited to soil type, soil texture (e.g., USCS), soil color, relative moisture content, depth of apparent water table, PID readings, blow counts (if split spoon samples are collected), sample recovery, total depth of borehole, length of well screen, length of well casing, sand pack interval, filter sand size, grout materials used, well seal interval, and all well construction materials. Notes should also include well development pumping rate, duration, and observations. Additional comments or observations should also be recorded, as appropriate.

5.0 LIGHT NON-AQUEOUS PHASE LIQUID (LNAPL) SAMPLING PROCEDURES

5.1 Potential Hazards

Traffic, pinch points, chemical (airborne and physical contact), and biological are all likely hazards to be encountered during LNAPL sampling, as well as slip/trip/fall potential. Additional hazards may be mentioned in the site-specific HASP and/or the daily JSA. If significant amounts of LNAPL are being handled, a Tyvek suit should also be worn.

5.2 Materials and Equipment Necessary for Task Completion

A list of equipment required to sample LNAPL from a monitoring well is presented below:

- Current site map detailing well locations;
- Field book or field computer for recording site data;
- Optical oil/water interface probe with a graduated measuring tape to 0.01 foot accuracy;
- Keys and tools to provide well access;
- Appropriate sample containers and labels. LNAPL samples will be collected in laboratory provided glassware with appropriate preservative, if applicable. A minimum of 10 ml is required for most laboratory analyses. In the case that sufficient volume is not obtained, a swabbing technique (described below) could be used;
- Sorbent pads (required for swabbing technique);
- Stainless steel or clear bottom-loading or top-loading bailer, depending on product thickness;
- Clean nylon or polypropylene bailer cord;
- Decontamination supplies;
- Blank chain-of-custody forms; and
- Cooler and ice for sample preservation.

5.3 Decontamination Requirements

During LNAPL sampling activities, dedicated sampling equipment (i.e., clear bailers, nitrile gloves, and bailer cord) may be utilized; thereby, minimizing decontamination requirements. However, a stainless steel bailer may be used and decontaminated between LNAPL sampling locations. The optical oil/water interface probe with a graduated measuring tape to 0.01 foot accuracy used to record the presence or absence and approximate thickness of LNAPL prior to sampling also requires decontamination between sampling locations. Decontamination procedures are detailed in Section 1.5.

5.4 Sampling Procedure

Immediately prior to sampling, each monitoring well should be gauged to obtain liquid levels (i.e., depth to LNAPL and depth to water) for estimation of current LNAPL thickness. Refer to Section 3.0 for appropriate well gauging procedures. Liquid level data should be recorded in a field book or field computer through the EDGE application or, if necessary, a field book.

LNAPL sampling may be performed via two different methods, based upon the LNAPL thickness/availability at the time of sampling: direct sample or swabbing. As indicated above, a minimum LNAPL volume of 10 mL is typically required by the analytical laboratory for most LNAPL characterization.

The following sequence of procedures will be implemented for the collection of LNAPL samples from monitoring wells:

1) A clean work area will be established so that sampling equipment will not come in contact with the ground surface or any other potentially contaminated surfaces near the wellhead.
2) A pre-cleaned stainless steel bailer or dedicated disposable bailer will be used for each well.
3) A new pair of nitrile gloves will be worn during sampling and replaced for each well.
4) Based on the gauged depth to LNAPL, an appropriate length of dedicated nylon or polypropylene cord will be tied to the sampling bailer.
5) An appropriately sized (i.e., 40 ml glass vial with plastic cap fitted with Teflon® lined septum) laboratory-provided sample container will be used to containerize the LNAPL sample.

6) The sampling bailer will be slowly lowered into the well until the liquid level is encountered. Once encountered, the sampling bailer should be lowered into the standing liquid column to a depth of approximately 1 foot, or other appropriate depth based on product thickness.

7) The bailer should be retrieved at a steady rate to avoid excess agitation.

8) The bailed sample should be visually evaluated for the presence or absence of LNAPL. If sufficient LNAPL volume is present (>10 ml), a direct sample of the LNAPL will be collected into the laboratory vial. If less than 10 ml of LNAPL is apparent, a sorbent pad may be used to absorb the LNAPL from the surface of the groundwater sample and the swab placed in the laboratory vial. The site-specific work plan should dictate whether a swab sample should be analyzed, or if the well should be monitored at a later date for re-sampling.

9) Labels will be completed and attached to the sample vials, indicating the sample collector's name, date, time, and location of sample; record same data in field computer or field notebook.

10) Store samples in a secure location until possession is transferred to the laboratory.

11) Nitrile gloves, bailer, bailer cord, and any other trash will be disposed of as solid waste.

5.5 Documentation

All site activities and conditions at the time of sampling should be recorded by field personnel in a field computer via the EDGE application or, if necessary, a field book may be used. The entry shall include the date, time, weather conditions, location (well name), personnel present onsite, and the aforementioned well gauging parameters. Additional comments or observations (e.g., color or apparent viscosity of LNAPL) should be recorded.

6.0 INDOOR AND AMBIENT AIR SAMPLING PROCEDURES

In preparation for indoor and/or ambient air sampling, appropriate facility personnel should be notified of intended sampling prior to mobilization. The purpose of this would be to confirm that there are not any non-routine activities occurring in the building, such as painting of indoor walls, which would cause incidental contamination of the samples.

6.1 Materials and Equipment Necessary for Task Completion

A list of equipment required to collect indoor and/or ambient air samples is presented below:

- Field data book or field computer for recording site data;
- Laboratory certified Summa canisters (standard size is 6 liters);
- Flow controllers (standard duration is 8-hours) with integrated vacuum gauge;
- Equipment for elevating sample intake height (examples: extended sampling inlets, zip ties to attach units to fencing, tables, etc);
- Camera; and
- Blank chain-of-custody forms.

6.2 Precautions to Avoid Incidental Contamination

EPA Method TO-15 is the most common method used for analysis of air samples at these sites. This method is highly sensitive to trace concentrations of volatile organic compounds (VOCs). To avoid incidental contamination:

- Do not wear cologne or fragrance on day of sampling;
- Do not use hand sanitizers or lotions;
- Do not store canisters near containers of gasoline, or any fuel; and
- Make sure there are no sources of VOCs in the vehicle used to transport the canisters.

6.3 Sampling Procedure

1) <u>Set Up Summa Canister</u>. Inlets of the flow controllers are to be placed in the breathing zone, approximately 4 to 6 feet above the ground surface. Elevate Summa canisters using appropriate materials available onsite or use laboratory-provided extended inlets (approximately 3 ft long sampling canes). Indoor air samples should be representative of air

in the buildings and should be placed away from obvious ventilation to outdoor air or sources of VOCs. Securely attach flow controller and extended sampling inlet if applicable.

2) Start Air Sample Collection. Open the valve. Document the initial vacuum (should be between approximately -30 inHg and -26 inHg) and the start time of the test. If the vacuum is significantly outside of the range or has a high rate of change, consider using an alternate canister or flow controller as there may be leakage.
3) Monitoring Summa Condition During Sampling Period. Several times during the sampling period, verify that the Summa is in good condition and that the vacuum is decreasing at an appropriate rate several times during the sampling period. An example of a reasonable frequency would be every two hours during an 8-hour event. During these checks, record the time, remaining vacuum, and canister condition. If necessary, obtain a permit to operate a camera, and take a least one photo of each sampling location.
4) Completing Air Sample Collection. Near the end of the sampling period, monitor the gauge more frequently. The sample collection should be stopped when the gauge reads approximately -5 inHg. At this point, close the canister valve. Record the sample end time and sample end vacuum. Ensure that the canister is labeled with the sample ID. Remove all of the attached equipment from the canister. Pack the canisters, flow controller wrapped in bubble wrap, chain of custody (additional information in the following section), and any other laboratory provided equipment back into the original packaging.

6.4 Documentation

All site activities and conditions at the time of air sampling should be recorded by field personnel. The entry shall include the date, time, weather conditions (including wind direction and start/end barometric pressure), sample locations and IDs, and personnel present onsite. Any observation that could influence the level of VOCs in the samples should be noted.

7.0 SURFACE WATER SAMPLING PROCEDURES

7.1 Field Procedures for Surface Water Sampling

7.1.1 General

Surface water sampling is performed to obtain samples for surface water bodies that are representative of existing surface water conditions. Surface water sampling (or gauging) within 3 feet of a bulkhead at certain facilities will require field personnel to wear a life vest.

Surface water sampling locations for surface water quality and groundwater interaction studies are selected based on the following:

1) Study objectives
2) Location of point surface discharges
3) Non-point source discharges and tributaries
4) Presence of structures (e.g., bridge, dam)
5) Accessibility

During surface water sampling it is important to obtain samples that are not impacted by the re-suspension of sediment produced because of improper or poor surface water sampling techniques.

7.1.2 Surface Water Sample Location Selection

Prior to conducting surface water sampling activities, the first requirement is the consideration and development of surface water sampling locations. It is important that all surface water sampling locations be selected in accordance with the work plan.

Wading for surface water samples increases the chances of disturbance of sediments from the floor of the surface water body. When wading for surface water samples be aware of potential safety and health risks. A life vest and safety line must be worn at all times where footing is unstable or when sampling in fast moving or more than 3 feet (0.9 m) deep. A two-person team is required for most surface water sampling activities. If the site conditions require the use of the life vest and safety line, the two people involved in the sampling must be competent swimmers.

Surface water samples must be collected with no suspended sediments. Surface water samples are collected commencing with the furthest downstream location to avoid sediment interference with upstream locations.

7.1.2.1 Rivers, Streams, and Creeks

Surface water samples are generally collected in areas of surface water bodies that are representative of the surface water body conditions. Representative surface water samples will usually be collected in sections of surface water bodies that have a uniform cross section and flow rate. Mixing is influenced by turbulence and water velocity, therefore the selection of surface water sampling locations immediately downstream of a riffle area (i.e., fast flow zone) will ensure good vertical mixing. These locations are also likely areas for deposition of sediment since this occurs in areas of decreased flow velocity.

Surface water sampling locations should not be established in areas near point source discharges. Surface water sampling of these source discharge points can be performed to assess the impact of these source areas on overall surface water quality. Sample tributaries as close to the mouth as possible. It is important to select surface water sample locations considering the impact downstream, including tributary flow and sediment.

In all instances, properly document all surface water sampling locations. Documentation may include photographs and tie-ins to known structures.

7.1.2.2. Sampling Equipment and Techniques

When collecting surface water samples, direct dipping of the sample container into the stream or water is acceptable unless the sample container contains preservatives. If preserved, a pre-cleaned unpreserved sample container should be used to collect the surface water sample. The surface water sample is then transferred to the appropriate preserved sample container. When collecting surface water samples, submerse the inverted bottle to the desired sample depth and tilt the opening of the sample container upstream to fill. During surface water sample collection, wading or movement may cause sediment deposits to be re-suspended and can result in biased samples. Wading is acceptable if the stream has a noticeable current and the samples are collected directly in the sample container when faced upstream. If the stream is too deep to wade in or if addition samples must be collected at various depths, additional sampling equipment will be required. Surface water samples should be collected about 6 inches (15 cm) below the surface, with the sample bottles being completely submerged. Taking the surface water sample at this depth eliminates the collection of floating debris in the sample container.

Surface water sample collection where the flow depth is less than 1 inch (<2.5 cm) requires the use of special equipment to eliminate sediment disturbance. Surface water sampling may be conducted with a container then transferred to the appropriate sample container, or collection may be performed using a peristaltic pump. A small excavation in the stream bed to create a sump for sample collection can also be considered but should be prepared in advance to allow all the sediment to settle prior to surface water sampling activities.

Teflon™ bailers can be used for surface water sampling if it is not necessary to collect surface water samples at specific depths. A bottom loading bailer with a check ball is sufficient. When the bailer is lowered through the water, the water is continually displaced through the bailer until the desired depth is reached. The bailer is retrieved and the check ball prohibits the release of the collected surface water sample. Bailers are not suitable in surface water bodies with strong currents, or where depth-specific sampling is required. For discrete and specified depth surface water sampling, and the parameters to be monitored do not require a Teflon™ coated sampling device, a standard Kemmerer or Van Dorn sampler can be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the sampler ends open while the sampler is being lowered. The sampler is lowered in a vertical position to allow water to pass through. The Van Dorn sampler is plastic and is lowered in a horizontal position. For both samplers, a messenger is sent down a rope when the sampler has reached the required depth. The messenger causes the stopper on the sampler to close. The sampler is then retrieved and the surface water sample can be collected through a valve. DO sample bottles can be filled by allowing overflow using a rubber tube attached to the valve. During depth-specific surface water sampling, take care not to disturb bottom sediments.

Glass beakers or stainless steel cups may also be used to collect surface water samples if parameter interference does not occur. The beaker or cup must be rinsed at least three times with the surface water sample prior to sample collection.

All equipment must be thoroughly decontaminated.

7.1.2.3 Field Notes for Surface Water Sampling

Record daily surface sampling activities, describe surface water sampling locations, sampling techniques, and, if applicable, provide a description of photographs taken. Visual observations are important and provide valuable information when interpreting surface water quality results. Observations include:

1) Weather conditions
2) Stream flow directions
3) Stream physical conditions (width, depth, etc.)
4) Tributaries
5) Effluent discharges
6) Impoundments
7) Bridges
8) Railway trestles
9) Oil sheens
10) Odors
11) Buried debris
12) Vegetation
13) Algae
14) Fish and other aquatic life
15) Surrounding industrial areas

The following factors should be considered for surface water sampling:

1) Predominant Surrounding Land Use: Observe the prevalent land use type in the vicinity and note any other land uses in the area which, although not dominant, may potentially affect surface water quality.

2) Local Watershed Erosion: Note the existing or potential erosion of soil in the local watershed and its movement into the stream. Erosion can be rated through visual observation of watershed stream characteristics including increases or decreases in turbidity.

3) Local Watershed Non-Point Source Pollution: This refers to problems or potential problems other than erosion and sedimentation. Nonpoint source pollution can be diffuse agricultural and urban runoff. Other factors may include feed lots, wetlands, septic systems, dams, impoundments, and mine seepage.

4) Estimated Stream Width: The estimated distance from shore at a transect representative of the stream width in the area.

5) Estimated Stream Depth: Riffle (rocky area), run (steady flow area), and pool (still area). Estimate the vertical distance from the water surface to the bottom of the surface water body at a representative depth at three locations.

6) High Water Mark: Estimate the vertical distance from the bank of the surface water body to the peak overflow level, as indicated by debris hanging in bank or flood plain vegetation, and deposition of silt. In instances where bank flow is rare, high water marks may not be evident.

7) Velocity: Record or measure the stream velocity in a representative run area.

8) Dam Present: Indicate the presence or absence of a dam upstream or downstream of the surface water sampling location. If a dam is present, include specific information detailing the alteration of the surface water flow.

9) Channelized: Indicate if the area surrounding the surface water sampling location is channelized.

10) Canopy Cover: Note the general proportion of open to shaded areas which best describes the amount of cover at the surface water sampling location.

7.2 References

For additional information pertaining to surface water sampling, the user of this manual may reference the following:

ASTM D5358 Practice for Sampling with a Dipper or Pond Sampler

ASTM D4489 Practices for Sampling of Waterborne Oils

ASTM D3325 Practice for the Preservation of Waterborne Oil Samples

ASTM D4841 Practice for Estimation of Holding Time for Water Samples Containing Organic and Inorganic Constituents

ASTM D4411 Guide for Sampling Fluvial Sediment in Motion

ASTM D4823 Guide for Core-Sampling Submerged, Unconsolidated Sediments

ASTM D3213 Practice for Handling, Storing, and Preparing Soft Undisturbed Marine Soil

ASTM D3976 Practice for Preparation of Sediment Samples for Chemical Analysis

ASTM E1391 Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing

ASTM D4581 Guide for Measurement of Morphologic Characteristics of Surface Water Bodies

ASTM D5906 Guide for Measuring Horizontal Positioning During Measurements of Surface Water Depths

ASTM D5073 Practice for Depth Measurement of surface water

8.0 SEDIMENT SAMPLING PROCEDURES

8.1. Introduction

Sediment sampling is conducted to obtain samples that are representative of existing chemical and/or physical conditions of sediment.

8.2 Equipment Decontamination

On environmental sites, sediment sampling equipment (e.g., split spoons, trowel, spoons, shovels, bowls, dredges, corers, scoops) are typically cleaned as follows:

1) Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2) Rinse with tap water.
3) Rinse with deionized water.
4) Air dry for as long as possible.

Additional or different decontamination procedures may be necessary if sampling for some parameters, including VOCs and metals.

8.3 Sample Site Selection

Before any sampling is conducted, the first requirement is to consider suitable sampling locations. Sampling locations should be selected in accordance with the work plan. Wading for sediment samples in lagoons, lakes, ponds, and slow-moving rivers and streams must be done with caution since bottom deposits are easily disturbed. Sampling must only be attempted where safe conditions exist and samples must be collected from undisturbed sediments. All sediment samples are to be collected commencing with the most downstream sample to avoid sediment interference with other downstream samples. A life vest and safety line should be worn in all cases where footing is unstable or where water is fast moving or over 3 feet (0.85 m) in depth. A second person may also be required for most of the sampling scenarios.

8.3.1. Rivers, Streams, and Creeks

Sediment samples may be collected along a cross-section of a river or stream in order to adequately characterize the bed material, or from specific sediment deposits as described in the work plan. A common procedure is to sample at quarter points along the cross-section of the sampling site selected. Samples may be composited as described in the work plan. Samples of dissimilar composition (e.g., grain size, organic content) should not be combined. Representative samples can usually be collected in portions of the surface water body that have a uniform cross-section and flow rate. Since mixing is influenced by turbulence and water velocity, the selection of a site immediately downstream of a riffle area (e.g., fast flow zone) are likely areas for deposition of sediment since the greatest deposition occurs where stream velocity slows.

A site that is clear of immediate point sources (e.g., tributaries and industrial and municipal effluents) is preferred for the collection of sediment samples unless the sampling is being performed to assess these sources.

8.4 Sampling Equipment and Techniques

8.4.1. General

Any equipment or sampling technique(s) [e.g., stainless steel, polyvinyl chloride (PVC)] used to collect a sample is acceptable so long as it provides a sample which is representative of the area being sampled and is consistent with the work plan.

8.4.2. Sediment Sampling Equipment and Techniques

A variety of methods may be used to collect sediment samples from a stream, river, or lake bed. Dredging (Peterson, Ponar, Van Veen), coring and scooping are acceptable sediment sample collection techniques. Precautions shall be taken to ensure that a representative sample of the targeted sediment is collected. Caution should be exercised when wading in shallow water so as not to disturb the area to be sampled. Samplers should be selected based on the interval to be sampled, type of sediment/sludge (silt, sand, gravel), and required sample volume. More than one sampler is often required to implement a sampling program at a site. The following describes some of these methods. Manufacturer's information should be consulted to determine the limitations of each type of sampling equipment.

8.4.3 Dredging

The Peterson dredge is best used for rocky bottoms, in very deep water, or when the stream velocity is rapid. The dredge should be lowered slowly as it approaches the bottom, so as to not disturb the lighter sediments.

The Ponar dredge is similar to the Peterson dredge in size and weight. The Ponar dredge is a "clam-shell" type unit that closes on contact with the river/lake bottom. Depending on the size of the unit, a winch is required for larger units, whereas smaller units are available for lowering by a hand line. Once retrieved, the unit is opened and the sample extracted using a sample scoop or spoon. The unit has been modified by the addition of side plates and a screen on top of the sample compartment. This permits water to pass through the sampler as it descends.

The Ponar grab sampler functions by the use of a spring-latch-messenger arrangement. The sampler is lowered to the bottom of the water body by means of a rope, then the messenger is sent down to trip the latch causing the sampler to close on the sediments. The sampler is then raised slowly to minimize the disturbance of the lighter sediments. Sediment is then placed into a stainless steel bowl, homogenized, and placed into the appropriate sample container (if collecting for VOC parameters, fill the VOC jars before homogenization).

8.4.4. Corers

Core samplers are used to obtain vertical columns of sediment. Many types of coring devices are available, depending on the depth of water from which the sample is to be collected, the type of bottom material, and the length of core to be obtained. They vary from hand-push tubes to weight or gravity-driven devices to vibrating penetration devices.

Coring devices are useful in contaminant monitoring due to the minimal disturbance created during descent. The sample is withdrawn intact, allowing the removal of only those layers of interest. Core liners consisting of plastic or Teflon may also be added, thereby reducing the potential for sample contamination and maintaining a stratified sample. The samples may be shipped to the lab in the tubes in which they were collected. The disadvantage of coring devices is that only a small sampling surface area and sample size is obtained, often necessitating repetitive sampling in order to collect the required amount of sediment for analysis. It is also often difficult to extract the sediment sample back out through the water column without losing the sample.

The core tube is pushed/driven into the sediment until only 4 inches (10 cm) or less of tube is above the sediment-water interface. When sampling hard or coarse sediments, a slight rotation of the tube while it is pushed will create greater penetration and reduce compaction. Cap the tube with a Teflon plug or a sheet of Teflon. The tube is then slowly withdrawn, keeping the sample in the tube. Before pulling the bottom part of the core above the water surface, it must be capped.

8.4.5 Scooping

The easiest way to collect a sediment sample is to scoop the sediment using a stainless steel spoon or scoop. This may be done by wading into the stream or pond and, while facing upstream (into the current), scooping the sample from along the bottom in an upstream direction. This method is only practical in very shallow water.

8.4.6 Mixing

Sediment samples collected for chemical analysis should be thoroughly mixed (except for VOCs) in a stainless steel bowl prior to placement in the appropriate sample container. Standard procedures exist for preparation of sediment samples (ASTM D3976). These should be followed or the laboratory informed of applicable procedures.

8.4.7 Air Monitoring

Prior to sediment/sludge sampling, measure the breathing space above the sample location with a PID, should the potential for volatiles be present, and use a hydrogen sulfide meter should hydrogen sulfide be present. Repeat these measurements during sampling. If either of these measurements exceed any of the air quality criteria established in the HASP, air purifying respirators (APRs) or supplied air systems will be required.

8.4.8 Sample Location Tie-In/Surveying

The recording of the sample locations and depth on the site plan is extremely important. This may be accomplished by manual measurement (i.e., swing ties), global positioning system (GPS) survey, or stadia methods. Manual measurements for each sample location should be tied into three permanent features (e.g., buildings, utility poles, hydrants). Diagrams with measurements should be included in the field book.

8.5 Field Notes

A bound field book is used to record daily activities, describe sampling locations and techniques, and describe photographs (if taken). Visual observations are important, as they may prove invaluable in interpreting water or sediment quality results. Observations shall include (as applicable) weather, stream flow conditions, stream physical conditions (width, depth, etc.), tributaries, effluent discharges, impoundments, bridges, railroad trestles, oil sheens, odors, buried debris, vegetation, algae, fish or other aquatic life, and surrounding industrial areas. The following observations should be considered:

- Predominant Surrounding Land Use: Observe the prevalent land use type in the vicinity (noting any other land uses in the area which, although not predominant, may potentially affect water quality).
- Local Watershed Erosion: The existing or potential erosion of soil within the local watershed (the portion of the watershed that drains directly into the stream) and its movement into a stream is noted. Erosion can be rated through visual observation of watershed and stream characteristics. (Note any turbidity observed during water quality assessment.)
- Local Watershed Non-point Source Pollution: This item refers to problems and potential problems other than siltation. Non-point source pollution is defined as diffuse agricultural and urban runoff (e.g., stormwater runoff). Other compromising factors in a watershed that may affect water quality are feedlots, wetlands, septic systems, dams and impoundments, and/or mine seepage.
- Estimated Stream Width: Estimate the distance from shore at a transect representative of the stream width in the area.

- Estimated Stream Depth: Riffle (rocky area), run (steady flow area), and pool (still area). Estimate the vertical distance from water surface to stream bottom at a representative depth at each of the three locations.
- High Water Mark: Estimate the vertical distance from the stream bank to the peak overflow level, as indicated by debris hanging in bank or floodplain vegetation, and deposition of silt or soil. In instances where bank overflow is rare, a high water mark may not be evident.
- Velocity: Record an estimate of stream velocity in a representative run area (see Section 12.0).
- Dam Present: Indicate the presence or absence of a dam upstream or downstream of the sampling station. If a dam is present, include specific information relating to alteration of flow.
- Channelized: Indicate whether the area around the sampling station is channelized.
- Canopy Cover: Note the general proportion of open to shaded area which best describes the amount of cover at the sampling station.
- Sediment Odors: Disturb sediment and note any odors described (or include any other odors not listed) which are associated with sediment in the area of the sampling station.
- Sediment Oils: Note the term which best describes the relative amount of any sediment oils observed in the sampling area.
- Sediment Characteristics: Note the grain size, color, consistency, layering, presence of biological organisms, man-made debris, etc. in accordance with standard ASTM soil description protocols.
- Sediment Deposits: Note those deposits described (or include any other deposits not listed) which are present in the sampling area. Also indicate whether the undersides of rocks not deeply embedded are black (which generally indicates low dissolved oxygen or anaerobic conditions).

8.6 References

For additional information pertaining to this topic, the user of this manual may reference the following:

ASTM D5358	Practice for Sampling with a Dipper or Pond Sampler
ASTM D4489	Practices for Sampling of Waterborne Oils
ASTM D3325	Practice for the Preservation of Waterborne Oil Samples

ASTM D4841 Practice for Estimation of Holding Time for Water Samples Containing Organic and Inorganic Constituents
ASTM D4416 Guide for Sampling Fluvial Sediment in Motion
ASTM D4823 Guide for Core-Sampling Submerged, Unconsolidated Sediments
ASTM D3213 Practice for Handling, Storing, and Preparing Soft Undisturbed Marine Soil
ASTM D3976 Practice for Preparation of Sediment Samples for Chemical Analysis
ASTM E1391 Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing
ASTM D4581 Guide for Measurement of Morphologic Characteristics of Surface Water Bodies
ASTM D5906 Guide for Measuring Horizontal Positioning During Measurements of Surface Water Depths
ASTM D5073 Practice for Depth Measurement of Surface Water
ASTM D5413 Test Methods for Measurement of Water Levels in Open-Water Bodies

9.0 SLUG TEST PROCEDURES

9.1 Materials and Equipment Necessary for Task Completion

Water level (data) logger capable of recording pressure and/or depth at sub-second time intervals (preferably a vented logger capable of advanced logging modes); vented, direct-read cable of sufficient length (with dessicant); interface tape/probe or water level meter; solid (mechanical) slug, pneumatic slug, or packer system [the introduction or removal of water is not recommended (e.g., bailer or bucket)]; 5 gallon bucket, traffic cones and/or barricades, deionized or distilled water and Alconox®; decontamination bucket and brush; and laptop computer or rugged reader.

9.2 Decontamination Requirements

Equipment utilized during slug testing must be thoroughly decontaminated with Alconox® and deionized/distilled water prior to and between uses at each test well to prevent cross contamination between wells. Any groundwater removed from the well during testing must be containerized and either treated and discharged to ground surface, or disposed of in an approved manner, preferably in a properly installed, onsite holding tank. If LNAPL is encountered/recovered, it should be containerized and properly disposed onsite. However, the preferred test initiation methods (solid and/or pneumatic slug) do not generate any groundwater.

9.3 Methodology for Slug Testing

Slug tests are utilized to provide in-situ estimations of hydraulic conductivity (k) in saturated media, most often in geologic formations that exhibit aquifer properties (low k media can also be tested with special consideration). Slug tests involve rapidly displacing the static water level in a well, and analyzing the well's rate and pattern of recovery back to near-static conditions. Falling head or slug-in tests involve analysis of displacement due to the addition of volume, and rising head or slug-out tests involve the analysis of displacement due to the removal of volume. Displacement is initiated using either a solid or pneumatic slug. Water level response is monitored immediately following the initial displacement and for the ensuing time period until the water level has returned to near-static level (generally within 5% of static). Water level response should be recorded using a water level (data) logger capable of recording pressure and/or depth at sub-second time intervals (preferably a vented logger). Logarithmic logging modes are preferred to shorten the data file while still providing high resolution data just after test initiation.

9.4 Field Procedures

1) Test Well Construction and Configuration - Well construction details are needed to perform slug test calculations and are important considerations when selecting appropriate wells for testing. Important as-built details include: total well depth, well screened interval(s), depth to (static) water, casing diameter, screen diameter, filter pack diameter, filter pack size, and filter pack interval. While these details should be documented on the well log, static water level and total well depth should be field-confirmed before the test. Of particular importance to the testing procedure is the relationship between static water level and well screened interval, and the degree of well development. Test results for poorly or insufficiently-developed wells may be strongly affected by drilling debris/disturbance in the formation that can create skin effects, lowering the apparent formation k. Analysis of testing data for wells screened across the water-table should consider drainage of the filter pack media. In addition, a pneumatic slug assembly should not be utilized unless the test well is screened below the water table and the water level remains above the screen throughout the test.

2) Test Setup and Initiation - Upon arrival, the test well should be gauged for static depth to water and total well depth so that the total water column length can be estimated. Well gauging data should be recorded in a rugged reader using an EDGE file, if available, or field form or book.

   a. Solid Slug
   The displacement volume of the slug is needed. It is suggested that the slug be prefabricated and calibrated for displacement volume prior to site use. Calculate the expected initial well displacement, using the slug volume and well casing radius, and deploy the data logger/cable to a depth just below that level while considering the slug length (to avoid conflict and tangling of the slug and transducer). Also consider the submergence depth limit of the data logger (usually indicated on the logger body). Generally, placing the data logger a foot or two below the bottom of the slug is good practice. Once submerged, allow the

data logger temperature to equilibrate with groundwater prior to initiating the test (up to 30 minutes).

While the data logger temperature equilibrates, secure the slug to an adequate length of disposable string or rope and hang in the well to a depth just above the water surface. Mark the string/rope to accommodate the slug length and tie off. Using the rugged reader or field computer, set up a new test (logarithmic mode or sub-second recording interval) in the data logger supplied software and start the test. Indicate in the file name the type of test and test number (e.g., rising or falling head; test 1 or 2). Once logging is initiated, quickly and smoothly lower the slug (slug-in or falling head test) to the submerged depth and tie off the string/rope (displacement should be instantaneous). Monitor the data logger data until the water level has returned to near-static level. Stop the falling head test.

Without moving the slug or data logger, set up a new test in the data logger supplied software with the same settings and indicate in the file name the type of test being performed (rising head or slug out). Start the test and once the data logger is running, instantaneously lift the slug and tie off the string/rope to its pre-test position (just above static). Monitor the data being recorded by the data logger and stop the test when the water level has returned to near-static.

b. Pneumatic Slug

If a high formation k is anticipated, solid slug removal is found to be too slow to capture well recovery, or to minimize equipment decontamination for wells with submerged screens, a pneumatic slug assembly should be utilized.

Open air release valve, secure pneumatic slug assembly to well casing and tighten coupling to provide an air tight seal. Insert the data logger/cable and deploy to the target submergence depth [it is generally best to keep the data logger shallow (~1-2 feet below static water level) and use small initial displacements to avoid dynamic recovery effects in high k formations]. Close the air release valve and attach the air pump or compressor. Pressurize the well and use the pressure gauge to set initial displacement. Check for air leaks using a soapy water mixture and sprayer (assembly must be air tight). Allow the water level to return to static and remove the air pump. Using the rugged reader or field computer, set up a new test (logarithmic mode or sub-second recording interval) in the data logger supplied software and start the test. Indicate in the file name the type of test and test number (e.g., rising head; test number). Once logging is initiated, open the air release valve and monitor the test data. Stop the test when the water level has returned to near-static.

3) Test Monitoring and Guidelines - The following are general guidelines for slug testing performance as published by Midwest Geosciences Group in "Field Guide for Slug Testing and Data Analysis:"

- Conduct at least three or more tests per well and if possible conduct both rising and falling head test data.
- Use two or more initial displacement values (2 slug sizes or air pressures applied) that vary by an order of magnitude or more.
- Final slug test initial displacement should be nearly equivalent to the first test's displacement.
- Allow tests to run until near-static conditions are achieved (+/- 5% of static)
- Digital slug test data files collected with the data loggers and/or EDGE files should be backed up to either a thumb drive, corporate email server, and/or corporate file server immediately after collection.

4) Test Data Reduction and Processing - Prior to slug test analyses, digital data logger files should be normalized so that multiple tests conducted on the same test well can be compared for the assessment of test validity and well conditions. Reducing the data as follows:

- From each raw data file, estimate the time of test initiation and the head (depth or pressure) under static conditions.

- In each slug test data file, subtract the time of test initiation from the elapsed time and save to a new field (normalized time or test time; start of test should be time zero).
- In each slug test data file, subtract the static pressure head from the test period pressure head values and save to a new field (deviation from static).
- To normalize the deviation from static values, divide that field by the displacement expected based upon the slug volume or air pressure head applied.
- Create a graphical plot of the normalized head data versus test time for each test performed on the test well. Review the data plots and confirm that the testing data for each repeat test roughly concur. Also confirm that the actual and expected initial displacements are nearly equal.
- If repeat testing data and/or expected versus actual initial displacements vary widely, review well completion details and testing methods prior to performing further analysis (step 5 below) as the results may not be valid (e.g., the well screen interval may be poorly developed or fouled, the data logger may have moved or placed too deep in the well, slug was removed too slowly). The well may need to be retested.

5) Test Data Analysis - For the purposes of this standard operating procedural document, it is assumed that slug test analysis software will be used to apply standard solution methods to the testing data. Various computer programs are available, such as AQTESOLV Professional. Choose an appropriate test solution method by considering the following well configurations (in AQTESOLV, use the Solution Expert):

   a. Submerged Screen and/or Confined Aquifer Well - If the well screen fully penetrates the intersecting aquifer, utilize the Cooper et al. Model or Hvorslev Model and analyze the curve match and/or best fit. If well is partially penetrating a confined formation, utilize the KGS Model or Hvorslev Model. If well screen is submerged in an unconfined formation, utilize the KGS Model or Bouwer and Rice Model.

b. Water-Table Intersects Well Screen - If the well screen is intersected by the water table, utilize the Bouwer and Rice Model (double straight line effect) or KGS Model.

c. Rapid Well Recovery in High k Formations - If well response to displacement is extremely rapid and normalized head plots display an oscillatory or concave-downward form, utilize the Butler and Zhan Model (most comprehensive solution available) or High-k Hvorslev Model for confined wells, or the High-k Bouwer and Rice Model.

9.5 Limitations

In general, results of slug test data analyses provide an initial estimate of formation k and have a small scale of relevance (particularly in high k settings). Slug tests can be strongly affected by the degree of well development and can be used diagnostically to assess the degree of well development. In most cases, slug testing should be performed on several wells in an area of interest to develop an understanding of the formation characteristics (e.g., heterogeneous or homogeneous formations).

10.0 PUMP TEST PROCEDURES

10.1 Materials and Equipment Necessary for Task Completion

Water-level (data) loggers (transducers) capable of recording pressure and/or depth at sub-second time intervals (preferably a vented logger capable of advanced logging modes for at least the pumping well); vented, direct-read cables of sufficient length (with dessicant packs); interface tape/probe or water-level meter; well pump (preferably a submersible pump), drop pipe and layflat or comparable discharge line of sufficient length, totalizing flow meter (recommended) and 5 gallon bucket, stop watch, rain gauge or nearby weather station; materials needed to monitor surface water bodies near the test site (e.g., staff gauge, weir, stakes, data logger, camera with permission from refinery personnel); traffic cones and/or barricades, deionized or distilled water and Alconox®; decontamination bucket and brush; laptop computer or rugged reader; portable generator or other power supply appropriate for the submersible pump; and containment (e.g., frac tank) or activated carbon filtration for the temporary staging or filtering of discharge water.

10.2 Decontamination Requirements

Equipment utilized during pumping tests must be thoroughly decontaminated with Alconox® and deionized/distilled water prior to and between uses at each test well to prevent cross contamination between wells. Any groundwater removed from the tested well must be containerized and either treated (filtered as appropriate) and discharged to ground surface, or disposed of in an approved manner, preferably in a properly installed, onsite holding tank. If LNAPL is encountered/recovered, it should be containerized and properly disposed of on or off-site.

10.3 Methodology for Pump Testing

10.3.1 Pre-test Considerations

In general, pumping tests are performed to estimate large-scale in-situ hydraulic properties of water-bearing strata in the subsurface (i.e., transmissivity and storativity) and average out local-scale heterogeneity that can limit the applicability of smaller-scale testing methods, such as slug tests. The geographical area influenced by a pumping test will be determined by the hydraulic properties of the strata being tested (including hydraulic properties of other strata supplying recharge to the pumped formation), boundary conditions, and on the duration of the test.

Pumping tests are also commonly performed to generate drawdown data from which hydraulic boundary conditions, hydraulic flow regime (e.g., anisotropy), and aquifer type (i.e., unconfined or confined, leaky confined) may be estimated. Smaller-scale pumping tests may also be utilized to address pumping efficiency and/or signal to noise ratio (pumping rate) at the pumping well, or to assist in remedial system design. However at this scale, the assumptions of some data analysis methods may not be applicable and should be considered prior to testing.

Appropriate design of a pumping test should include review of site-specific information regarding the geology and hydrogeology of the test area. Pumping test design should also consider the goal(s) of the test (i.e., scale of application of derived aquifer properties, identification of boundary influences, sources of recharge, well efficiency). This should include review of available lithologic well logs or test boring logs, geologic maps, cross sections, structure contour maps, isopach maps, and any other available information so that a conceptual model relating geologic units to hydrostratigraphic units or water-bearing strata can be developed. Additional pre-test considerations should include identification of any potential positive or negative hydraulic barriers, tidal effects, and/or influence from other wells that may be pumping in the test area. Without sufficient knowledge of factors influencing water-levels and hydrology of the test area, test results could be misinterpreted.

Often times, budget considerations and/or time limitations will necessitate the use of an existing monitoring well as the pumping well and/or existing wells as observation points. While this is generally acceptable, the wells must be screened appropriately with respect to the goals of the test and knowledge of well construction is critical to applying test solutions. Wells should also be redeveloped prior to testing if they are relatively old or if records of sufficient well development at the time of installation are not readily available.

Pumping tests can be divided into two general classifications: step-drawdown tests and constant rate tests. Step tests typically involve pumping a well at progressively higher rates or “steps” at intervals of one or two hours per step (typically up to 3 steps). They are often used to estimate the yield a well will sustain during a constant rate pumping test and to evaluate well efficiency (frictional head losses between the screen/gravel pack and the formation). Constant rate pumping tests are used primarily to evaluate hydraulic properties of water-bearing strata for design of groundwater treatment systems and/or water supply purposes (e.g., groundwater allocation). Where budgets permit, the best pumping test approach is to first perform a step-drawdown test on the pumping well to evaluate well efficiency and sustainable yield (and to gauge whether or not the pumping well needs additional development), allow recovery to near-static conditions, and then initiate a constant rate test.

The test duration is subject to goals of the test and to budget considerations. Optimally, a constant rate test should be run until all drawdowns have stabilized or boundary conditions are identified, and gravity drainage effects are curtailed; however, this is seldom practical due to time limitations. In most instances, an 8 hour constant rate test will be adequate, and a 24 hour test will be sufficient for higher sensitivity sites. Occasionally a 72 hour pumping test is warranted, though this is usually reserved for large scale water supply work. If there are any unexplained water level anomalies observed toward the scheduled end of a test, the test should be continued if at all possible.

The approximate test flow rate needs to be determined in advance for proper pump and discharge design selection, and sizing of discharge containment. If it is not appropriate to perform a step test, sustainable yield can be estimated from slug test data or a brief (<30 minutes) pumping episode the day before the actual test. Generally, it is best to pump the test well at a rate that maximizes the signal to noise ratio (a higher pumping rate does not influence test scale and should not be used as a means to shorten the test duration).

If testing must be performed in an area where contamination is known to be present, careful consideration of the impacts of the test scale should be considered prior to testing so that the spread of subsurface contamination is not increased. If floating product (LNAPL) is present at or near the pumping well, drawdown should be limited so as to not impact uncontaminated soils below the static water table (i.e., create a “smear” zone or allow for the significant migration of free-phase product). Discharge water must be either 1) treated prior to discharge or 2) containerized for on or off-site disposal. If it is to be discharged directly on-site and allowed to infiltrate, it must be routed sufficiently far enough from the test area as to avoid any artificial recharge effects. All appropriate withdrawal and discharge permits must be obtained and complied with. If discharge water is to be treated on-site, proper contaminant loading calculations for the test flow rate, approximate contaminant loading and test duration must be performed in advance to insure treatment is sufficient. Any on-site treatment should also include at least one discharge effluent sample analysis by an approved laboratory to document treatment effectiveness.

10.3.2 Pre-Test Water Level Monitoring

Water-level conditions in the test area should be monitored for at least one week prior to initiation of testing to identify background trends and factors influencing groundwater levels in the test area. Data loggers should be deployed in all wells to be utilized in the pumping test and set to record depth or pressure at a resolution that is high enough to identify any potential trends (generally a 15 minute recording interval is sufficient for background monitoring). A manual water level should be measured with a water-level meter or interface probe and referenced to the top of casing mark to calibrate the data logger data at the time of deployment and at sufficient intervals throughout the recording period to validate the data and provide backup data in the event that a data logger was to fail.

Ideally, groundwater levels should be static prior to starting a pumping test so that pumping influences alone can be readily evaluated. Any significant precipitation events within the previous several days (documented through use of a site rain gauge or nearby weather station) will usually result in noticeable water level changes. If there are any major water level changes observed that cannot be explained prior to testing, additional investigation into possible area influences (e.g., local well pumping or construction de-watering) should be conducted.

10.3.3 Pumping Test Set Up

Prior to starting the test, all well measuring points (i.e. top of casing) should be clearly marked and preferably surveyed to the nearest 0.01 feet in elevation. The horizontal distance between all wells utilized should be measured and illustrated on a base map. If there are any surface water bodies in the vicinity, a staff gauge (or similar measuring device) should be set up and surveyed to evaluate possible test influences on water levels or stream flow.

The preferred pump to be used for a pumping test is a submersible centrifugal pump powered by either existing site power or a portable generator. These pumps are not explosion proof, so a conductivity probe must be tied into the pump controls to alleviate any possibility of product coming into contact with the pump (if product is anticipated). If the test pump is designed to pump total fluids (e.g. air operated double diaphragm pump, jack pump, etc.) discharge must either be containerized, or treatment must include an oil/water separator to handle any floating product. The submersible pump should be set deep enough to maintain flow during the test period or at a maximum of just above the screened interval, using a handling line to support the pump's weight [**NOTE:** extreme care must be taken that the power cord is neither bearing any of the pumps weight, nor damaged during installation due to the potential for severe electric shock]. A check valve (or two check valves) should be installed above the pump in the discharge line to prevent backflow into the well after testing.

Discharge piping from the pump should include a flow meter (preferably with totalizer), followed by a flow adjustment valve. The flow meter should be installed in a straight section of hard piping of sufficient length to avoid meter distortion caused by turbulence (typically about 10 pipe diameters on either side of the meter). In low-flow pumping tests, flow rate can be calculated by measuring the exact time required to fill a known-sized container (bucket and stop watch) several times throughout the testing period. The bucket and stop watch method of estimating flow should also be used to back up and check the flow meter data.

Precise and frequent water-level measurements (to the nearest 0.01 feet) and time denotations before, during, and after pumping tests are critical to achieving accurate test results. In terms of prioritization, data loggers should be utilized in at least the pumping well and observation wells closest to the pumping well. Wells further from the pumping well may be manually monitored, due to the reduced likelihood that early-time drawdown will be critical at distal locations. Back-up manual measurements should be collected at least hourly during the first 8 hours of the test, and then at least every 3 hours, to verify data logger measurements. Readings from the transducers are not completely reliable until they have been submerged for at least 30 minutes (sensor equilibration period). All field personnel should have watches with a second hand, and they should all be calibrated to the same time. Liquid level measurements should be obtained using an optical oil/water interface probe with a graduated measuring tape to 0.01 foot accuracy for those wells with floating product. For wells without product, a water-level meter may be sufficient. All non-dedicated probes must be properly decontaminated after each level reading to prevent any possibility of cross- contamination between wells.

Data loggers should be deployed in each selected well to a depth that will maintain submergence through the test period. Data loggers selected should be capable of being submerged to that anticipated depth (typically noted on the instrument body). The transducer cable should be secured at the wellhead (manufacturer supplied hangers, well caps, or electrical tape/cable ties) to minimize any movement of the sensor. Care must be taken that the transducer cable is not damaged from rough edges at the well head, and that no vehicles run over the cable. The data logger installed in the pumping well will need to be installed at a depth that will maintain submergence through the test, but also remain clear of the submersible pump (and pump noise if possible). In addition, wells with floating product may require an inner PVC stilling well surrounding the data logger cable to prevent damage from contact with the product. A stilling well may also eliminate the need for any water-level corrections for product thickness.

10.3.4 Running the Test

Once the data loggers have been deployed and secured, tests should be set up in each device and each device either started or “future” started to begin logging when the pump is turned on. The data logger in the pumping well should be set to logarithmic logging mode to capture sub-second data during the early portion of the test. If possible, the pump discharge control valve should be have been pre-set (based on the step test or mini pump test) to the desired flow rate prior to turning on the pump. However, depending on the test pumps performance curves, minor flow rate adjustments are generally needed during the first hour or two of the test to correct for the additional lift required by the pump due to increasing drawdown. In addition, movement of the discharge hose after the test has been started should be avoided, since any change in the elevation of the discharge will affect the pumping rate. All changes in flow rate should be recorded and time stamped.

A minimum of two field personnel are needed to run a pumping test, with additional personnel required for tests with multiple observations wells or additional complexity. One person should be designated to turn on the pump, monitor and adjust flow rate, maintain discharge and treatment, maintain the generator, etc. The second person should be responsible for data logger management and manual water-level measurements. As a rule of thumb regarding the frequency of manual well gauging, one measurement every half minute during the first 5 to 10 minutes, followed by one measurement every 3 to 5 minutes during the first hour, one measurement every 10 to 20 minutes for the second hour, and one hourly measurement thereafter is acceptable.

Throughout the test, data loggers should be downloaded in real time through use of direct-read, vented cables (or non-vented with a barometric logger for compensation) to monitor water-level conditions. It is essential that some data reduction be accomplished in the field, so that major water level trends are recognized during the test. At a minimum, drawdown trends from the pumping well and two of the nearest monitoring wells need to be semi-log plotted against time so that deviations indicative of boundary conditions can be discerned before pumping is ceased. This will allow decisions to be made about whether the test should run longer than planned.

Generally, water quality samples are collected during a pumping test for laboratory analysis of constituents of concern. These are generally collected after the first hour of pumping and just prior to pump shutdown. If the test is of more than 24 hours duration, it is advisable to collect additional samples during the testing period. All groundwater samples should be collected following Evergreen Field Procedures.

10.3.5 Post-test Recovery

At the conclusion of the test, water level recovery data should be collected until near-static conditions are re-established. This requires the installation of a check valve in the discharge line above the submersible pump to prevent backflow. The recovery data has the advantage in that there are no variations in the curve produced due to variations in pumping rate and is independent of test length. In water-table aquifers, however, the effects of formation de-watering can cause the recovery trends to be substantially different from drawdown trends. Consequently, recovery (residual drawdown) data should be used in conjunction with drawdown data where possible.

10.3.6 Data Analysis

The data collected during pumping tests are analyzed to estimate aquifer hydraulic properties, such as transmissivity, conductivity, and storage. Data collected by transducers must be downloaded and transformed (dimensionless drawdown or displacement from static) prior to analysis. Analysis typically involves curve matching of site data to type curves established in literature for particular flow regimes. Curve matching is commonly performed utilizing computer software, such as HydroSOLV's AQTESOLV program, along with diagnostic methods and derivative analysis to best estimate aquifer properties through identification of flow regimes and conditions.

It is noted that the mathematical solutions used in pumping test analysis include many assumptions that must be considered in the context of each test area (e.g., the formation is of uniform thickness and of infinite areal extent). In addition, some of the values incorporated into typical pumping test solutions are not actually measured, but are educated estimates (e.g., porosity based on lithology, etc.). Many problems associated with pumping test data evaluation are due to not recognizing, and/or correcting for, deviations from the theoretical solution employed. Some of the more common analytical errors occur due to: partial well penetration effects, formation de-watering effects, casing storage effects, poor pumping well efficiency and/or the application of incorrect equations or units. Consequently, a thorough understanding of the underlying assumptions inherent to the solution employed is required before the validity of the results can be trusted.

APPENDIX C
SOIL BORING AND MONITORING WELL LOGS

Remedial Investigation Report
Area of Interest 1
Philadelphia Refinery Complex
Philadelphia, Pennsylvania
Philadelphia Refinery Operations,
a series of Evergreen Resources Group, LLC
3144 Passyunk Avenue, Philadelphia, Pennsylvania

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-001 PAGE 1 OF 1

Aquaterra Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **5/15/15** COMPLETED: **5/15/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
EASTING (ft):
LAT:
LONG:
GROUND ELEV (ft):
TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered**
BOREHOLE DEPTH (ft): **6.0**
WELL CASING DIA. (in): **---**
BOREHOLE DIA. (in): **2**
LOGGED BY: **LM**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟩		**SANDY CLAY WITH SILT AND GRAVEL** ; dark reddish brown	■	1600 BH-14-001 _0-2			228.4	
	🟥		**CLAYEY SILT WITH FINE TO MEDIUM GRAVEL** ; dark grayish brown	■	1630 BH-14-001 _2-4			258.7	
5	🟩		**SANDY CLAY** ; dark grayish green and brown	■	1700 BH-14-001 _4-6			364.7	5
			Borehole terminated at 6 feet.						
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-002 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/15/15** COMPLETED: **5/15/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
EASTING (ft):
LAT:
LONG:
GROUND ELEV (ft):
TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered**
BOREHOLE DEPTH (ft): **6.0**
WELL CASING DIA. (in): **---**
BOREHOLE DIA. (in): **2**
LOGGED BY: **LM**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SANDY CLAY WITH SILT AND GRAVEL** ; reddish brown with black	■	1715 BH-14-002 _0-2			25.2	
	▨		**CLAY WITH GRAVEL** ; dark brown with gray	■	1745 BH-14-002 _2-4			100.3	
5	▨		**CLAY** ; dark gray and brown	■	1815 BH-14-002 _4-6			42.0	5
			Borehole terminated at 6 feet.						
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-003 PAGE 1 OF 1

Aquaterra Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **5/20/15** COMPLETED: **5/20/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▩		**SANDY CLAY WITH SILT** ; brown and black	■	1230 BH-14-003 _0-2			56.3	
	▩		**GRAVELLY CLAY** ; black; bricks	■	BH-14-003@ 2-4'			128.3	
5	▨		**CLAY** ; brown and black	■	BH-14-003@ 4-6'			173.1	5
	▨		**CLAY** ; reddish brown	■	BH-14-003@ 6-8'			280.3	
	▥		**SANDY SILT WITH CLAY AND GRAVEL** ; reddish brown	■	1300 BH-14-003 _8-10			986.2	
10	●		**SANDY GRAVEL WITH SILT** ; dark red	■	BH-14-003@ 10-12'			754.6	10
	●		**SANDY GRAVEL WITH SILT** ; orangeish red	■	BH-14-003@ 12-14'			684.1	
15	▥		**SANDY SILT WITH GRAVEL** ; reddish brown	■	BH-14-003@ 14-16'			410.3	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-004

PAGE 1 OF 1

Aquaterra
Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **5/27/15** COMPLETED: **5/29/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟥		**SANDY SILT WITH FINE GRAVEL** ; black and brown	■	0800 BH-14-004 _0-2			241.5	
	🟩		**CLAY** ; light orange; cohesive	■	BH-14-004@ 2-4'			154.3	
5	🟥		**SANDY SILT** ; orange and black; fine-grained; layered	■	BH-14-004@ 4-6'			271.2	5
	🟥		**SANDY SILT** ; orange and black	■	BH-14-004@ 6-8'			689.9	
	🟥		**SANDY SILT** ; red and orange; fine-grained; multicolored (red, orange, gray, black)	■	1400 BH-14-004 _8-10			963.4	
10	🟧		**SANDY GRAVEL WITH SILT** ; tan and gray; fine to coarse-grained; multicolored (tan, gray, white, brown, red)	■	BH-14-004@ 10-12'			895.8	10
	🟥		**SANDY SILT WITH GRAVEL AND CLAY** ; reddish brown; and gray - black clayey silts	■	BH-14-004@ 12-14'			843.2	
15	🟥		**SANDY SILT WITH GRAVEL** ; reddish brown; fine-grained; rounded; multicolored gravel. Sample submitted for geotech analysis of foc and grain size	■	BH-14-004@ 14-16'			854.3	15
			Borehole terminated at 16 feet.						
20 25 30									20 25 30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-005

PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/27/15** COMPLETED: **6/4/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟩		**SILTY CLAY** ; brown and tan; micaceous	■	0900 BH-14-005 _0-2			927.6	
	🟥		**CLAYEY SILT WITH FINE GRAVEL** ; dark brown; micaceous	■	BH-14-005@ 2-4'			848.3	
5	🟩		**SILTY CLAY WITH SAND AND GRAVEL** ; dark brown and gray	■	BH-14-005@ 4-6'			665.7	5
	🟥		**CLAYEY SILT** ; tan and brown	■	BH-14-005@ 6-8'			437.5	
	🟩		**CLAY** ; dark gray and brown	■	BH-14-005@ 8-10'			1187	
10	🟩		**SILTY CLAY** ; gray and brown; multicolored (gray, brown, orange, and white)	■	1300 BH-14-005 _8-10			1560	10
	🟩		**SANDY CLAY** ; gray and brown	■	BH-14-005@ 12-14'			837	
15	🟩		**CLAY** ; light gray	■	BH-14-005@ 14-16'			719	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

GEO FORM 304 PHILLY AOI-1 APRIL2015 TO JUNE2015.GPJ STANTEC ENVIRO TEMPLATE 010509.GDT 7/17/15

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-006 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/27/15** COMPLETED: **5/28/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **20.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▥		**SILTY CLAY** ; brown and tan; micaceous		1000 BH-14-006 _0-2			264.5	
	🟥		**SANDY SILT WITH CLAY AND GRAVEL** ; brown; micaceous		BH-14-006@ 2-4'			524.1	
5	▨		**CLAY** ; light tan and brown; plasticly		BH-14-006@ 4-6'			672	5
	▥		**SILTY CLAY** ; light tan and brown; loose		BH-14-006@ 6-8'			592	
	▨		**CLAY** ; light brown and gray		BH-14-006@ 8-10'			389	
10	▨		**CLAY** ; white and tan; multicolored (white, tan, brown, and orange)		BH-14-006@ 10-12'			392	10
	🟧		**SANDY GRAVEL WITH SILT** ; brown and tan; multicolored (brown, tan , red, and white)		BH-14-006@ 12-14'			983	
15	🟧				BH-14-006@ 14-16'			387	15
	▨		**CLAY** ; grayish blue		1300 BH-15-006 _15-17			1137	
	🟧		**SANDY GRAVEL WITH SILT** ; reddish brown; Sample submitted for geotech analysis of foc and grain size		BH-14-006@ 18-20'			444	
20			Borehole terminated at 20 feet.						20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-007
PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/15/15** COMPLETED: **5/18/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟥		**SANDY SILT** ; multicolored	■	1300 BH-14-007 _0-2			11.0	
	🟥		**SANDY SILT** ; multicolored, micaceous	■	BH-14-007@ 2-4'			99	
5	🟥		**SANDY SILT WITH FINE TO MEDIUM GRAVEL** ; fine-grained; multicolored	■	BH-14-007@ 4-6'			211.7	5
	🟩		**CLAY** ; dark gray	■	BH-14-007@ 6-8'			269.1	
	🟨		**GRAVELLY SAND WITH CLAY** ; black with gray	■	BH-14-007@ 8-10'			363.1	
10	🟩		**SANDY CLAY** ; dark gray to light gray; fine to medium-grained	■	BH-14-007@ 10-12'			338.1	10
	🟩		**CLAY** ; dark gray	■	BH-14-007@ 12-14'			360	
15	🟩		**CLAY** ; greenish gray and white	■	0700 BH-14-007 _14-16			493.1	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

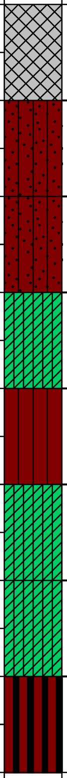
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-008 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/20/15** COMPLETED: **5/21/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**



Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			SANDY CLAY WITH SILT AND GRAVEL ; dark brown; bricks and timbers		0800 BH-14-008 _0-2			0.5	
			SANDY SILT WITH GRAVEL ; multicolored		BH-14-008@ 2-4'			69.8	
5			**SANDY SILT WITH CLAY** ; dark brown with gray		BH-14-008@ 4-6'			248.6	5
			SILTY CLAY ; brownish gray and black		BH-14-008@ 6-8'			153.7	
			SILT ; brown		BH-14-008@ 8-10'			163	
10			**SILTY CLAY** ; brown and gray		1230 BH-14-008 _10-12			175	10
			SILTY CLAY ; brown and gray		BH-14-008@ 12-14'			306	
15			**CLAYEY SILT** ; gray; Sample submitted for geotech analysis of foc and grain size		BH-14-008@ 14-16'			81.6	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-009 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/20/15** COMPLETED: **5/22/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			SANDY CLAY WITH SILT ; multicolored, micaceous, glass, timbers, and bricks		1200 BH-14-009 _0-2			0.9	
			SILTY CLAY ; orangeish brown; micaceous		BH-14-009@ 2-4'			24.8	
5			**SILT** ; multicolored (silver, orange, brown, white), micaceous		BH-14-009@ 4-6'			25.7	5
					BH-14-009@ 6-8'			66.0	
			SILT ; dark gray		BH-14-009@ 8-10'			783	
10			**SANDY GRAVEL WITH SILT** ; dark brown and black		BH-14-009@ 10-12'			691.3	10
			GRAVELLY SAND WITH SILT ; reddish brown and gray; medium to coarse-grained		BH-14-009@ 12-14'			745	
15			**SANDY GRAVEL WITH SILT** ; reddish brown; multicolored		1330 BH-14-009 _14-16			880.1	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-010 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/19/15** COMPLETED: **5/19/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
EASTING (ft):
LAT:
LONG:
GROUND ELEV (ft):
TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered**
BOREHOLE DEPTH (ft): **16.0**
WELL CASING DIA. (in): **---**
BOREHOLE DIA. (in): **2**
LOGGED BY: **LM**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SANDY CLAY WITH SILT AND GRAVEL** ; brown and tan	■	0800 BH-14-010 _0-2			150.4	
	▨		**SANDY SILT** ; fine to medium-grained; multicolored, micaceous	■	BH-14-010@ 2-4'			597.4	
5	▨		**SANDY GRAVEL WITH SILT** ; black; fine to coarse-grained	■	BH-14-010@ 4-6'			686	5
	▨		**SILTY CLAY** ; brownish gray and green	■	BH-14-010@ 6-8'			549	
	▨		**CLAY** ; moist; multicolored (brown, tan, gray, green)	■	BH-14-010@ 8-10'			458.3	
10	▨		**CLAY WITH GRAVEL** ; multicolored (white, brown, tan, gray)	■	BH-14-010@ 10-12'			741.3	10
	▨		**SANDY SILT** ; dark brown and gray; fine-grained	■	BH-14-010@ 12-14'			831	
15	▨		**GRAVELLY SAND AND SILT** ; reddish brown and gray; bricks	■	1500 BH-14-010 _14-16			907.1	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-011 PAGE 1 OF 1

Aquaterra Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **5/6/15** COMPLETED: **5/8/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**CLAY** ; orange; cohesive	■	1400 BH-14-011 _0-2			501.7	
	▨		**SANDY SILT WITH MEDIUM TO COARSE GRAVEL** ; black	■	BH-14-011@ 2-4'			529.1	
5	▨		**SANDY SILT AND MEDIUM TO COARSE GRAVEL** ; black; bricks and glass	■	BH-14-011@ 4-6'			590.7	5
	▨		**SANDY SILT WITH FINE TO MEDIUM GRAVEL** ; black; oily	■	BH-14-011@ 6-8'			600.3	
	▨		**SANDY SILT** ; black; fine to medium-grained	■	BH-14-011@ 8-10'			716	
10	▨		**SANDY SILT** ; black; fine to medium-grained; bricks and glass	■	BH-14-011@ 10-12'			976.1	10
	▨		**SANDY SILT** ; black; fine-grained; oily, timbers	■	BH-14-011@ 12-14'			1216	
15	▨		**SANDY SILT WITH CLAY** ; black and gray; timbers	■	1200 BH-14-011 _14-16			3882	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-012 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/8/15** COMPLETED: **5/14/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SILTY CLAY** ; orange	■	1200 BH-14-012 _0-2			618.5	
	▨		**SANDY GRAVEL WITH SILT** ; tan; medium to coarse-grained; modified	■	BH-14-012@ 2-4'			60.9	
5	▨			■	BH-14-012@ 4-6'			40.7	5
	▨		**SANDY CLAY WITH SILT AND GRAVEL** ; black; oily sheen, LNAPL, tarry	■	BH-14-012@ 6-8'			525.7	
	▨		**SILTY SAND WITH GRAVEL** ; multi-colored, timbers	■	BH-14-012@ 8-10'			787.6	
10	▨		**GRAVELLY CLAY** ; black; oily, timbers	■	BH-14-012@ 10-12'			989.3	10
	▨			■	BH-14-012@ 12-14'			1107	
15	▨			■	1300 BH-14-012 _14-16			1297	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-013 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/11/15** COMPLETED: **5/11/15**
DRILLING COMPANY: **Sweeney**
DRILLING EQUIPMENT: **Backhoe**
DRILLING METHOD:
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **14.0**
BOREHOLE DIA. (in): **24**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**GRAVEL SOME FINE TO MEDIUM SAND** ; black; fine to coarse-grained; moist; subangular	█	1400 BH-15-013 _0-2			174	
	▨		**SOME FINE TO MEDIUM SAND** ; black; moist; bricks and debris	█	BH-14-013@ 2-4'			169	
5	▨			█	1415 BH-15-013 _4-6			238	5
	▨		**SOME FINE TO COARSE GRAVEL LITTLE FINE TO MEDIUM SAND** ; tan and gray; moist; subangular; bricks, wood, and debris	█	BH-14-013@ 6-8'			223	
	▨			█	BH-14-013@ 8-10'			147	
10	▨			█	BH-14-013@ 10-12'			90.1	10
	▨			█	1430 BH-15-013 _12-14			51.5	
			Borehole terminated at 14 feet.						
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-017 PAGE 1 OF 1

Aquaterra
Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **5/12/15** COMPLETED: **5/12/15**
DRILLING COMPANY: **Sweeney**
DRILLING EQUIPMENT: **Backhoe**
DRILLING METHOD:
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **14.0**
BOREHOLE DIA. (in): **24**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SAND SOME FINE TO MEDIUM GRAVEL** ; grayish tan and black; fine to medium-grained; moist; subangular	■	0900 BH-15-017 _0-2			295	
	▨		**LITTLE FINE TO MEDIUM SAND** ; black; moist	■	BH-14-017@ 2-4'			229	
5	▨		**SANDY CLAY LITTLE FINE TO MEDIUM GRAVEL** ; black; fine to medium-grained; moist to wet; subangular; bricks	■	1030 BH-15-017 _4-6			618	5
	▨		**SANDY CLAY SOME FINE TO MEDIUM GRAVEL LITTLE SILT** ; black; fine to medium-grained; moist to wet; subangular; bricks and debris	■	BH-14-017@ 6-8'			292	
	▨			■	BH-14-017@ 8-10'			146	
10	▨			■	BH-14-017@ 10-12'			99.7	10
	▨			■	1100 BH-15-017 _12-14			94.9	
			Borehole terminated at 14 feet.						
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-018
PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **11/26/14** COMPLETED: **12/12/14**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SANDY CLAY WITH SILT** ; light brown; Utility clearing completed via backhoe to a depth of 10 ft bgs.		1400 BH-14-018 _0-2			6.7	
	▨		**SILTY CLAY** ; black and brown		BH-14-018@ 2-4'			14.8	
5	▨		**CLAY** ; gray and black; Cohesive.		BH-14-018@ 4-6'			48.3	5
	▨		**CLAY** ; Fill (concrete, rebar, steel)		BH-14-018@ 6-8'			86	
	🟩		**CLAY WITH GRAVEL**		BH-14-018@ 8-10'			121.3	
10	🟨		**SAND AND GRAVEL** ; black and white; fine to coarse-grained; moist to wet; Black, white, red, and green in color.	☒	0945 BH-14-018 _10-12	0.5	10 18 14 15	367	10
	🟨		**SAND AND GRAVEL** ; red and brown; fine to medium-grained; moist; Gravel (red, white, and green)	☒	BH-14-018@ 12-14'	0.8	10 18 14 15	207	
15	🟨			☒	BH-14-018@ 14-16'	0.7	12 12 12 9	216	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-019 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **11/26/14** COMPLETED: **12/12/14**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟩		**SANDY CLAY WITH SILT AND GRAVEL** ; dark brown; Utility clearing completed vis backhoe to a depth of 8 ft bgs.		0800 BH-14-019 _0-2			3.3	
	🟩		**CLAY** ; light orangeish brown		BH-14-019@ 2-4'			15.2	
5	🟩		**CLAY** ; dark blueish gray		BH-14-019@ 4-6'			24.1	5
	🟩		**CLAY** ; dark tan to brown		BH-14-019@ 6-8'			53.7	
	🟨		**SAND AND GRAVEL** ; black and white; medium-grained; Black, white, red, and green in color.	☒	BH-14-019@ 8-10'	0.5	15 18 22 15	202	
10	🟨 🟩		**SAND AND GRAVEL** ; dark gray; medium-grained **SILTY CLAY** ; black and gray; moist	☒	1120 BH-14-019 _10-12 BH-14-019@ 11-12'	1,2	6 8 10 11	234 15	10
	🟨		**SAND AND GRAVEL** ; black and green; angular; Black, green, and red in color.	☒	BH-14-019@ 12-14'	0.5	12 11 14 18	103	
15	🟨		**SAND AND GRAVEL** ; red and white; dry; Red, white, green, and gray in color.	☒	BH-14-019@ 14-16'	1.2	21 15 19 20	117	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

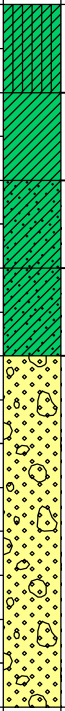
BH-14-020

PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **11/25/14** COMPLETED: **12/12/14**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in):
CHECKED BY:



Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			CLAY WITH SILT ; dark gray to tan; loose; Utility clearing completed via backhoe to a depth of 8 ft bgs.		1400 BH-14-020 _0-2			8.8	
			CLAY ; orangeish brown with tan		BH-14-020@ 2-4'			14.1	
5			**CLAY AND SAND** ; orangeish brown with tan; fine-grained		BH-14-020@ 4-6'			38.1	5
			SANDY CLAY WITH SILT AND GRAVEL ; gray to black; medium-grained		BH-14-020@ 6-8'			56.7	
			SAND AND COARSE GRAVEL ; red and white; medium to coarse-grained; moist; Red, white, and green in color	☒	BH-14-020@ 8-10'	0.8	7 16 18 16	45	
10				☒	BH-14-020@ 10-12'	1	15 14 12 22	52	10
				☒	1035 BH-14-020 _12-14	0.7	18 22 24 25	154	
15				☒	BH-14-020@ 14-16'	1.3	13 16 19 18	97	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-021

PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **11/25/14** COMPLETED: **12/12/14**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
EASTING (ft):
LAT:
LONG:
GROUND ELEV (ft):
TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered**
BOREHOLE DEPTH (ft): **16.0**
WELL CASING DIA. (in): **---**
BOREHOLE DIA. (in):
LOGGED BY: **LM/SS**
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			SANDY CLAY ; orangeish brown; Utility clearing completed via backhoe to a depth of 8 ft bgs.		0800 BH-14-021 _0-2			16.8	
			CLAY ; black		BH-14-021@ 2-4'			45.8	
5			**CLAY** ; gray		BH-14-021@ 4-6'			83.2	5
			CLAY ; blueish gray		BH-14-021@ 6-8'			298.7	
			SILTY SAND ; gray and black; moist	☒	0900 BH-14-021 _8-10	1	3 4 10 15	340	
10			**SAND AND COARSE GRAVEL** ; red and brown; moist	☒	BH-14-021@ 10-12'	0.3	6 8 30 30	292	10
			SAND AND FINE GRAVEL ; red and gray; fine to coarse-grained; rounded; Red, gray, brown, green, and white in color	☒	BH-14-021@ 12-14'	1	12 17 21 22	335	
15				☒	BH-14-021@ 14-16'	0.8	50/1 50/1	309	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-022 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/12/15** COMPLETED: **5/12/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **2.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SANDY GRAVEL SOME CLAY** ; dark brown; fine to medium-grained; dry to moist; subrounded	■	1445 BH-15-022 _0-2			0.6	
			Borehole terminated at 2 feet.						
5									5
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-023 PAGE 1 OF 1

Aquaterra Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **5/12/15** COMPLETED: **5/12/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
EASTING (ft):
LAT:
LONG:
GROUND ELEV (ft):
TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered**
BOREHOLE DEPTH (ft): **2.0**
WELL CASING DIA. (in): **---**
BOREHOLE DIA. (in): **2**
LOGGED BY: **NS**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SILTY CLAY LITTLE FINE TO MEDIUM SAND AND FINE TO MEDIUM GRAVEL** ; yellowish brown; dry to moist; subangular	■	1500 BH-15-023 _0-2			14	
			Borehole terminated at 2 feet.						
5									5
10									10
15									15
20									20
25									25
30									30

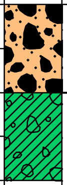
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-024 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **2/24/15** COMPLETED: **2/24/15**
DRILLING COMPANY: **Sweeney**
DRILLING EQUIPMENT: **Backhoe**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Backhoe**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **4.0**
BOREHOLE DIA. (in):
CHECKED BY:



Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			SANDY GRAVEL ; dark gray and black; fine to medium-grained; Utility clearing completed via backhoe to a depth of 4 ft bgs.	■	0900 BH-14-024 _0-2			297.3	
			GRAVELLY CLAY ; black; Boring terminated due to damaged fire line at edge of cleared location.	■	BH-14-024@ 2-4'			894.5	
			CA / Safety ceased work in this work location						
5			Borehole terminated at 4 feet.						5
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

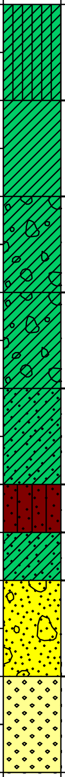
WELL / PROBEHOLE / BOREHOLE NO:
BH-14-025 PAGE 1 OF 1

Aquaterra Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **4/28/15** COMPLETED: **6/2/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **HSA**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger/Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**



Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			SANDY CLAY ; dark gray		1200 BH-14-025 _0-2			487	
			CLAY ; grayish tan and brown		BH-14-025@ 2-4'			522.7	
5			**CLAY WITH FINE GRAVEL** ; grayish tan and brown		BH-14-025@ 4-6'			386.7	5
			CLAY WITH FINE GRAVEL ; brownish gray and black; angular		BH-14-025@ 6-8'			383.7	
			SANDY CLAY WITH SILT AND FINE GRAVEL ; dark red and grayish tan; coarse-grained		BH-14-025@ 8-10'			394.7	
10			**SANDY SILT WITH FINE GRAVEL** ; dark red and brown; fine to coarse-grained		BH-14-025@ 10-11'			399	10
			SANDY CLAY WITH SILT AND FINE GRAVEL ; dark gray; rounded; multicolored gravel (beige, tan, and white)		BH-14-025@ 11-12'			441.3	
			SAND WITH GRAVEL ; red to reddish brown; fine to coarse-grained		BH-14-025@ 12-14'			501.7	
15			**SAND** ; dark brown; medium to coarse-grained; multicolored		1400 BH-14-025 _14-16			964.1	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-026
PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **2/24/15** COMPLETED: **3/3/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			SILTY GRAVEL WITH SAND AND CLAY ; black; Utility clearing completed via backhoe to a depth of 8 ft bgs.		1400 BH-14-026 _0-2			642.7	
			SANDY GRAVEL WITH SILT AND CLAY ; black with dark gray		BH-14-026@ 2-4'			738.1	
5			**CLAY** ; dark gray		BH-14-026@ 4-6'			887.1	5
			CLAY ; dark gray and black		BH-14-026@ 6-8'			1024.7	
			SAND AND CLAY ; gray and brown; fine-grained; moist	☒	BH-14-026@ 8-10'	1.7		192	
10				☒	BH-14-026@ 10-12'	2		262	10
			SANDY CLAY LITTLE FINE GRAVEL ; gray; fine-grained; moist; rounded	☒	BH-14-026@ 12-14'	2		307	
15				☒	1530 BH-14-026 _14-16	2		462	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-028

PAGE 1 OF 1

Aquaterra Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **5/4/15** COMPLETED: **5/4/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **2.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**GRAVELLY SILT** ; light tan	■	1200 BH-14-028 _0-2			17.8	
			Borehole terminated at 2 feet.						
5									5
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-029 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/4/15** COMPLETED: **5/4/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):	EASTING (ft):
LAT:	LONG:
GROUND ELEV (ft):	TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered**	WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered**	BOREHOLE DEPTH (ft): **2.0**
WELL CASING DIA. (in): **---**	BOREHOLE DIA. (in): **2**
LOGGED BY: **LM**	CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**GRAVELLY SILT** ; light tan	■	1300 BH-14-029 _0-2			18.6	
			Borehole terminated at 2 feet.						
5									5
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-030 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/4/15** COMPLETED: **5/4/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **2.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**GRAVELLY SILT** ; dark brown	■	1400 BH-14-030 _0-2			24.8	
			Borehole terminated at 2 feet.						
5									5
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-031
PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/4/15** COMPLETED: **5/4/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **2.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**GRAVELLY SILT** ; dark tan and orange	■	1100 BH-14-031 _0-2			38.6	
			Borehole terminated at 2 feet.						
5									5
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-032 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/12/15** COMPLETED: **5/12/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **2.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SANDY CLAY WITH SILT AND GRAVEL** ; brown and tan	■	0800 BH-14-032 _0-2			8.3	
			Borehole terminated at 2 feet.						
5									5
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-033 PAGE 1 OF 1

Aquaterra Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **5/12/15** COMPLETED: **5/12/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **4.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SANDY GRAVEL WITH SILT** ; brown and tan	■	0900 BH-14-033 _0-2			0.5	
	▨			■	1430 BH-14-033 _2-4			5.7	
			Borehole terminated at 4 feet.						
5									5
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-034 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/12/15** COMPLETED: **5/12/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT:
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **4.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SANDY CLAY WITH SILT AND FINE GRAVEL** ; dark brown	■	0830 BH-14-034 _0-2			4.8	
	▨		**SANDY SILT** ; multicolored, bricks, shells, glass, and debris	■	1400 BH-14-034 _2-4			6.8	
			Borehole terminated at 4 feet.						
5									5
10									10
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-035

PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/14/15** COMPLETED: **5/15/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟧		**SANDY GRAVEL WITH SILT** ; tan and brown	■	0800 BH-14-035 _0-2			557.6	
	🟩		**SANDY CLAY WITH SILT** ; brown and gray	■	BH-14-035@ 2-4'			286.3	
5	🟩		**SILTY CLAY** ; brown; moist	■	BH-14-035@ 4-6'			424	5
	🟥		**SILT** ; brown and gray	■	BH-14-035@ 6-8'			186	
	🟩		**SILTY CLAY** ; dark gray	■	BH-14-035@ 8-10'			385.7	
10	🟩		**CLAY** ; white and tan	■	BH-14-035@ 10-12'			78.1	10
	🟥		**CLAYEY SILT** ; white and tan; multicolored	■	1000 BH-14-035 _12-14			246	
15	🟥			■	1200 BH-14-035 _14-16			163.2	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-036

PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **5/13/15** COMPLETED: **5/14/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**SANDY CLAY WITH SILT** ; dark gray	■	0900 BH-14-036 _0-2			337.6	
	●		**SANDY GRAVEL WITH SILT** ; dark gray and black	■	BH-14-036@ 2-4'			170.2	
5	●			■	BH-14-036@ 4-6'			183.6	5
	▨		**SANDY CLAY WITH SILT** ; dark gray	■	1400 BH-14-036 _6-8			246.8	
	▥		**CLAYEY SILT** ; grayish brown	■	BH-14-036@ 8-10'			87.3	
10	▥		**CLAYEY SILT** ; brown to orange	■	BH-14-036@ 10-12'			47.5	10
	▨		**CLAY** ; whiteish orange and gray	■	BH-14-036@ 12-14'			100.1	
15	▨			■	BH-14-036@ 14-16'			46.7	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**	WELL / PROBEHOLE / BOREHOLE NO:	Aquaterra Technologies, Inc.
LOCATION: **AOI-1**	**BH-14-038** PAGE 1 OF 1	
PROJECT NUMBER:		

DRILLING / INSTALLATION:	NORTHING (ft):	EASTING (ft):
STARTED **5/1/15** COMPLETED: **5/5/15**	LAT:	LONG:
	GROUND ELEV (ft):	TOC ELEV (ft):
DRILLING COMPANY: **Sweeney**	INITIAL DTW (ft): **Not Encountered**	WELL DEPTH (ft): **---**
DRILLING EQUIPMENT: **Backhoe**	STATIC DTW (ft): **Not Encountered**	BOREHOLE DEPTH (ft): **16.0**
DRILLING METHOD:	WELL CASING DIA. (in): **---**	BOREHOLE DIA. (in): **2**
SAMPLING EQUIPMENT:	LOGGED BY: **LM**	CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▩		**SANDY GRAVEL WITH SILT** ; light brown to dark brown	■	0800 BH-14-038 _0-2			89.0	
	▩		**SANDY CLAY WITH SILT** ; dark gray and brown; timbers	■	BH-14-038@ 2-4'			283.1	
5	🟥		**SANDY SILT** ; dark brown and green	■	BH-14-038@ 4-6'			397.1	5
	🟩		**SILTY CLAY** ; dark olive green and gray; wet	■	BH-14-038@ 6-7'			364.7	
	▨		**CLAY** ; dark gray	■	BH-14-038@ 7-8'			768.1	
	▨			■	BH-14-038@ 8-10'			841.3	
10	▨		**CLAY** ; dark gray and brown	■	BH-14-038@ 10-12'			858.3	10
	🟧		**SANDY GRAVEL WITH SILT** ; dark tannish brown and reddish brown	■	0800 BH-14-038 _12-13			874.1	
15	🟧		**SANDY GRAVEL WITH SILT** ; reddish brown	■	0900 BH-14-038 _13-15			750.7	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-039 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **2/17/15** COMPLETED: **2/17/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
EASTING (ft):
LAT:
LONG:
GROUND ELEV (ft):
TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered**
BOREHOLE DEPTH (ft): **15.0**
WELL CASING DIA. (in): **---**
BOREHOLE DIA. (in):
LOGGED BY: **LM/TD**
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟩		**CLAY WITH GRAVEL AND SILT** ; dark gray and black; hydrocarbon staining; angular; Utility clearing completed via backhoe to a depth of 8 ft bgs. Black staining.		1400 BH-14-039 _0-2			410.7	
	🟩		**CLAY WITH FINE GRAVEL AND SILT** ; dark gray and black; fine-grained		BH-14-039@ 2-4'			37.3	
5	🟩		**CLAY** ; dark gray; Cohesive.		BH-14-039@ 4-6'			48.1	5
	🟩				BH-14-039@ 6-8'			156.1	
	🟨		**SANDY CLAY** ; dark brown; wet **SAND WITH SILT** ; black; fine to coarse-grained; wet	☒	1530 BH-14-039 _8-10	1.2		582.5	
10	🟨		**SAND AND FINE TO COARSE GRAVEL** ; reddish brown; fine to coarse-grained; moist; (Trenton).	☒	BH-14-039@ 10-12'	0.5		98.8	10
	🟨			☒	BH-14-039@ 12-14'	1		74.4	
	🟨			☒	BH-14-039@ 14-15'	0.5		48.4	
15			Borehole terminated at 15 feet.						15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-040
PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **2/16/15** COMPLETED: **2/17/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM/TD**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **15.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟩		**SANDY CLAY WITH SILT AND FINE GRAVEL** ; orangeish brown and dark gray; fine-grained; rounded; Utility clearing completed via backhoe to a depth of 8 ft bgs.		1100 BH-14-040 _0-2			0.8	
	🟫		**SANDY GRAVEL WITH SILT** ; dark brown		BH-14-040@ 2-4'			1.6	
5	🟩		**GRAVELLY CLAY** ; dark gray		BH-14-040@ 4-6'			226.7	5
	🟩		**CLAY** ; dark gray and tan		BH-14-040@ 6-8'			348.7	
	🟨		**SAND AND FINE TO COARSE GRAVEL** ; reddish brown; fine to coarse-grained; wet; (Trenton). Poorly sorted.	☒	BH-14-040@ 8-10'	1		18.8	
10	🟨		**SAND AND GRAVEL** ; reddish brown; fine to coarse-grained; wet to moist; (Trenton). Fewer and finer gravel than previous sample.	☒	BH-14-040@ 10-12'	1		268.3	10
	🟨			☒	BH-14-040@ 12-14'	1		371.3	
	🟨			☒	1320 BH-14-040 _14-15	0.7		473.6	
15			Borehole terminated at 15 feet.						15
20									20
25									25
30									30

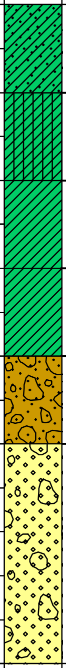
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-041 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **2/16/15** COMPLETED: **2/17/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM/TD**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **15.0**
BOREHOLE DIA. (in):
CHECKED BY:



Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			SANDY CLAY WITH SILT ; dark brown to tan; Utility clearing completed via backhoe to a depth of 8 ft bgs.		0900 BH-14-041 _0-2			0.8	
			SILTY CLAY ; dark gray with brown; Dark gray with brown streaks in color.		BH-14-041@ 2-4'			1.8	
5			**CLAY** ; dark gray with brown; Dark gray with brown streaks in color.		BH-14-041@ 4-6'			2.8	5
			CLAY ; dark gray with brown; moist; Dark gray with brown streaks in color.		BH-14-041@ 6-8'			30.1	
			GRAVEL WITH MEDIUM TO COARSE SAND ; gray and red; moist; Multi-colored quartzite gravel. (Trenton).	☒	BH-14-041@ 8-10'	0.7		83.2	
10			**SAND SOME FINE TO MEDIUM GRAVEL** ; reddish brown; fine to coarse-grained; Poorly sorted, heterogeneous.	☒	1254 BH-14-041 _10-12	1.1		195.5	10
				☒	BH-14-041@ 12-14'	1.5		152.6	
				☒	BH-14-041@ 14-15'	0.7		131.8	
15			Borehole terminated at 15 feet.						15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-042 PAGE 1 OF 1

Aquaterra Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **5/7/15** COMPLETED: **5/7/15**
DRILLING COMPANY: **Sweeney**
DRILLING EQUIPMENT: **Backhoe**
DRILLING METHOD:
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **14.0**
BOREHOLE DIA. (in): **24**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟩		**SILTY CLAY TRACE FINE TO MEDIUM GRAVEL** ; black and gray; moist; subangular	■	1300 BH-15-042 _0-2			87.5	
	🟩		**SILTY CLAY** ; black and gray; moist	■	BH-14-042@ 2-4'			124	
5	🟩		**SILTY CLAY TRACE FINE TO MEDIUM SAND** ; gray and brown; moist to dry	■	BH-14-042@ 4-6'			62.1	5
	🟨		**SILTY SAND LITTLE MEDIUM TO COARSE GRAVEL** ; gray and dark brown; fine-grained; moist; subrounded; slightly micaceous	■	1400 BH-15-042 _6-8			437	
	🟨		**SAND LITTLE FINE GRAVEL** ; gray; fine to medium-grained; moist to wet; subrounded	■	BH-14-042@ 8-10'			420	
10	🟨		**SAND LITTLE SILT TRACE FINE TO MEDIUM GRAVEL** ; gray; fine to medium-grained; wet; subrounded; water seepage at 11 feet bgs.	■	BH-14-042@ 10-12'			379	10
	🟩		**CLAY LITTLE SILT LITTLE FINE GRAVEL** ; orangeish brown; moist; subrounded	■	BH-14-042@ 12-14'			2.6	
			Borehole terminated at 14 feet.						
15									15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-043

PAGE 1 OF 1

Aquaterra
Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **5/8/15** COMPLETED: **5/8/15**
DRILLING COMPANY: **Sweeney**
DRILLING EQUIPMENT: **Backhoe**
DRILLING METHOD:
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **14.0**
BOREHOLE DIA. (in): **24**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟥		**GRAVELLY SILT LITTLE FINE TO MEDIUM SAND TRACE CLAY** ; brown and orangeish brown; fine to medium-grained; moist; subangular	■	0930 BH-15-043_0-2			18.6	
	🟩		**SILTY CLAY TRACE FINE TO MEDIUM GRAVEL** ; gray; moist; subangular	■	BH-14-043@2-4'			35.3	
5	🟩			■	BH-14-043@4-6'			116.9	5
	🟩		**CLAY LITTLE FINE TO MEDIUM SAND TRACE FINE TO MEDIUM GRAVEL** ; gray and black; moist; subangular	■	1130 BH-15-043_6-8			198	
	🟨		**SILTY SAND LITTLE FINE GRAVEL** ; dark gray; fine to medium-grained; moist to wet; subrounded	■	BH-14-043@8-10'			159	
10	🟩		**CLAY LITTLE SILT LITTLE FINE GRAVEL** ; dark brown; moist; subrounded	■	BH-14-043@10-12'			25.2	10
	🟩		**CLAY LITTLE SILT** ; orangeish brown and grayish brown; moist; mottled	■	BH-14-043@12-14'			18.3	
15			Borehole terminated at 14 feet.						15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-044 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **2/17/15** COMPLETED: **2/17/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM/TD**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **15.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			SILTY CLAY ; orange to brown; Utility clearing completed via backhoe to a depth of 8 ft bgs.		1230 BH-14-044 _0-2			0.9	
			CLAY ; orange and gray		BH-14-044@ 2-4'			48.4	
5			**CLAY** ; Very cohesive.		BH-14-044@ 4-6'			10.6	5
			GRAVELLY CLAY WITH SILT SOME SAND ; gray to black		BH-14-044@ 6-8'			117.9	
			SILTY SAND ; gray; fine-grained; soft; moist; mottled	☒	BH-14-044@ 8-9'	2		17.6	
10			**SANDY CLAY WITH SILT** ; light gray and orange; fine-grained; very stiff; moist; mottled		BH-14-044@ 9-10'			3.7	10
			SAND AND COARSE GRAVEL SOME CLAY	☒	BH-14-044@ 10-12'	0.5		20.6	
			SAND AND FINE GRAVEL ; orangeish brown; fine to coarse-grained; moist	☒	1425 BH-14-044 _12-14	2		528.6	
				☒	BH-14-044@ 14-15'	1		353.1	
15			Borehole terminated at 15 feet.						15
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-045

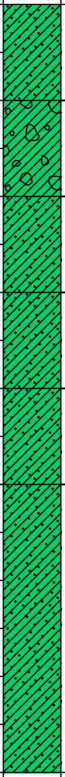
PAGE 1 OF 1

Aquaterra Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **4/29/15** COMPLETED: **5/1/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Jackhammer with spoon**
DRILLING METHOD:
SAMPLING EQUIPMENT: **Hand Auger to 8 feet**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**



Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			SANDY CLAY WITH GRAVEL ; dark orange		1400 BH-14-045 _0-2			0.8	
			GRAVELLY CLAY ; dark gray and light gray		BH-14-045@ 2-4'			395	
5			**SANDY CLAY WITH SILT** ; dark gray		BH-14-045@ 4-6'			433.9	5
			SANDY CLAY WITH SILT ; dark gray; moist		BH-14-045@ 6-8'			530.5	
			SANDY CLAY WITH SILT ; reddish orange and dark gray		1200 BH-14-045 _8-10			916.1	
10			**SANDY CLAY WITH SILT** ; orangeish brown and dark gray		BH-14-045@ 10-12'			514	10
					BH-14-045@ 12-14'			509	
15					BH-14-045@ 14-16'			496	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-046 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **2/18/15** COMPLETED: **2/18/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟩		**SANDY CLAY WITH SILT AND GRAVEL** ; orangeish brown; Utility clearing completed via backhoe to a depth of 8 ft bgs.		0900 BH-14-046 _0-2			0.7	
	🟥		**SILT WITH CLAY** ; black with gray		BH-14-046@ 2-4'			420.7	
5	🟥		**SANDY SILT WITH FINE GRAVEL** ; brown; rounded		BH-14-046@ 4-6'			307	5
			No description.		BH-14-046@ 6-8'			284.1	
	🟨		**SILTY SAND AND GRAVEL** ; red and brown; dry; Gray and white mixed gravel.	☒	BH-14-046@ 8-10'	2		419	
10	🟨		**SAND AND GRAVEL** ; red and white; medium to coarse-grained; wet; Red, white and gray mixed gravel.	☒	BH-14-046@ 10-12'	2		753	10
	🟨		**SAND AND GRAVEL** ; red and white; medium to coarse-grained; wet; Red, white, green, and gray mixed gravel. Visible LNAPL.	☒	BH-14-046@ 12-14'	2		1001	
15	🟨			☒	1320 BH-14-046 _14-16	0.7		1017	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-047 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **11/21/14** COMPLETED: **2/18/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**GRAVELLY CLAY** ; reddish brown; Utility clearing completed via backhoe to a depth of 8 ft bgs.	■	0900 BH-14-047 _0-2			60.6	
	▨		**GRAVELLY CLAY WITH SILT** ; black	■	BH-14-047@ 2-4'			178.3	
5	▨		**CLAY WITH SILT AND SAND** ; gray; Silty sand white, black, and brown in color.	■	BH-14-047@ 4-6'			285.4	5
	▨		**CLAY** ; gray to reddish brown	■	BH-14-047@ 6-8'			388.5	
	░		**SAND WITH GRAVEL** ; brown; medium-grained; moist; rounded	☒	BH-14-047@ 8-10'	2		390	
10	░		**SAND AND COARSE GRAVEL** ; red and brown; dry; Red, brown, and white in color. Mixed sand and gravel.	☒	BH-14-047@ 10-12'	2		797	10
	░		**SAND AND GRAVEL** ; red and brown; moist; rounded; Red, brown, and white mixed sand. Green, red, and white mixed gravel.	☒	1000 BH-14-047 _12-14	2		991	
15	░		**SAND AND FINE GRAVEL** ; red and green; medium to coarse-grained; wet; rounded; Red, green, brown, white, and gray in color.	☒	BH-14-047@ 14-16'	0.7		922	15
20 25 30			Borehole terminated at 16 feet.						20 25 30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-14-048 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **11/24/14** COMPLETED: **12/12/14**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**GRAVEL WITH SAND AND SILT** ; white and tannish brown; medium-grained; Utility clearing completed via backhoe to a depth of 8 ft bgs. Gravel (ballast) **CLAY** ; brown and gray		0830 BH-14-048 _0-2			30.0	
	▨		**SANDY SILT WITH CLAY** ; black and dark gray		BH-14-048@ 2-4'			45.2	
5	▨		**GRAVEL** ; medium-grained; Gravel (ballast)		BH-14-048@ 4-6'			67.3	5
	🟩		**SANDY CLAY WITH SILT** ; coarse-grained		BH-14-048@ 6-8'			193.8	
	🟩		**SANDY CLAY** ; gray and brown; fine-grained; moist	☒	BH-14-048@ 8-10'	1.7	2 3 4 7	30	
10	🟨		**SAND LITTLE CLAY** ; gray and brown; fine-grained; moist	☒	BH-14-048@ 10-12'	0.8	3 4 8 12	15	10
	🟩		**SILTY CLAY LITTLE FINE SAND** ; gray and brown; fine-grained; moist	☒	BH-14-048@ 12-14'	1.5	6 10 15 18	8	
15	🟨		**SILTY SAND AND FINE GRAVEL** ; gray and brown; fine-grained; moist; rounded; Gravel (gray, white, and red)	☒	1220 BH-14-048 _14-16	1	12 15 20 19	124	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
BH-14-049 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **11/24/14** COMPLETED: **2/18/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM//SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	🟩		**CLAY WITH SILT** ; brown with dark gray; Utility clearing completed via backhoe to a depth of 8 ft bgs.		1400 BH-14-049 _0-2			55.2	
	🟩		**CLAY** ; orangeish brown and tan		BH-14-049@ 2-4'			78.1	
5	🟩		**CLAY** ; blueish gray; Cohesive.		BH-14-049@ 4-6'			143.1	5
	🟩		**CLAY WITH GRAVEL** ; blueish gray		BH-14-049@ 6-8'			253	
	🟥		**SILT WITH SAND AND COARSE GRAVEL** ; brown; dry; rounded; Gravel red, green, white in color.	☒	BH-14-049@ 8-10'	0.7		0.9	
10	🟥		**SAND WITH SAND AND COARSE GRAVEL** ; gray and dark gray; dry to moist; rounded	☒	BH-14-049@ 10-12'	2		100.4	10
	🟥			☒	BH-14-049@ 12-14'	2		386	
15	🟨		**SAND AND GRAVEL TRACE SILT** ; brown and gray; fine to coarse-grained	☒	0845 BH-14-049 _14-16	1		462	15
			Borehole terminated at 16 feet.						
20									20
25									25
30									30

PROJECT: **2015-11_PHL_AOI1_Boring Installations**
LOCATION: **PHL AOI1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-15-001 PAGE 1 OF 1

Aquaterra Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **11/24/15** COMPLETED: **11/24/15**
DRILLING COMPANY: **Sweeney**
DRILLING EQUIPMENT: **Backhoe**
DRILLING METHOD: **Backhoe**
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
EASTING (ft):
LAT:
LONG:
GROUND ELEV (ft):
TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered**
BOREHOLE DEPTH (ft): **15.0**
WELL CASING DIA. (in): **---**
BOREHOLE DIA. (in): **12**
LOGGED BY: **NS**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▩		**SANDY SILT LITTLE GRAVEL** ; black; fine to coarse-grained; moist; subangular; Fill (glass, bricks, debris)	■	BH-15-001@ 0-2'			1.0	
	▩		**SILTY CLAY LITTLE GRAVEL** ; brownish gray; fine-grained; moist; subangular; Fill (bricks)	■	BH-15-001@ 2-4'			1.6	
5	🟩		**SILTY CLAY SOME SAND** ; brownish gray; fine to medium-grained; moist	■	BH-15-001@ 4-6'			1.7	5
	🟩			■	BH-15-001@ 6-8'			0.6	
	🟩		**SILTY CLAY LITTLE SAND LITTLE GRAVEL** ; brownish gray; fine to medium-grained; moist; subrounded	■	BH-15-001@ 8-10'			1.0	
10	🟨		**SILTY SAND TRACE GRAVEL** ; grayish brown; fine to medium-grained; moist to wet; subrounded; Wet at 13 feet bgs	■	BH-15-001@ 10-12'			6.5	10
	🟨			■	BH-15-001@ 12-14'			0.8	
	🟨			■	1300 BH-15-001 _14-15			1.0	
15			Borehole terminated at 15 feet.						15

PROJECT: **2015-11_PHL_AOI1_Boring Installations**
LOCATION: **PHL AOI1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-15-002 PAGE 1 OF 1

Aquaterra
Technologies, Inc.

DRILLING / INSTALLATION:
STARTED **11/24/15** COMPLETED: **11/24/15**
DRILLING COMPANY: **Sweeney**
DRILLING EQUIPMENT: **Backhoe**
DRILLING METHOD: **Backhoe**
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **16.0**
BOREHOLE DIA. (in): **12**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			SANDY SILT SOME GRAVEL LITTLE CLAY ; black; fine to medium-grained; moist; subangular; Fill (glass, wood, bricks, debris)						
					1415 BH-15-002 _0-2			176.4	
					BH-15-002@ 2-4'			215.1	
5					BH-15-002@ 4-6'			272.6	5
			SILTY CLAY ; light gray; moist; Fill						
					BH-15-002@ 6-8'			113.9	
			SANDY CLAY ; gray; moist to wet						
					BH-15-002@ 8-10'			518.0	
10									10
					BH-15-002@ 10-12'			1197	
					BH-15-002@ 12-14'			1037	
15					1430 BH-15-002 _14-16			1199	15

Borehole terminated at 16 feet.

PROJECT: **2015-11_PHL_AOI1_Boring Installations**
LOCATION: **PHL AOI1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-15-003 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **12/10/15** COMPLETED: **12/10/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT: **Hand Auger**
DRILLING METHOD: **Hand Auger**
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **---**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **---**
BOREHOLE DEPTH (ft): **2.0**
BOREHOLE DIA. (in): **2**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**GRAVEL** ; tan; dry; Fill	■	0700 BH-15-003 _1-2			0.0	
	▨		**SANDY SILT** ; brown; dry; Fill	■					
			Borehole terminated at 2 feet.						
5									5
10									10
15									15

PROJECT: **2015-11_PHL_AOI1_Boring Installations**
LOCATION: **PHL AOI1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

BH-15-004

PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **12/10/15** COMPLETED: **12/10/15**
DRILLING COMPANY: **Aquaterra**
DRILLING EQUIPMENT: **Hand Auger**
DRILLING METHOD: **Hand Auger**
SAMPLING EQUIPMENT: **Hand Auger**

NORTHING (ft):
EASTING (ft):
LAT:
LONG:
GROUND ELEV (ft):
TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered**
BOREHOLE DEPTH (ft): **2.0**
WELL CASING DIA. (in): **---**
BOREHOLE DIA. (in): **2**
LOGGED BY: **LM**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	▨		**GRAVEL** ; dry; Fill	■	0730 sample not analyzed			0.0	
	▨		**SANDY SILT** ; tan and orangeish brown; dry; Fill	■					
			Borehole terminated at 2 feet.						
5									5
10									10
15									15

Aquaterra
Technologies, Inc.

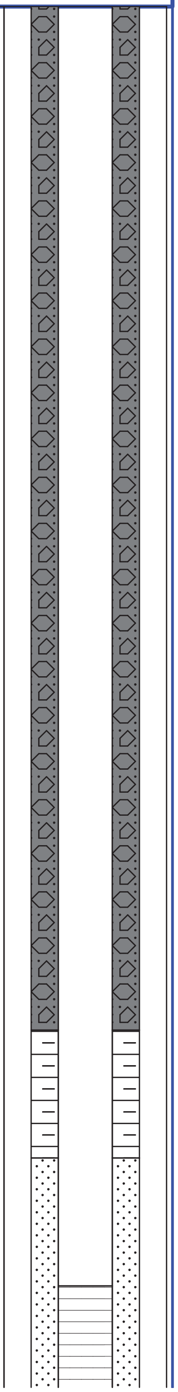
MONITORING WELL LOG: Arco-1

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **Arco Property**
JOB NO.:
LOGGED BY: **Tiffani Doerr**
DATES DRILLED: **6/28/11**
TOTAL DEPTH: **40'**

DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD: **Split Spoons**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **8"**
ELEVATION:

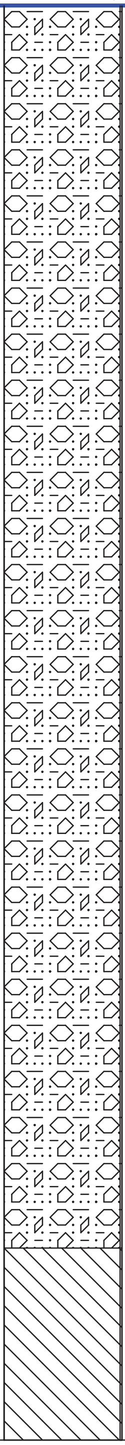
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
0					
				Sample 0'-2' for laboratory analysis	4" PVC - Stick Up 2' Grout 0-16'
	0.0		FILL: orange-brown silty sand w/few fine gravel and brick/slag frags, sl moist, no odor. Same to 9'.	Borehole cleared to 5' for utilities via air knife	
-5					
	0.0				
	0.0				
	0.0				
	0.0		Orange and gray layered SILT, moist.		
-10	0.0		Same; very moist.		4" PVC - Riser 0-20'
	0.0				
	0.0		Same with few very fine sands. Same to 15'.		
	0.0				
	0.0				
-15	0.0		SAND and GRAVEL: fine-coarse multi-colored quartz and quartzite gravels up to 1.5", poorly sorted, semi-round.		
	0.0				Bentonite 16-18'
	0.0		Same w/layer of fine-medium sand from 17.5'-18'.		
	0.0		Same SAND and GRAVEL, moist.		Sand 18-40'
	0.0				
-20	0.0		No recovery - pushed large gravel.		
	0.0				

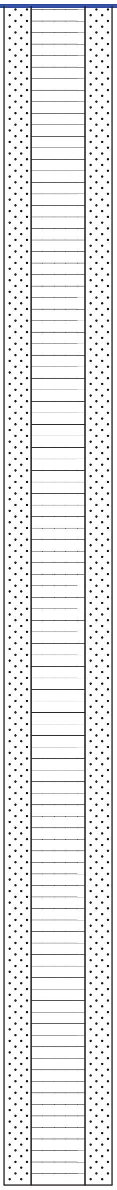
WELL DIAGRAM



MONITORING WELL LOG: Arco-1

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.0		Same.		4" PVC - Screen 20-40'	
	0.0					
	0.0		Same - saturated. Slight old petroleum odor, too coarse to sample for lab analysis, mostly gravels.			
-25	0.0					
			No recovery - pushed large gravel.			
	1047		Same SAND and GRAVEL with 2" sand in bottom of spoon. Sheen.			
-30			Same as 28'-30' (able to sample sand layers for lab analysis; sample from 29.5-32').	Sample 29.5'-32' for laboratory analysis		
	142					
	1250		Medium SAND with few fine GRAVEL; yellow/gray/brown.			
	1213					
			Coarse SAND with less and smaller GRAVEL.			
-35	415					
	1710		Yellow/gray/brown fine-medium SAND with trace fine GRAVEL to 39'			
	1392					
	237					
			39'-40' red sandstone fragments then multi-colored SAND and GRAVEL.			
	0.0					
-40			40'-42' spoon no recovery - rock in tip; however, second foot (41'-42' pushed easilly; probably top of clay)			
				Sample 41'-42' for laboratory analysis		
	0.0		Red-gray CLAY; trace fine gravel.			





Aquaterra Technologies, Inc.

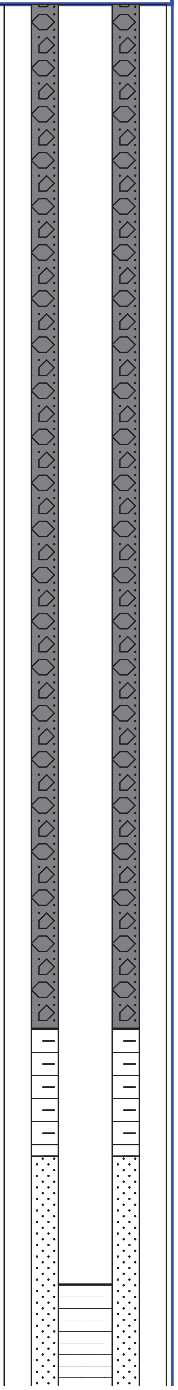
MONITORING WELL LOG: Arco-1

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **Arco Property**
JOB NO.:
LOGGED BY: **Tiffani Doerr**
DATES DRILLED: **6/28/11**
TOTAL DEPTH: **40'**

DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD: **Split Spoons**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **8"**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
0					4" PVC - Stick Up 2'
				Sample 0'-2' for laboratory analysis	Grout 0-16'
	0.0		FILL: orange-brown silty sand w/few fine gravel and brick/slag frags, sl moist, no odor. Same to 9'.	Borehole cleared to 5' for utilities via air knife	
-5					
	0.0				
	0.0				
	0.0				
	0.0		Orange and gray layered SILT, moist.		
-10	0.0		Same; very moist.		4" PVC - Riser 0-20'
	0.0				
	0.0		Same with few very fine sands. Same to 15'.		
	0.0				
	0.0				
-15	0.0		SAND and GRAVEL: fine-coarse multi-colored quartz and quartzite gravels up to 1.5", poorly sorted, semi-round.		
	0.0				Bentonite 16-18'
	0.0		Same w/layer of fine-medium sand from 17.5'-18'.		
	0.0		Same SAND and GRAVEL, moist.		Sand 18-40'
	0.0				
-20	0.0		No recovery - pushed large gravel.		
	0.0				

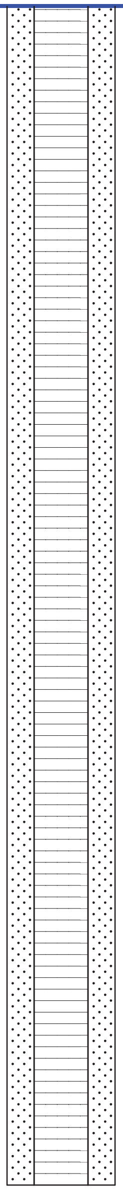
WELL DIAGRAM



MONITORING WELL LOG: Arco-1

Aquaterra Technologies, Inc.

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.0		Same.		4" PVC - Screen 20-40'	
	0.0					
	0.0		Same - saturated. Slight old petroleum odor, too coarse to sample for lab analysis, mostly gravels.			
-25	0.0					
			No recovery - pushed large gravel.			
	1047		Same SAND and GRAVEL with 2" sand in bottom of spoon. Sheen.			
-30			Same as 28'-30' (able to sample sand layers for lab analysis; sample from 29.5-32').	Sample 29.5'-32' for laboratory analysis		
	142					
	1250		Medium SAND with few fine GRAVEL; yellow/gray/brown.			
	1213					
			Coarse SAND with less and smaller GRAVEL.			
-35	415					
	1710		Yellow/gray/brown fine-medium SAND with trace fine GRAVEL to 39'			
	1392					
	237					
			39'-40' red sandstone fragments then multi-colored SAND and GRAVEL.			
	0.0					
-40			40'-42' spoon no recovery - rock in tip; however, second foot (41'-42' pushed easilly; probably top of clay)			
				Sample 41'-42' for laboratory analysis		
	0.0		Red-gray CLAY; trace fine gravel.			



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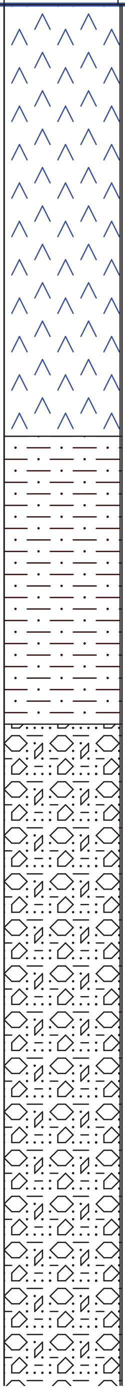
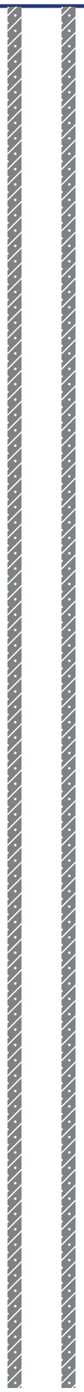
MONITORING WELL LOG: **Arco-1D**

PROJECT:	**Sunoco-Philadelphia Refinery**	DRILLING CO.:	**Parratt Wolff**
SITE LOCATION:	**Arco Property**	DRILLING METHOD:	**Hollow Stem Auger & Mud Rotary**
JOB NO.:		SAMPLING METHOD:	**Split Spoons**
LOGGED BY:	**Tiffani Doerr**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**7/6/11-7/7/11**	WELLBORE DIAMETER:	**6.25"**
TOTAL DEPTH:	**75'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Deep well installed adjacent to shallow well Arco-1; deep well augered to approximate depth of shallow well prior to collection of any split spoons. Logged soil begins at 43' - use shallow log for shallow lithology in this location.	Sample recovery full unless otherwise noted. Cleared for utilities via air knife to 5'		
-5						
-10					Grout slurry (0'-61')	
-15						
-20						
-25						



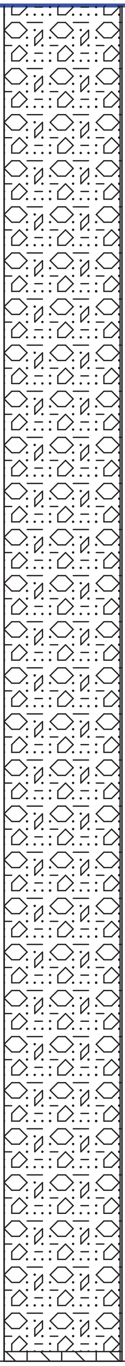
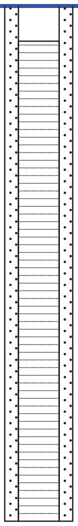


Aquaterra
Technologies, Inc.

MONITORING WELL LOG: Arco-1D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-30						
-35						
-40	0.0					
	0.0		Red-gray CLAY with few very fine gray sand laminations. Clay becomes loose with some gravles from 45' to 46'.			
	0.0			44' Sample submitted to laboratory for analysis		
-45	0.0					
	0.0		At 46.8' orange laminated clayey fine SAND.			
	0.0		Loose light brown clayey fine SAND with some orange zones. 2" medium-coarse sand at 48'. White quartzite gravel at 49'. No recovery 49'-51'.	47' Sample submitted to laboratory for analysis		
	0.0					
-50						
	0.0		Coarse gray SAND with layers of gray clayey sand and orange clayey sand. Possible very weathered petroleum odor.			
	0.0					
-55						
			Gray fine plastic SAND.			
-60						
					Bentonite (61'-63')	
			Hard drilling from 61.5' to 67' - attempt spoon at 63', no recovery.			
					Sand (63'-75')	

MONITORING WELL LOG: Arco-1D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-65					Screen (65'-75')	
			Attempt spoon at 68' - no recovery.			
-70						
	0.0		Yellow fine-coarse GRAVEL (quartz and quartzite) with few fines. Difficult drilling on tough gravels.			
-75						
-80						
-85				Attempts to rheem borehole for well installation difficult due to swelling of clay layer and loose gravles. After numerous attempts, could only get well screen to 75' depth.		
-90			At 92.5' - hit solid layer (no sound of gravels) - no recovery in spoon, but used sieve to screen cuttings - black and silver mica flakes in cuttings. SCHIST.			

Aquaterra
Technologies, Inc.

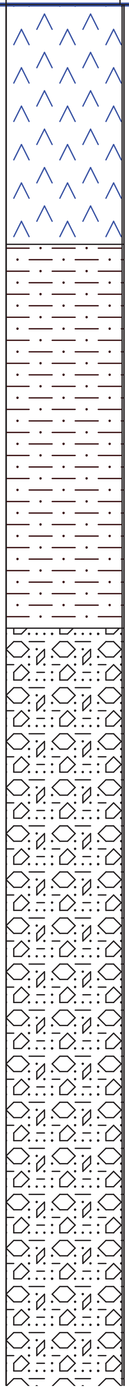
MONITORING WELL LOG: **Arco-2**

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **Arco Property**
JOB NO.:
LOGGED BY: **Tiffani Doerr**
DATES DRILLED: **6/28/11-6/29/11**
TOTAL DEPTH: **39'**

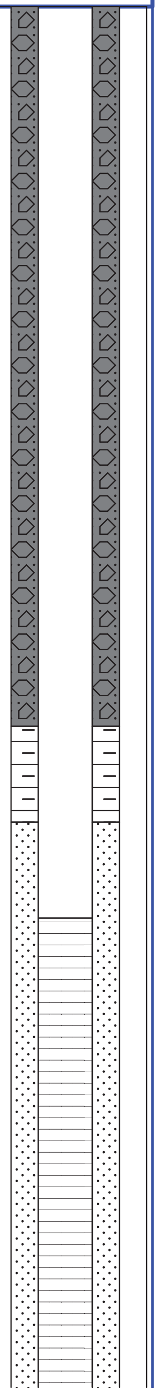
DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD: **Split Spoons**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **8"**
ELEVATION:

Depth (feet)	OVM (ppm)	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
				4" PVC - Stick Up 2' Grout 0-15'
			Sample at 0'-2' for lab analysis.	
	0.0	FILL to 5'	Borehole cleared to 5' for utilities via air knife	
-5		Medium brown, moist, sl plastic very fine sandy SILT to 7'.		
	0.0			
	0.0	Gray-brown SILT, moist, no odors.		
	0.0	No recovery; lg pink quartzite in tip		
	0.0			
-10	0.0	Orange and gray layered SILT to 13'.		4" PVC - Riser 0-19'
	0.0			
	0.0			
	0.0	SAND and GRAVEL: multi-colored sands and gravels, overall reddish brown color.		
	0.0			
-15	0.0			
	0.0	Same		Bentonite 15-17'
	0.0			
	0.0	Same		Sand 17-39'
	0.0			
-20	0.0	Very hard drilling - no recovery		
	0.0			
	0.0	Same - moist, no odors		4" PVC - Screen 19-39'
	0.0			
	0.0	Same - saturated, no odors.	Sample at 24'-26' for lab analysis.	
-25	0.0			
	0.0	Same		
	0.0			
		Same - 4" recovery. Possible		

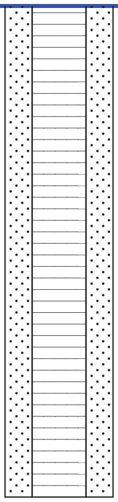
USCS



WELL DIAGRAM



MONITORING WELL LOG: Arco-2

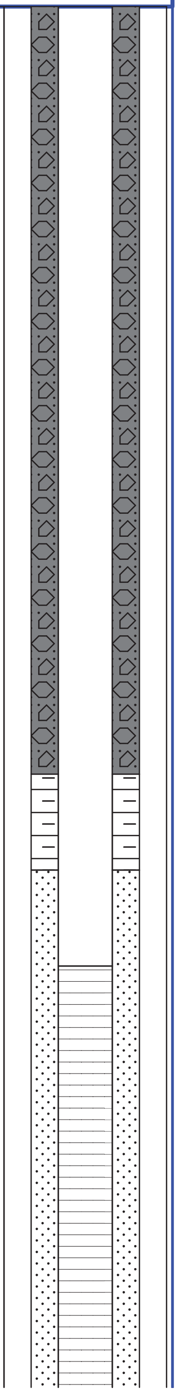
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	14		sheen			
-30			Same - 2" gray-brown sand layer at bottom of spoon.	Sample at 30'-32' for lab analysis.		
	1321					
	1218		Mostly coarse SAND w/ few fine-medium GRAVELS			
	1257					
	1254		Same with trace fine gravels			
-35	1333					
	989		Same			
	0.0					
	0.0		Same - transition from red-brn sand to yellow sand to gray sand at bottom			
	0.0					
-40	0.0		Gray CLAY w/reddish layers to 41.5'.	Sample at 40' for lab analysis.		
			Orange fine SAND and CLAY.			

Aquaterra Technologies, Inc.

MONITORING WELL LOG: **Arco-3**

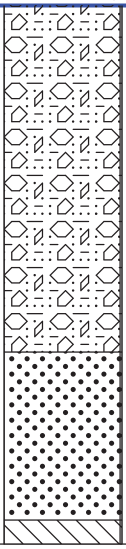
PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **Arco Property**
JOB NO.:
LOGGED BY: **Tiffani Doerr**
DATES DRILLED: **6/29/11**
TOTAL DEPTH: **40'**

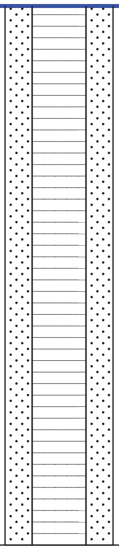
DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD: **Split Spoons**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **8"**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0					4" PVC - Stick Up 2' Grout 0-16'	
				Sample at 0'-2' for lab analysis.		
			FILL to 5'	Borehole cleared to 5' for utilities via air knife		
-5	0.0		Sl plastic, orange-brown, moist sandy SILT to 8'.			
	0.0					
	0.0		Orange fine sandy SILT into gray silt to 11'. Multi-colored layers, varyous amounts of fine sand and clay.			
	0.0					
-10	0.0				4" PVC - Riser 0-20'	
	0.0		Alt layers of reddish gray fine and medium SAND.			
	0.0		SAND and GRAVEL: multi-colored sands and gravels, overall reddish brown color; 20% gravel.			
	0.0					
			No recovery			
-15						
	0.0		Same, moist.		Bentonite 16-18'	
	0.0					
	0.0		Same		Sand 18-40'	
	0.0					
-20	0.0		Fine sand grading into coarse sand with trace gravel near bottom - fining up sequence.			
	0.0					
	0.0		Same - saturated at 23'.		4" PVC - Screen 20-40'	
	1581			Sample at 23'-24' for lab analysis.		
			Same.			
-25	1252					
			Brown gray fine-coarse gravel (green and red).			
	1606					
			Same - less gravel (10%)			

MONITORING WELL LOG: Arco-3

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	1804					
-30			Same - trace gravel.			
	1765					
			Same			
	233					
			Same			
-35	223					
			Same - no gravel.			
	243					
	267		Orange-gray fine-coarse SAND, no gravel with 3" gray sandy CLAY in bottom.			
-40						





Company Confidential

PIEZOMETER INSTALLATION REPORT

A01 1

Piezometer No. AS-6

Location See Fig.

Date 2/11/82 Time

Project ARCO REFINERY

Project No. 81C2256 Installed By SLG

Method of Installation Hollow stem auger

LOG OF BORING AND PIEZOMETER

BORING

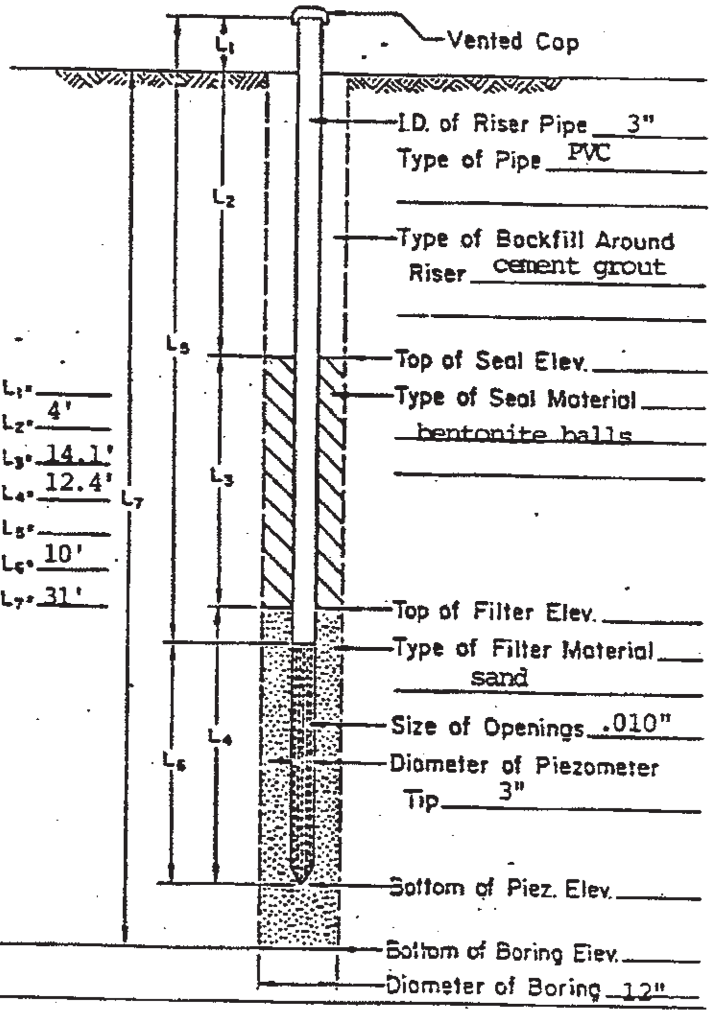
Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer PVC

Ground Elev.

Top of Riser Elev.



L1= 4'

L2=

L3= 14.1'

L4= 12.4'

L5=

L6= 10'

L7= 31'

I.D. of Riser Pipe 3"

Type of Pipe PVC

Type of Backfill Around Riser cement grout

Top of Seal Elev.

Type of Seal Material bentonite balls

Top of Filter Elev.

Type of Filter Material sand

Size of Openings .010"

Diameter of Piezometer Tip 3"

Bottom of Piez. Elev.

Bottom of Boring Elev.

Diameter of Boring 12"

Remarks

Inspected By SLG

RW-110

Aquaterra Technologies, Inc.
Subsurface Log: S-160

Project Name: Pollack St Sewer
Location: Tank 178
Boring Number: S-160
Casing Elevation: N/A
Screen Diameter: 2" **Length:** 20'
Casing Diameter: 2" **Length:** 3'
Drilling Method: Hollow Stem Auger Drilling

Owner: Sunoco, Inc. (R&M)
Permit No.: N/A
Log By: Cathy Grzybek
Driller: B.L. Meyers
Slot Size: 0.020"
Type: PVC
Sample Method: Cuttings

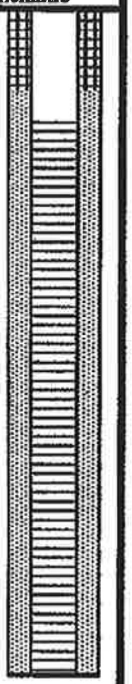
Date: 15-May-03
Borehole Dia: 6.25"
Water Level (Init): NA
Rig Type:

Construction Details

Total Well Depth: 23'
Screen Interval: 3'-23'
Sand Pack Interval: 2'-23'
Completion Details: Completed with 8-inch manhole cover and locking cap

Bentonite Interval: 1'-2'
Cement/Grout Interval: NA
Sand Pack Type: No. 2 sand

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
▒ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Sample Number	Lithology	Well Schematic
0	0'-5'			NA, Hydroexcavated to 7' bgs.	
5	5'-10'			No cuttings available	
10	10'-15'	0		Black/gray silt, sand, and gravel	
15	15'-20'			No cuttings available Wet at 18' bgs	
20	20'-23'			Gray, plastic clay	
23					
				Well set at 23' bgs	

NOTE: Shaded sample submitted for laboratory analysis

RW- 111

Aquaterra Technologies, Inc.
Subsurface Log: S-172

Project Name: Pollack St Sewer
Location: Tank 178
Boring Number: S-172
Casing Elevation: N/A
Screen Diameter: 2" **Length:** 17'
Casing Diameter: 2" **Length:** 4.5'
Drilling Method: Hollow Stem Auger Drilling

Owner: Sunoco, Inc. (R&M)
Permit No.: N/A
Log By: M. Brad Spancake
Driller: B.L. Meyers
Slot Size: 0.020"
Type: PVC
Sample Method: Cuttings

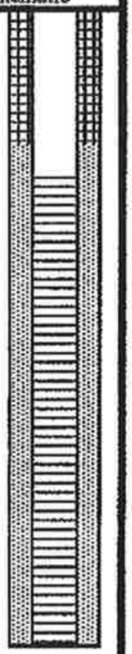
Date: 19-May-03
Borehole Dia: 6.25"
Water Level (Init): NA
Rig Type:

Construction Details

Total Well Depth: 21.5'
Screen Interval: 4.5'-21.5'
Sand Pack Interval: 3.5'-21.5'
Completion Details: Completed with 8-inch manhole cover and locking cap

Bentonite Interval: 1.5'-3.5'
Cement/Grout Interval: NA
Sand Pack Type: No. 2 sand

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
▨ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Sample Number	Lithology	Well Schematic
0	0'-5'			NA, Hydroexcavated to 7' bgs.	
5	5'-10'	108		Brown grey silty clay, some coarse sand, slight moisture	
10	10'-15'	208		Dark brown silty clay, coarse sand, some gravel.	
15	15'-20'	285		Wet, same as above, more sand and gravel.	
20	20'-21.5'	390		Same as above	
21.5				Refusal at 21.5'	
				Borehole complete at 21.5' BGS	

NOTE: Shaded sample submitted for laboratory analysis

RW-11.2

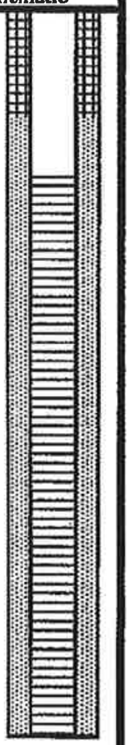
Aquaterra Technologies, Inc.
Subsurface Log: S-173

Project Name: Pollock St Sewer
Owner: Sunoco, Inc. (R&M)
Location: Tank 178
Permit No.: N/A
Boring Number: S-173
Log By: M. Brad Spancake
Date: 27-May-03
Casing Elevation: N/A
Driller: B.L Meyers
Borehole Dia: 6.25"
Screen Diameter: 4" **Length:** 20'
Slot Size: 0.020"
Water Level (Init): NA
Casing Diameter: 4" **Length:** 5'
Type: PVC
Drilling Method: Hollow Stem Auger Drilling
Sample Method: Split-Spoon/Grab
Rig Type:

Construction Details

Total Well Depth: 25'
Bentonite Interval: 1'-3'
Screen Interval: 5'-25'
Cement/Grout Interval: NA
Sand Pack Interval: 3'-25'
Sand Pack Type: No. 2 sand
Completion Details: Completed with 8-inch manhole cover and locking cap

☐ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Sample Number	Lithology	Well Schematic
0				Augered to 10'	
2					
4					
6					
8					
10	10-12'	0	1	Brown silt, sand, gravel, and rock fragments	
12	12-14'	156	2	Rock, sand, and gravel in brown silt matrix	
14	14-16	510	3	Same as above Compacted gravel and rock material, brown silt and coarse sand	
16	16-18	NA		No sample	
18	18-20	710	4	Same as above	
25					
				Borehole completed at 25' bgs	

NOTE: Shaded sample submitted for laboratory analysis

RW-401

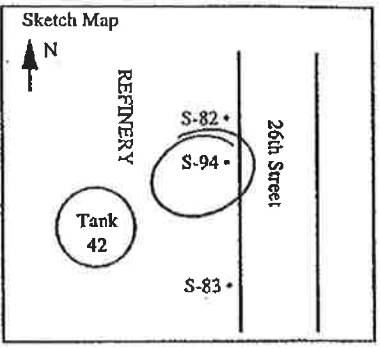
GES

Groundwater & Environmental Services, Inc.

Drilling Log

Project Sun Philadelphia Refinery
Owner Sun Company., Inc. (R&M)
Location 3144 Passyunk Ave., Phila.
Permit No. N/A
Boring number S-94
Total Depth 50 ft. Diameter 10 in.
Casing Elevation N/A
Water Level: Initial 22.5 ft. Static N/A
Screen Dia. 6 in.
Length 35 ft. Slot Size N/A
Casing Dia. 6 in.
Length 16 ft. Type Galvanized wire wrap
Drilling Method Mud Rotary
Sample Method Split-spoon
Completion Details One foot steel stick-up riser.
Driller Summit Drilling Co.
Log By M. Haslett Date 9 September 1993

Sketch Map



Depth (feet)	Blow Count	Well Const.	OVM (ppm)	Initial Water Depth	Lithology
0					LIMESTONE BALLAST - Silty clay.
	4,2,3,4				
5			1403		CLAY - Silty clay, moist, stained.
					- Silty clay with angular stone fragments, stained, wet.
	6,11, 12,16		3		- Brown, thick clay, some silt, no odor.
10			7		- Dark gray, thick clay, odor.
	13,16, 18,24				- Light gray clay, some sand, wet, no odor.
15					
	7,10, 30,54				SAND - Light gray, silty fine sand, some medium gravel, moist odor.
20			119		
	52,50,-,-		711	▽	GRAVEL - Gravel, coarse sand, some silt.
25			200		COBBLES - Heavy cobbles, odor.
30	50,-,-,-				

Groundwater & Environmental Services, Inc.

Drilling Log

Project Sun Philadelphia Refinery
Owner Sun Company., Inc. (R&M)
Location 3144 Passyunk Ave., Phila.
Permit No. N/A
Boring number S-94
Total Depth 50 ft. Diameter 10 in.
Casing Elevation N/A
Water Level: Initial 22.5 ft. Static N/A
Screen Dia. 6 in.
Length 35 ft. Slot Size N/A
Casing Dia. 6 in.
Length 16 ft. Type Galvanized wire wrap
Drilling Method Mud Rotary
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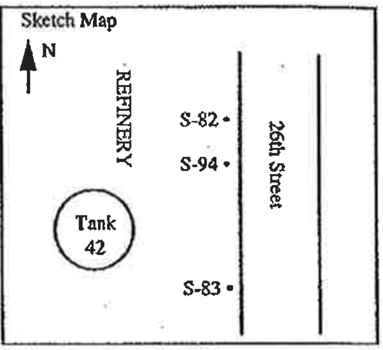
Sketch Map



Depth (feet)	Blow Count	Well Const.	OVM (ppm)	Initial Water Depth	Lithology
30	N/A				COBBLES
			320		SAND - Medium sand, brown, moist.
35	15,26, 13,10		27		CLAY - Brown silty clay, moist, some fine sand, odor.
					- Red/Orange silty clay, odor, moist.
	7,14, 16,33				SAND - Dark mauve sand, some silty clay, wet, strong odor.
40					
	10,16, 16,25				CLAY - Dark mauve silty clay, moist, slight odor, some mica, black and fine sand.
45					
	7,12, 26,55				- Dark mauve clay, some silt, slight odor, moist.
50					COMPLETED BORING AT 50 FEET.

CALCULATION WORKSHEET

Order No. 18116 (01-91)

PAGE ______ OF ______

CLIENT

JOB NUMBER

SUBJECT

BASED ON

DRAWING NUMBER

BY E. DZIEDZIC (GES)

CHECKED BY

APPROVED BY

DATE 5/18/94

LITHOLOGY: ~~PA-20~~ PH-21
LOCATION: 26th STREET BETWEEN 42 AND 83 TANKS

(RW-402)

DEPTH	LITH. LOG	BLOW COUNT	RECOVERY	
5		9,3,4,8	0	FILL - CRUSHED STONE FILL, NO RECOVERY
10		3,2,6,11	10"	CLAY - TAN SILTY CLAY, WET, NO ODOR
15		3,2,2,4	20"	CLAY - GRAY AND TAN SILTY CLAY, MOIST NO ODOR
* 20		19,20,21,22	15"	SAND - GRAY SAND W/ PEBBLES AND GRAVEL, STRONG ODOR, WET
22		33,44,50/6"	8"	GRAVEL - GRAVEL W/ SAND MATRIX, PEBBLES AND COBBLES, DRY, ODOR
24		34,41,89,88	5"	GRAVEL - MULTI-COLORED PEBBLES AND COBBLES, DRY, ODOR
26		100/6"	4"	GRAVEL - MULTI-COLORED PEBBLES AND COBBLES, SAND MATRIX, DRY, ODOR
28		25,57/6"	3"	GRAVEL - SAME LITHOLOGY, WET, SOME ODOR ROUGH AUGERING
30		21,~~27~~,33,52,50/6"	12"	SAND - POORLY SORTED SAND AND GRAVEL, MOIST, ODOR
32		100/[illegible]"	0	NO RECOVERY, BOULDER?
34		5,3,3,2	13"	CLAY - TAN SILTY/CLAY, WET, NO ODOR
36		5,9,11,13	15"	SAND - GRAY MED SAND, WET, STRONG ODOR, STAINED IN MIDDLE
38		4,18,17,10	12"	SAND - RED AND BROWN MED - FN SAND, WET, ODOR
40		29,10,4,8	17"	SAND - RED FN SAND, WET, NO ODOR
42		5,7,12,13	14"	SAND - RED INTERLAYERED COARSE AND FN SAND, WET
44		4,5,14,10	18"	SAND - RED INTERLAYERED COARSE AND FN SAND, RED SILT
46		6,6,7,6	20"	CLAY - RED SILTY CLAY, MOIST
48		4,5,4,4	20"	CLAY - RED INTERLAYERED CLAY AND FN SAND, MOIST

* APPROX. 10 ft of WATER APPAREN , BORE HOLE !

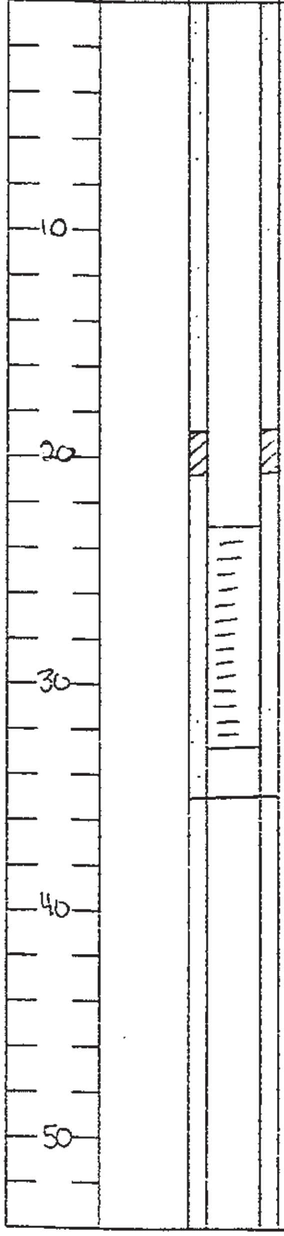
GROUNDWATER & ENVIRONMENTAL SERVICES, INC.
DRILLING LOG

GES

Sketch Map

Project RW-INSTALLATION
Owner SUN COMPANY, INC
Location PHILA. REFINERY
Permit No. N/A
Well Number RW-402
Total Depth 35 FT **Diameter** 10.25 ID
Casing Elevation N/A
Water Level: Initial N/A **Static** N/A
Screen Dia. 6 INCH
Length 10' **Slot Size** 0.040 INCH
Casing Dia. 6 INCH
Length 25' **Type** PVC
Drilling Method AUGER
Sample Method N/A
Completion Details FLUSH MOUNT w/ LOCKING CHIMNEY PLUG
Driller HUNTINGDON-EMPIRE
Log By N/A **Date** MAY 94

Depth (feet)	Sample No.	Well Const.	OVA (ppm)	Blow Count	Lithology



SAND PACK	#2
TOP OF SAND	21'
TOP OF BENTONITE	19'
TOP OF SCREEN	23'
BOTTOM OF SCREEN	33'
SCREEN	STAINLESS STEEL VEE WIRE

RW-403

A01 1

Groundwater & Environmental Services, Inc.

Drilling Log

Project Sun Philadelphia Refinery

Owner Sun Company., Inc.

Location 3144 Passyunk Ave., Phila.

Permit No. N/A

Boring number S-90

Total Depth 50 ft. Diameter 14 in.

Casing Elevation 27.81 ft.

Water Level: Initial 18.12 Static N/A

Screen Dia. 6 in.

Length 35 ft. Slot Size 0.02

Casing Dia. 6 in.

Length 17 ft. Type Galvanized wire wrap

Drilling Method Hollow-stem Auger

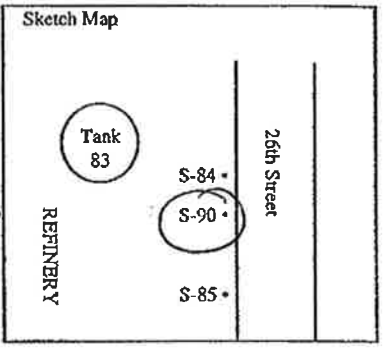
Sample Method Split-spoon

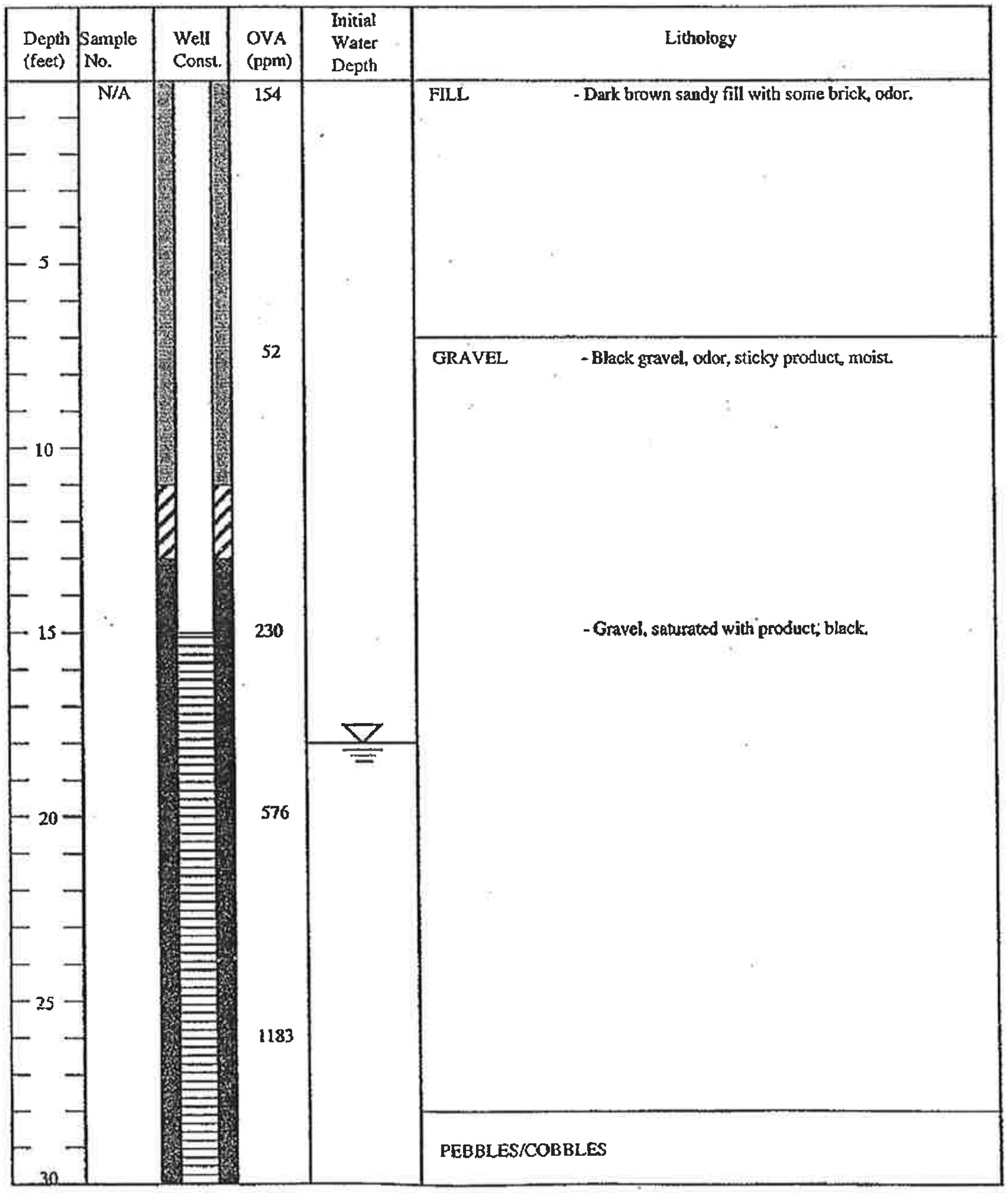
Completion Details Three foot high steel riser stick-up.

Driller B.L. Myers Bros.

Log By E. Dziedzic

Date 1 July 1993





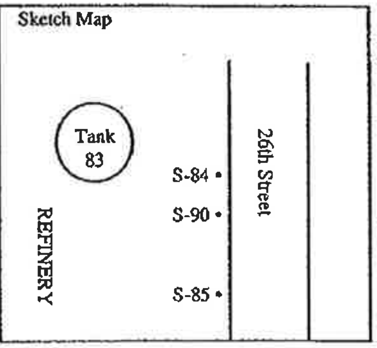
Depth (feet)	Sample No.	Well Const.	OVA (ppm)	Initial Water Depth	Lithology
	N/A		154		FILL - Dark brown sandy fill with some brick, odor.
			52		GRAVEL - Black gravel, odor, sticky product, moist.
			230		- Gravel, saturated with product, black.
				▽	
			576		
			1183		
					PEBBLES/COBBLES

Groundwater & Environmental Services, Inc.

Drilling Log

Project Sun Philadelphia Refinery
Owner Sun Company., Inc.
Location 3144 Passyunk Ave., Phila.
Permit No. N/A
Boring number S-90
Total Depth 50 ft. Diameter 14 in.
Casing Elevation 27.81 ft.
Water Level: Initial 18.12 Static N/A
Screen Dia. 6 in.
Length 35 ft. Slot Size 0.02
Casing Dia. 6 in.
Length 17 ft. Type Galvanized wire wrap
Drilling Method Hollow-stem Auger
Sample Method Split-spoon
Completion Details Three foot steel riser stick-up.
Driller B.L. Myers Bros.
Log By E. Dziedzic Date 1 July 1993

Sketch Map



Depth (feet)	Sample No.	Well Const.	OVA (ppm)	Initial Water Depth	Lithology
30	N/A				PEBBLES/COBBLES
			1060		SAND - Black coarse sand and gravel, saturated, slight odor.
			27		SILT - Brown sandy silt, wet, slight odor.
35					
40			0		CLAY - Tan silty clay, moist, no odor.
45					
50					COMPLETED BORING AT 50 FEET.

CALCULATION WORKSHEET Order No. 19114 (01-91)

PAGE 1 OF 2

CLIENT: SUN PHILADELPHIA REFINERY

JOB NUMBER:

SUBJECT: Boring Logs for Recovery Well - Pilot Holes

BASED ON:

DRAWING NUMBER:

BY: E. DRIEDZIC (GES)

CHECKED BY:

APPROVED BY:

DATE: 5/5/94

PH-13 LITHOLOGY

DEPTH	GRAPHIC LOG		BLOWS	RECOVERY	LOCATION: 26th STREET ADJACENT TO S-85 (RW-404)	
	Lith.					
3						
5			15,6,2,1	NO RECOVERY	-	▽ INITIAL WATER AT 5 ft
7			3,2,3,2	14"	CLAY - BLACK CLAY, WET, [illegible]	
9			4,3,2,3	6"	FILL - LEAFY/FLAKY OIL SOAKED FILL, BLACK, WET	
11			4,4,4,4	7"	FILL LEAFY/FLAKY OIL SOAKED FILL, BLACK, WET	
13			7,3,7,2	1"	FILL - LEAFY/FLAKY OIL SOAKED FILL, BLACK, WET	
15			3,1,4,2	6"	FILL - LEAFY/FLAKY OIL SOAKED FILL; SOME SILT, OIL SOAKED, BLACK, WET	
17			4,7,6,6	9"	SAND - BROWN AND BLACK MED-GRAINED SAND, MOIST, STRONG ODOR	
19			11,23,26,24	10"	SAND - GRAY SAND AND COBBLE-SIZE GRAVEL, MOIST, ODOR	
21			9,23,24,25	7"	SAND - POORLY SORTED SAND AND GRAVEL, MULTI-COLORED CLASTS, FINE SAND, WET, ODOR	
23			99/6"	NO RECOVERY		
25					SAND - POORLY SORTED SAND AND GRAVEL, BLACK STRONG ODORS	
27			23,29,31,35	12"	SAND - POORLY SORTED SAND AND GRAVEL, SOME COBBLES, MULTI-COLORED CLASTS, MOIST, ODORS	
29			23,13,4,7	8"	SAND - GREENISH-TAN FN. GRAINED SAND, MOIST, SL. ODOR	
31			3,8,5,8	14"	SAND - GREENISH-TAN FN. GRAINED SAND, WET, ODOR	
33						

CALCULATION WORKSHEET Order No. 18116 (01-91)

PAGE 2 OF 2

CLIENT SUN PHILADELPHIA REFINERY

JOB NUMBER

SUBJECT. Boring Logs for Recovery Well - Pilot Holes

BASED ON

DRAWING NUMBER

BY E. DZIEMZIC (CES)

CHECKED BY

APPROVED BY

DATE 5/5/94

DEPTH	GRAPHIC LOG		BLOWS	RECOVERY	PH-B LITHOLOGY LOCATION: 26th STREET ADJACENT TO S-85 (RW-404)
	Lith.				
33			3,2,1,2	20"	SILT - TAN SILT, MOIST, SL. ODOR
35			4,5,5,6	18"	SAND - GREENISH TAN SAND, WET, ODOR FN - MED. GRAINED
37			8,11,9,8	24"	SAND - TAN MEDIUM GRAINED SAND
39			5,5,6,10	14"	SAND - REDDISH-BROWN FN GRAINED SAND,
41			6,6,10,12	20"	SAND - REDDISH-BROWN FN GRAINED SAND, WET, SLIGHT ODOR
43			5,9,9,9	13"	SAND - REDDISH-BROWN FN GRAINED SAND, SOME SILT IN MIDDLE, WET
45			3,3,6,15	16"	SAND - REDDISH-BROWN FN GRAINED SAND, BROWN AT BOTTOM, WET
47			6,8,11,17	5"	SAND - REDDISH-BROWN FN GRAINED SAND, 1/4" CLAY/PEAT LENS AT BOTTOM
49			4,7,7,13	12"	SAND - DARK BROWN FN GRAINED SAND AND SILT, MOIST
51			10,13,11,10	3"	SAND - COARSE GRAINED SAND, ODOR, WET
53				6"	SAND - FN - MED GRAINED ~~SOG~~ SAND, REDDISH BROWN, ODOR
55			4,6,4,2	4"	SAND - CLAY FN-MED GRAINED SAND WITH WOOD, PEBBLES, ODOR
57					SAND - GRAY COARSE GRAINED SAND WITH WOOD ON TOP, RED-BROWN FN GRAINED SAND IN MIDDLE, POORLY SORTED SAND AND GRAVEL ON BOTTOM, WET
59					
[illegible]					
[illegible]					

GROUNDWATER & ENVIRONMENTAL SERVICES, INC.

DRILLING LOG

GES

Project RW-Installation
Owner Sun Company, Inc

Location Phila. Refinery
Permit No. N/A

Well Number RW-404
Total Depth 34' Diameter 10.25 I.D.

Casing Elevation N/A
Water Level: Initial N/A Static N/A

Screen Dia. 6 Inch
Length 10 Ft. Slot Size 0.040 Inch

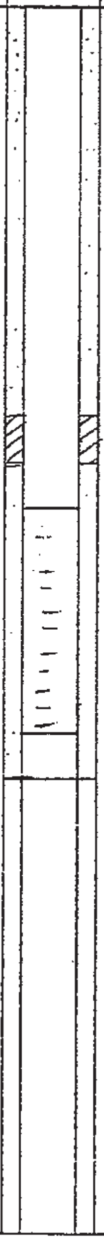
Casing Dia. 6 Inch
Length 25 Ft. Type PVC

Drilling Method Auger
Sample Method N/A

Completion Details 2 Ft PVC Stick-up w/ Locking Chimney Plug

Driller Huntingdon-Empire
Log By N/A Date MAY 94

Sketch Map

Depth (feet)	Sample No.	Well Const.	OVA (ppm)	Blow Count	Lithology
					Sand Pack #2 Top of Sand 20 Ft. Top of Bentonite 18 Ft Top of Screen 22 Ft. Bottom of Screen 32 Ft. Screen Stainless Steel Vee Wire
10					
20					
30					
40					
50					

Page ______ of ______

CALCULATION WORKSHEET

Order No. 19116 (01-91)

PAGE ____ OF ____

CLIENT	JOB NUMBER
SUBJECT	
BASED ON	DRAWING NUMBER

BY E. DZIEDZIC (GES)	CHECKED BY	APPROVED BY	DATE 5/17/94

DEPTH	LITH. LOG	BLOW COUNT	RECOVERY	LITHOLOGY: PH-20 26th STREET FARTHEST SOUTH (RW-405)
5		7,17,7,7	~~0~~ 1"	CLEAN FILL, BLACK CLAYEY SILT ON SPOON EXTERIOR, MOIST
10		9,27,10,7	5"	SAND - BLACK MED SAND, STRONG ODOR, DRY
15		10,14,25,25	4"	SAND - POORLY SORTED SAND AND GRAVEL, MULTI-COLORED CLASTS, DRY, ST. ODOR
20		5,19,30,86	14"	GRAVEL - POORLY SORTED MULTI-COLORED PEBBLES AND COBBLES, DRY, ODOR
22		25,31,50/3	6"	GRAVEL - POORLY SORTED PEBBLES AND COBBLES, SOME SAND, DRY, SL. ODOR
24		5,35,55,50	12"	GRAVEL - POORLY SORTED GRAVEL, MULTI-COLORED, SOME SAND, MOIST, ODOR ▽ WATER @ 24 ft
26		~~1, 1,~~ 50/6"	5"	GRAVEL - POORLY SORTED SANDS AND GRAVELS, WET, ODOR
28		7,22,19,14	10"	GRAVEL - POORLY SORTED GRAVEL IN SANDY MATRIX, SILT AT BOTTOM, WET ODOR
30		8,19,15,12	10"	GRAVEL - POORLY SORTED GRAVEL IN SANDY MATRIX, WET, ODOR
32		8,13,9,7	0	GRAVEL? NO RECOVERY, ROUGH AUGERING
34		2,1,2,1	17"	SI CLAY TAN SILTY CLAY MOIST
36		0,0,0,0	20"	SILT TAN SILT w/ FN SAND, MOIST
38		7,7,6,6	19"	SILT TANISH GREEN FN SAND AND SILT, WET
40		1,2,4,18	16"	SAND RED AND TAN FN SAND, WET
42		10,12,14,18	20"	SILT RED SILT, SOME FN SAND, MOIST
44		0,0,5,4	15"	SAND RED MED GRAINED SAND
46		10,20,20,22	18"	SAND RED MED-COARSE SAND CLAYEY SILT LAYER IN MIDDLE, WET

DTW = 25.20

DTW = 25.05

DT D 6.75

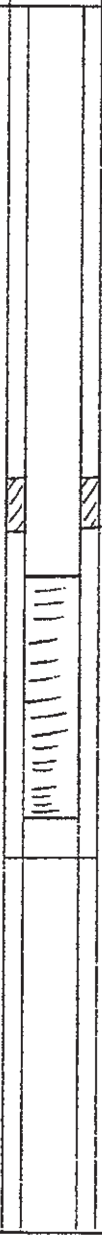
GROUNDWATER & ENVIRONMENTAL SERVICES, INC.

DRILLING LOG

GES

Sketch Map

Project RW-INSTALLATION
Owner SUN COMPANY, INC
Location PHILA. REFINERY
Permit No. N/A
Well Number RW-405
Total Depth 37.5Ft Diameter 10.25ID
Casing Elevation N/A
Water Level: Initial N/A Static N/A
Screen Dia. 6 INCH
Length 10 FT Slot Size 0.040 Inch
Casing Dia. 6 INCH
Length 26.5FT Type PVC
Drilling Method AUGER
Sample Method N/A
Completion Details 1 Ft PVC STICK-UP W/ LOCKING CHIMNEY PLUG
Driller HUNTINGDON-EMPIRE
Log By N/A Date JUNE 94

Depth (feet)	Sample No.	Well Const.	OVA (ppm)	Blow Count	Lithology
10 20 30 40 50					SAND PACK #2 Top of SAND 23.5 Ft Top of BENTONITE 21.5 Ft Top of SCREEN 25.5 Ft BOTTOM of SCREEN 35.5 Ft SCREEN STAINLESS STEEL VEE WIRE

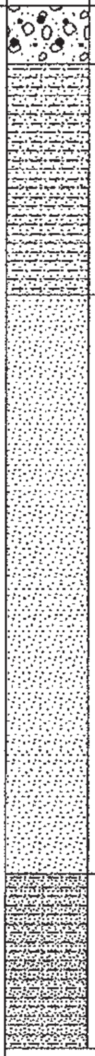
Page ______ of ______

Handex®

Handex Of Maryland

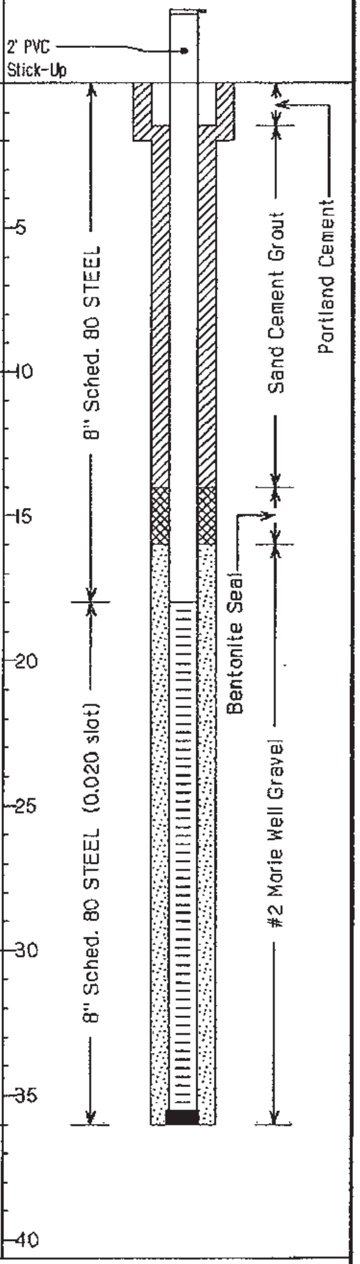
WELL LOG: RW-406

Permit #: *N/A*
Drill Date: *11/20/00*
Use: *Monitoring Well*
Location: *Sunoco Belmont Terminal, PA*
Owner Loc #:
Owner: *Sunoco, Inc*
Handex Loc #: *110535.032.T3045.900*
Owner Address: *3144 Passyunk Ave. Philadelphia, PA*
BORING – Depth: *36 ft.* Diameter: *14 in.*
Drilling Method: *Hollow Stem Auger*
CASING – Length: *18 ft.* Diameter: *8 in.*
Sampling Method:
SCREEN – Length: *20 ft.* Diameter: *8 in.*
Static Water Level:
WELL – Depth: *36 ft.*



Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description
						FILL – Brown M-78 Sand, some coarse Gravel
						Olive green Silty SAND
5						
10						Brown medium SAND
15						
20						
25						
30						Reddish brown fine SAND and SILT
35						
						File name: 11055408
40						

Well Diagram



Geologist: Stephanie Rogers
Driller: B.L. Myers Bros.

S-41

LOG of BORING No. AB-6

DATE 1/25/82 SURFACE ELEV. ______ LOCATION See Plate

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		Asphalt and stone					
		Stiff brown fine sandy clayey SILT					
5	16			24.6	NP	NP	
10		becoming more sandy @ 10 feet					
	10			19.6			
	83	Dense to very dense brown and gray coarse to fine gravelly silty coarse to fine SAND		14.9			
15	65			9.2			
	146			5.2			
	120			5.6			
20	110			6.0			M
	80			6.0			
25	105			5.3			
	90			9.0			
	43			12.4			
30	37			9.1			
35							

COMPLETION DEPTH 32.0 feet FLUID Depth enc. @ 26 ft. Date 1/25/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER Hole caved @ 17 ft. upon completion

PIEZOMETER INSTALLATION REPORT

S-41

roject ARCO REFINERY

Project No. 81C2256 Installed By MHK

Method of Installation ~~Hollow stem auger~~

Piezometer No. AS-1

Location See Fig.

Date 2/6/82 Time

LOG OF BORING AND PIEZOMETER

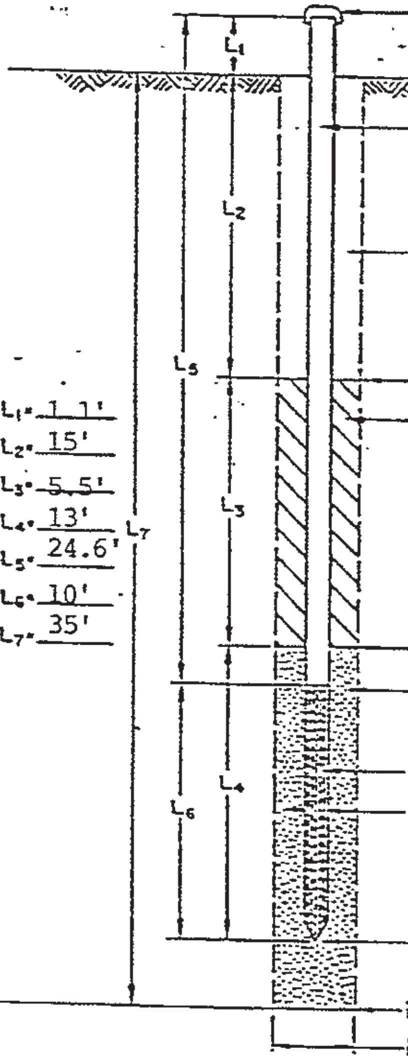
BORING.		
Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer PVC

Ground Elev. 23.93'

Top of Riser Elev. 25.01'



Vented Cap

I.D. of Riser Pipe 3"

Type of Pipe PVC

Type of Backfill Around Riser concrete & bentonite slurry mixture

Top of Seal Elev. 8.93'

Type of Seal Material Bentonite slurry

L1= 1.1'
L2= 15'
L3= 5.5'
L4= 13'
L5= 24.6'
L6= 10'
L7= 35'

Top of Filter Elev. 3.43'

Type of Filter Material sand

Size of Openings .010"

Diameter of Piezometer Tip 3"

Bottom of Piez. Elev. 9.57'

Bottom of Boring Elev. -11.07'

Diameter of Boring 12"

emarks

Inspected By MHK

S-42I

LOG of BORING No. AD-1

DATE 2/2-3/82 SURFACE ELEV. LOCATION See Plate

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0			Cinders and gravel					
5		15	Stiff brown and gray mottled clayey SILT					
10		11						
15		45						
20		64	Dense to very dense brown and gray coarse to fine SAND and GRAVEL					
25		37						
30		35	less gravel encountered @ 30 feet					
35		50						
40		11						
		14	Red brown silty CLAY					
45		54	See next page for description					

COMPLETION DEPTH 67.0 feet FLUID Depth enc. @ 28 ft. Date 2/2/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER

NO 81 C 2256A

S-42I

LOG of BORING No. AD-1 (cont'd.)

DATE 2/2-3/82 SURFACE ELEV. ______ LOCATION See Plate

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45								
50	■	25						
55	■	41	Medium dense to very dense gray and tan silty coarse to fine SAND					
60	■	100/5"						
65	■	36						
70								

COMPLETION DEPTH 67.0 feet FLUID Depth enc. @ 28 ft. Date 2/2/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER

NO 81 C 2256A

WCC KP

S-42 I

PIEZOMETER INSTALLATION REPORT

Piezometer No. AD-1

Project ARCO Refinery

Location See Figure

Project No. 81C2256 Installed By MHK

Date 2/5/82 Time

Method of Installation Hollow stem auger

LOG OF BORING AND PIEZOMETER

BORING.

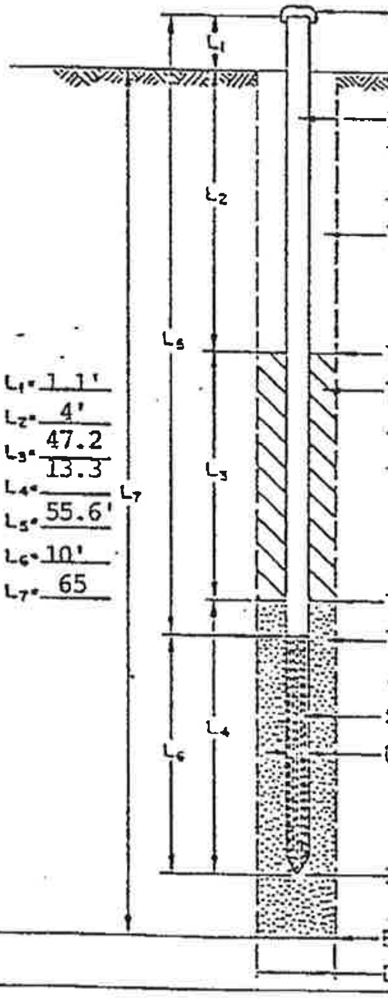
Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer PVC

Ground Elev. 23.72

Top of Riser Elev. 23.56'



L1 = 1.1'
L2 = 4'
L3 = 47.2
L4 = 13.3
L5 = 55.6'
L6 = 10'
L7 = 65

Vented Cap

I.D. of Riser Pipe 3"

Type of Pipe PVC

Type of Backfill Around Riser cement and bentonite grout

Top of Seal Elev. 19.72

Type of Seal Material bentonite slurry

Top of Filter Elev. -27.44

Type of Filter Material sand

Size of Openings .010"

Diameter of Piezometer Tip 3"

Bottom of Piez. Elev. -40.78

Bottom of Boring Elev. -41.28

Diameter of Boring 12"

Remarks

Inspected By MHK

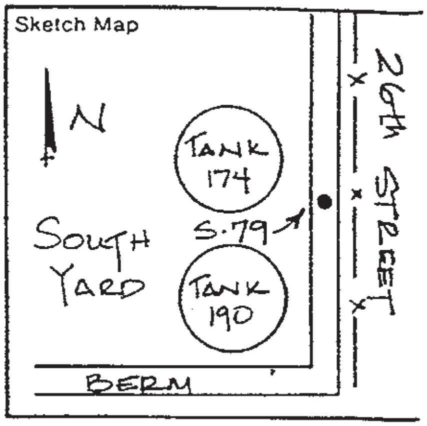
S-43

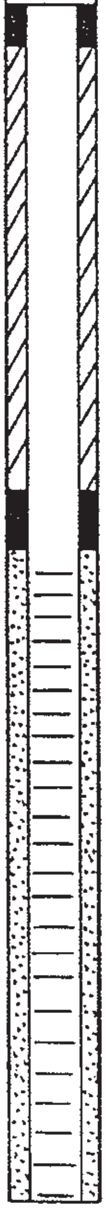
Groundwater
& Environmental Services, Inc.

Drilling Log

Project SUN: Atlantic Refinery Owner Sun Refining & Mktg.
Location Philadelphia, PA Permit No. Not required
Well Number S-79 Total Depth 34 feet Diameter 10 inch
Casing Elevation ______ Water Level: Initial 26.0 Static 26.82
Screen: Dia. 4 inch Length 20 feet Slot Size 0.02 inch
Casing: Dia. 4 inch Length 14 feet Type PVC Sch 40
Drilling Method Hollow stem auger Sample Method N/A
Completion Details Steel riser with locking cap
Driller B. L. Myers Bros Log By J. J. Smith Date Drilled 5 Aug. '88

Sketch Map





Depth (Feet)	Sample Number	Well Construction	Ova Reading	LITHOLOGY
1				FILL - Asphalt with coarse ballast stone.
2				SILT - Light brown with sand - dark brown from 2.5
4				- light green with sand from 4.0
10				- brown, damp
12				COBBLES - Red, green, white (primarily sandstone) with silt
13				SILT - brown with small sandstone pebbles at 13.0
18				- red with pebbles and cobbles
22				- moist cuttings
26				COBBLES - Red, green, white, (primarily sandstone), wet with medium sand.

S-43

Groundwater
& Environmental Services, Inc.

Project SUN: Atlantic Refinery

Well Number S-79

Date 5 August 1988

Depth (Feet)	Sample Number	Well Construction	Ova Reading	LITHOLOGY
32				
				SILT - Brown, damp with sandstone cobbles and pebbles
34				
				END HOLE

S-44

LOG of BORING No. AS-2

DATE 1/28-29/82 SURFACE ELEV. ________ LOCATION See Plate

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0								
5	■	11	Stiff brown clayey SILT					
10	■	27						
15	■	23						
20	■	55	Medium dense to very dense gray coarse to fine SAND and GRAVEL					
25	■	60						
30	■	35	containing less gravel @ 29 feet					
35	■	8	gray silty clay seam					
40	■	30						
45								

COMPLETION DEPTH 41.0 feet FLUID Depth enc. @ 27 ft. Date 1/28/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER

JOB NO 81 C 2256A

WCC RP

PIEZOMETER INSTALLATION REPORT

S-44

Piezometer No. AS-2

Location See Fig.

Date 1/28-1/29/82 Time

roject ARCO REFINERY

roject No. 81C2256 Installed By SLG

Method of Installation Hollow stem auger

LOG OF BORING AND PIEZOMETER

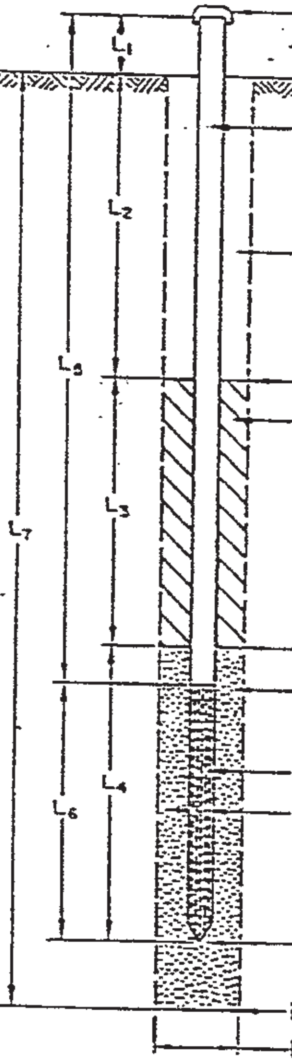
BORING.		
Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer PVC

Ground Elev. 20.97'

Top of ~~Riser~~ casing Elev. 22.97'



Vented Cap

I.D. of Riser Pipe 3"

Type of Pipe PVC

Type of Backfill Around Riser concrete

Top of Seal Elev. 1.97"

Type of Seal Material bentonite balls

Top of Filter Elev. -.03'

Type of Filter Material sand

Size of Openings .010"

Diameter of Piezometer Tip 3"

Bottom of Piez. Elev. -18.03

Bottom of Boring Elev. -20.03

Diameter of Boring 12"

L1 =

L2 = 19'

L3 = 2' 18'

L4 =

L5 =

L6 = 15'

L7 = 41'

marks

Inspected By SLG

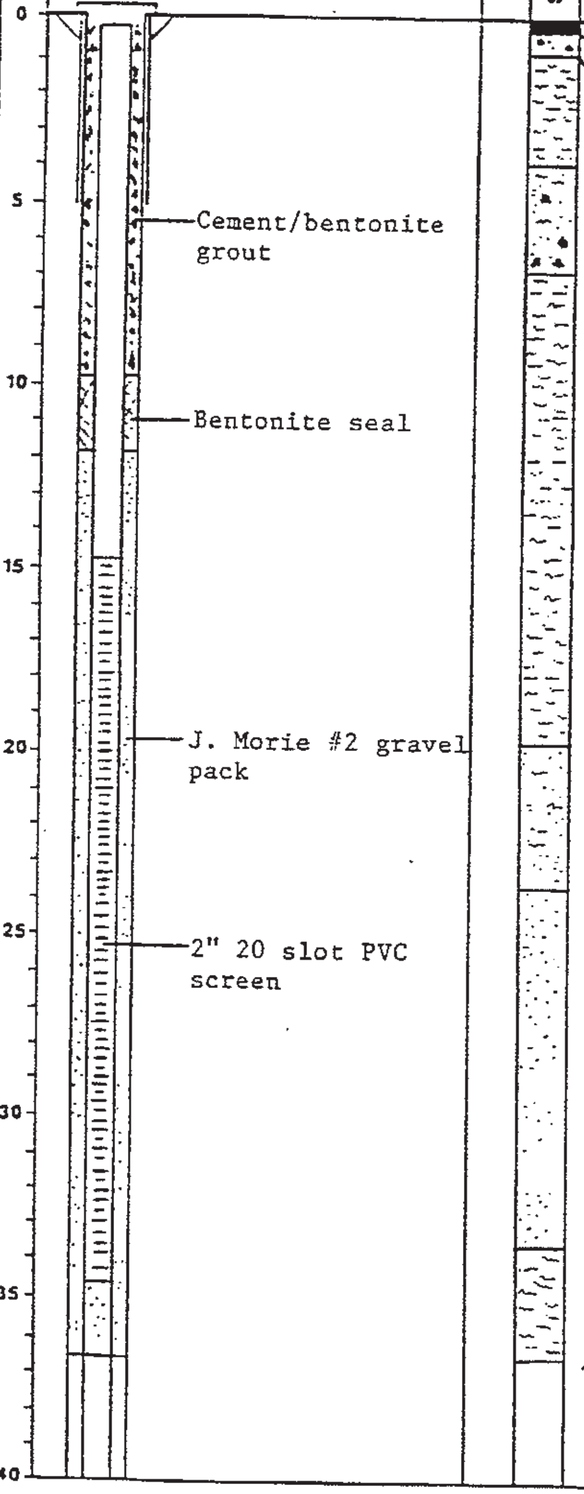
S-45

WELL #69

WELL ELEVATION: 24.73
WELL INSTALLED: 7-29-87
WELL DEVELOPED:
WELL DEPTH:

BORING

SURFACE ELEVATION:
DRILLING METHOD: Hollow Stem Auger
BORING DEPTH: 37.0



0.0 - 0.5 BLACK TOP
0.5 - 1.0 FILL
1.0 - 4.0 SILT: brown and gray, some clay
4.0 - 7.0 FILL: cinders, sand, silt
7.0 - 20.0 SILT: brown, sandy, trace clay
20.0 - 24.0 SAND: poorly sorted, cobbles, silt
24.0 - 34.0 SAND: variegated, fine to coarse, wet, strong odor
34.0 - 37.0 SILT: gray, sandy, clay, lens of gravel at 36.0 - 36.25, odors

TOTAL DEPTH 37.0

SAMPLE DATA

BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
		1		
		2		
		3		
		4		
		5		

Drilled By Hardin-Huber
Logged By Peter J. Dougherty
Client Atlantic
Job No. 522-239-00
Page 1 Of 1

EEI ENGINEERING ENTERPRISES, INC.

S-46

LOG of BORING No. AB-15

DATE 1/26/82 SURFACE ELEV. ______ LOCATION See Plate

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0			Crushed stone					
			Stiff gray fine sandy clayey SILT					
5	■	17						
10	■	41	Medium dense to very dense gray coarse to fine SAND and GRAVEL					
15	■	20						
20	■	100/6"						
	■	87						
25	■	99						
	■	117						
30								

COMPLETION DEPTH 28.0 feet FLUID Depth enc. @ 20 ft. Date 1/26/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER Hole caved @ 16 ft. upon completion

NO 81 C 2256A

S-46

PIEZOMETER INSTALLATION REPORT

roject ARCO REFINERY

oject No. 81C2256 Installed By SLG

Method of Installation Hollow stem auger

Piezometer No. AS-6

Location See Fig.

Date 2/11/82 Time

LOG OF BORING AND PIEZOMETER

BORING.

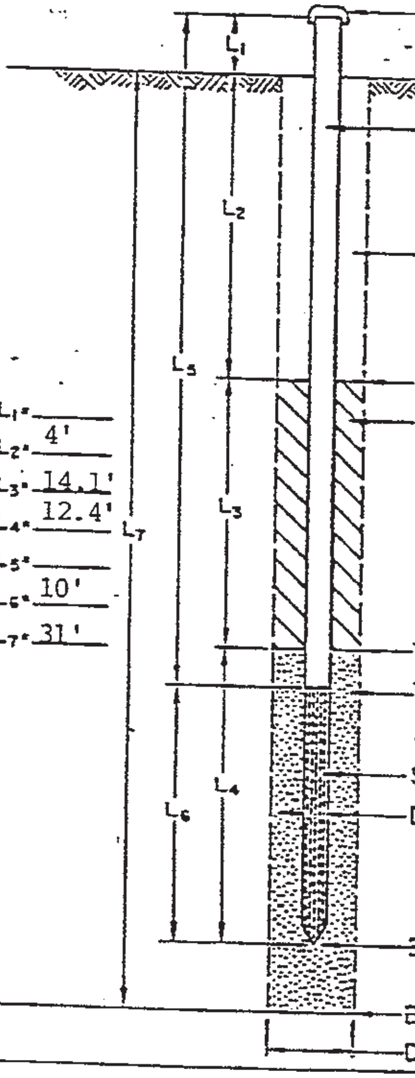
Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer PVC

Ground Elev.

Top of Riser Elev.



L1 =
L2 = 4'
L3 = 14.1'
L4 = 12.4'
L5 =
L6 = 10'
L7 = 31'

I.D. of Riser Pipe 3"

Type of Pipe PVC

Type of Backfill Around Riser cement grout

Top of Seal Elev.

Type of Seal Material bentonite balls

Top of Filter Elev.

Type of Filter Material sand

Size of Openings .010"

Diameter of Piezometer Tip 3"

Bottom of Piez. Elev.

Bottom of Boring Elev.

Diameter of Boring 12"

marks

Inspected By SLG

Aquaterra Technologies, Inc.
Subsurface Log: S-46D

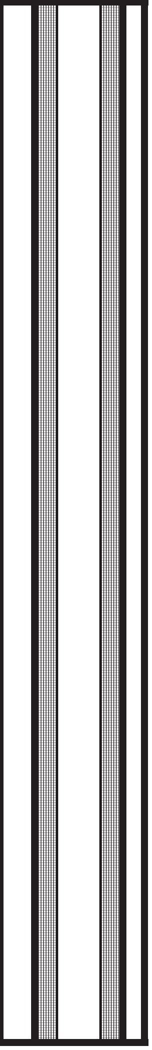
Project Name: Sunoco Philadelphia Refinery AOI - 1
Owner: Sunoco, Inc. (R&M)
Location: Philadelphia, PA
Permit No.:

Boring Number: S-46D
Log By: M.B. Spancake
Date: 3/17-18/05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25'
Screen Diameter: 2" **Length:** 15'
Slot Size:
Water Level (Init): 58'
Casing Diameter: 2" **Length:** 56'
Type: PVC
Drilling Method: Hollow Stem Auger/ Mud Rotary
Sample Method: Split Spoon
Rig Type: HAS/Mud rotary

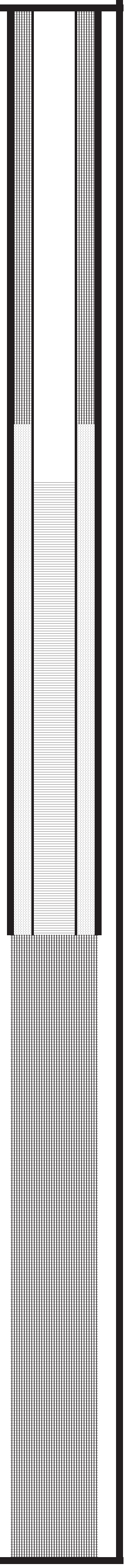
Construction Details

Total Well Depth: 69' BGS
Outer Steel Casing Interval: 0'-48'
Screen Interval: 54'-69'
Bentonite Interval: 0'-52'
Sand Pack Interval: 52'-69'
Cement/Grout Interval:
Completion Details: Completed with 2' Steel stick-up
Sand Pack Type: # 2

☐ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Vacuum Utility Clearance to 9' below ground surface (bgs).	
5					
10	10-12	45	1	Brown coarse sandy gravel, moist, poorly sorted.	
	12-14	28	0.75	Same as above. Rock fragment in bottom of spoon. Slightly more moisture.	
	14-16	823	1	Wet, poorly sorted, coarse sandy gravel. Brownish-red in color.	
15					
	16-18	829	1	Same as above.	
	18-20	817	1.5	Same as above.	
20	20-22	267	0.75	Same as above, gravel is slightly larger.	
	22-24	744	1.75	Same as above, gravel is smaller and less abundant, more coarse sandy gravel matrix.	
	24-26	760	1	Brownish red, coarse, sandy gravel, wet.	
25					
	26-28	20	2	Same as above, more gravel and pebbles.	
	28-30	0	2	Same as above, changing to a wet, gray, fine sand at 28.5'. Slight clay content from 28.5'-29' bgs.	
30	30-32	13	NM	Same as above, changing to a coarse sand and very small gravel.	
	32-34	9	2	Coarse sandy gravel turning to a fine sandy gray clay towards bottom.	
	34-36	122	1	Fine brown silty sand, wet.	
35					
	36-38	11	1.25	Gray clayey silt, slight moisture to dry.	

Aquaterra Technologies, Inc.
Subsurface Log: S-46D (Continued)

Depth (ft)					Well Schematic
	38-40	2	0.75	Same as above, more clay content.	
40	40-42	0	1.5	Same as above.	
	42-44	0	2	Gray clayey silt.	
45	44-46	0	1.5	Gray fine sandy silt, slight clay.	
	46-48	0	1.5	Same as above.	
	48-50	0	1.25	Same as above.	
50	50-52	0	1.75	Same as above.	
	52-54	NM	1.5	Same as above. Changing to a green coarse sand. Large quartz fragment sand and in bottom and serpentine fragment.	
55	54-56	0	0.5	Note: The spoon advanced only 0.75 feet. Coarse brown orange coarse pebble matrix. Moist.	
	56-58	0	1	Same as above. No gravel or pebble present in bottom of spoon.	
	58-60	0	1	Same as above. Changed to medium sand at bottom of shoe. Moist to wet.	
60	60-62				
65	65-67	0	1.5	Medium brown orange sand and pebble. Wet. Changing to a medium greenish gray wet sand.	
70	70-72	0	1	White medium and fine sand matrix with large pebble fragments. Wet End augers. Remove augers from borehole and fill with grout. Will move well location 15' east. Advanced augers to 48' BGS and set 4"-steel casing. Begin with mud rotary drilling on 4/5/05. Advance mud rotary to 75' BGS and collect spoon.	
75	75-77	0	1.75	White and light gray saprolitic mica schist. Some dark gray banding is present. Blow count = 5-23-36-46	
80	80-82	0	1.25	Light gray highly weathered mica schist with darker banding. Slight green coloration. Blow count = 14-27-42-46	
85	85-87	0	2	Greenish gray saprolitic mica shist in top 1.5'. Changing to a dark grayish green weathered mica schist. Blow count = 27-43-50-50.	
90	90-92	0		Greenish gray and tan weathered mica schist, very dense and compact. Blow count = 47-52-50/0.3	

S-47 I

LOG of BORING No. AD-3

DATE 2/10-11/82 **SURFACE ELEV.** ______ **LOCATION** See Plate

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0			Gravel					
5	■	13	Stiff gray clayey SILT					
10	■	66						
15	■	33						
20	■	82	Medium dense to very dense gray coarse to fine SAND and GRAVEL					
25	■	72						
30	■	29						
35	■	12	gray silty clay seam					
40	■	13	Stiff gray silty CLAY					
	■	10						
45								

COMPLETION DEPTH 44.0 feet **FLUID Depth** enc. @ 24 ft. **Date** 2/10/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER

Job NO 81 C 2256A

WCC HP

S-47-I

PIEZOMETER INSTALLATION REPORT

ject ARCO Refinery

ject No. 81C2256 Installed By SLG

Method of Installation Hollow stem auger

Piezometer No. AD-3

Location See Figure

Date 2/11/82 Time

LOG OF BORING AND PIEZOMETER

BORING

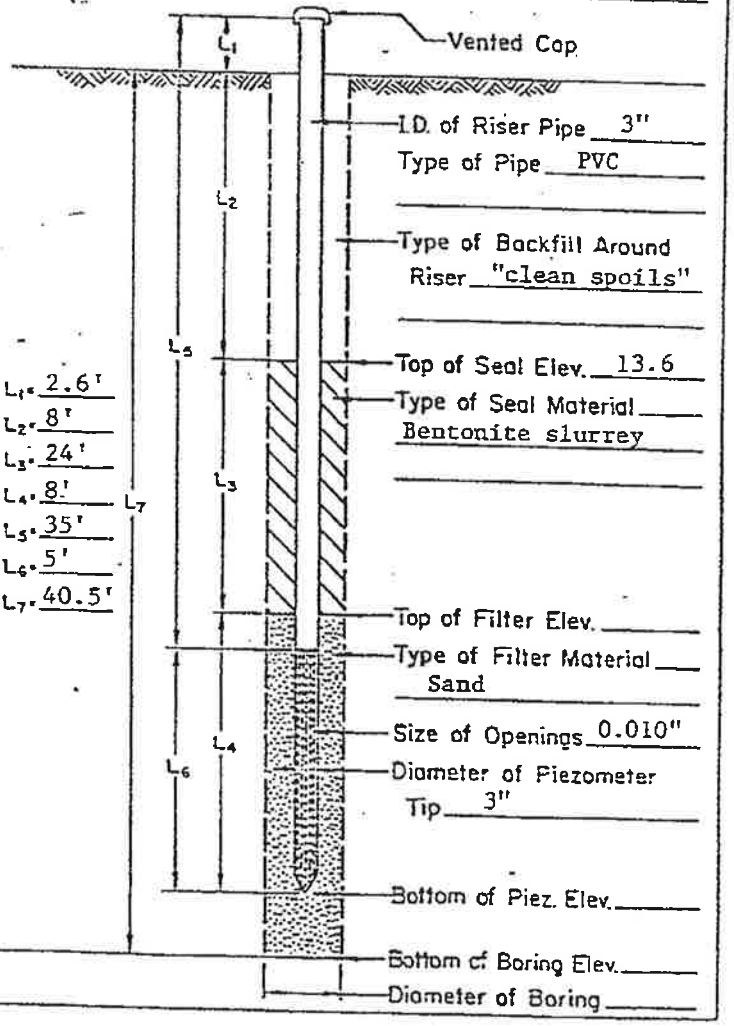
Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer PVC

Ground Elev. 19.0

Top of Riser Elev. 21.63



L1 = 2.6'
L2 = 8'
L3 = 24'
L4 = 8'
L5 = 35'
L6 = 5'
L7 = 40.5'

I.D. of Riser Pipe 3"

Type of Pipe PVC

Type of Backfill Around Riser "clean spoils"

Top of Seal Elev. 13.6

Type of Seal Material Bentonite slurrey

Top of Filter Elev.

Type of Filter Material Sand

Size of Openings 0.010"

Diameter of Piezometer Tip 3"

Bottom of Piez. Elev.

Bottom of Boring Elev.

Diameter of Boring

narks

Inspected By SLG

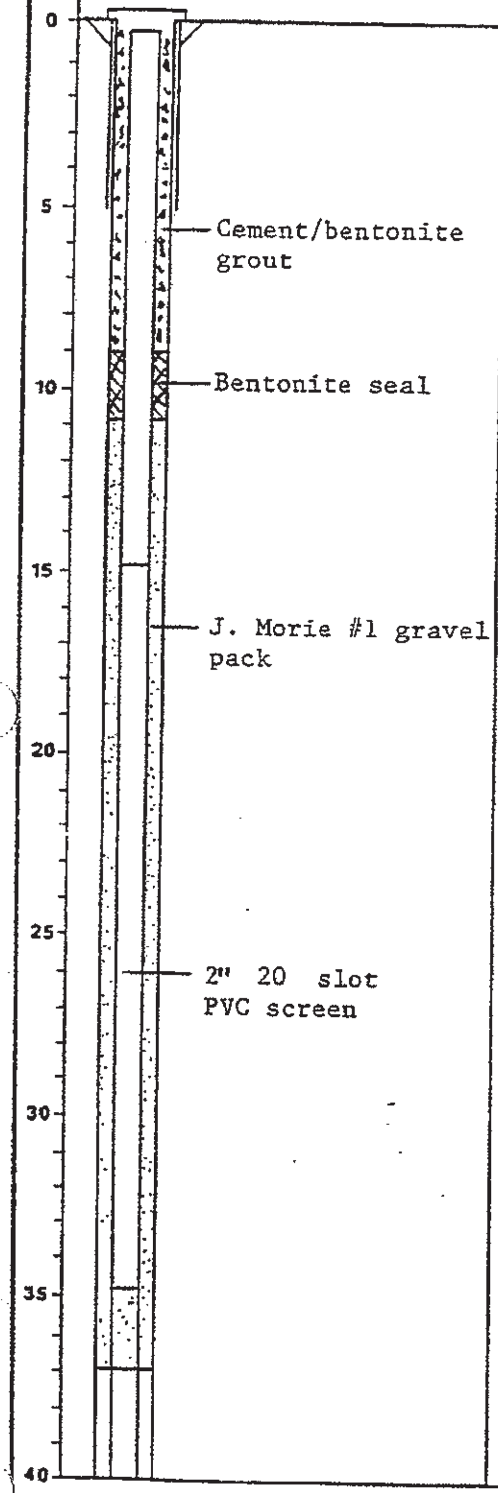
S-49

WELL #67

WELL ELEVATION:
WELL INSTALLED: 7-21-87
WELL DEVELOPED:
WELL DEPTH:

BORING

SURFACE ELEVATION:
DRILLING METHOD: Hollow Stem Auger
BORING DEPTH: 37.0



0.0 - 2.0 FILL: gravel, stone
2.0 - 7.0 FILL: dark brown silt, clay, gravel

7.0 - 8.5 SAND AND GRAVEL

8.5 - 13.0 CLAY: gray, silty, sandy, moist

13.0 - 15.0 SILT: clayey, trace sand, moist
15.0 - 18.0 SAND: variegated, clayey, some gravel
18.0 - 23.0 SAND AND GRAVEL: variegated, trace silt, strong odors

23.0 - 24.0 SAND AND GRAVEL: variegated, trace silt, strong odors
24. 0 - 30.0 SAND AND GRAVEL: variegated, with some silt, hydrocarbon present

30.0 - 32.0 SAND AND GRAVEL: variegated, with trace silt, wet, strong odors
32.0 - 36.5 SAND: clean, wet

TOTAL DEPTH 37.0

SAMPLE DATA

		BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
				1		
				2		
				3		
				4		
				5		

Drilled By Hardin-Huber
Logged By Peter J. Dougherty
Client Atlantic
Job No. 522-239-00
Page 1 Of 1

EEI ENGINEERING ENTERPRISES, INC.

S-50

C.V.M. industries

geotechnical division inc.

post office box 2 • huntingdon valley, pennsylvania

215-947-2555

Client ARCO REFINERY
Project WELLS AND TEST BORINGS
Location PHILADELPHIA, PA.
Project No. -
Boring No. SM-57 Depth 27.0'
Elevation
Spoon Size 2"
Casing Size
Core Size
Bit No.
Hammers:
Spoon, weight 140# Drop 30"
Drive, weight Drop
Date Started 8-1-85

Driller SB
Helper WGH
Inspector
Job No. 3115

Ground Water Data:
WATER AT 23.5'
TOTAL PIPE - 30.0'

Date Completed 8-1-85

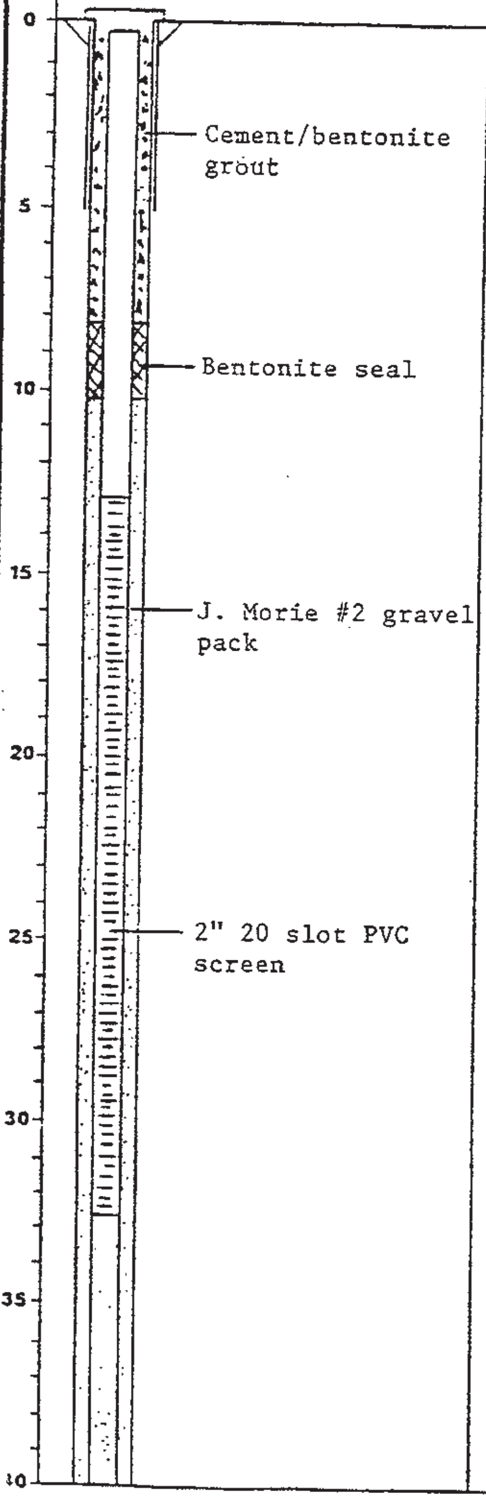
Depth	Casing Blows	STRATA CLASSIFICATION	SAMPLING DATA Depth	SAMPLING DATA No.	SAMPLING DATA Blows per 6"	REMARKS
		BLACK ASH CINDERS 8.5'	4.0- 6.0	S-1	2-2 3-2	
		TAN SILT AND CLAY. SOME VERY FINE SAND. 15.0'				SAMPLE HOLE OFFSET APPROXIMATELY 2.0-4.0' ON 8-2-85
		GREY CLAY, TRACE VERY FINE TO FINE SAND. 18.0'				
		MULTI-COLORED FINE TO COARSE SAND AND GRAVEL. 27.0'	21.0- 23.0	S-2	27-60 83-114	
		COMPLETE AT 27.0'				

SHEET NO. .... OF ....

S-51

WELL #68

WELL ELEVATION: 26.14
WELL INSTALLED: 7-22-87
WELL DEVELOPED:
WELL DEPTH:



SOIL TYPE: USCS | SYMBOLS

BORING

SURFACE ELEVATION:
DRILLING METHOD: Hollow Stem Auger
BORING DEPTH: 40.0

0.0 - 1.5 FILL
1.5 - 4.5 SILT: brown, sandy

4.5 - 6.5 SILT: dark gray, some fine sand, moist, slight odor
6.5 - 12.0 SILT AND CLAY: dark gray

12.0 - 17.0 SAND AND GRAVEL: dark brown

17.0 - 20.0 SAND: dark brown, silty, gravel, moist, odor present

20.0 - 27.0 SAND: dark brown, silty, slightly finer gravel, wet, slight odors

27.0 - 32.0 SAND: variegated, some gravel, little silt, wet, strong odors

32.0 - 36.5 SAND: variegated, medium to coarse, some gravel

36.5 - 40.0 SAND: gray, medium to coarse, some silt and clay

TOTAL DEPTH 40.0

SAMPLE DATA

BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
		1		
		2		
		3		
		4		
		5		

Drilled By Hardin-Huber
Logged By Peter J. Dougherty
Client Atlantic
Job No. 522-239-00
Page 1 Of 1

ENGINEERING ENTERPRISES, INC.

A01 I

S-52

Company Confidential

PIEZOMETER INSTALLATION REPORT

Project: ARCO REFINERY
Project No. 81C2256 Installed By PFM
Piezometer No. AS-3
Location See Fig.
Date 2/2/82 Time
Method of Installation Hollow stem auger

LOG OF BORING AND PIEZOMETER

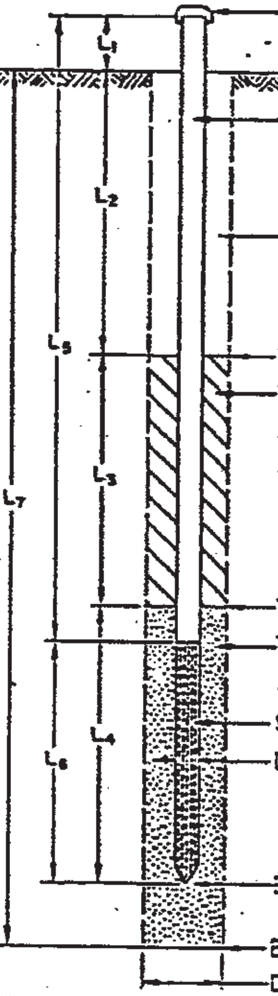
BORING

Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer PVC

Ground Elev. 22.55'
Top of Riser Elev. 24.05'



I.D. of Riser Pipe 3"
Type of Pipe PVC
Type of Backfill Around Riser cement grout
Top of Seal Elev. 9.55'
Type of Seal Material bentonite slurry
Top of Filter Elev.-3.78'
Type of Filter Material sand
Size of Openings .010"
Diameter of Piezometer Tip 3"
Bottom of Piez. Elev. 20.45
Bottom of Boring Elev.-22.45
Diameter of Boring 12"

L1= 1.5'
L2= 13'
L3= 13.3'
L4= 16.7'
L5= 29.5'
L6= 15'
L7= 45'

Remarks

Inspected By PFM

S-52

NO 81 C 2256A

LOG of BORING No. AS-3

DATE 1/29/82 **SURFACE ELEV.** ________ **LOCATION** See Plate

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0								
5	■	13	Stiff gray clayey SILT					
10	■	29						
15	■	31						
20	■	22						
25	□	100/3"	Medium dense to very dense coarse to fine SAND and GRAVEL					
30	■	35						
35	■	66						
40	■	26						
45								

COMPLETION DEPTH 41.0 feet **FLUID Depth** enc. @ 28 ft. **Date** 1/29/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER

WCC

S-77

C.V.M. industries

geotechnical division inc.

post office box 2 • huntingdon valley, pennsylvania

215-947-2555

Client ARCO

Project WELL INSTALLATION

Location PHILADELPHIA, PA.

Project No. 9200

Boring No. SM-3 Depth 20.0'

Elevation

Spoon Size Casing Size

Core Size Bit No.

Hammers:

Spoon, weight Drop

Drive, weight Drop

Date Started 12-20-84

Driller SB

Helper WGH

Inspector MC

Job No. 2890

Ground Water Data:

0 HRS: WATER AT 16.1'

TOTAL PIPE - 23.0'

Date Completed 12-20-84

Depth	Casing Blows	STRATA CLASSIFICATION	Depth	SAMPLING DATA No.	Blows per 6"	REMARKS
		MISCELLANEOUS FILL 3.5'				
		GREY SILTY CLAY. 8.0'				
		TAN AND GREY FINE SAND TRACE GRAVEL. 20.0'				
		COMPLETE AT 20.0				

SHEET NO. .... OF ....

S-78

LOG of BORING No. AS-11

DATE 2/8/82 SURFACE ELEV. ______ LOCATION See Plate

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0			FILL - sand and gravel with rubble					
5	■	4	Firm black and gray oily silty CLAY					
10	■	21	Stiff gray fine sandy clayey SILT					
15	■	8	Stiff gray and brown mottled clayey SILT					
20	■	44	Dense to very dense gray coarse to fine SAND and GRAVEL					
25	■	29						
30	■	53						
35								

COMPLETION DEPTH 32.0 feet FLUID Depth enc. @ 24 ft. Date 2/8/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER

B NO 81 C 2256A

NCC

PIEZOMETER INSTALLATION REPORT

S-78

Piezometer No. AS-11

Project ARCO REFINERY

Location See Fig.

Project No. 81C2256 Installed By PFM

Date 2/8/82 Time

Method of Installation Hollow stem auger

LOG OF BORING AND PIEZOMETER

BORING.

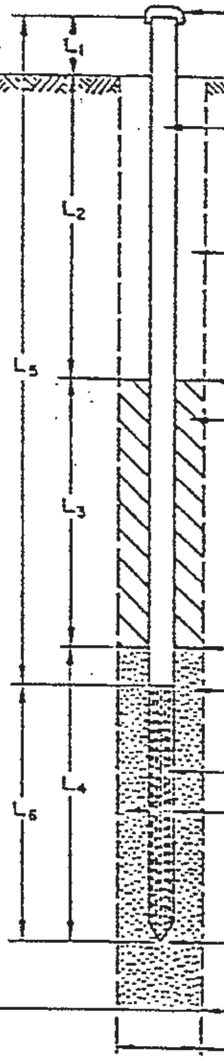
Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer PVC

Ground Elev. 28.52

Top of Riser Elev. 30.52'



Vented Cap

I.D. of Riser Pipe 3"

Type of Pipe PVC

Type of Backfill Around Riser sand-cement grout

Top of Seal Elev. 11.52"

Type of Seal Material bentonite balls

L1= 2'
L2= 17'
L3= 2'
L4= 11.5' L7
L5= 22.5'
L6= 10'
L7= 35'

Top of Filter Elev. 9.52'

Type of Filter Material sand

Size of Openings .010"

Diameter of Piezometer Tip 3"

Bottom of Piez. Elev. -1.98'

Bottom of Boring Elev. -6.48'

Diameter of Boring 12"

Remarks

Inspected By PFM

S-79

C.V.M. industries

geotechnical division inc.
post office box 2 • huntingdon valley, pennsylvania
215-947-2555

Client ARCO REFINERY
Project WELLS AND TEST BORINGS
Location PHILADELPHIA, PA.
Project No.
Boring No. SM-5B Depth 24.0'
Elevation
Spoon Size 2" Casing Size
Core Size Bit No.
Hammers:
Spoon, weight 140# Drop 30"
Drive, weight Drop
Date Started 8-1-85

Driller SB
Helper WGH
Inspector
Job No. 3115

Ground Water Data:
O. Hrs:
WATER AT 10.0'

TOTAL PIPE = 27.0'

Date Completed 8-1-85

Depth	Casing Blows	STRATA CLASSIFICATION	SAMPLING DATA			REMARKS
			Depth	No.	Blows per 6"	
		ASH - CINDER FILL 5.0'	4.0- 6.0	S-1	1-3 7-14	SAMPLE HOLE OFFSET APPROXIMATELY 2.0' to 4.0' OF WELL
		GREY CLAY OVER PEAT 19.0'	13.5- 15.5	S-2	3-3 4-5	
		MULTI-COLORED FINE TO COARSE SAND. 24.0'				THIS HOLE SHOWS SIGNS OF A TRAPPED WATER LEVEL. ABOVE THE ORGANIC STRATA: 9.0'-10.0' AREA
		COMPLETE AT 24.0'				

SHEET NO. .... OF ....

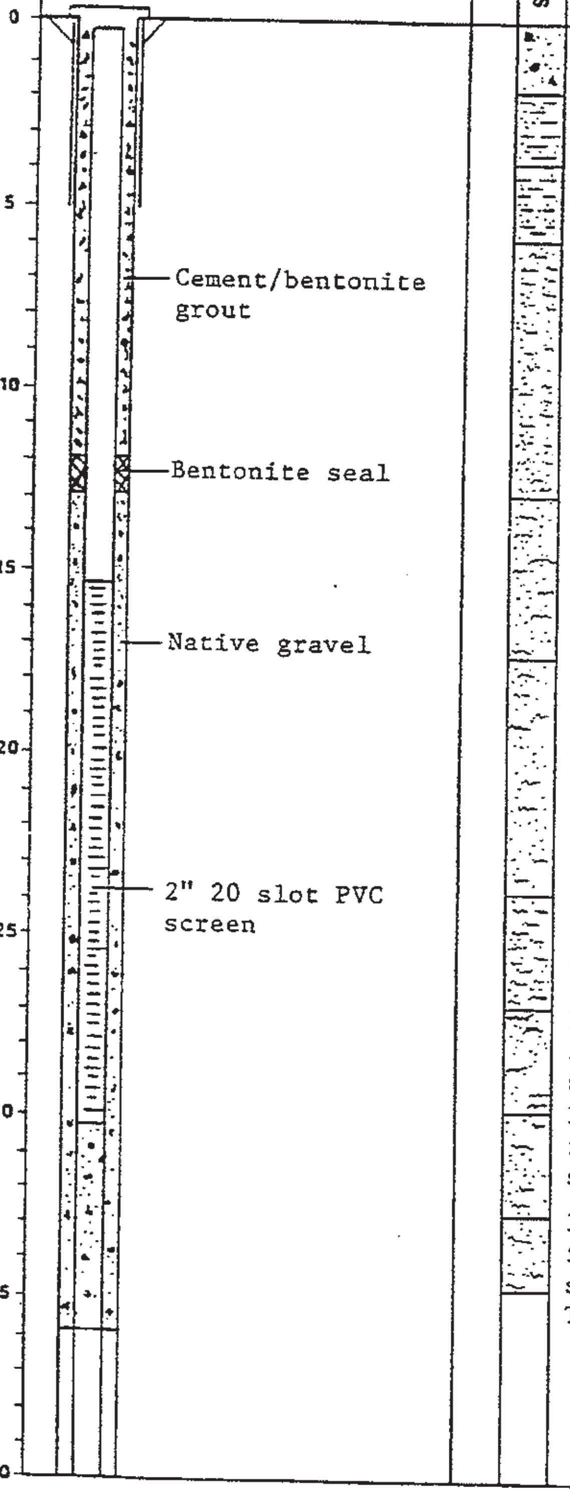
S-80

WELL #72

WELL ELEVATION: 34.47
WELL INSTALLED: 7-27-87
WELL DEVELOPED:
WELL DEPTH:

BORING

SURFACE ELEVATION:
DRILLING METHOD: Hollow Stem Auger
BORING DEPTH: 36.0



0.0 - 2.0 FILL: sand, silt, gravel

2.0 - 4.0 CLAY: dark gray, silty, sandy, odors present

4.0 - 6.0 CLAY: light gray, silty, sandy

6.0 - 13.0 SILT: dark gray, clayey, sand and gravel, strong odors

13.0 - 17.5 SAND: black, silty, wet, strong odors

17.5 - 24.0 SAND: variegated, gravel, silt, dense, strong odor

24.0 - 27.0 SILT: dark brown, sandy, micaceous, highly saturated

27.0 - 30.0 SAND: brown, fine to coarse, gravel with silt

30.0 - 33.0 SAND: variegated, fine to coarse, gravel, some silt, wet, strong, odors

33.0 - 35.0 SAND: brown, fine to coarse, gravel, trace silt, wet, odors

TOTAL DEPTH 36.0

SAMPLE DATA

	-	BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
				1		
				2		
				3		
				4		
				5		
				6		

Drilled By Hardin-Huber
Logged By Peter J. Dougherty
Client Atlantic
Job No. 522-239-00
Page 1 Of 1

EEI ENGINEERING ENTERPRISES, INC.

Aquaterra Technologies, Inc.
Subsurface Log: S-80D

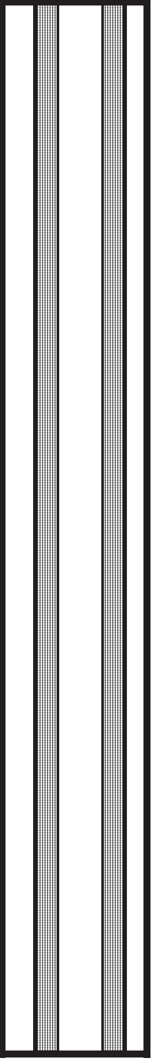
Project Name: Sunoco Philadelphia Refinery AOI - 1
Owner: Sunoco, Inc. (R&M)
Location: Philadelphia, PA
Permit No.:

Boring Number: S-80D
Log By: M.B. Spancake
Date: 3/15-31/05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25'
Screen Diameter: 2" **Length:** 15'
Slot Size: 0.02
Water Level (Init): 70'
Casing Diameter: 2" **Length:** 66'
Type: PVC
Drilling Method: Hollow Stem Auger/ Mud Rotary
Sample Method: Split Spoon
Rig Type: HSA Rig/Mud Rotary

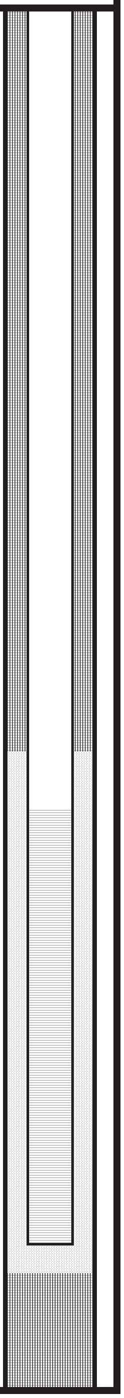
Construction Details

Total Well Depth: 79' BGS
Outer Steel Casing Interval: 0'-58'
Screen Interval: 64'-79'
Bentonite Interval: 0-62'
Sand Pack Interval: 62'-79'
Cement/Grout Interval:
Completion Details: Completed with 2' Steel stick-up
Sand Pack Type: 62'-79'

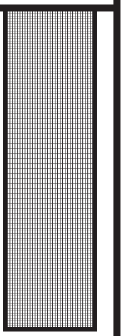
□ = Backfill
■ = Cement/Grout
▨ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Vacuum Utility Clearance to 9' below ground surface (bgs). Advance augers to 10' BGS and begin split spoons	
5					
10	10-12	21	2	Wet gray sandy clay changing to a wet gray medium sand	
	12-14	43	2	Wet gray and brown fine to medium sand, some small gravel	
	14-16	NM	0	No recovery	
15					
	16-18	102	1.5	Coarse sand and gravel, some gray clayey silt	
	18-20	48	1	Coarse sand and pebble fragments, reddish brown in color, slight moisture	
20	20-22	660	1	Poorly sorted coarse sandy gravel, quartz fragments and small pebble Moist	
	22-24	1485	1.75	Sams as above, changing to a reddish gray medium sand and smaller gravel toward bottom	
	24-26	959	1.5	Same as above, changing to a brownish gray clayey silt	
25					
	26-28	1435	1.75	Reddish brown clayey silt and fine sand, moist to wet	
	28-30	1511	2	Wet brown poorly sorted sandy gravel and silt, black staining present towards bottom of spoon.	
30	30-32	967	1.25	Wet poorly sorted coarse sandy gravel, gray in color.	
	32-34	697	1.25	Coarse sandy gravel, poorly sorted and wet. Gravel is small. Rock fragment in bottom of spoon.	
	34-36	44	2	Wet poorly sorted gravel with fine and medium sand. Some brown silt	
35					
	36-38	87	2	Same as above, changing to a gray and brown moist silt in bottom 3"	

Aquaterra Technologies, Inc.
Subsurface Log: S-80D (Continued)

Depth (ft)					Well Schematic
	38-40	11	1	Fine gray and brown sand, slight moisture	
40	40-42	4.5	1.5	Moist brownish gray silty clay changing to a moist light brown clay	
	42-44	19	2	Wet gray medium sandy gravel - Note: could be cave-in from above	
45	44-46	9	2	Wet gray medium sand and silt, slight clay content towards bottom	
	46-48	5	2	Same as above, changing to a reddish brown silty clay at 47' BGS	
	48-50	NM	0	No recovery	
50	50-52	0	1	Reddish brown clay, moist	
	52-54	0	1.25	Same as above.	
55	54-56	0	1.5	Same as above.	
	56-58	0	1	Same as above.	
	58-60	NM	NS	Set 4" steel casing at 58' BGS. Continue drilling with mud rotary on 3/29/2005	
60	60-62	NM	NS	Advanced Mud rotary to 62' BGS	
	62-64	0	NM	Reddish brown moist clay becoming sandy towards bottom Blow Count: 4-4-4-4	
65	64-66	0	NM	Moist reddish brown coarse sand, slight clay content Blow Count: 9-11-10-11	
	66-68	0	NM	Moist to wet coarse sand reddish brown in color. Some small gravel Blow Count: 10-10-9-10	
	68-70	0	NM	Moist reddish brown coarse sand Blow Count: 11-9-18-18	
70	70-72	0	0.5	Reddish brown coarse sand and some small gravel, wet Blowcount: 17-21-18-19	
75	75-77	0	0.5	Same as above, gravel lense at 76' BGS with very coarse sand. Blowcount: 20-20-16-20	
80	80-82	0	0.5	Brown coarse sand and some small gravel, wet. Blowcount: 38-15-22-16	

Aquaterra Technologies, Inc.
Subsurface Log: S-80D (Continued)

Depth (ft)					Well Schematic
85	85-87	0	2"	Dark greenish gray silt, some pebble. Silt had some dark brown layering	
				Blowcount: 27-25-40-31	
				Rollerbit starting slight refusal at 87' BGS. Slow advancement	
90	90-92	0	2'	Small gravel (white, tan, red, green and gray) with very coarse sand.	
				Blowcount: 19-17-15-50/4"	
	92-94	0	0.75	Dark greenish gray tight silt, slight clay content, some medium sand	
				Blowcount: 21-30-28-20	
95				Rollerbit started "jumping" at 95' BGS, only advance 1" in 45 minutes	
				End boring	

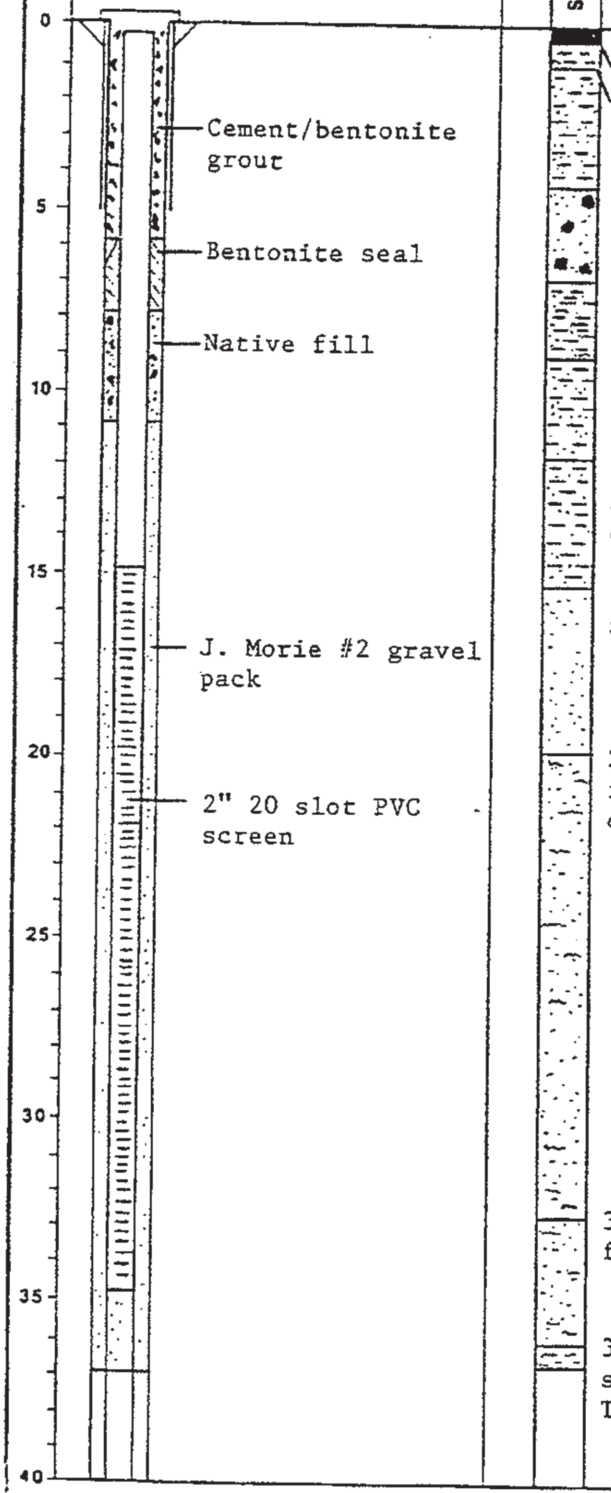
S-81

WELL #70

WELL ELEVATION: 38.85
WELL INSTALLED: 7-23-87
WELL DEVELOPED:
WELL DEPTH:

BORING

SURFACE ELEVATION: 28.97
DRILLING METHOD: Hollow Stem Auger
BORING DEPTH: 37.0



0.0 - 0.5 BLACK TOP
0.5 - 1.0 SILT: brown, sandy
1.0 - 4.5 CLAY: dark gray, silty, sandy, strong odor
4.5 - 7.0 FILL: brick and gravel
7.0 - 9.0 CLAY: black, silty, sandy, strong odor
9.0 - 12.0 CLAY: black, sandy
12.0 - 15.5 CLAY: gray, sandy, silt and gravel, wet, slight odor
15.5 - 20.0 SAND: variegated, gravel, dry, slight odor
20.0 - 33.0 SAND: variegated, fine to coarse, gravel with clay and trace silt
33.0 - 36.5 SAND: brown, fine to coarse, trace silt
36.5 - 37.0 SILT: light brown, sandy, clayey, micaceous
TOTAL DEPTH 37.0

SAMPLE DATA

		BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
				1		
				2		
				3		
				4		
				5		
				6		

Drilled By Hardin-Huber
Logged By Peter J. Dougherty
Client Atlantic
Job No. 522-239-00

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ENGINEERING ENTERPRISES, INC.

S-82

LOG of BORING No. AS-5

DATE 2/5/82 SURFACE ELEV. ______ LOCATION See Plate

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0			FILL - oily black sand and cinders with rubble					
5	■	3	Stiff gray silty CLAY					
10	■	42	Stiff to hard brown and gray mottled gravelly clayey SILT					
15	■	12						
20	■	37	Medium dense to very dense brown and gray coarse to fine SAND and GRAVEL					
25	■	93						
30	■	127						
35								

COMPLETION DEPTH 32.0 feet FLUID Depth enc. @ 15 ft. Date 2/5/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER

NO 81 C 2256A

5-82

PIEZOMETER INSTALLATION REPORT

roject ARCO REFINERY

oject No. 81C2256 Installed By PFM

Method of Installation Hollow stem auger

Piezometer No. AS-5

Location See Fig.

Date 2/5/82 Time

LOG OF BORING AND PIEZOMETER

BORING.

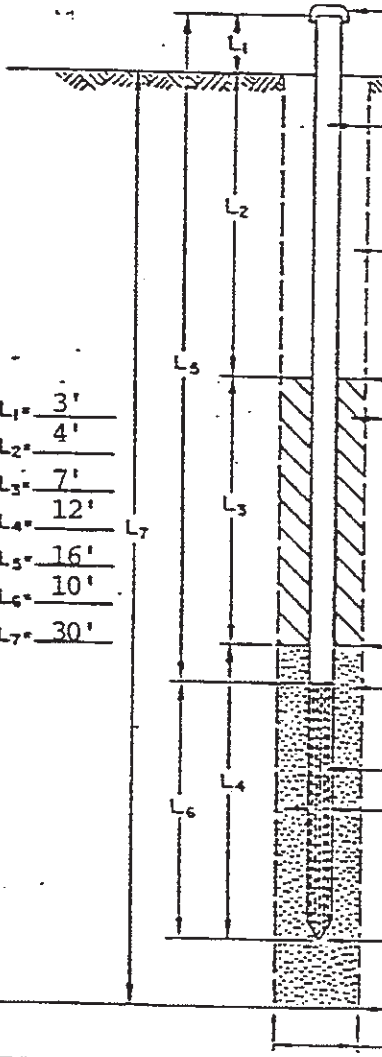
Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer

Ground Elev. 23.89

Top of Riser Elev. 26.89



L1= 3'

L2= 4'

L3= 7'

L4= 12'

L5= 16'

L6= 10'

L7= 30'

I.D. of Riser Pipe 3"

Type of Pipe PVC

Type of Backfill Around Riser cement, sand, bentonite grout

Top of Seal Elev. 19.89'

Type of Seal Material bentonite balls

Top of Filter Elev. 12.89'

Type of Filter Material sand

Size of Openings .010"

Diameter of Piezometer Tip 3"

Bottom of Piez. Elev. .89'

Bottom of Boring Elev. -6.11'

Diameter of Boring 12"

Remarks

Inspected By PFM

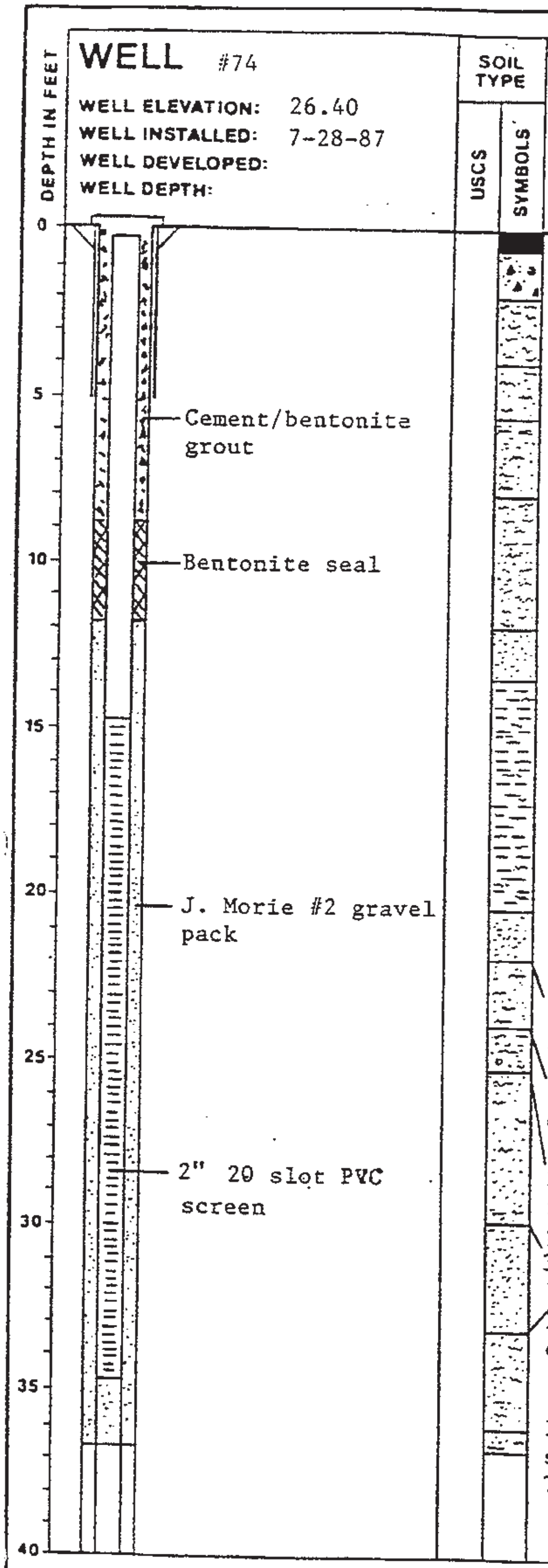
S-83

WELL #74

WELL ELEVATION: 26.40
WELL INSTALLED: 7-28-87
WELL DEVELOPED:
WELL DEPTH:

BORING

SURFACE ELEVATION:
DRILLING METHOD: Hollow Stem Auger
BORING DEPTH: 37.0



0.0 - 0.5 BLACK TOP

0.5 - 2.0 FILL: silt, sand gravel

2.0 - 4.0 SILT: dark brown, sandy, clayey, no odor

4.0 - 5.5 SAND: black, silty no odor

5.5 - 8.0 SAND: gray, fine, silty, fuel oil odor present

8.0 - 12.0 SILT: brown and gray, clayey, some sand, no odor

12.0 - 13.5 SAND: green, fine micaceous, no odor

13.5 - 20.5 CLAY: brown, silty, no odor

20.5 - 22.0 SAND: gray, fine to coarse, gravel with trace silt, saturated by hydrocarbons

22.0 - 24.0 SAND: variegated, gravel, fine to coarse, silt, free product

24.0 - 25.5 SILT, SAND, AND GRAVEL: stratified, variegated, free product

25.5 - 30.0 SAND: variegated, fine to coarse, silty, free product

30.0 - 33.5 SAND: gray, fine to coarse, gravel

33.5 - 36.5 SILT: brown, clayey, some sand

36.5 - 37.0 SAND: gray, silty, strong odors

TOTAL DEPTH 37.0

SAMPLE DATA

		BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
				1		
				2		
				3		
				4		
				5		

Drilled By Hardin-Huber
Logged By Peter J. Dougherty
Client Atlantic
Job No. 522-239-00

ENGINEERING ENTERPRISES, INC.

S-84

WELL PR-1

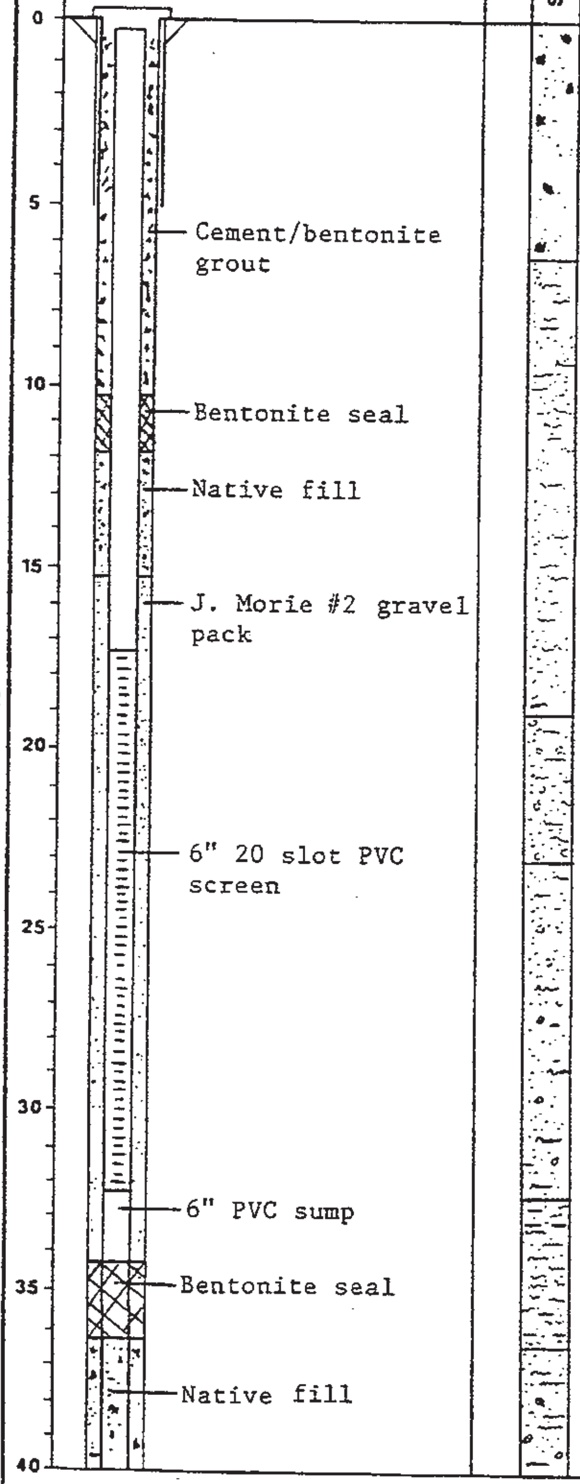
WELL ELEVATION:
WELL INSTALLED: 8/18/87
WELL DEVELOPED: 8/19/87
WELL DEPTH: 34.5

SOIL TYPE: USCS | SYMBOLS

BORING

SURFACE ELEVATION:
DRILLING METHOD: Mud Rotary
BORING DEPTH: 43.5

SAMPLE DATA						
		BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE



0.0 - 6.5 FILL: silt, sand, gravel, brick

6.5 - 19.0 SAND: fine, silty

19.0 - 23.0 SAND: silty, some gravel

23.0 - 32.5 SAND: slightly silty, some gravel

32.5 - 36.5 SILT: sandy, clayey

36.5 - 43.5 SAND: silty, some gravel

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ENGINEERING ENTERPRISES, INC.

5-84

DEPTH IN FEET	WELL PR-1 Cont.	SOIL TYPE		BORING Cont.	SAMPLE DATA						
		USCS	SYMBOLS				BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
40											
				TOTAL DEPTH 43.5							
45											
50											
55											
60											
65											
70											
75											
80											

EEI ENGINEERING ENTERPRISES, INC.

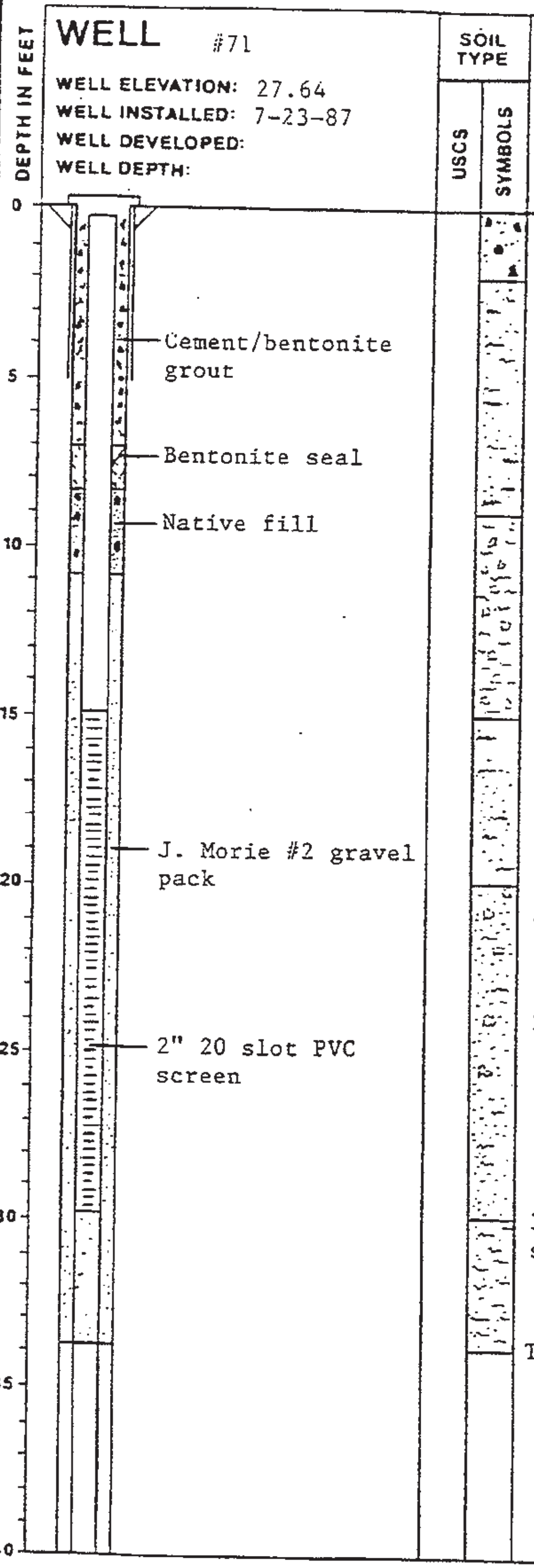
S-85

WELL #71

WELL ELEVATION: 27.64
WELL INSTALLED: 7-23-87
WELL DEVELOPED:
WELL DEPTH:

BORING

SURFACE ELEVATION:
DRILLING METHOD: Hollow Stem Auger
BORING DEPTH: 34.0



0.0 - 2.0 FILL

2.0 - 9.0 SAND: black, silty some clay and fill material, oily

9.0 - 15.0 GRAVEL: black, clayey, silty

15.0 - 20.0 SAND: brown and gray, fine to medium, trace silt, saturated, strong odors

20.0 - 30.0 SAND: variegated, gravel, silt, saturated

24.0 FREE PRODUCT

30.0 34.0 SILT: brown, gray, sandy, clayey

TOTAL DEPTH 34.0

SAMPLE DATA

	-	BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
				1		
				2		
				3		
				4		
				5		

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Logged By Peter J. Dougherty
Client Atlantic
Job No. 522-239-00

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EEI ENGINEERING ENTERPRISES, INC.

PIEZOMETER INSTALLATION REPORT

S-86

Project ARCO REFINERY

oject No. ~~81C2256~~

Installed By PFM

Piezometer No. AS-4

Location See Fig.

Date 2/9/82 Time

Method of Installation Hollow stem auger

LOG OF BORING AND PIEZOMETER

BORING.

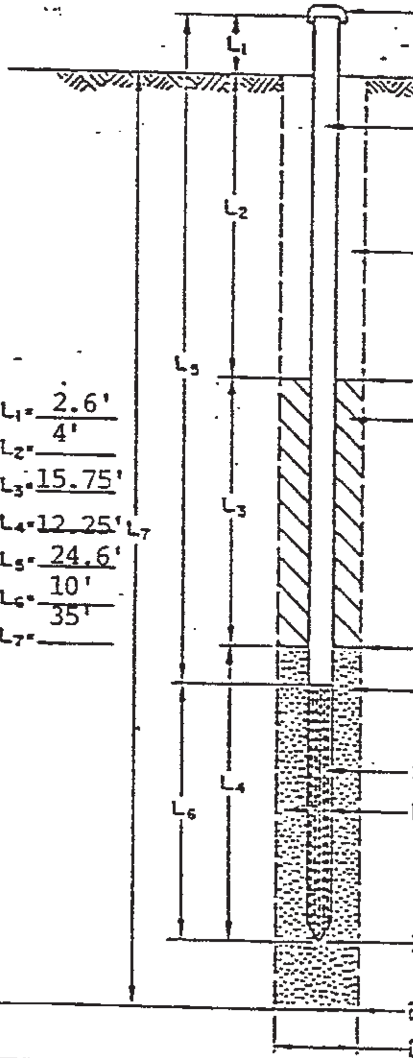
Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer PVC

Ground Elev. 23.77'

Top of Riser Elev. 24'



L1= 2.6'

L2= 4'

L3= 15.75'

L4= 12.25'

L5= 24.6'

L6= 10'

L7= 35'

I.D. of Riser Pipe 3"

Type of Pipe PVC

Type of Backfill Around Riser cement grout

Top of Seal Elev. 19.77'

Type of Seal Material bentonite slurry

Top of Filter Elev. 4.02'

Type of Filter Material sand

Size of Openings .010"

Diameter of Piezometer Tip 3"

Bottom of Piez. Elev. -8.23'

Bottom of Boring Elev. -11.23

Diameter of Boring 12"

Remarks

Inspected By PFM

S-87 I

LOG of BORING No. AD-2

DATE 1/28/82 **SURFACE ELEV.** ______ **LOCATION** See Plate

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0								
5	▮	8	FILL - oily black sandy clayey silt with rubble					
10	▮	2	Firm gray clayey SILT becoming more sandy with depth					
15	▮	13						
20	▮	127						
25	▮	28	Medium dense to dense gray coarse to fine SAND trace gravel					
30	▮	44	becoming more gravelly @ 30 feet					
35	▮	18						
40	▮	18	Firm gray and red brown sandy CLAY					
45			See next page for description					

COMPLETION DEPTH 56.5 feet **FLUID Depth** enc. @ 26 ft. **Date** 1/28/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER

B NO 81 C 2256A

S-87 I

LOG of BORING No. AD-2 (cont'd.)

DATE 1/28/82 **SURFACE ELEV.** ______ **LOCATION** See Plate

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45	■	25						
50	■	11	Medium dense red brown silty coarse to fine SAND					
55	■	22						
60								

COMPLETION DEPTH 56.5 feet **FLUID Depth** enc. @ 26 ft. **Date** 1/28/82

SAMPLER: 2" O.D. SPLIT-BARREL SAMPLER

LOG JOB NO 81 C 2256A

WCC KP

5-87 I

PIEZOMETER INSTALLATION REPORT

Project ARCO Refinery

Project No. 81C2256 Installed By STG

Method of Installation Hollow stem auger

Piezometer No. AD-2

Location See Figure

Date 2/28/82 Time

LOG OF BORING AND PIEZOMETER

BORING

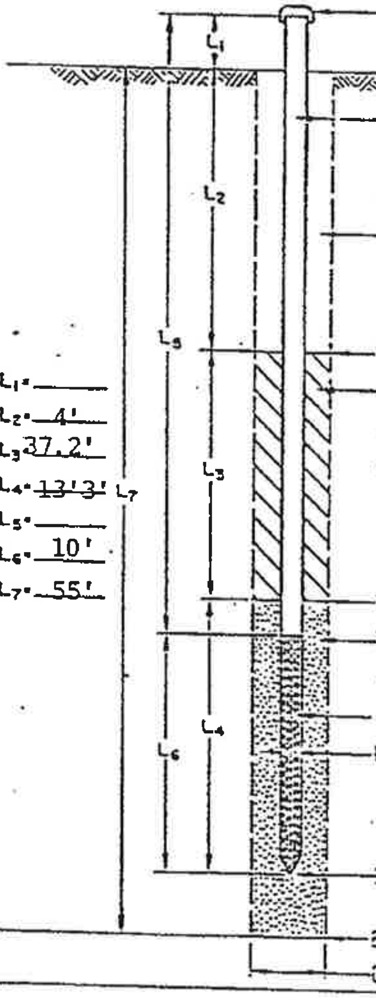
Depth in ft.	Description	Symbol

PIEZOMETER

Type of Piezometer PVC

Ground Elev.

Top of Riser Elev.



Vented Cap

I.D. of Riser Pipe 3"

Type of Pipe PVC

Type of Backfill Around Riser cement grout

Top of Seal Elev.

Type of Seal Material - bentonite slurry

Top of Filter Elev.

Type of Filter Material sand

Size of Openings .010"

Diameter of Piezometer Tip 3"

Bottom of Piez. Elev.

Bottom of Boring Elev.

Diameter of Boring 12"

L1 =

L2 = 4'

L3 37.2'

L4 = ~~13'3'~~

L5 =

L6 = 10'

L7 = 55'

Remarks

Inspected By STG

S-88

WELL PR-2

WELL ELEVATION:
WELL INSTALLED: 8/19/87
WELL DEVELOPED: 8/20/87
WELL DEPTH: 34.5

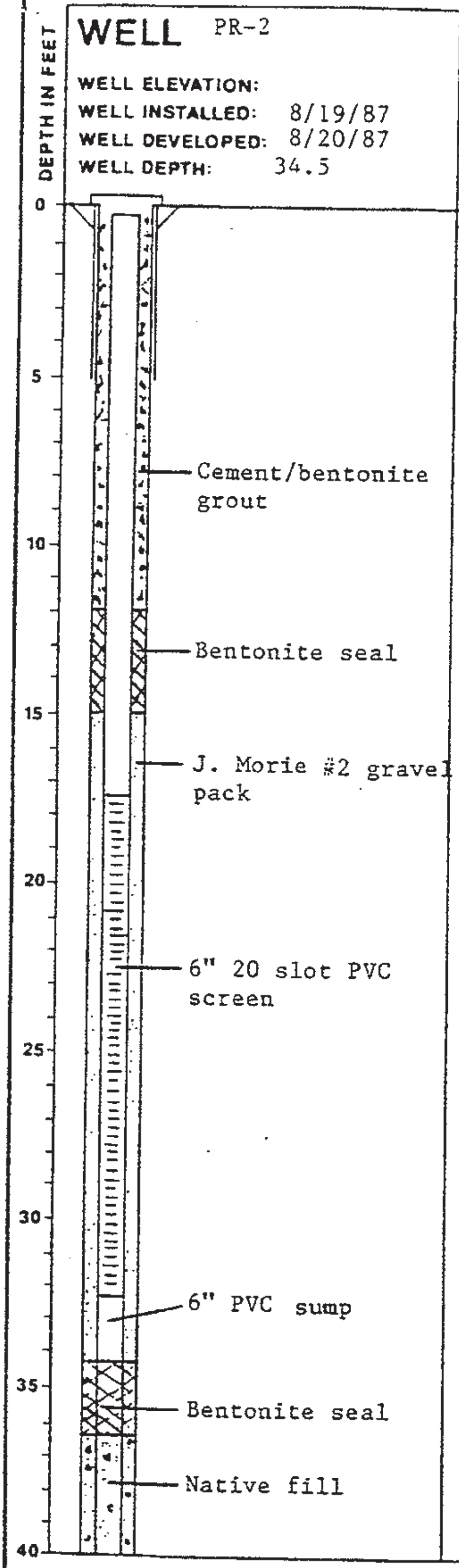
SOIL TYPE: USCS | SYMBOLS

BORING

SURFACE ELEVATION:
DRILLING METHOD: Mud Rotary
BORING DEPTH: 44.0

SAMPLE DATA

		BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE



0.0 - 15.0 FILL: black, sand, silty, clay, wood, oily

(5.0 - 7.0 thick oily waste)

15.0 - 18.0 SAND: gray, fine, silty

18.0 - 27.0 SAND: clayey, gravel, some silt

27.0 - 31.5 COBBLES

31.5 - 38.5 SAND: fine, silty, some clay

38.5 - 40.5 SAND: some cobbles

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Client Atlantic
Job No. 522-239-00
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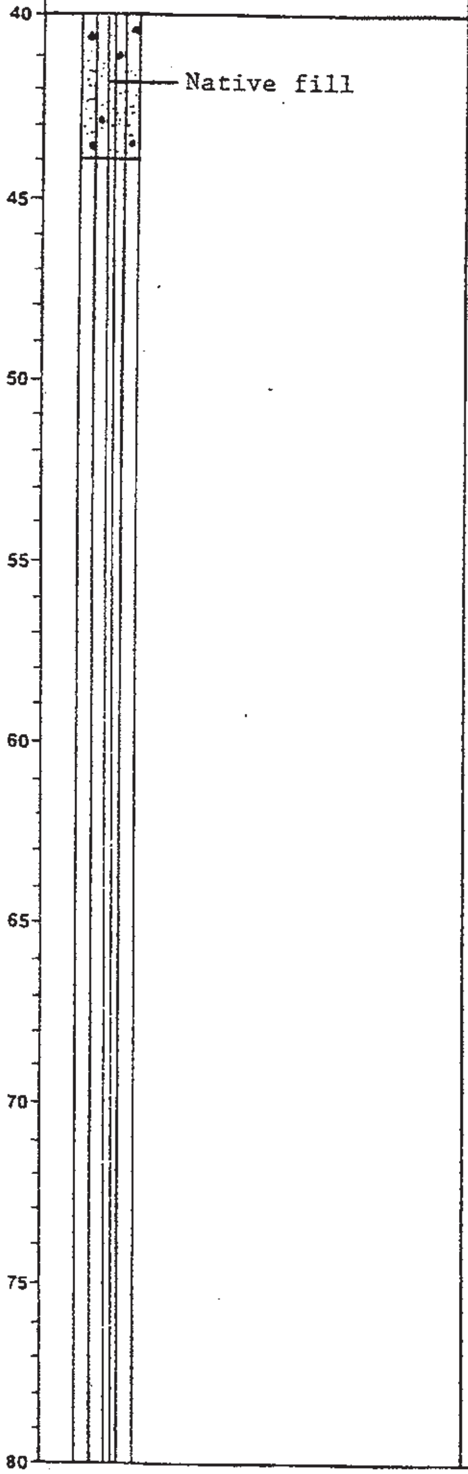
EEI ENGINEERING ENTERPRISES, INC.

S-88

DEPTH IN FEET	WELL PR-2 Cont.	SOIL TYPE USCS	SOIL TYPE SYMBOLS	BORING Cont.			BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
40				40.5 - 44.0 SAND: silty, some clay							
				TOTAL DEPTH 44.0							



EEI ENGINEERING ENTERPRISES, INC.

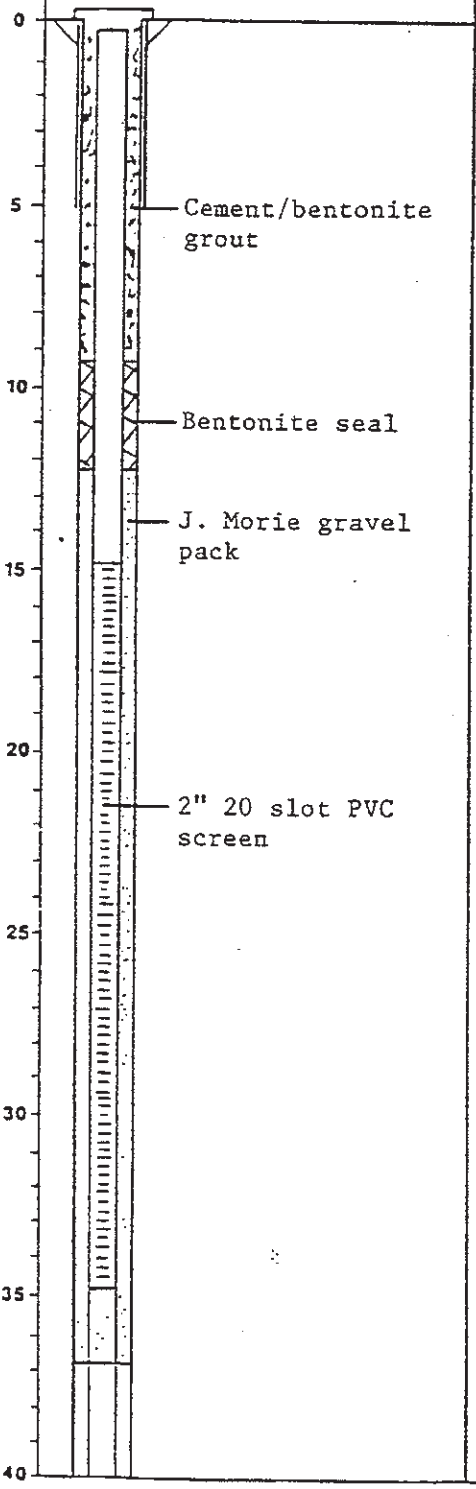
S-89

WELL #75

WELL ELEVATION: 28.99
WELL INSTALLED: 7-29-87
WELL DEVELOPED:
WELL DEPTH:

BORING

SURFACE ELEVATION:
DRILLING METHOD: Hollow Stem Auger
BORING DEPTH: 37.0



SOIL TYPE: USCS / SYMBOLS

0.0 - 1.0 FILL: gravel
1.0 - 4.0 FILL: silt, sand, glass

4.0 - 9.0 SILT: black, sandy, oily

9.0 - 16.0 SILT: black, sandy, trace clay, oily

16.0 - 22.0 SAND AND GRAVEL: variegated, trace silt, dry, no odor

22.0 - 25.5 SAND: variegated, silty, fine to coarse, sand, gravel, cobbles

25.5 - 26.0 SAND: gray, fine to coarse, silty, strong odors

26.0 - 30.0 SAND AND SILT: fine to coarse, sand, cobbles, fairly dry, odors present

30.0 - 34.0 SAND: variegated, fine to coarse, trace silt, slight odor

34.0 - 37.0 SAND: brown and gray, fine, silty, slightly clayey, wet, odor present

TOTAL DEPTH 37.0

SAMPLE DATA

		BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
				1		
				2		
				3		
				4		
				5		
				6		

Drilled By Hardin-Huber
Logged By Peter J. Dougherty
Client Atlantic
Job No. 522-239-00
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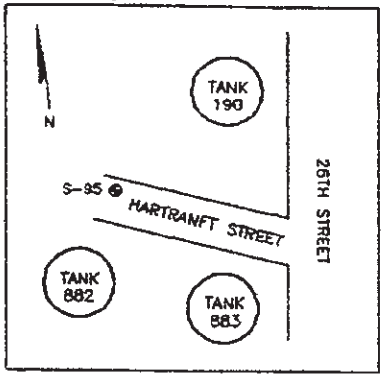
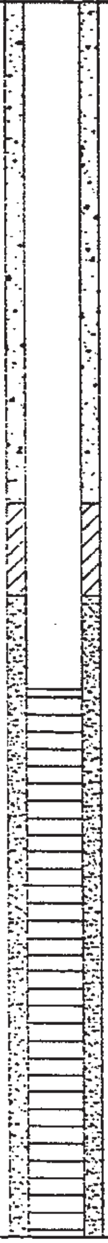
EEI ENGINEERING ENTERPRISES, INC.

GROUNDWATER & ENVIRONMENTAL SERVICES, INC.
DRILLING LOG

Project Sun Philadelphia Refinery **Owner** Sun Company, Inc. (R & M)
Location South Yard **Permit No.** NA
Well Number S-95 **Total Depth** 30 ft. **Diameter** 10 in.
Casing Elevation 25.34 ft. **Water Level: Initial** 21 ft. **Static** 22.01 ft.
Screen Dia. 4 in. **Length** 15 ft. **Slot Size** 0.02 in.
Casing Dia. 4 in. **Length** 15 ft. **Type** Sch. 40 PVC
Drilling Method Hollow-Stem Auger **Sample Method** Split-spoon
Completion Details 2 ft. stick-up locking cap w/6 in. steel protective casing
Driller B. L. Myers Brothers, Inc. **Log By** MDH **Date** 4/4/94

Sketch Map

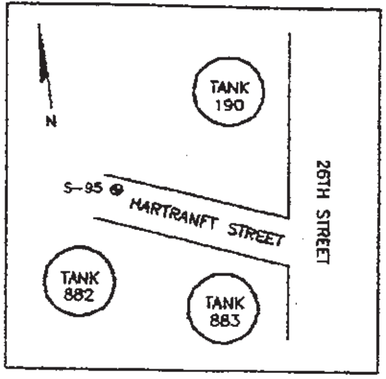


Depth (feet)	Sample No.	Well Const.	OVM (ppm)	Blow Count	Lithology	
					FILL	– Limestone gravel
					CLAY	– Orange/brown silty clay, no odor, dry
5			0	3,4,6,9		– Same lithology, no odor, slight increase in moisture
10			0	3,4,15 Refusal		– Brown silty clay, no odor, slightly moist
					SAND	– Purple coarse sand and gravel, some weathered small pebbles
15			0	6,18,18,12		– Gray poorly-sorted coarse sand, some rounded cobbles and pebbles, no odor, dry
20			106	8,15,26,25		– Same lithology, some silty clay, slight odor, increase in moisture
					▽	Initial groundwater encountered at 21 feet.
					▼	Static groundwater level at 22.01 feet.
25			623	5,6,6,7		– Same lithology, some fine sands, strong odor, very wet

GROUNDWATER & ENVIRONMENTAL SERVICES, INC.
DRILLING LOG

Project Sun Philadelphia Refinery
Owner Sun Company, Inc. (R & M)
Location South Yard
Permit No. NA
Well Number S-95
Total Depth 30 ft. **Diameter** 10 in.
Casing Elevation 25.34 ft.
Water Level: Initial 21 ft. **Static** 22.01 ft.
Screen Dia. 4 in.
Length 15 ft. **Slot Size** 0.02 in.
Casing Dia. 4 in.
Length 15 ft. **Type** Sch. 40 PVC
Drilling Method Hollow-Stem Auger
Sample Method Split-spoon
Completion Details 2 ft. stick-up locking cap w/6 in. steel protective casing
Driller B. L. Myers Brothers, Inc.
Log By MDH **Date** 4/4/94

Sketch Map



Depth (feet)	Sample No.	Well Const.	OVM (ppm)	Blow Count	Lithology
					SAND — Running sands, very wet, strong odor
30			960	3,3,5,9	
					WELL COMPLETED AT 30 FEET.
35					

Groundwater & Environmental Services, Inc.

Drilling Log

Project Sun : Philadelphia Refinery

Owner Sun Company, Inc. (R&M)

Location 3144 Passyunk Ave.

Permit No. N/A

Well number S-98

Total Depth 35 ft. Diameter 10 in.

Casing Elevation 30.94 ft.

Water Level: Initial 26 ft. Static 24.66 ft.

Screen Dia. 4 in.

Length 20 ft. Slot Size 0.020 in. PVC

Casing Dia. 4 in.

Length 15 ft. Type PVC riser

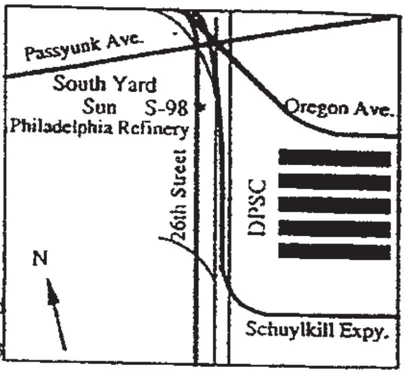
Drilling Method Hollow stem auger

Sample Method split-spoon

Completion Details Completed with sanitary plug & iron stick-up with locking lid

Driller B. L. Myers Bros., Inc.

Log By E. Dziedzic Date 6 December 1993

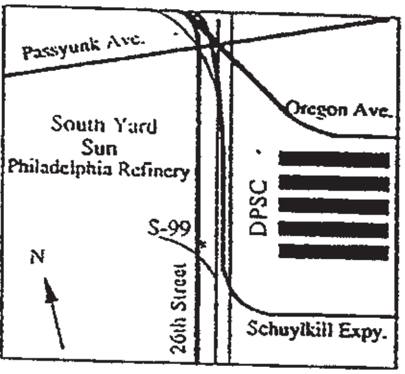


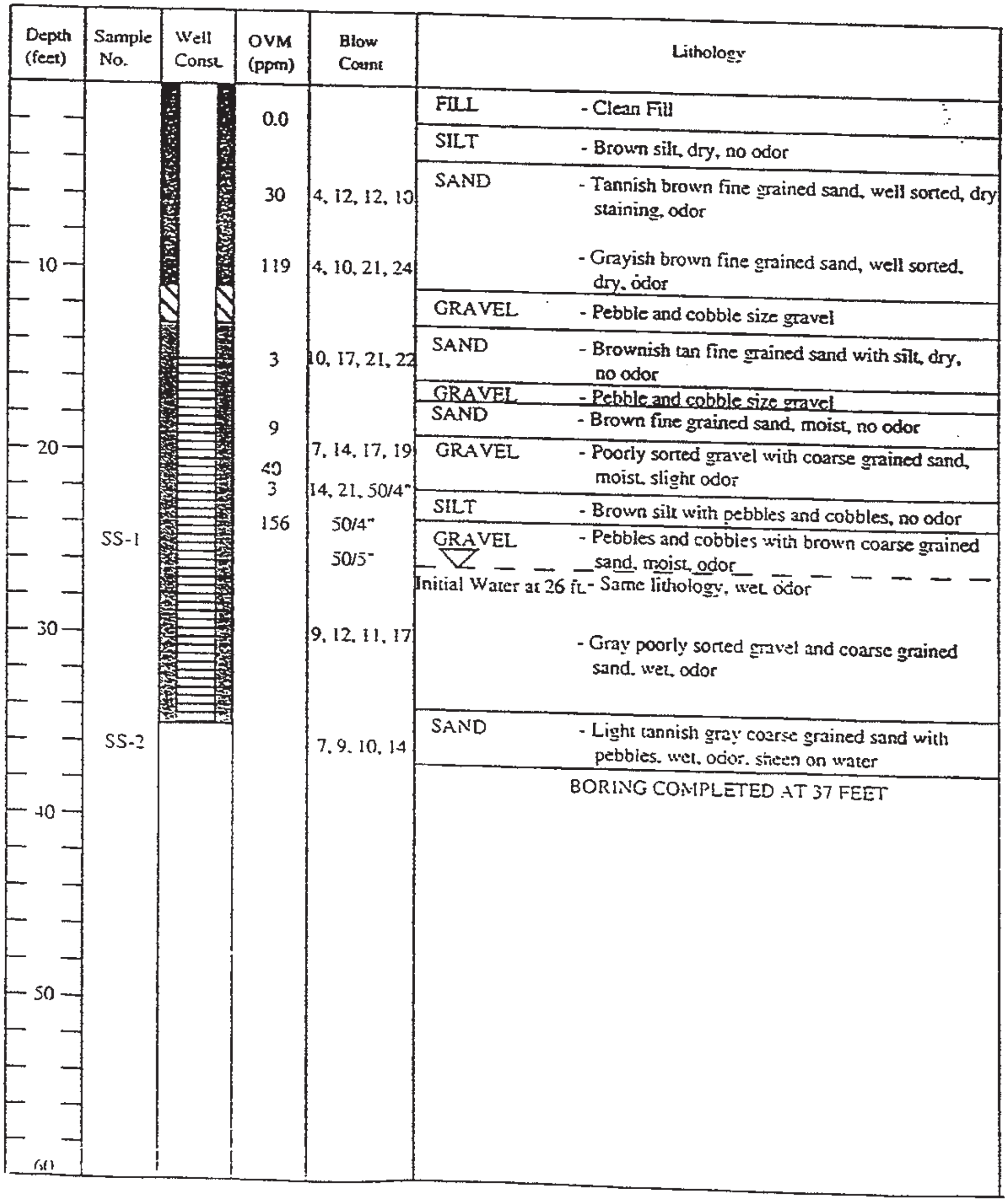
Depth (feet)	Sample No.	Well Const.	OVM (ppm)	Blow Count	Lithology	
			0.0		FILL	- Clean Fill - Brown silt with fill, dry, no odor
			0.0	2, 5, 8, 10		
			33	5, 4, 7, 9	SAND	- Gray silty sand, dry, no odor - Grayish tan silty sand, poorly sorted, dry, odor
10			1360	4, 7, 7, 8		- Gray sand, moist, odor
			396	4, 5, 8, 10		- Dark gray med. grained sand, stained, wet, odor
			16	5, 9, 10, 11	CLAY	- Light tan clay, no odor, moist
			4	6, 9, 6, 12		- Tan and brown interlayered clay, moist, no odor
			10	9, 9, 11, 14	SILT	- Light gray and light tan interlayered silt, moist, no odor
20			0.0	4, 5, 6, 5		- Brown sandy silt with pebbles and organic remains, moist, slight odor
			966	50/4"		
			786	11, 13, 14, 17	GRAVEL	- Pebble size gravel (quartz and sandstone), dry, odor
	SS-1		1020	19, 20, 23, 50/3"		- Pebble size gravel in sandy matrix, moist, odor - Cobble size gravel in sandy matrix, wet, odor
			1140	11, 19, 22, 27	▽ Initial Water at 26 ft.	
30			1135	19, 22, 24, 22		- Interlayered pebbles, cobbles, and brown med. grained sand, saturated, odor
			57	1, 1, 1, 1		- Poorly sorted gravel and brown coarse sand, wet, odor
				No Recovery		- Poorly sorted grayish brown coarse grained sand and gravel, wet, odor
						BORING COMPLETED AT 35 FEET
40						
50						
60						

Groundwater & Environmental Services, Inc.

Drilling Log

Project Sun : Philadelphia Refinery
Owner Sun Company, Inc. (R&M)
Location 3144 Passyunk Ave.
Permit No. N/A
Well number S-99
Total Depth 35 ft. Diameter 10 in.
Casing Elevation 26.05 ft.
Water Level: Initial 26 ft. Static 24.21 ft
Screen Dia. 4 in.
Length 20 ft. Slot Size 0.020 in. PVC
Casing Dia. 4 in.
Length 15 ft. Type PVC riser
Drilling Method Hollow stem auger
Sample Method split-spoon
Completion Details Completed with sanitary plug & iron stick-up with locking lid
Driller B. L. Myers Bros., Inc.
Log By E. Dziedzic Date 7 December 1993



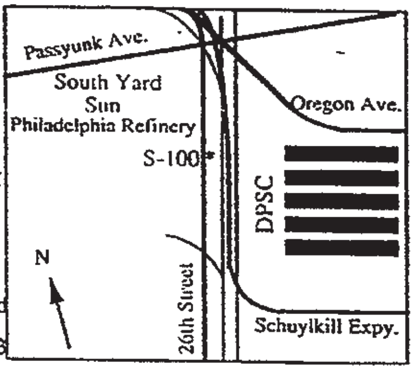


Depth (feet)	Sample No.	Well Const.	OVM (ppm)	Blow Count	Lithology
			0.0		FILL - Clean Fill
					SILT - Brown silt, dry, no odor
			30	4, 12, 12, 10	SAND - Tannish brown fine grained sand, well sorted, dry staining, odor
10			119	4, 10, 21, 24	- Grayish brown fine grained sand, well sorted, dry, odor
					GRAVEL - Pebble and cobble size gravel
			3	10, 17, 21, 22	SAND - Brownish tan fine grained sand with silt, dry, no odor
					GRAVEL - Pebble and cobble size gravel
			9		SAND - Brown fine grained sand, moist, no odor
20			40	7, 14, 17, 19	GRAVEL - Poorly sorted gravel with coarse grained sand, moist, slight odor
			3	14, 21, 50/4"	
			156	50/4"	SILT - Brown silt with pebbles and cobbles, no odor
	SS-1			50/5"	GRAVEL - Pebbles and cobbles with brown coarse grained sand, moist, odor
					Initial Water at 26 ft. - Same lithology, wet, odor
30				9, 12, 11, 17	- Gray poorly sorted gravel and coarse grained sand, wet, odor
	SS-2			7, 9, 10, 14	SAND - Light tannish gray coarse grained sand with pebbles, wet, odor, sheen on water
					BORING COMPLETED AT 37 FEET
40					
50					
60					

Groundwater & Environmental Services, Inc.

Drilling Log

Project Sun : Philadelphia Refinery Owner Sun Company, Inc. (R&M)
Location 3144 Passyunk Ave. Permit No. N/A
Well number S-100 Total Depth 35 ft. Diameter 10 in.
Casing Elevation 29.08 ft. Water Level: Initial 24 ft. Static 23.39 ft.
Screen Dia. 4 in. Length 20 ft. Slot Size 0.020 in. PVC
Casing Dia 4 in. Length 15 ft. Type PVC riser
Drilling Method Hollow stem auger Sample Method split-spoon
Completion Details Completed with sanitary plug & iron stick-up with locking lid
Driller B. L. Myers Bros., Inc. Log By E. Dziedzic Date 13 December 1993

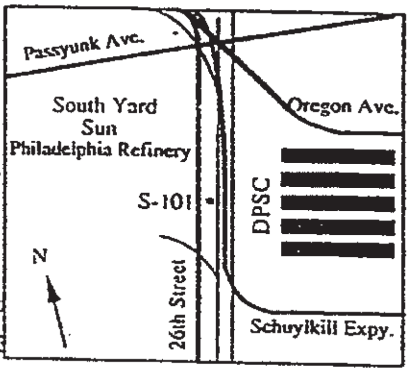


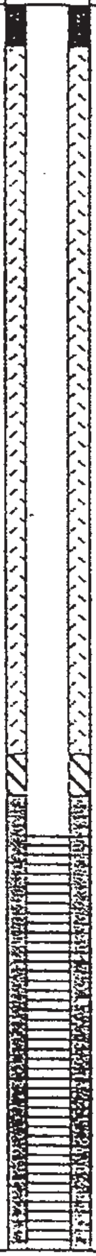
Depth (feet)	Sample No.	Well Const.	OVM (ppm)	Blow Count	Lithology
					FILL - Black sandy fill with brick and stone, dry, no odor - Brown silty fill, wet, no odor
			1.7	4, 3, 3, 5	- Same lithology, wet, no odor
10			49	2, 3, 4, 6	SILT - Greenish gray sandy silt, wet, odor
			4	5, 10, 12, 17	- Brown, tan, and greenish gray clayey silt, dry, no odor
20			1	7, 6, 8, 13	CLAY - Gray and tan layered clay, rare pebbles, dry, no odor
					Initial Water at 24 ft.
	SS-1		2	5, 5, 9, 15	- Same lithology, wet, no odor
					GRAVEL - Cobble size gravel
30			2	4, 5, 7, 10	SILT - Gray and tan interlayered silt with pebbles and cobbles, wet, no odor
	SS-2		2	3, 6, 6, 9	- Gray and tan silt with some sand, wet, no odor
					BORING COMPLETED AT 37 FEET
40					
50					
60					

Groundwater & Environmental Services, Inc.

Drilling Log

Project Sun : Philadelphia Refinery
Owner Sun Company, Inc. (R&M)
Location 3144 Passyunk Ave.
Permit No. N/A
Well number S-101
Total Depth 35 ft. Diameter 10 in.
Casing Elevation 51.28 ft.
Water Level: Initial 49 ft. Static 47.48 ft.
Screen Dia. 4 in.
Length 20 ft. Slot Size 0.020 in. PVC
Casing Dia. 4 in.
Length 40 ft. Type PVC riser
Drilling Method Hollow stem auger
Sample Method split-spoon
Completion Details Completed with sanitary plug & iron stick-up with locking li
Driller B. L. Myers Bros., Inc.
Log By E. Dziedzic Date 20 December 199





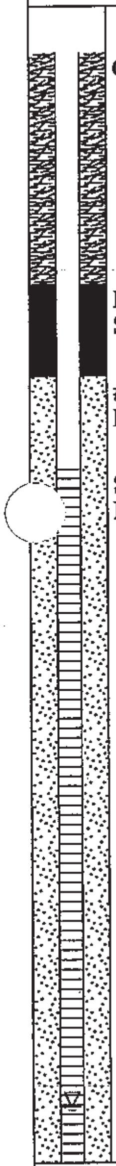
Depth (feet)	Sample No.	Well Const.	OVM (ppm)	Blow Count	Lithology	
			9		FILL	- Ash and cinder fill, dry, no odor, some wood
			8			
10						
			4			- Gray silty fill, dry, no odor
			5	7, 8, 9, 10		- Brown silty fill with wood fragments and crushed stone, dry, no odor
20			0.0	3, 5, 7, 8		- Brown silty fill with gray clay, crushed stone, brick, and glass, moist, no odor
				3, 7, 8, 12		- Same fill
30				6, 9, 14, 14		- No split-spoon yield
						- Auger resistance, creosote like odor
				50/0"		- Split-spoon refusal - Auger resistance (pebbles/cobbles?)
40			37	12, 50/5"	SAND	- Brown coarse sand and small pebbles, dry, slight odor
			102	17, 50/4"		- Same lithology with some fill, moist and soft, odor
					Initial Water at 49 ft.	
50	SS-1			7, 15, 14, 13		- Coarse sand with pebbles, wet, strong odor, sheen on water
				3, 5, 12, 16	CLAY	- Tan and greenish gray clay, some silt, moist, slight odor
60	SS-2			1, 1, 1, 1	SAND	- Tan fine grained sand with silt, wet, slight odor

BORING COMPLETED AT 60 FEET

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	08/12/02 08/13/02	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-116**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	4		∇ **23.8**	**30.0**		




Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm)
			SILT; some fine to coarse sand, little fine gravel, dark brown, dry.	1.6	0.0
Grout			SAND, fine to coarse; trace silt, black, dry. CLAY AND SILT; trace fine sand, brown, dry.	0.8	0.0 0.0
	5		SILT AND CLAY; little fine to medium sand, brown, dry.	1.8	0.0
Bentonite Seal			SILT AND CLAY; little fine to medium sand, brown, dry.	2.0	0.0
#1 Sand and Riser			SILT AND CLAY; trace fine sand, brown, dry.	1.5	0.0
Schedule 40 PVC, 20 Slot	10		SILT; some clay, trace fine sand, brown, dry.	1.4	0.0
			SILT; little fine sand, little clay, brown, dry. SILT; some fine sand, little clay, brown and gray, dry.	1.6	0.0 0.0
			SAND, fine to medium; little silt, brown, dry. SAND, fine to medium; trace silt, brown, dry.	0.7	0.0 0.0
	15		SAND, fine to coarse AND GRAVEL, fine; brown, moist.		0.0
			SILT; little fine sand, little clay, brown, moist.	0.6	0.0
			SAND, fine to coarse; some fine gravel, tan and brown, dry.	2.0	17.1
	20		SAND, fine to coarse; some fine gravel, tan and brown, dry.	1.6	16.8
			SAND, fine to coarse; some fine gravel, tan and brown, dry.	1.2	14.5
			SAND, medium to coarse; some fine gravel, some fine sand, brown and dark	1.1	103

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

oject No. **62SU.01011.02** Date **August 2002**

Log of Well

Figure

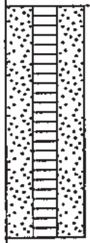
(sheet 1 of 2)

DRILL LOGS AUG 2002.GPJ
LOG OF BOREHOLE

SECOR
International Incorporated

Logged By: SM	Dates Drilled: **08/12/02** **08/13/02**	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc.** **Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger** **Split Spoon**	Well Number: **S-116**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 4	Surface Elev.(ft.):	Groundwater Depth (ft.): ▽ **23.8**	Total Depth (ft.): **30.0**	Drive wt.(lbs.):	Drop Dist.(in.):

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm)
			red, dry.		
			SAND, medium to coarse; some fine gravel, some fine sand, brown and dark red, moist.	1.1	204
			SAND, fine to medium; some fine gravel, some coarse sand, dark red and brown, wet.	1.3	1196
	30				
	35				
	40				
	45				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

ject No. **62SU.01011.02** Date **August 2002**

Log of Well

Figure

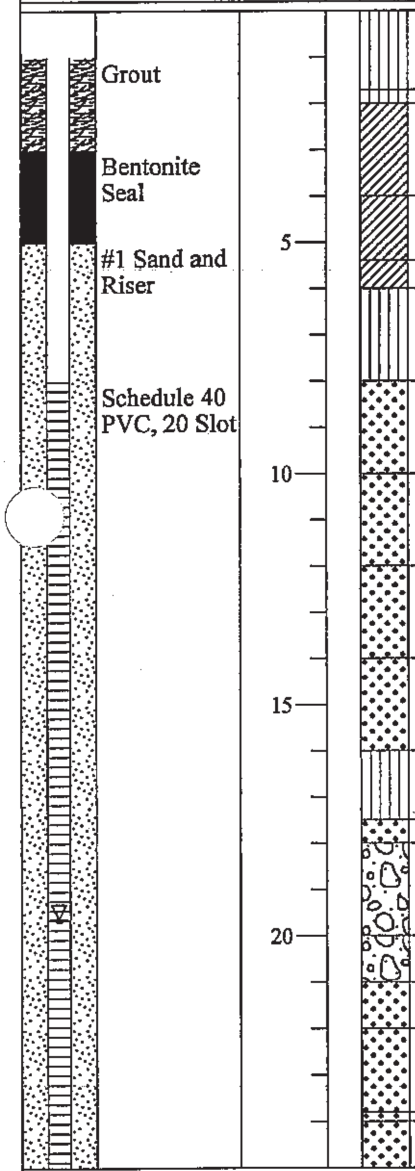
(sheet 2 of 2)

DRILL LOGS AUG 2002.GPJ
LOG OF BOREHOLE

SECOR
International Incorporated

Logged By:	Date Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	08/13/02	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-117**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	4		⊽ 19.63	28.0		



Description	Recovery (feet)	PID Reading (ppm)
SILT; some fine to coarse sand, little fine gravel, brown and black, dry.	1.7	7.3
SILT; some clay, little fine sand, brown and black, dry.	0.6	850
CLAY; some silt, some fine to coarse sand, black and brown, moist.		2171
CLAY; trace fine sand, little silt, brown and black, dry.	1.4	1670
CLAY; little silt, some fine sand, black and brown, dry.		163
SILT; little fine sand, trace clay, black, dry.	0.3	1280
SAND, fine to medium; little coarse sand, brown, dry.	0.2	252
SAND, fine to coarse; little fine to coarse gravel, dark red and brown, dry.	0.6	646
SAND, fine to coarse; little fine gravel, dark red and brown, dry.	0.7	804
SAND, medium to coarse; some fine sand, some fine gravel, brown, red and tan, dry.	2.0	848
SILT; some fine to coarse sand, little clay, brown and black, dry.	2.0	564
SAND, fine to coarse; little fine gravel, trace silt, black, dry.	2.0	1028
SAND, fine to coarse AND GRAVEL, fine to coarse; reddish-brown and black, moist.		2141
SAND, fine to coarse AND GRAVEL, fine; black, wet.	1.6	1816
SAND, fine to coarse; some fine gravel, brown, wet.		1787
SAND, fine to coarse; some fine gravel, trace clay, trace silt, brown, wet.	2.0	948
SAND, fine to medium; gray, white and pink, dry.	1.5	396
SAND, fine to medium; some coarse sand, some fine gravel, black, wet.		793

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ject No. **62SU.01011.02** Date **August 2002**

Log of Well

Figure

DRILL LOGS AUG 2002.GPJ
LOG OF BOREHOLE

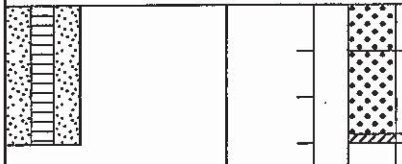
(sheet 1 of 2)

SECOR

International Incorporated

Logged By: SM	Date Drilled: 08/13/02	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc.** **Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger** **Split Spoon**	Well Number: **S-117**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 4	Surface Elev.(ft.):	Groundwater Depth (ft.): ∇ **19.63**	Total Depth (ft.): **28.0**	Drive wt.(lbs.):	Drop Dist.(in.):



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm)
			SAND, fine to medium AND SAND, coarse; gray, wet.	2.0	805
			CLAY; trace silt, trace fine sand, orangish-brown, wet.		9.5
	30				
	35				
	40				
	45				

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ject No. **62SU.01011.02** Date **August 2002**

Log of Well

DRILL LOGS AUG 2002.GPJ
LOG OF BOREHOLE

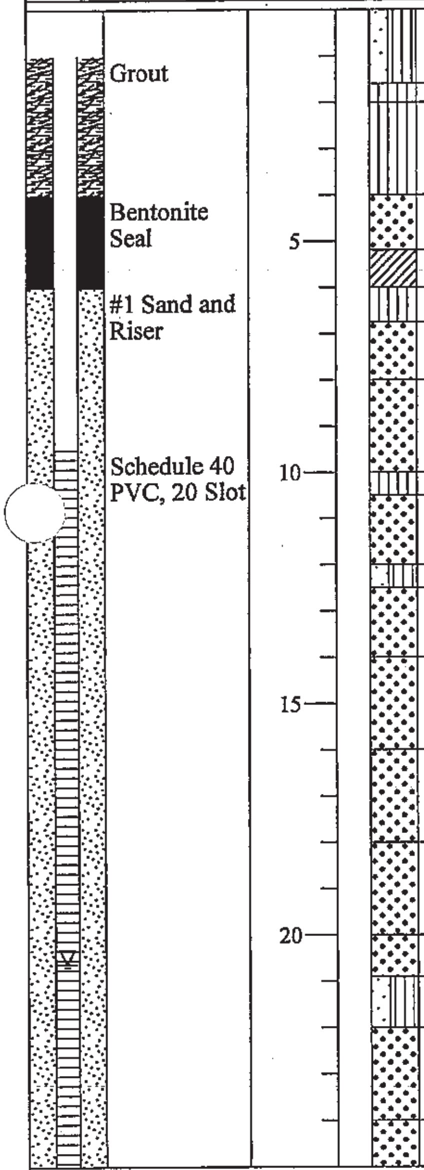
Figure

(sheet 2 of 2)

SECOR
International Incorporated

Logged By: **SM**	Date Drilled: **08/14/02**	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc. Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger Split Spoon**	Well Number: **S-118**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 4	Surface Elev.(ft.):	Groundwater Depth (ft.): ⊻ **20.62**	Total Depth (ft.): **29.5**	Drive wt.(lbs.):	Drop Dist.(in.):



Description	Recovery (feet)	PID Reading (ppm)
SILT AND SAND, fine to coarse; little fine gravel, brown, dry.	2.0	0.0
SILT; little fine sand, trace clay, dark brown, dry.	0.7	0.0
SILT; some clay, little fine to coarse sand, dark brown, dry.		0.0
SAND, coarse AND SAND, fine to medium; trace silt, black, moist.	1.0	18.4
CLAY; some silt, little fine sand, black and brown, moist.		277
SILT; little fine sand, little clay, brown and gray, dry.	1.6	0.0
SAND, fine to medium; some coarse sand, little fine gravel, brown, dry.		9.0
SAND, fine to medium; some coarse sand, some fine gravel, dark red, white and brown, dry.	1.5	0.0
SILT; some clay, little fine to coarse sand, brown, dry.	1.3	0.0
SAND, fine to medium; some coarse sand, red, white and brown, dry.		8.4
SILT AND SAND, fine to coarse; little fine gravel, brown, dry.	1.5	0.0
SAND, fine to coarse; some silt, some fine gravel, red, white and brown, dry.		9.9
SAND, fine to medium; some fine gravel, some coarse sand, red, white and brown, dry.	0.5	18.8
SAND, fine to medium; little coarse sand, little silt, little fine gravel, dark red and brown, dry.	1.1	25.9
SAND, fine; some medium to coarse sand, little fine gravel, red and brown, dry.	1.2	83.2
SAND, fine; some medium to coarse sand, little fine gravel, red and brown, moist.	1.4	228
SAND, fine AND SILT; some medium to coarse sand, trace fine gravel, brown and red, wet.		118
SAND, fine to coarse; some fine gravel, brown, wet.	1.7	647
SAND, fine; some medium to coarse sand, little gravel, brown, wet.	2.0	1823

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oject No. **62SU.01011.02** Date **August 2002**

Log of Well

Figure

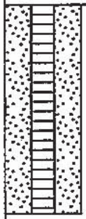
(sheet 1 of 2)

DRILL LOGS AUG 2002.GPJ
LOG OF BOREHOLE

SECOR
International Incorporated

Logged By:	Date Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	08/14/02	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-118**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	4		⊻ 20.62	29.5		



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm)
			SAND, fine; some medium to coarse sand, little gravel, brown, wet.	2.0	2092
			SAND, fine to medium; some coarse sand, little fine to coarse gravel, brown, wet.	1.5	1657
	30				
	35				
	40				
	45				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

oject No. **62SU.01011.02** Date **August 2002**

Log of Well

DRILL LOGS AUG 2002.GPJ
LOG OF BOREHOLE

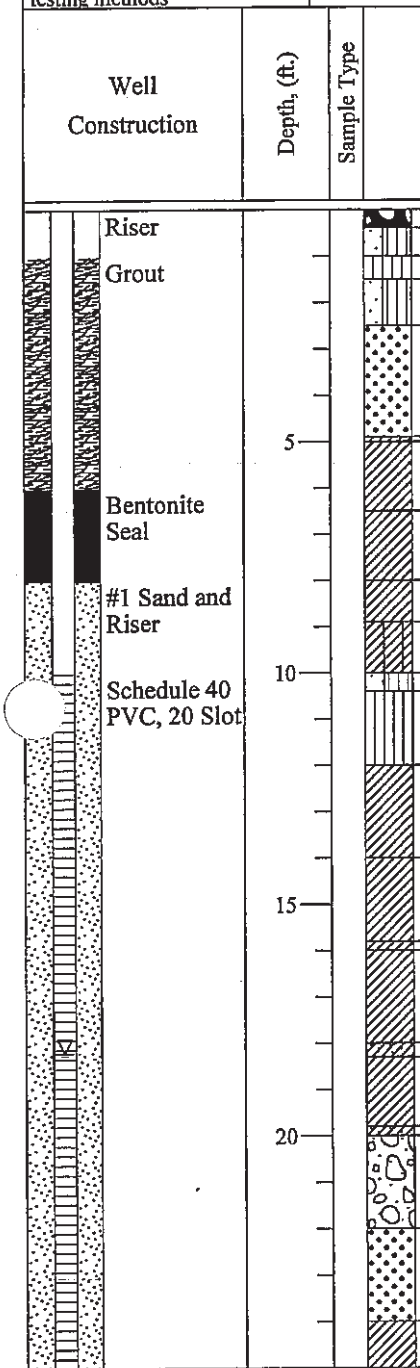
Figure

(sheet 2 of 2)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	08/26/02 08/27/02	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-125**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	4		⊽ 18.2	30.0		



Description	Recovery (feet)	PID Reading (ppm)
ASPHALT		
SILT AND SAND, fine; some medium to coarse sand, some fine gravel, brown, dry.		5.5 166
SILT; some fine to coarse sand, pieces of brick, dark brown, dry.		103
SILT AND SAND, fine; some medium to coarse sand; large cobble sized piece of brick, dark gray and black, dry.		68.4
SAND, fine to coarse; little silt, little fine gravel, black, dry (wet at bottom).		
CLAY; little silt, little fine to medium sand, gray, moist.	1.0	334
CLAY; trace fine sand, trace silt, brown and gray, moist.		121
CLAY; little silt, trace fine sand, brown and gray, dry.		5.6
CLAY; little silt, trace fine sand, brown and gray, dry.	1.1	29.5
SILT AND CLAY; little fine sand, brown and gray, dry.		9.5
SILT AND SAND, fine to coarse; trace fine gravel, gray and black, moist.	1.4	25.6
SILT; little fine to medium sand, trace clay, brown and gray, dry.		21.6
CLAY; some silt, little fine to coarse sand, gray, dry.	2.0	19.4
CLAY; little silt, little fine sand, gray, dry.	2.0	11.1
CLAY; some silt, trace fine sand, gray, wet.	2.0	0.0
CLAY; little silt, trace fine sand, gray, dry to moist at top of section, wet at bottom of section.		0.0
CLAY AND SAND, fine to coarse; dark brown, moist.	2.0	9.5
CLAY; little silt, trace fine sand, brown and gray, dry.		0.0
CLAY AND SAND, fine to medium; gray, moist.	0.7	0.0
SAND, fine to coarse AND GRAVEL, fine; trace silt, brown, gray and red, moist.		169
SAND, fine; some medium to coarse sand, little fine gravel, green and gray, moist to wet, product present.	0.6	2230
CLAY; trace fine sand, gray, moist.	0.6	5.5

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

oject No. **62SU.01011.02** Date **August 2002**

Log of Well

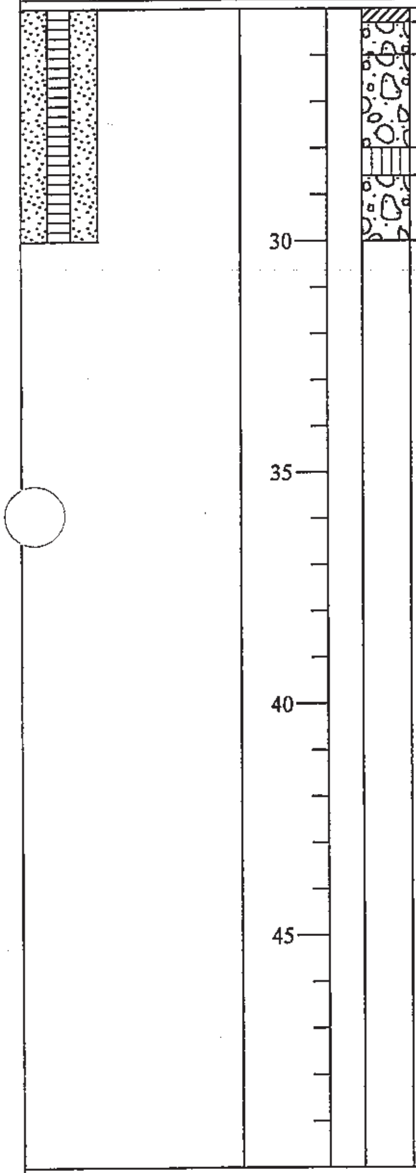
Figure

(sheet 1 of 2)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	**08/26/02** **08/27/02**	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-125**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	4		∇ **18.2**	**30.0**		



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm)
			SAND, fine to coarse AND GRAVEL, fine; brown, wet.		152
			SAND, fine to coarse AND GRAVEL, fine; red, white and brown, wet.	0.8	357
			SILT; some clay, little fine to coarse sand, little fine gravel, gray, wet.	1.3	141
			SAND, fine to coarse AND GRAVEL, fine; brown, wet.		221

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

ject No. **62SU.01011.02** Date **August 2002**

Log of Well

DRILL LOGS AUG 2002.GPJ
LOG OF BOREHOLE

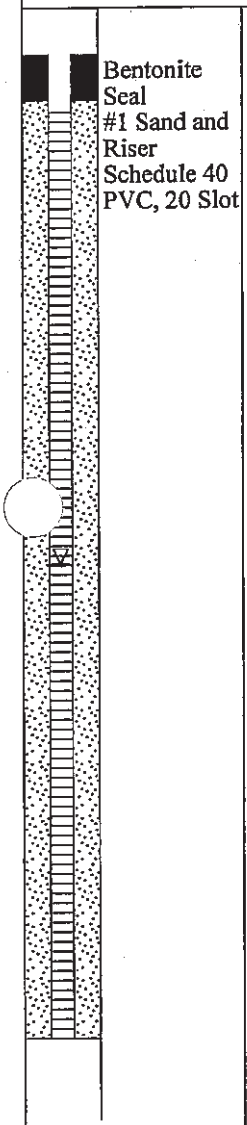
Figure

(sheet 2 of 2)

Logged By:	Date Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	09/18/02	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-126**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	4		∇ 12	24.0		

Well Construction



Depth, (ft.)	Description	Recovery (feet)	PID Reading (ppm)
	SILT AND SAND, fine; some medium to coarse sand, trace fine gravel, piece of brick, black and brown, dry.	2.0	0.0
	SILT AND CINDERS; black, dry.	0.7	0.0
5	SAND, fine to medium AND SILT; little cinders, piece of wire mesh, black, moist.	1.0	17
	SAND, fine to medium AND SILT; little cinders, black, moist.	0.7	24
	SILT; little clay, little fine to coarse sand, piece of wood in end of spoon, black, moist.		40
	SAND, fine; little medium to coarse sand, black, moist.	1.2	24
	SILT; little clay, little cinders, brown, moist.		20.4
	SILT; some cinders, little fine to coarse sand, black, moist.		27.3
10	SAND, fine AND SILT; little medium to coarse sand, black, dry. Piece of brick at 10.6 feet and in end of spoon.	0.8	5.9
	SAND, fine to medium; some silt, some coarse sand, little pieces of brick, black, wet.	0.5	70.1
15	NO RECOVERY; brick in shoe of spoon.	0.0	
	SAND, fine to medium; some silt, pieces of brick, black, wet.	1.2	40.1
	SAND, fine; trace medium sand, slight sheen, black, wet.		218
	SAND, fine; trace medium sand, black, wet.	1.0	84.4
	SAND, fine; some medium to coarse sand, little silt, black, wet.		45.5
20	SAND, fine to coarse; some silt, nail in end of spoon, black, wet.	0.4	67.3
	SAND, fine to medium; some coarse sand, little silt, little cinders, black, wet.	1.3	49.7
	CLAY; little fine to medium sand, little silt, gray and brown, moist.		5.4
	SILT AND SAND, fine to coarse; trace clay, gray, wet.		50.3

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oject No. **62SU.01011.02** Date **August 2002**

Log of Well

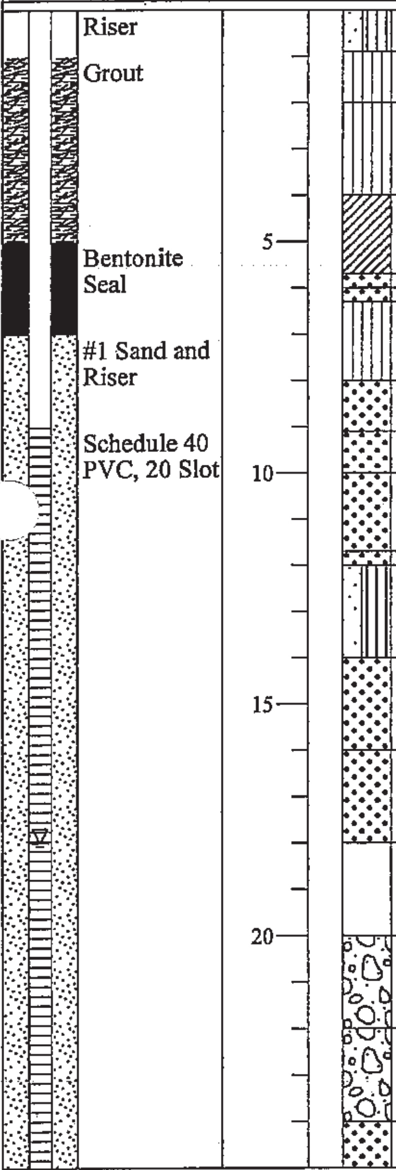
Figure

(sheet 1 of 1)

SECOR
International Incorporated

Logged By:	Date Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	09/19/02	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-127**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	4		∇ 18	30.0		



Description	Recovery (feet)	PID Reading (ppm)
SAND, fine AND SILT; some medium to coarse sand, brown, dry.	0.7	0.0
SILT; little fine to medium sand, trace clay, black and gray, dry.		119
SILT; some clay, trace fine sand, gray, moist.	0.5	765
CLAY; little fine sand, little silt, gray, dry.	2.0	1017
SAND, fine; some clay, little medium to coarse sand, gray, dry.	1.5	1311
SAND, fine; little silt, little medium to coarse sand, gray, dry.		480
SILT; little fine sand, little clay, gray, moist.		642
SAND, fine; little silt, little medium to coarse sand, gray, dry.	0.7	784
SAND, fine; little silt, trace medium sand, brown, dry.		221
SAND, fine; some silt, trace medium sand, gray, moist.	1.2	490
SAND, fine; some medium to coarse sand, little fine gravel, brown, dry.	0.4	17.4
SAND, coarse AND SILT; some fine to medium sand, gray, brown and dark red, moist.		212
SAND, fine to medium; some coarse sand, some fine gravel, brown, dark red and gray, moist.	0.9	918
SAND, fine to coarse; little fine gravel, trace silt, dark red, brown and gray, moist to wet.	2.0	979
NO RECOVERY; stone in shoe of spoon.	0.0	
GRAVEL, fine and SAND, coarse; some fine to medium sand, gray and red, wet.	0.8	489
GRAVEL, fine AND SAND, fine to coarse, dark red and brown, wet.	2.0	869
SAND, medium to coarse, some fine sand, some fine gravel, dark red and brown	2.0	850

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oject No. **62SU.01011.02** Date **August 2002**

Log of Well

Figure

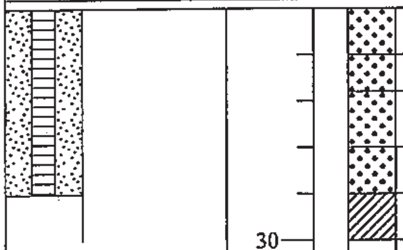
DRILL LOGS AUG 2002.GPJ
LOG OF BOREHOLE

(sheet 1 of 2)

SECOR
International Incorporated

Logged By:	Date Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	09/19/02	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-127**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	4		⊻ 18	**30.0**		



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm)
			with a little bit of green, wet.		
			SAND, medium to coarse, some fine sand, some fine gravel, dark red and brown with a little bit of green, wet.	2.0	419 60.3
			SAND, medium; some fine sand, little coarse sand, trace fine gravel, brown, wet.	1.2	82.2
			SAND, medium; some fine sand, little coarse sand, trace fine gravel, brown, wet.		0.0
	30		CLAY; trace fine silt, brown, moist.		
	35				
	40				
	45				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01011.02** Date **August 2002**

Log of Well

Figure

DRILL LOGS AUG 2002.GPJ
LOG OF BOREHOLE

(sheet 2 of 2)

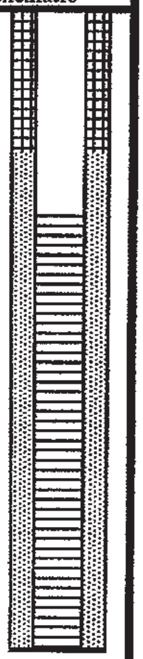
Aquaterra Technologies, Inc.
Subsurface Log: S-161

Project Name: Pollack St Sewer **Owner:** Sunoco, Inc. (R&M)
Location: Tank 178 **Permit No.:** N/A
Boring Number: S-161 **Log By:** Cathy Grzybek **Date:** 15-May-03
Casing Elevation: N/A **Driller:** B.L. Meyers **Borehole Dia:** 6.25"
Screen Diameter: 2" **Length:** 15' **Slot Size:** 0.020" **Water Level (Init):** NA
Casing Diameter: 2" **Length:** 5' **Type:** PVC
Drilling Method: Hollow Stem Auger Drilling **Sample Method:** Cuttings **Rig Type:**

Construction Details

Total Well Depth: 21' **Bentonite Interval:** 1'-4'
Screen Interval: 6'-21' **Cement/Grout Interval:** NA
Sand Pack Interval: 4'-21' **Sand Pack Type:** No. 2 sand
Completion Details: Completed with 8-inch manhole cover and locking cap

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
▒ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Sample Number	Lithology	Well Schematic
0	0'-5'			NA, Hydroexcavated to 7' bgs.	
5	5'-10'	0.1		Silt, sand, and gravel Auger moist at 10'	
10	10'-15'			Same as above Harder drilling at 15'	
15	15'-20'	1.7		Cobbles	
20 21	20'-21'	15		Cobbles, some sandy clay, dark gray gravel and clay	
				Borehole complete at 21' BGS	

NOTE: Shaded sample submitted for laboratory analysis

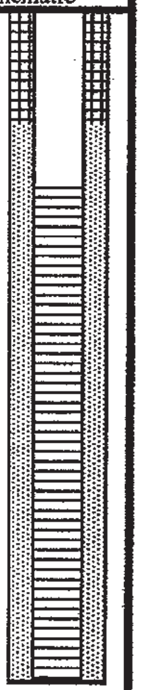
Aquaterra Technologies, Inc.
Subsurface Log: S-162

Project Name: Pollack St Sewer
Owner: Sunoco, Inc. (R&M)
Location: Tank 178
Permit No.: N/A
Boring Number: S-162
Log By: Cathy Grzybek
Date: 15-May-03
Casing Elevation: N/A
Driller: B.L Meyers
Borehole Dia: 6.25"
Screen Diameter: 2" **Length:** 17'
Slot Size: 0.020"
Water Level (Init): NA
Casing Diameter: 2" **Length:** 3'
Type: PVC
Drilling Method: Hollow Stem Auger Drilling
Sample Method: Cuttings
Rig Type:

Construction Details

Total Well Depth: 22'
Bentonite Interval: 0'-3'
Screen Interval: 5'-22'
Cement/Grout Interval: NA
Sand Pack Interval: 3'-22'
Sand Pack Type: No. 2 sand
Completion Details: Completed with 8-inch manhole cover and locking cap

☐ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Sample Number	Lithology	Well Schematic
0	0'-5'			NA, Hydroexcavated to 7' bgs.	
5	5'-10'			Silt, sandy gravel, some clay	
10	10'-15'	7		Moist clay	
15	15'-20'	.4,19.9		Cobbles and clay at 16'bgs	
20	20'-22'	287,333		Cobbles and clay	
22					
				Borehole complete at 22' BGS	

NOTE: Shaded sample submitted for laboratory analysis

Aquaterra Technologies, Inc.
Subsurface Log: S-164

Project Name: Pollack St Sewer
Location: Tank 178
Boring Number: S-164
Casing Elevation: N/A
Screen Diameter: 2" **Length:** 20'
Casing Diameter: 2" **Length:** 4'
Drilling Method: Hollow Stem Auger Drilling

Owner: Sunoco, Inc. (R&M)
Permit No.: N/A
Log By: Cathy Grzybek
Driller: B.L. Meyers
Slot Size: 0.020"
Type: PVC
Sample Method: Cuttings

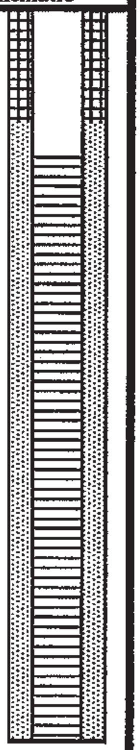
Date: 16-May-03
Borehole Dia: 6.25"
Water Level (Init): NA
Rig Type:

Construction Details

Total Well Depth: 24'
Screen Interval: 4'-24'
Sand Pack Interval: 3'-22'
Completion Details: Completed with 8-inch manhole cover and locking cap

Bentonite Interval: 0'-3'
Cement/Grout Interval: NA
Sand Pack Type: No. 2 sand

☐ = Backfill
■ = Cement/Grout
▦ = Bentonite
▒ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Sample Number	Lithology	Well Schematic
0	0'-5'			NA, Hydroexcavated to 7' bgs.	
5	5'-10'	0.1		Dark brown/gray silt, sand, and clay	
10	10'-15'	6.1		Gray clay with fine sand, cobbles around 11'bgs	
15	15'-20'			Soft clay	
20	20'-25'			Soft clay to 23', cobbles	
24					
				Borehole complete at 24' BGS	

NOTE: Shaded sample submitted for laboratory analysis

Aquaterra Technologies, Inc.
Subsurface Log: S-171

Project Name: Pollack St Sewer
Location: Tank 178
Boring Number: S-171
Casing Elevation: N/A
Screen Diameter: 2" **Length:** 17'
Casing Diameter: 2" **Length:** 5'
Drilling Method: Hollow Stem Auger Drilling

Owner: Sunoco, Inc. (R&M)
Permit No.: N/A
Log By: M. Brad Spancake
Driller: B.L Meyers
Slot Size: 0.020"
Type: PVC
Sample Method: Cuttings

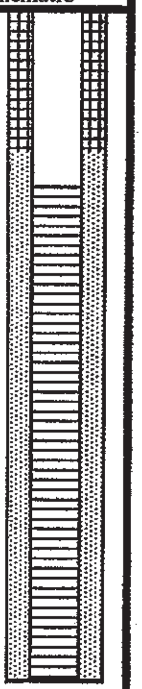
Date: 19-May-03
Borehole Dia: 6.25"
Water Level (Init): NA
Rig Type:

Construction Details

Total Well Depth: 22'
Screen Interval: 5'-22'
Sand Pack Interval: 4'-22'
Completion Details: Completed with 8-inch manhole cover and locking cap

Bentonite Interval: 0'-4'
Cement/Grout Interval: NA
Sand Pack Type: No. 2 sand

☐ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

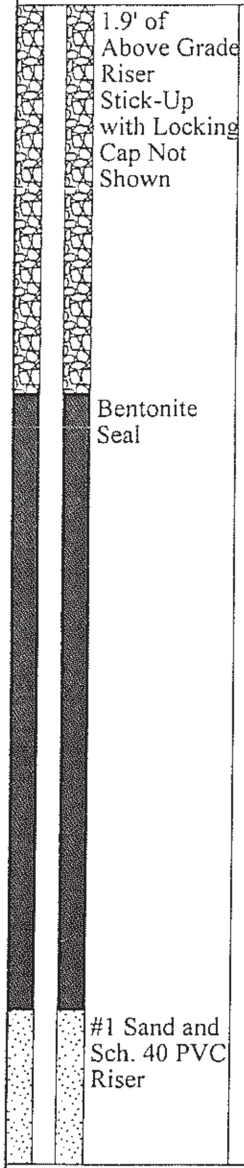
Depth (ft)	Sample Depth (ft)	OVM (ppm)	Sample Number	Lithology	Well Schematic
0	0'-5'			NA, Hydroexcavated to 7' bgs.	
5	5'-10'			Grey silty clay	
10	10'-15'	76		Slightly moist grey silty clay	
15	15'-20'	257		Grey silty clay, becoming wet, gravel and coarse sand.	
20	20'-22'	40		Same as above, wet	
22					
				Borehole complete at 22' BGS	

NOTE: Shaded sample submitted for laboratory analysis

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/18/03 12/19/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-179**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 17.73	35.0	NA	NA



Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
		Soft dig interval; no samples.		
5				
		No sample; HSA only.		
10	☒	CLAYEY SILT, low plasticity, saturated, light gray (very stained), up to 3/4" gravel (sub-angular), petroleum odor, (ML).	1.1	720
	☒	CLAYEY SILT, low plasticity, saturated, light gray to black (very stained), up to 3/4" gravel (sub-angular), petroleum odor, (ML).	0.8	392
	☒	CLAYEY SILT, low plasticity, saturated, light gray to black (very stained), up to 3/4" gravel (sub-angular), petroleum odor, (ML).	0.8	674

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

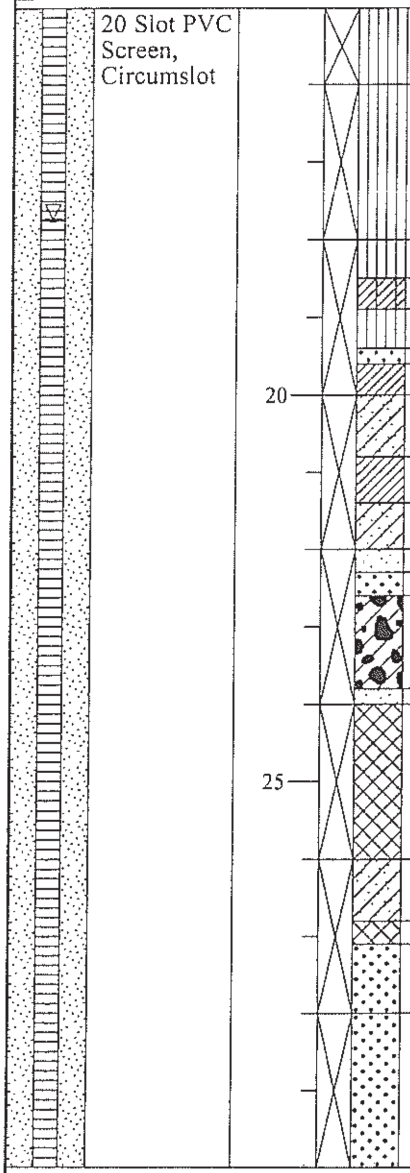
Approved by ____________

Figure (sheet 1 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/18/03 12/19/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-179**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		⊽ 17.73	**35.0**	**NA**	**NA**



Description	Recovery (feet)	PID Reading (ppm above background)
CLAYEY SILT, low plasticity, saturated, light gray to black (very stained), up to 3/4" gravel (sub-angular) and inclusions of concrete (approx. 1") fill, petroleum odor, (ML).	1.0	7048
CLAYEY SILT, low plasticity, wet, light gray to black (very stained), up to 3/4" gravel (sub-angular) and inclusions of red brick and wood fill fragments, petroleum odor, (ML). SILTY CLAY, slight plasticity, wet, black, no odor, (CL-ML). CLAYEY SILT, low plasticity, wet, light gray to black, approx. 1% to 3% 1/4" gravel inclusions, no odor, (ML).	1.3	553
SAND, non-plastic, moist, brown, coarse grained, up to 1/2" gravel (sub-rounded) present, no odor, (SW). CLAY, low plasticity, moist, gray to black, up to 1/2" gravel (sub-angular) present, no odor, (CL). CLAYEY SAND, slight plasticity, saturated, brown, fine grained gravel (angular), petroleum odor, (SC).	0.8	9741
SANDY CLAY, low plasticity, saturated, brown, petroleum odor, (CL). CLAYEY SAND, slight plasticity, saturated, brown, fine grained gravel (angular) present at approx. 50% to 70%, petroleum odor, (SC). SAND, non-plastic, saturated, brown, medium grained, petroleum odor, (SP). SAND, non-plastic, saturated, brown, coarse grained, rounded to sub-rounded inclusions of red brick, petroleum odor, (SW).	1.3	6022
CLAYEY GRAVEL, slight plasticity, saturated, light gray, rounded to sub-rounded inclusions of red brick, petroleum odor, (GC). SAND, non-plastic, saturated, light gray, fine grained, petroleum odor, (SP). FILL, red brick and wood fragments plugged sampler resulting in minimal recovery.	0.3	0.0
CLAYEY SAND, slight plasticity, saturated, dark green to gray, fine grained (approx. 1" on edge) gravel (sub-angular), strong petroleum odor, (SC). FILL, dark reddish brown brick. SAND, non-plastic, saturated, brown, medium grained, up to 1" gravel (sub-rounded), strong petroleum odor, (SW).	2.0	9998
SAND, non-plastic, saturated, multi-colored green, red, and gray, medium grained, up to 1" gravel (sub-rounded to well-rounded), strong petroleum odor, (SW).	1.8	9999+

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

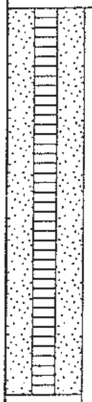
Approved by ______________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	**12/18/03** **12/19/03**	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-179**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		⊻ 17.73	**35.0**	**NA**	**NA**



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
		☒	CLAYEY SAND, slight plasticity, saturated, dark green to gray, fine through coarse grained, greater than 1" gravel (sub-rounded) wedged in sampling shoe and red brick fragments (approx. 1/2") also present at less than 1%, petroleum odor, (SC).	1.2	9999+
		☒	SAND, very slight plasticity, saturated, brown, fine grained, trace clay, petroleum odor, (SP).	2.0	1567
			CLAY, low to medium plasticity, saturated, mottled gray and light brown, petroleum odor, (CL).		
	35				
	40				

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 3 of 3)

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

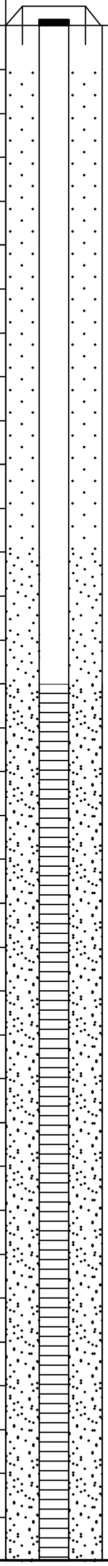
S-180 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **1/21/15** COMPLETED: **1/21/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in): **12**
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy. Well overdrilled to install 6" recovery well. Original well was 4".							1-12' bgs: Bentonite 12-35' bgs: Sand 15-35' bgs: 30-slot PVC Screen
5									5	
10									10	
15									15	
20									20	
25									25	
30									30	



Borehole terminated at 35 feet.

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/18/03 12/18/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-180**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **18.78**	**35.0**	**NA**	**NA**

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
1.8' of Above Grade Riser Stick-Up with Locking Cap Not Shown	5		Soft dig interval; no samples.		
		☒	SANDY CLAY, low plasticity, wet, brown, pieces of asphalt present, no odor, (CL).	0.5	409
Bentonite Seal	10	☒	No recovery.	0.0	
		☒	SAND, non-plastic, wet, brown, medium through coarse grained, no odor, (SP). GRAVEL, non-plastic, wet, brown, angular with median size approx. 1/2", no odor, (GW). FILL, red brick fragments.	1.0	90.5
#1 Sand and Sch. 40 PVC Riser		☒	CLAYEY GRAVEL, low plasticity, wet, brown, up to 1/2" gravel (angular) present, pieces of rock wedged in sampling shoe yielded low recovery, no odor, (GC).	0.5	476

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

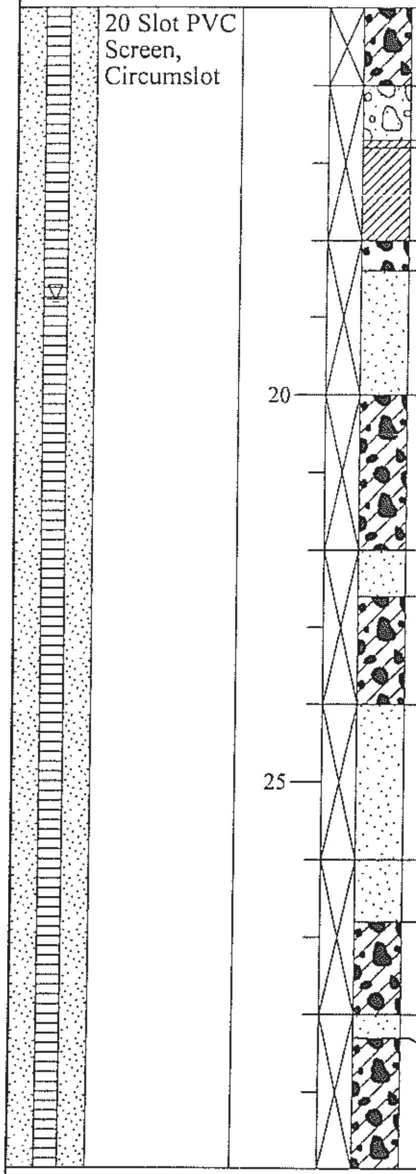
Approved by ____________

Figure (sheet 1 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	**12/18/03** **12/18/03**	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-180**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **18.78**	**35.0**	**NA**	**NA**



Depth, (ft.)	Description	Recovery (feet)	PID Reading (ppm above background)
	SANDY GRAVEL, non-plastic, wet, reddish brown, coarse grained sand, petroleum odor, (GWS). CLAY, low plasticity, wet, black (stained), petroleum odor, (CL). CLAY, low plasticity, moist, tan, petroleum odor, (CL).	1.3	340
	GRAVEL, non-plastic, wet, dark gray, coarse grained, up to 1/2" gravel (angular), petroleum odor, (GP). SAND, non-plastic, wet, dark gray (significantly stained), medium grained, up to 3/4" gravel (sub-rounded) present at base, petroleum odor, (SP).	2.0	9999+
20	CLAYEY GRAVEL, slight plasticity, wet, brown, up to 3/4" gravel (angular), petroleum odor, (GC).	1.0	190
	SAND, non-plastic, wet, brown, coarse grained, petroleum odor, (SP). CLAYEY GRAVEL, slight plasticity, wet, brown (significantly stained), up to approx. 1/2" gravel (angular), petroleum odor, (GC).	0.6	749
25	SAND, non-plastic, wet, gray (significantly stained), coarse grained, up to 1/2" sub-rounded and 3/4" sub-angular gravel, petroleum odor, (SP).	0.8	9999+
	SAND, non-plastic, wet, multi-colored, coarse grained, petroleum odor, (SP). CLAYEY GRAVEL, slight plasticity, wet, reddish brown (significantly stained), greater than 1" gravel (sub-rounded), petroleum odor, (GC).	1.3	9999+
	SAND, non-plastic, wet, multi-colored, coarse grained, petroleum odor, (SP). CLAYEY GRAVEL, slight plasticity, wet, brown (significantly stained), greater than 1" gravel (well-rounded to angular), strong petroleum odor, (GC).	1.5	9999+

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

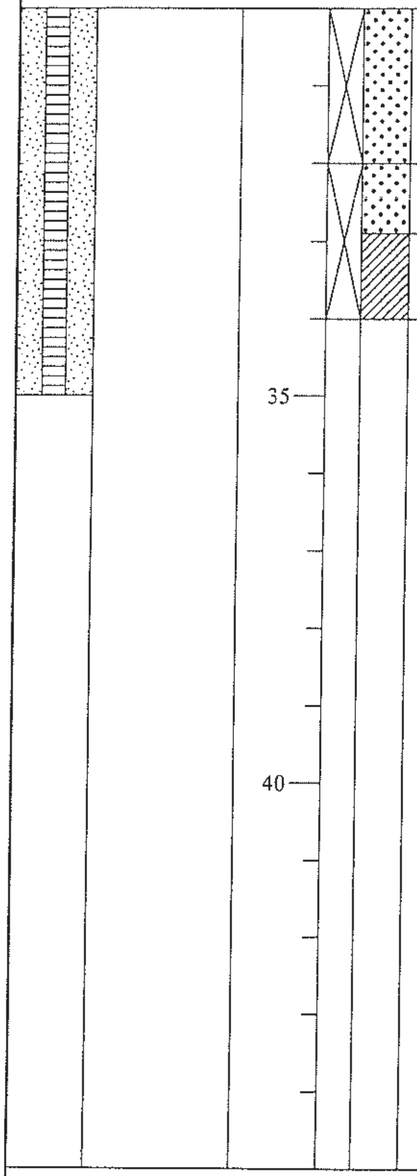
Approved by

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/18/03 12/18/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-180**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **18.78**	**35.0**	**NA**	**NA**



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			SAND, very slight plasticity, wet, brown (significantly stained), medium grained, some clay and gravel (sub-rounded) up to 3/4", strong petroleum odor, (SW).	1.3	2022
			SAND, very slight plasticity, wet, dark brown (significantly stained), medium grained, some clay and gravel (sub-rounded) up to 3/4", strong petroleum odor, (SW). SANDY CLAY, low plasticity, saturated, tan to brown, fine grained sand present between 30% to 40%, strong petroleum odor, (CL).	2.0	1907

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 3 of 3)

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

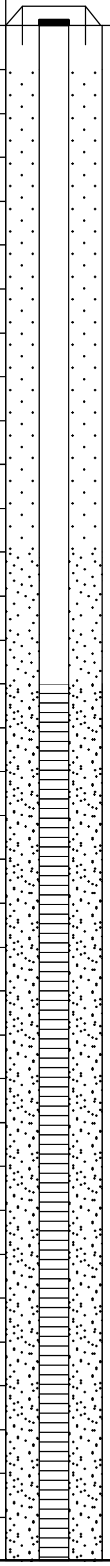
WELL / PROBEHOLE / BOREHOLE NO:
S-181 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **1/22/15** COMPLETED: **1/22/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in): **12**
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy.							
			Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	
										1-12' bgs: Bentonite
10									10	
15									15	
20									20	
										12-35' bgs: Sand
25									25	15-35' bgs: 30-slot PVC Screen
30									30	

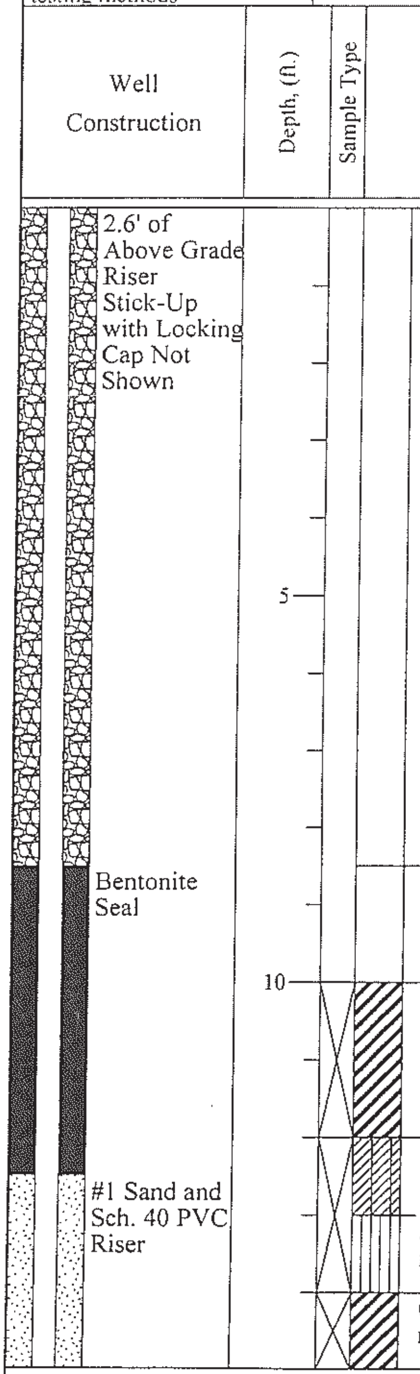


Borehole terminated at 35 feet.

SECOR
International Incorporated

Logged By: JM	Dates Drilled: 12/17/03 12/18/03	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc. Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger Split Spoon**	Well Number: **S-181**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): **10.25**	Surface Elev.(ft.):	Groundwater Depth (ft.): ▽ **19.75**	Total Depth (ft.): **35.0**	Drive wt.(lbs.): **NA**	Drop Dist.(in.): **NA**



Description	Recovery (feet)	PID Reading (ppm above background)
Soft dig interval; no samples.		
No sample; HSA only.		
CLAY, high plasticity, wet, gray, pieces of red brick wedged in sampling shoe yielded low recovery, petroleum odor, (CH).	0.5	73.2
SILTY CLAY, slight plasticity, wet, mottled gray and tan, gradational to unit below, no odor, (CL-ML).	2.0	0.0
SILT, low plasticity, moist, mottled gray and tan, gradational from unit above, no odor, (ML).		
CLAY, high plasticity, moist, cream with some brown (possibly iron staining) mottling, no odor, (CH).	2.0	0.0

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

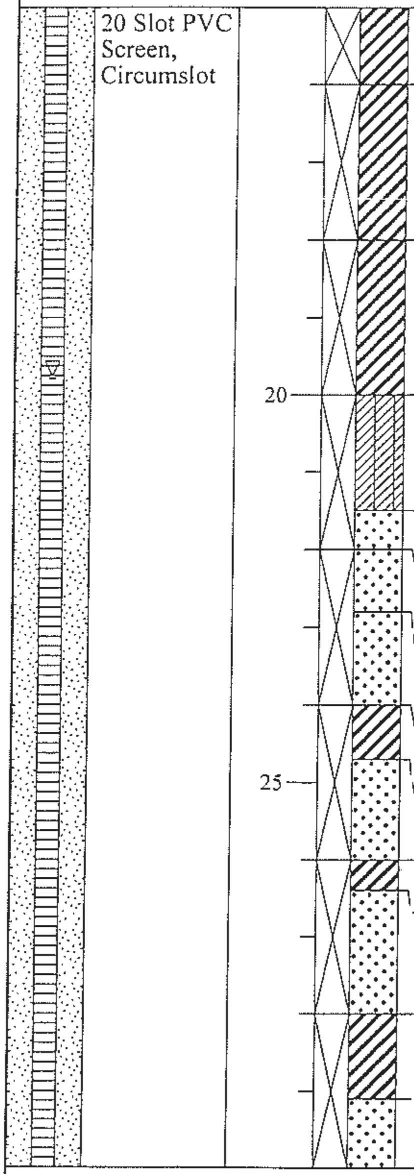
Approved by ____________

Figure (sheet 1 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	**12/17/03** **12/18/03**	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-181**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **19.75**	**35.0**	**NA**	**NA**



Description	Recovery (feet)	PID Reading (ppm above background)
CLAY, high plasticity, moist, cream with some brown (possibly iron staining) mottling, no odor, (CH).	1.0	0.0
CLAY, high plasticity, moist, cream with some brown (possibly iron staining) mottling, no odor, (CH).	2.0	69.8
SILTY CLAY, low to medium plasticity, moist, tan to light brown, no odor, (CL-ML).	1.0	108
SAND, non-plastic, moist, red to yellow, medium grained, pieces of gravel (greater than 1") wedged in sampling shoe yielded low recovery, no odor, (SW).	1.3	9999+
SAND, non-plastic, wet, red to yellow, medium grained, pieces of gravel (greater than 1") wedged in sampling shoe yielded low recovery, petroleum odor, (SW).		
SAND, non-plastic, moist, gray and red (stained), medium grained, approx. 1" gravel (sub-rounded) present, product sheen from free water present, petroleum odor, (SW).	0.8	9999+
CLAY, high plasticity, wet, tan to brown, cave-in from units above, petroleum odor, (CH).		
SAND, non-plastic, saturated, reddish brown, medium grained, abundant gravel (sub-rounded) present up to 1", product soaked, petroleum odor, (SW).		
CLAY, high plasticity, wet, tan to brown, cave-in from units above, petroleum odor, (CH).	1.3	9999+
SAND, non-plastic, saturated, reddish brown, medium grained, abundant gravel (sub-rounded) present up to 1", product soaked, petroleum odor, (SW).		
CLAY, high plasticity, saturated, brown, 1/4" gravel (angular) present, petroleum odor, (CH).	0.8	9999+
SAND, non-plastic, saturated, reddish brown, medium grained, abundant gravel (sub-rounded) present up to 1", product soaked, petroleum odor, (SW).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

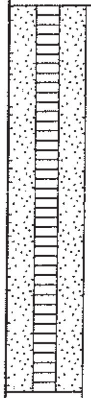
Approved by ____________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By: JM	Dates Drilled: 12/17/03 12/18/03	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc.** **Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger** **Split Spoon**	Well Number: **S-181**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 10.25	Surface Elev.(ft.):	Groundwater Depth (ft.): ∇ 19.75	Total Depth (ft.): 35.0	Drive wt.(lbs.): NA	Drop Dist.(in.): NA



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
		☒	SAND, non-plastic, saturated, reddish brown (stained), medium grained, approx. 50% gravel (angular) present up to 1" on edge, strong petroleum odor, (SW).	1.1	9999+
		☒	SAND, non-plastic, saturated, brown (stained), medium through coarse grained, approx. 50% gravel (rounded to sub-rounded) present less than 1/2" on edge, petroleum odor, (SW).	2.0	9999+
			SAND, non-plastic, wet, brown, fine grained, petroleum odor, (SP).		
	35				
	40				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 3 of 3)

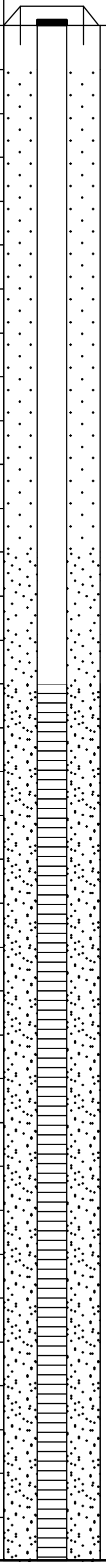
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
S-182 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **1/23/15** COMPLETED: **1/23/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in): **12**
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy.							
			Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	
										1-12' bgs: Bentonite
10									10	
15									15	
20									20	
										12-35' bgs: Sand
25									25	15-35' bgs: 30-slot PVC Screen
30									30	

Borehole terminated at 35 feet.

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	**12/11/03** **12/11/03**	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-182**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **19.86**	**35.0**	**NA**	**NA**

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
2.6' of Above Grade Riser Stick-Up with Locking Cap Not Shown			Soft dig interval; no samples.		
Bentonite Seal	5				
			CLAYEY SILT, non-plastic, wet, brown, petroleum odor, (ML).	1.9	1371
	10		CLAYEY SILT, non-plastic, wet, brown, no odor, (ML).	2.0	717.8
			CLAYEY SAND, low plasticity, moist, gray, petroleum odor, (SC).		2157.8
#1 Sand and Sch. 40 PVC Riser			CLAY, high plasticity, moist, tan, petroleum odor, (CH).		
			CLAY, low plasticity, moist, mottled gray and brown, petroleum odor, (CL).	0.8	404.5

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 1 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/11/03 12/11/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-182**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 19.86	35.0	NA	NA

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
20 Slot PVC Screen, Circumslot					
			CLAY, high plasticity, moist, light tan to gray, petroleum odor, (CH).	2.0	1611
			CLAYEY SAND, low plasticity, moist, gray, strong petroleum odor, (SC).		
			CLAY, high plasticity, moist, light tan to gray, petroleum odor, (CH).		
			CLAY, high plasticity, moist, cream to gray, no odor, (CH).	2.0	767
∇			CLAYEY GRAVEL, slight plasticity, moist, cream to gray, up to 1" gravel (rounded), petroleum odor, (GC).		
	20		CLAY, low plasticity, moist, light gray, petroleum odor, (CL).	1.5	2713.6
			GRAVELLY SAND, non-plastic, moist, red and gray, up to 1" gravel, petroleum odor, (SW).		
			CLAY, low plasticity, moist, mottled light gray and brown, slightly sandy, petroleum odor, (CL).	2.0	1830
			GRAVELLY SAND, non-plastic, moist, red and gray, up to 1" gravel, petroleum odor, (SW).		
			CLAY, low plasticity, moist, mottled light gray and brown, slightly sandy, petroleum odor, (CL).	0.9	3034.8
	25		GRAVELLY SAND, non-plastic, moist, red and gray, up to 1" gravel, petroleum odor, (SW).		
			SANDY CLAY, low plasticity, moist, brown, petroleum odor, (CL).	2.0	2004.7
			GRAVELLY SAND, non-plastic, moist, red, up to 1" gravel, petroleum odor, (SW).		
			SANDY CLAY, low plasticity, moist, brown, petroleum odor, (CL).	1.3	2757.8
			GRAVELLY SAND, non-plastic, moist, red, up to 1" gravel, petroleum odor, (SWG).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

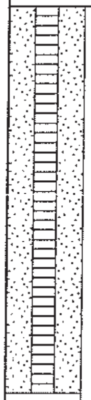
Approved by ____________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/11/03 12/11/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-182**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 19.86	35.0	NA	NA



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
		☒	CLAYEY SAND, slight plasticity, saturated, red and brown, rock fragments present, petroleum odor, (SC).	0.9	1188
		☒	SANDY CLAY, low plasticity, moist, brown, petroleum odor, (CL).	1.9	2714
			GRAVELLY SAND, non-plastic, moist, red, trace clay and up to 1" gravel, petroleum odor, (SWG).		
	35				
	40				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 3 of 3)

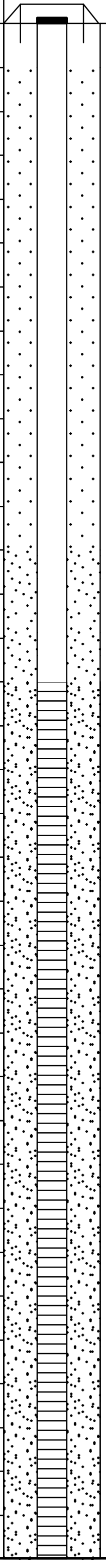
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
S-183 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **1/21/15** COMPLETED: **1/21/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in): **12**
CHECKED BY:

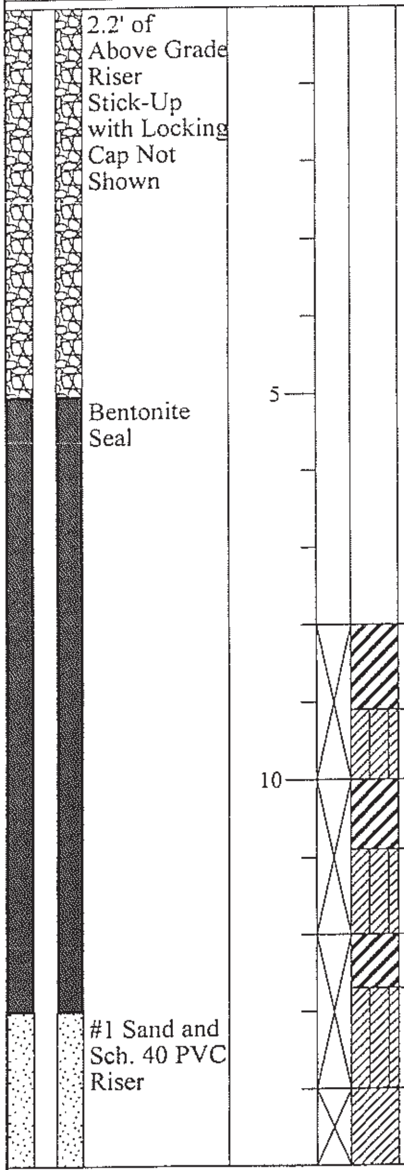
Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy.							
			Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	
										1-12' bgs: Bentonite
10									10	
15									15	
20									20	
										12-35' bgs: Sand 15-35' bgs: 30-slot PVC Screen
25									25	
30									30	

Borehole terminated at 35 feet.

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/11/03 12/12/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-183**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 20.61	35.0	NA	NA



Description	Recovery (feet)	PID Reading (ppm above background)
Soft dig interval; no samples.		
CLAY, high plasticity, wet, gray, no odor, (CH).	2.0	234
SILTY CLAY, low plasticity, moist, mottled brown and gray, no odor, (CL-ML).		
CLAY, high plasticity, wet, gray, no odor, (CH).	1.9	466
SILTY CLAY, low plasticity, moist, mottled brown and gray, no odor, (CL-ML).		
CLAY, high plasticity, moist, mottled brown and gray, no odor, (CH).	1.5	237.8
SILTY CLAY, low plasticity, moist, mottled brown and gray, no odor, (CL-ML).		
CLAY, low plasticity, moist, yellowish orange to tan, no odor, (CL).	2.0	18.2

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

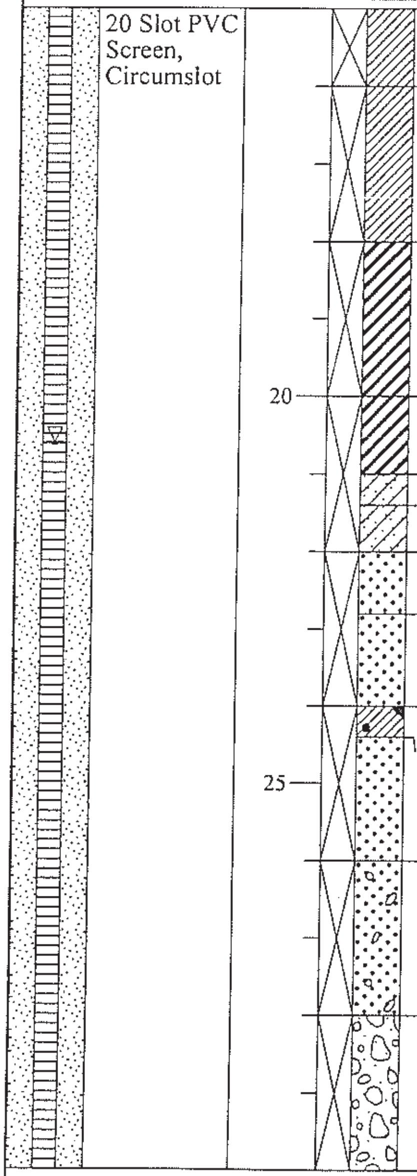
Approved by __________

Figure (sheet 1 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/11/03 12/12/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-183**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		⊻ **20.61**	**35.0**	**NA**	**NA**



Description	Recovery (feet)	PID Reading (ppm above background)
CLAY, low plasticity, moist, yellowish orange to tan, no odor, (CL).	1.1	140.5
CLAY, high plasticity, wet, tan, no odor, (CH).	1.5	15.6
CLAY, high plasticity, wet, brown, no odor, (CH). CLAYEY SAND, low plasticity, wet, gray, no odor, (SC). CLAYEY SAND, low plasticity, wet, red to brown, no odor, (SC).	2.0	923.6
SAND, non-plastic, wet, gray, medium grained, up to 1/4" fine gravel (sub-rounded), petroleum odor, (SW). SAND, non-plastic, wet, reddish brown, medium grained, trace clay and up to 1/4" fine gravel (sub-rounded), petroleum odor, (SW).	2.0	2045.9
GRAVELLY CLAY, low plasticity, wet, yellowish brown, fine grained gravel and trace sand, petroleum odor, (CLG). SAND, non-plastic, wet, reddish brown, medium grained, some gravel (sub-rounded) up to 1/2", petroleum odor, (SW).	1.6	3212.9
GRAVELLY SAND, non-plastic, wet, reddish brown, medium grained, top 12" was cave-in, petroleum odor, (SWG).	2.0	2835.6
SANDY GRAVEL, non-plastic, saturated, reddish brown, petroleum odor, (GWS).	2.0	2879.8

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

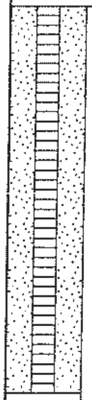
Approved by ____________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By: JM	Dates Drilled: 12/11/03 12/12/03	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc. Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger Split Spoon**	Well Number: **S-183**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 10.25	Surface Elev.(ft.):	Groundwater Depth (ft.): ∇ 20.61	Total Depth (ft.): 35.0	Drive wt.(lbs.): NA	Drop Dist.(in.): NA



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
		☒	GRAVELLY SAND, non-plastic, saturated, brown, medium grained, some gravel (sub-angular) up to 1", petroleum odor, (SWG).	1.3	3189.3
		☒	SAND, non-plastic, saturated, brown, medium grained, petroleum odor, (SP).	0.9	2790.7
	35				
	40				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 3 of 3)

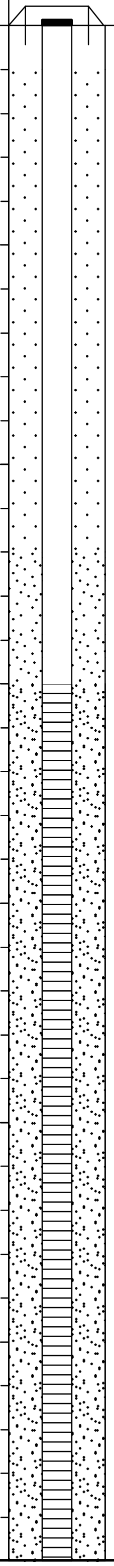
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
S-184 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **1/13/15** COMPLETED: **1/13/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in): **12**
CHECKED BY:



Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy.							
			Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	
										1-12' bgs: Bentonite
10									10	
15									15	
20									20	
										12-35' bgs: Sand 15-35' bgs: 30-slot PVC Screen
25									25	
30									30	

Borehole terminated at 35 feet.

SECOR

International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/12/03 12/12/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-184**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ **20.3**	**35.0**	**NA**	**NA**

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
2.0' of Above Grade Riser Stick-Up with Locking Cap Not Shown			Soft dig interval; no samples.		
	5				
Bentonite Seal					
		☒	SILTY CLAY, low plasticity, wet, brown to gray, trace sand, petroleum odor, (CL-ML).	1.5	453
	10	☒	CLAY, low to medium plasticity, moist, brown to gray, petroleum odor, (CL).	1.9	434.5
		☒	CLAY, high plasticity, moist, brown to gray, petroleum odor, (CL).	1.6	1034.5
#1 Sand and Sch. 40 PVC Riser		☒	CLAY, high plasticity, moist, gray to cream, petroleum odor, (CL).	0.7	90.6

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 1 of 3)

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/12/03 12/12/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-184**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 20.3	35.0	NA	NA

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
20 Slot PVC Screen, Circumslot			SILT, low plasticity, moist, cream, petroleum odor, (ML).		
			SANDY CLAY, low plasticity, moist, light brown, some gravel (sub-rounded) up to 1/4", petroleum odor, (CL).	1.7	207.5
			CLAY, low plasticity, moist, light brown, some medium grained sand and gravel (rounded to sub-rounded) up to 1/4", petroleum odor, (CL).	2.0	148.4
	20		SAND, non-plastic, moist, dark brown, medium through coarse grained, petroleum odor, (SP).	1.5	311.4
∇			CLAY, high plasticity, moist, brown, petroleum odor, (CL).		
			GRAVELLY SAND, non-plastic, saturated, brown, medium grained, gravel up to 1", petroleum odor, (SWG).		
			No recovery.	0.0	
	25		CLAYEY SAND, non-plastic, wet, reddish brown, greater than 1" gravel wedged in sampling shoe yielded low recovery, petroleum odor, (SC).	0.2	483.5
			SANDY CLAY, low plasticity, saturated, light brown, petroleum odor, (CL).	2.0	1354.3
			CLAYEY SAND, non-plastic, wet, reddish brown, medium grained, gravel (sub-rounded) up to 3/4", petroleum odor, (SC).		
			SANDY CLAY, low plasticity, saturated, light brown, petroleum odor, (CL).	1.0	160.7
			SANDY GRAVEL, non-plastic, saturated, dark brown, large gravel wedged in sampling shoe yielded low recovery, petroleum odor, (GWS).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

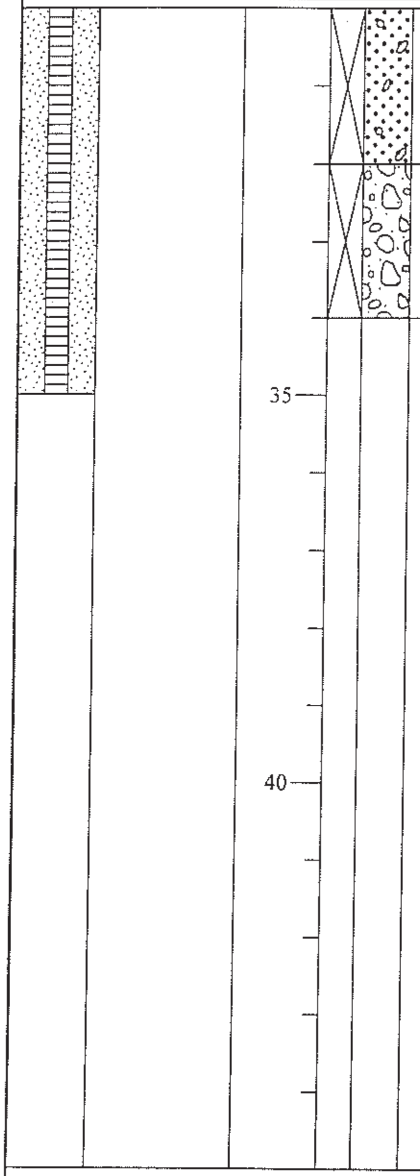
Approved by

Figure

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/12/03 12/12/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-184**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ 20.3	35.0	NA	NA



Description	Recovery (feet)	PID Reading (ppm above background)
GRAVELLY SAND, non-plastic, wet, brown to yellowish brown, coarse grained, greater than 1" gravel wedged in sampling shoe yielded low recovery, petroleum odor, (SWG).	1.1	2571.3
SANDY GRAVEL, non-plastic, saturated, yellowish brown, petroleum odor, (SWG).	1.0	2978.7

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by __________

Figure (sheet 3 of 3)

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

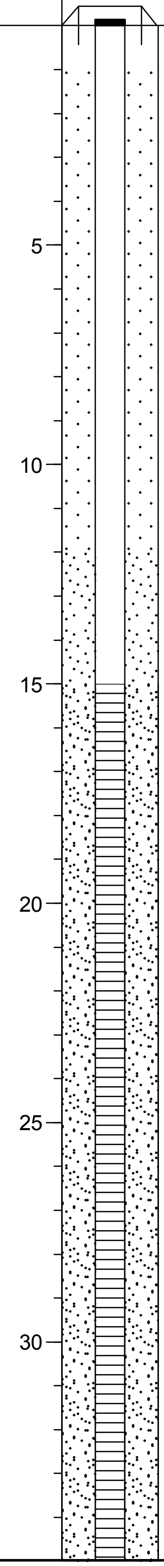
S-185 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **1/13/15** COMPLETED: **1/13/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in): **12**
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy.							
			Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	
										1-12' bgs: Bentonite
10									10	
15									15	
20									20	
										12-35' bgs: Sand 15-35' bgs: 30-slot PVC Screen
25									25	
30									30	

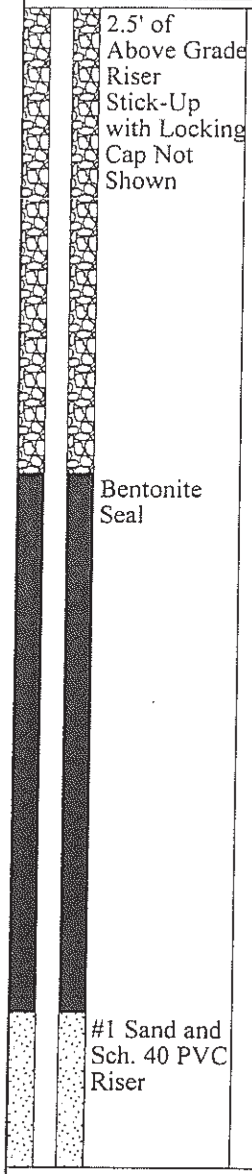


Borehole terminated at 35 feet.

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/15/03 12/16/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-185**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 20.78	35.0	NA	NA



Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
		Soft dig interval; no samples.		
5				
		No sample; HSA only.		
10	☒	SANDY SILT, non-plastic, saturated, dark brown, petroleum odor, (ML).	1.3	439.3
		CLAY, high plasticity, wet, gray to green, petroleum odor, (CH).		
	☒	SANDY SILT, non-plastic, moist, dark brown, petroleum odor, (ML).	1.9	9999+
		CLAY, high plasticity, moist, gray to green, petroleum odor, (CH).		
	☒	FILL, angular rock fragments up to 1/2" on edge, possible cave-in from near surface unit.	0.5	9999+

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by __________

Figure (sheet 1 of 3)

Logged By: JM	Dates Drilled: 12/15/03 12/16/03	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc.** **Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger** **Split Spoon**	Well Number: **S-185**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 10.25	Surface Elev.(ft.):	Groundwater Depth (ft.): ∇ 20.78	Total Depth (ft.): 35.0	Drive wt.(lbs.): NA	Drop Dist.(in.): NA

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
20 Slot PVC Screen, Circumslot			CLAY, high plasticity, moist, green, petroleum odor, (CH).		
			CLAY, high plasticity, moist, green, petroleum odor, (CH).	0.8	39.0
			CLAYEY SILT, non-plastic, moist, green, petroleum odor, (ML).		
			CLAY, high plasticity, moist, green, petroleum odor, (CH).		
			SANDY CLAY, low plasticity, saturated, gray to green, petroleum odor, (CL).	2.0	238.3
			SANDY CLAY, low plasticity, saturated, gray to green, up to 1/4" gravel inclusions, petroleum odor, (CL).		
			CLAY, high plasticity, moist, green, petroleum odor, (CH).		
	20		CLAY, high plasticity, moist, green, petroleum odor, (CH).	0.4	27.9
∇			CLAY, high plasticity, moist, greenish tan, trace sand, red brick, and up to 1/4" gravel (angular) present, petroleum odor, (CH).	0.8	9999+
	25		CLAY, low plasticity, saturated, gray to green, trace fine sand and up to 1/4" gravel present, petroleum odor, (CL).	0.5	295
			GRAVELLY SAND, slight plasticity, saturated, gray to green, some clay present, petroleum odor, (SWG).	1.0	6448.3
			GRAVELLY SAND, slight plasticity, saturated, gray to green, some clay present, petroleum odor, (SWG).	0.9	234.7

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

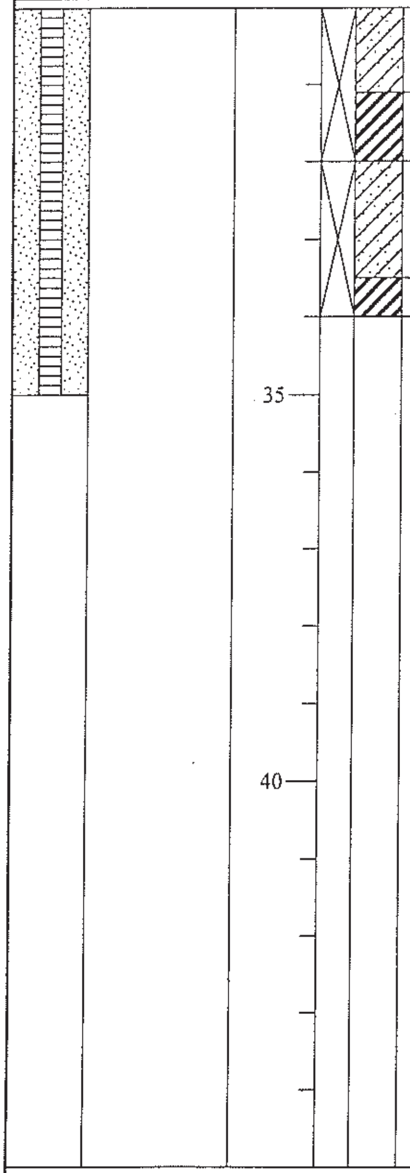
Approved by

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/15/03 12/16/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-185**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 20.78	35.0	NA	NA



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			CLAYEY SAND, non-plastic, wet, gray to green, petroleum odor, (SC).	0.6	9999+
			SANDY CLAY, high plasticity, saturated, gray to green, petroleum odor, (CH).		
			CLAYEY SAND, non-plastic, saturated, gray to green, up to 3/4" gravel (rounded), petroleum odor, (SC).	2.0	138.6
			CLAY, high plasticity, saturated, gray to green (product stained), petroleum odor, (CH).		
	35				
	40				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by

Figure (sheet 3 of 3)

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

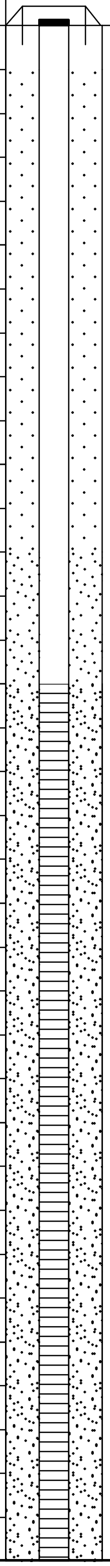
WELL / PROBEHOLE / BOREHOLE NO:
S-186 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **1/8/15** COMPLETED: **1/8/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in): **12**
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy.							
			Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	
										1-12' bgs: Bentonite
10									10	
15									15	
20									20	
										12-35' bgs: Sand
25									25	15-35' bgs: 30-slot PVC Screen
30									30	



Borehole terminated at 35 feet.

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/16/03 12/16/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-186**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ **21.04**	**35.0**	**NA**	**NA**

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
1.9' of Above Grade Riser Stick-Up with Locking Cap Not Shown			Soft dig interval; no samples.		
	5				
Bentonite Seal			No sample; HSA only.		
	10	☒	SILTY CLAY, non-plastic, saturated, mottled gray to brown, red brick fragments (less than 1/8"), petroleum odor, (CL-ML).	1.0	931.8
#1 Sand and Sch. 40 PVC Riser		☒	SAND, non-plastic, moist, brown, medium through coarse grained, small (less than 1/8") angular gravel and roots present, petroleum odor, (SW). SILTY CLAY, non-plastic, saturated, mottled gray to brown, red brick fragments (less than 1/8"), petroleum odor, (CL-ML).	1.3	1891.7
		☒	SILT, slight plasticity, moist, gray, petroleum odor, (ML).	1.7	534.5

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ______________

Figure (sheet 1 of 3)

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/16/03 12/16/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-186**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **21.04**	**35.0**	**NA**	**NA**

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
20 Slot PVC Screen, Circumslot			CLAY, high plasticity, saturated, gray (stained), petroleum odor, (CH). SILTY CLAY, low plasticity, saturated, gray, trace fine sand and fine gravel up to 3/4", petroleum odor, (CL-ML). SILTY CLAY, low plasticity, saturated, gray, petroleum odor, (CL-ML).	1.4	2232.7
			CLAY, high plasticity, wet, gray to brown, fine through coarse grained trace sand, petroleum odor, (CH).	1.0	90.9
	20		SANDY CLAY, low plasticity, saturated, brown, petroleum odor, (CL).	1.7	2514.6
∇			CLAYEY SAND, low plasticity, saturated, light gray with black streaking (stained), petroleum odor, (CL).		
			SAND, non-plastic, moist, gray to brown, fine through coarse grained, trace greater than 1" fine gravel (well-rounded), petroleum odor, (SW).	0.8	3411.5
			CLAY, high plasticity, saturated, gray, trace sand, petroleum odor, (CH).	1.3	3477
	25		SAND, non-plastic, saturated, brown with black and reddish brown product staining, fine grained, some coarse sand through fine gravel (approx. 3/4", sub-rounded), petroleum odor, (SW).		
			SAND, non-plastic, saturated, brown with black and reddish brown product staining, fine grained, some coarse sand through fine gravel (approx. 3/4", sub-rounded), petroleum odor, (SW).	1.1	3300.6
			SAND, non-plastic, saturated, brown with significant black and reddish brown product staining, fine grained, some coarse sand through fine gravel (approx. 3/4", sub-rounded), petroleum odor, (SW).	0.8	3333.4

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

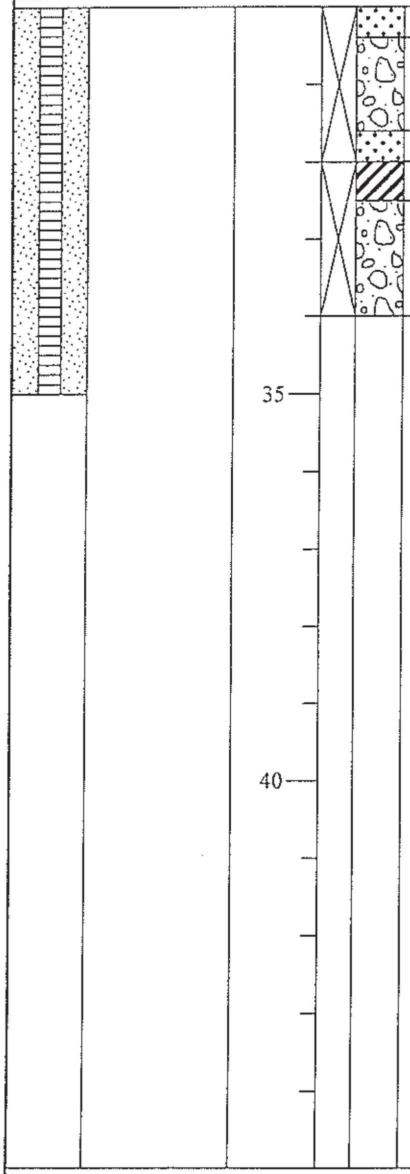
Approved by ______________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By: **JM**	Dates Drilled: 12/16/03 12/16/03	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc.** **Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger** **Split Spoon**	Well Number: **S-186**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): **10.25**	Surface Elev.(ft.):	Groundwater Depth (ft.): ▽ **21.04**	Total Depth (ft.): **35.0**	Drive wt.(lbs.): **NA**	Drop Dist.(in.): **NA**



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			SAND, non-plastic, saturated, brown with significant black and reddish brown product staining, fine through coarse grained, coarse sand present in trace amounts, some gravel, petroleum odor, (SW).	0.9	3345
			SANDY GRAVEL, non-plastic, saturated, brown, coarse grained, abundant fine gravel (approx. 1/8" to 1/4", sub-rounded through sub-angular), petroleum odor, (SWG).		
			SAND, non-plastic, saturated, brown with significant black and reddish brown product staining, fine through coarse grained, coarse sand present in trace amounts, some gravel, petroleum odor, (SW).	1.8	3333.5
			CLAY, high plasticity, saturated, gray, trace coarse sand (sub-angular), petroleum odor, (CH).		
			SANDY GRAVEL, non-plastic, saturated, brown, coarse grained, abundant fine gravel (approx. 1/8" to 1/4", sub-rounded through sub-angular), petroleum odor, (SWG).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by

Figure (sheet 3 of 3)

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

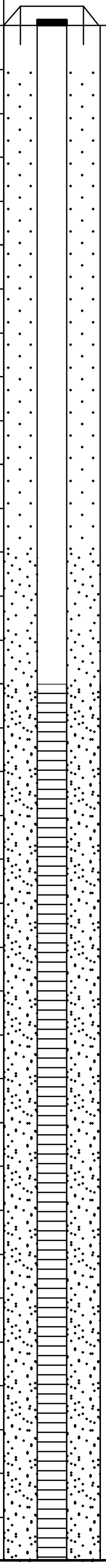
WELL / PROBEHOLE / BOREHOLE NO:
S-187 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **1/7/15** COMPLETED: **1/7/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in): **12**
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy. Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	1-12' bgs: Bentonite
10									10	
15									15	
20									20	
25									25	12-35' bgs: Sand 15-35' bgs: 30-slot PVC Screen
30									30	

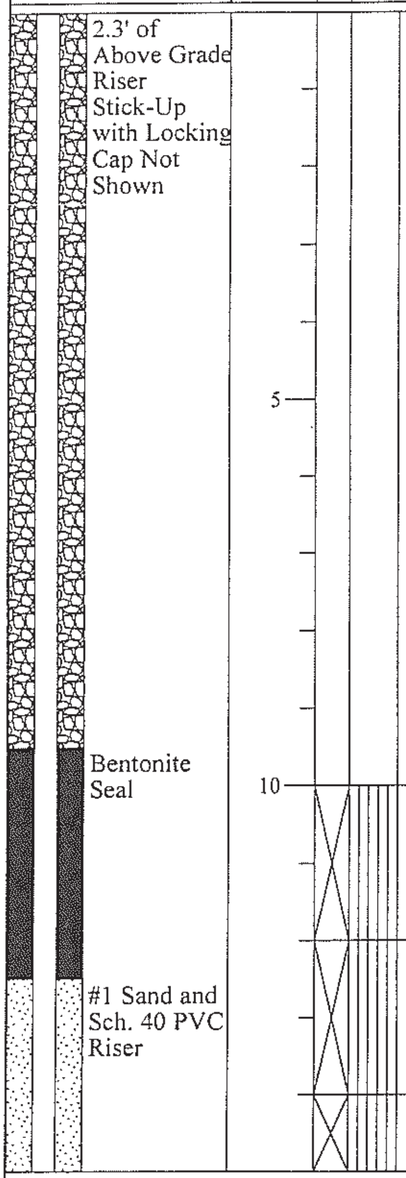


Borehole terminated at 35 feet.

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/16/03 12/16/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-187**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **21.6**	**35.0**	**NA**	**NA**



Description	Recovery (feet)	PID Reading (ppm above background)
Soft dig interval; no samples.		
SILT, slight plasticity, wet, mottled gray and brown, wet at top gradational to moist on bottom, petroleum odor, (ML).	1.5	1680
CLAYEY SILT, slight plasticity, moist, brown and gray, trace fine sand, petroleum odor, (ML).	2.0	2824.8
CLAYEY SILT, low plasticity, moist, brown and gray, petroleum odor, (ML).	0.7	1165.8

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 1 of 3)

SECOR
International Incorporated

Logged By: **JM**	Dates Drilled: **12/16/03** **12/16/03**	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc.** **Philadelphia Refinery, PA**		Method/Equipment: **Hollow Stem Auger** **Split Spoon**	Well Number: **S-187**
See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): **10.25**	Surface Elev.(ft.):	Groundwater Depth (ft.): ▽ **21.6**	Total Depth (ft.): **35.0**	Drive wt.(lbs.): **NA**	Drop Dist.(in.): **NA**

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
20 Slot PVC Screen, Circumslot					
			CLAY, high plasticity, wet, tan to brown, petroleum odor, (CH).	2.0	1452.8
			CLAY, high plasticity, wet, tan to brown, no odor, (CH).	0.9	568
	20		CLAY, high plasticity, wet, tan to brown, trace sand, petroleum odor, (CH).	0.8	1145.9
▽			SAND, non-plastic, wet, tan, fine grained, up to 1" fine gravel (rounded), petroleum odor, (SW).		
			CLAY, high plasticity, wet, brown, no odor, (CH).	0.8	506.8
			SAND, non-plastic, wet, tan, fine grained, up to 3/4" fine gravel (sub-rounded), no odor, (SW).		
	25		SAND, non-plastic, saturated, tan, medium grained, up to 1 1/4" fine gravel (sub-rounded), strong petroleum odor, (SW).	0.9	1136.8
			SAND, non-plastic, saturated, tan, medium grained, up to 1 1/4" fine gravel (sub-rounded), strong petroleum odor, (SW).	0.9	1792.6
			No recovery.	0.0	

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

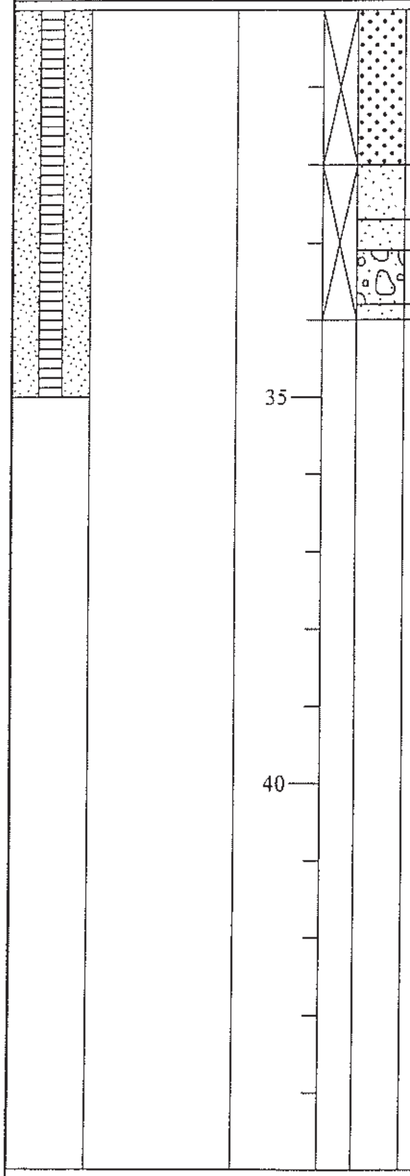
Approved by ____________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By: JM	Dates Drilled: 12/16/03 12/16/03	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc.** **Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger** **Split Spoon**	Well Number: **S-187**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 10.25	Surface Elev.(ft.):	Groundwater Depth (ft.): ∇ 21.6	Total Depth (ft.): 35.0	Drive wt.(lbs.): NA	Drop Dist.(in.): NA



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			SAND, non-plastic, saturated, brown, medium through coarse grained, approx. 1 1/4" gravel wedged in sampling shoe yielded low recovery, petroleum odor, (SW).	0.8	3245.7
			SAND, non-plastic, saturated, brown, fine through medium grained, slightly clayey, petroleum odor, (SP).	0.8	2140.3
			SAND, non-plastic, saturated, brown, medium grained, petroleum odor, (SP).		
			SANDY GRAVEL, non-plastic, saturated, brown (highly stained with product), up to 1" gravel (sub-rounded) present, petroleum odor, (GWS).		
			SAND, non-plastic, saturated, brown, medium grained, petroleum odor, (SP).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by ____________

Figure (sheet 3 of 3)

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

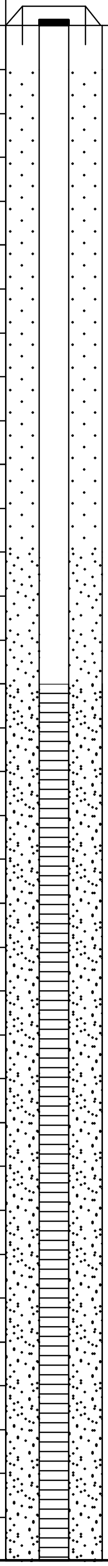
WELL / PROBEHOLE / BOREHOLE NO:

S-188 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **1/6/15** COMPLETED: **1/6/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **NS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in): **12**
CHECKED BY:

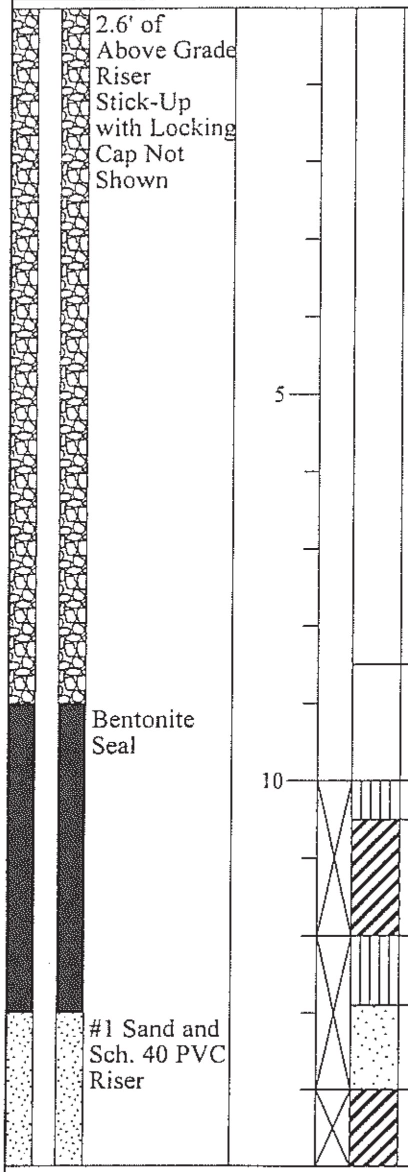
Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
5 10 15 20 25 30			See original log for soil stratigraphy. Well overdrilled to install 6" recovery well. Original well was 4".						5 10 15 20 25 30	 1-12' bgs: Bentonite 12-35' bgs: Sand 15-35' bgs: 30-slot PVC Screen

Borehole terminated at 35 feet.

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/17/03 12/17/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-188**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ 21.5	35.0	NA	NA



Description	Recovery (feet)	PID Reading (ppm above background)
Soft dig interval; no samples.		
No sample; HSA only.		
SILT, non-plastic, wet, brown, cave-in, no odor, (ML).	2.0	159
CLAY, high plasticity, moist, cream to tan, up to 1" gravel (sub-rounded), no odor, (CH).		
SILT, non-plastic, wet, gray, cave-in with up to 1/4" gravel (sub-angular), no odor, (ML).	1.7	169
SAND, non-plastic, moist, tan, medium grained, up to 1" fine gravel (red and sub-rounded), no odor, (SP).		
CLAY, high plasticity, moist, cream, no odor, (CH).	1.7	332

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 1 of 3)

SECOR
International Incorporated

Logged By: JM	Dates Drilled: 12/17/03 12/17/03	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc.** **Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger** **Split Spoon**	Well Number: **S-188**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 10.25	Surface Elev.(ft.):	Groundwater Depth (ft.): ∇ 21.5	Total Depth (ft.): 35.0	Drive wt.(lbs.): NA	Drop Dist.(in.): NA

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
20 Slot PVC Screen, Circumslot			SAND, non-plastic, moist, yellowish brown, medium grained, no odor, (SP).		
			GRAVELLY CLAY, high plasticity, moist, gray, up to 1/4" gravel (sub-rounded), no odor, (CL).	2.0	82.3
			SAND, non-plastic, moist, yellowish brown to red, medium grained, no odor, (SP).		
			No recovery.	0.0	
	20		CLAYEY SILT, low plasticity, moist, brown, up to 1" gravel (sub-rounded), petroleum odor, (ML).	1.7	9999+
∇			SAND, non-plastic, moist, reddish brown, fine grained, petroleum odor, (SP).		
			SANDY CLAY, low plasticity, moist, brown, fine grained sand and up to 1/4" gravel (sub-angular), petroleum odor, (CL).	1.7	9999+
			CLAYEY SAND, slight plasticity, moist, reddish brown, fine grained, up to 1" gravel (sub-rounded), petroleum odor, (SP).		
			SANDY CLAY, low plasticity, moist, brown, up to 1/4" gravel (angular), petroleum odor, (CL).	0.8	9999+
	25		SAND, non-plastic, wet, reddish brown, medium grained, up to 1/4" gravel (sub-angular), petroleum odor, (SW).		
			SANDY CLAY, low plasticity, wet, brown, up to 1" gravel (sub-angular), petroleum odor, (CL).	1.2	5958
			SAND, slight plasticity, wet, reddish brown (stained), medium grained with trace clay and up to 20% 1" gravel (sub-rounded to rounded), petroleum odor, (SW).		
			SANDY CLAY, low plasticity, wet, brown, up to 1" gravel (sub-angular), petroleum odor, (CL).	1.2	7882
			SAND, slight plasticity, wet, reddish brown (stained), medium grained with trace clay and up to 20% 1" gravel (sub-rounded to rounded), petroleum odor, (SW).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/17/03 12/17/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-188**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 21.5	35.0	NA	NA

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			VERY SANDY CLAY, slight plasticity, saturated, dark brown, medium grained with large 1 1/2" gravel wedged in sampling shoe yielded low recovery, petroleum odor, (CL).	0.4	9999+
			SANDY CLAY, slight plasticity, saturated, dark brown, medium grained with large 1 1/4" gravel wedged in sampling shoe yielded low recovery, petroleum odor, (CL).	0.3	4468
	35				
	40				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by ____________

Figure (sheet 3 of 3)

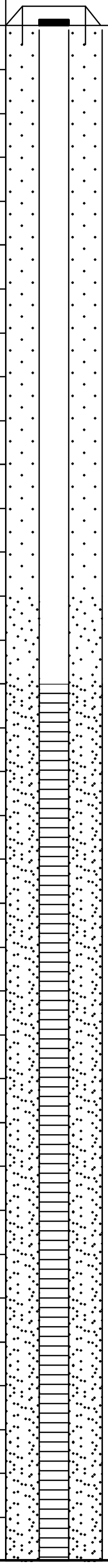
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
S-189 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **3/3/15** COMPLETED: **3/3/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in):
CHECKED BY:



Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy.							
			Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	
										0-13' bgs: Bentonite Seal
10									10	
15									15	
20									20	
										13-35' bgs: Sand 15-35' bgs: PVC Screen
25									25	
30									30	

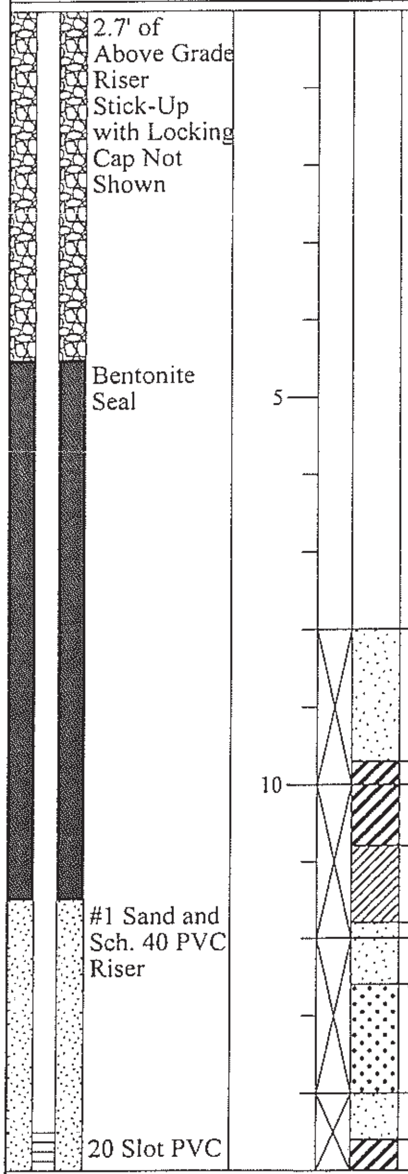
Borehole terminated at 35 feet.

SECOR

International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	**01/14/04** **01/14/04**	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-189**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ **22.61**	**34.5**	**NA**	**NA**



Description	Recovery (feet)	PID Reading (ppm above background)
Soft dig interval; no samples.		
SAND, non-plastic, wet, black (significantly stained), fine grained, petroleum odor, (SP).	1.8	1328.7
CLAY, high plasticity, moist, tan, petroleum odor, (CH).		
CLAY, high plasticity, moist, tan, no odor, (CH).	1.6	254.3
CLAY, low plasticity, moist, mottled reddish brown and gray, no odor, (CL).		
SAND, non-plastic, moist, light gray, fine grained, no odor, (SP).		
SAND, non-plastic, saturated, dark gray (stained), fine grained, petroleum odor, (SP).	1.3	534.8
SAND, non-plastic, wet, reddish brown to gray (stained green in discrete areas), medium grained, 1/2" to 1" gravel (angular to rounded), no odor, (SW).		
SAND, non-plastic, saturated, black to gray (stained), fine grained, petroleum odor, (SP).	1.7	1579.5
CLAY, high plasticity, moist, light brown to gray, petroleum odor, (CH).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

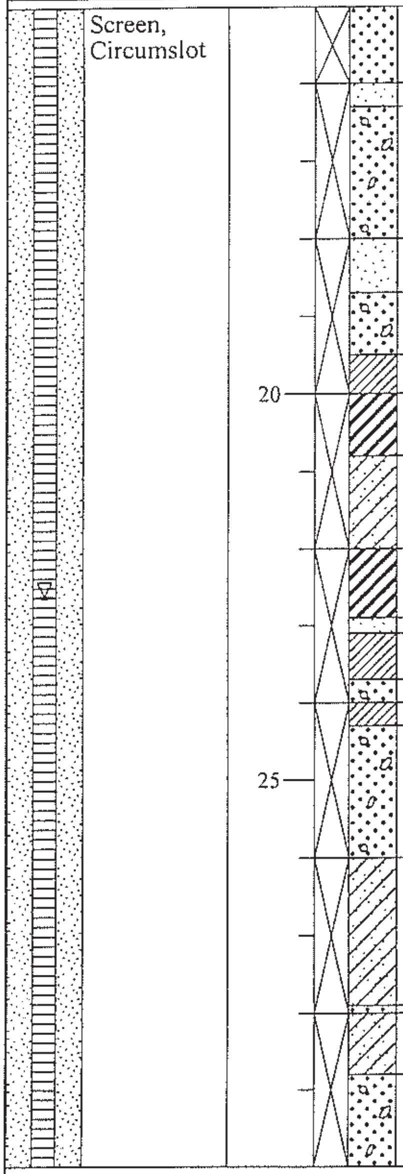
Approved by

Figure (sheet 1 of 3)

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Logged By: JM	Dates Drilled: 01/14/04 01/14/04	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc. Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger Split Spoon**	Well Number: **S-189**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 10.25	Surface Elev.(ft.):	Groundwater Depth (ft.): ∇ 22.61	Total Depth (ft.): 34.5	Drive wt.(lbs.): NA	Drop Dist.(in.): NA



Depth, (ft.)	Description	Recovery (feet)	PID Reading (ppm above background)
	SAND, non-plastic, wet, yellowish brown (stained green in discrete areas), medium grained, approx. 5% 1/2" and smaller gravel (angular) and red brick fragment inclusions, petroleum odor, (SW).		
	SAND, non-plastic, wet, black, fine grained, cave-in from above, no odor, (SP).	1.8	990.3
	GRAVELLY SAND, slight plasticity, saturated, light brown (some staining), medium grained, approx. 30% gravel (well-rounded) up to 1", no odor, (SWG).		
	SAND, non-plastic, saturated, gray, fine grained, cave-in from above, petroleum odor, (SP).	2.0	2993.6
	GRAVELLY SAND, slight plasticity, saturated, light brown (some staining), medium grained, approx. 30% gravel (well-rounded) up to 1", petroleum odor, (SWG).		
20	CLAY, medium plasticity, moist, reddish brown, trace fine sand, petroleum odor, (CL).	1.5	2006.4
	CLAY, medium plasticity, wet, reddish brown, trace medium sand at approx. 1% to 3%, slow grade to unit below, petroleum odor, (CH).		
	CLAYEY SAND, non-plastic, wet, reddish brown to yellow brown, medium grained, approx. 40% clay with 1/2" gravel (sub-rounded) at base, slow grade from unit above, petroleum odor, (SC).		
	CLAY, high plasticity, wet, reddish brown, petroleum odor, (CH).	1.9	1689.4
	SAND, non-plastic, wet, yellow brown, medium grained, petroleum odor, (SP).		
	SANDY CLAY, low plasticity, moist, reddish brown, less than 1% sub-rounded 1" gravel, petroleum odor, (CL).		
	GRAVELLY SAND, non-plastic, wet, yellow brown, medium through coarse grained, approx. 40% gravel (angular) up to 1" on edge, petroleum odor, (SWG).	1.3	1582.4
25	SANDY CLAY, low plasticity, saturated, reddish brown, fine grained sands, petroleum odor, (CL).		
	GRAVELLY SAND, non-plastic, saturated, reddish brown with some yellow brown (stained), medium through coarse grained, trace clay and approx. 30% gravel (rounded) up to 1 1/4", petroleum odor, (SWG).	1.5	991.9
	CLAYEY SAND, non-plastic, wet, reddish brown, fine grained, cave-in from above, no odor, (SC).		
	GRAVELLY SAND, non-plastic, saturated, yellow brown to gray, medium grained, greater than 1" gravel wedged in base of sampler, no odor, (SWG).	0.9	576.3
	CLAYEY SAND, non-plastic, saturated, brown, fine grained, cave-in from above, no odor, (SC).		
	GRAVELLY SAND, non-plastic, saturated, mottled reddish brown to tan, fine through medium grained, approx. 30% gravel (sub-angular to rounded) approx.		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

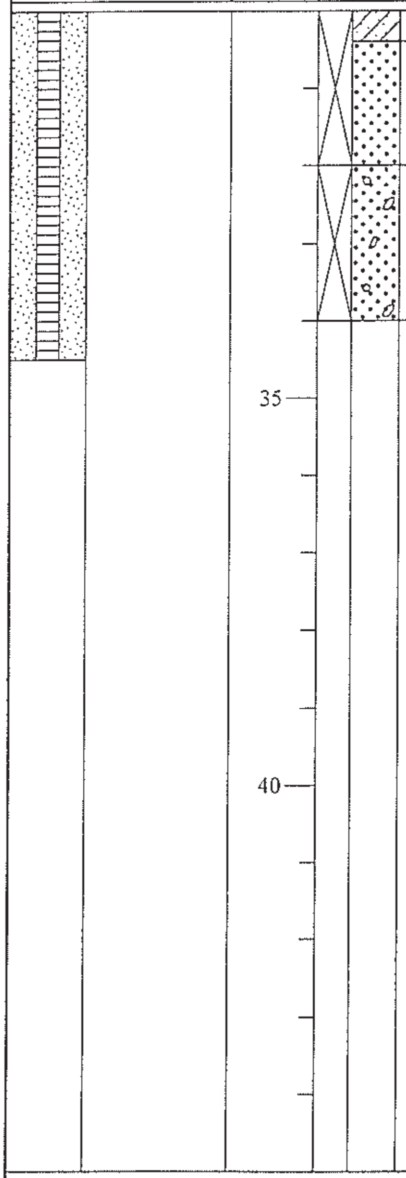
Approved by ____________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	**01/14/04** **01/14/04**	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-189**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		⊻ **22.61**	**34.5**	**NA**	**NA**



Description	Recovery (feet)	PID Reading (ppm above background)
1/2", petroleum odor, (SWG).	0.8	2613.4
CLAYEY SAND, non-plastic, saturated, brown, fine grained, petroleum odor, (SC).		
SAND, non-plastic, saturated, jet black (significantly stained), medium grained, approx. 15% to 20% greater than 1 1/4" gravel (sub-rounded to rounded),strong petroleum odor, (SW).		
GRAVELLY SAND, non-plastic, saturated, jet black (significantly stained), medium grained, approx. 50% gravel (angular) up to 1", petroleum odor, (SWG).	1.3	1751.2

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 3 of 3)

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

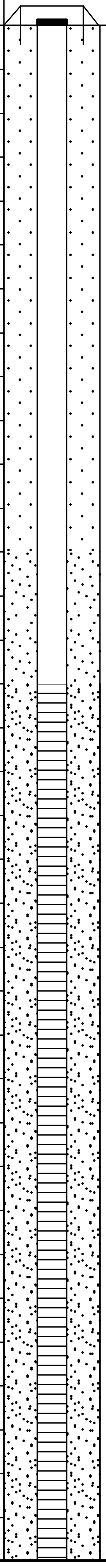
WELL / PROBEHOLE / BOREHOLE NO:

S-190

PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **2/26/15** COMPLETED: **2/26/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
EASTING (ft):
LAT:
LONG:
GROUND ELEV (ft):
TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
WELL DEPTH (ft): **35.0**
STATIC DTW (ft): **Not Encountered**
BOREHOLE DEPTH (ft): **35.0**
WELL CASING DIA. (in): **6**
BOREHOLE DIA. (in): **8.25**
LOGGED BY: **TD**
CHECKED BY:

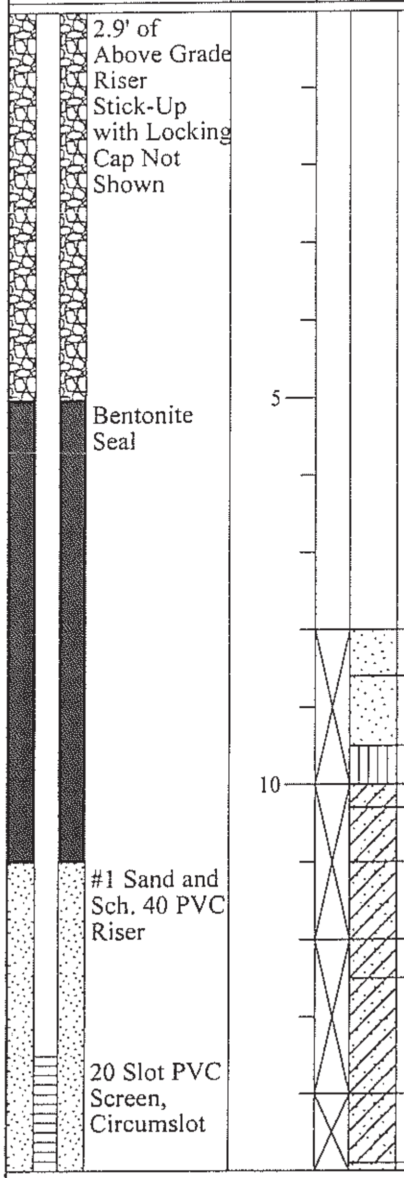
Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy.							
			Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	0-12' bgs: Bentonite
10									10	
15									15	
20									20	
										12-35' bgs: Sand
25									25	15-35' bgs: 30-slot PVC Screen
30									30	

Borehole terminated at 35 feet.

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	01/13/04 01/14/04	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-190**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		⊽ 22.31	33.5	NA	NA



Description	Recovery (feet)	PID Reading (ppm above background)
Soft dig interval; no samples.		
SAND, non-plastic, moist, gray to brown, fine grained, no odor, (SP).	1.7	337
SAND, non-plastic, wet, gray to reddish brown (stained with product), fine grained, no odor, (SP).		
CLAYEY SILT, low plasticity, wet, reddish brown, angular gravels present approx. 1" on edge, petroleum odor, (ML).		
SAND, slight plasticity, moist, light brown, fine grained, petroleum odor, (SC).	1.3	9999+
SAND, slight plasticity, moist, reddish brown to yellow, fine grained, up to 1/2" gravels (angular), petroleum odor, (SC).		
SAND, slight plasticity, moist, reddish brown to yellow (significantly stained), fine grained, up to 1/2" gravels (angular), strong petroleum odor, (SC).		
SAND, slight plasticity, moist, brown (stained), fine through medium grained, trace clay with approx. 1/4" gravels (angular), petroleum odor, (SC).	1.3	9999+
SAND, slight plasticity, moist, brown (stained), fine through medium grained, trace clay, petroleum odor, (SC).		
CLAYEY SAND, slight plasticity, wet (driller injected water to cool lead auger), gray, fine grained, strong petroleum odor, (SC).	1.6	3312.8

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

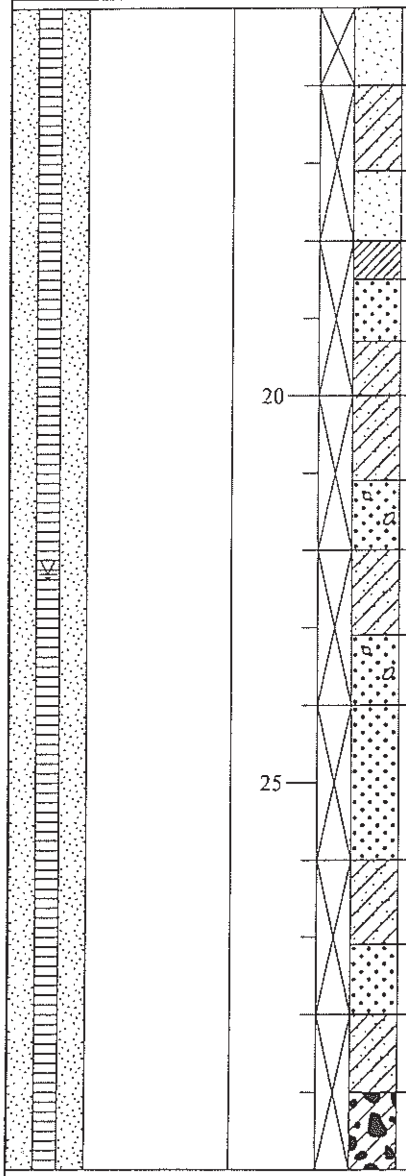
Approved by ____________

Figure (sheet 1 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	01/13/04 01/14/04	Parratt-Wolff, Inc.	Sunoco, Inc. Philadelphia Refinery, PA	Hollow Stem Auger Split Spoon	S-190

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 22.31	33.5	NA	NA



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			SAND, non-plastic, wet, yellow brown, medium grained, approx. 1% to 2% of less than 1/4" gravel (angular) with large (greater than 1") gravel at base of sampler, petroleum odor, (SP).		
			CLAYEY SAND, slight plasticity, wet, gray, fine grained, strong petroleum odor, (SC).	2.0	110.8
			SAND, non-plastic, wet, yellow brown, medium through coarse grained, approx. 1% to 2% of less than 1/4" gravel (angular), no odor, (SP).		
			SANDY CLAY, slight plasticity, wet, gray, fine grained, cave-in from above, no odor, (CL).		
			SAND, non-plastic, wet, yellow brown, medium grained, approx. 30% to 40% gravel (well-rounded), no odor, (SW).	1.5	542.9
			CLAYEY SAND, slight plasticity, wet, reddish brown, fine grained, no odor, (SC).		
	20		CLAYEY SAND, slight plasticity, saturated, brown, fine grained, cave-in from above, no odor, (SC).	1.3	454.8
			GRAVELLY SAND, slight plasticity, saturated, reddish brown, fine through coarse grained, trace clay with abundant gravel (angular to rounded) from approx. 1/4" to greater than 1" on edge, no odor, (SWG).		
∇			CLAYEY SAND, slight plasticity, wet, brown, fine grained, cave-in from above, no odor, (SC).	1.6	674.5
			GRAVELLY SAND, slight plasticity, saturated, brown, fine through coarse grained with average size medium grained, trace clay with approx. 40% gravel (angular to well-rounded) from approx. 3/4" to 1", no odor, (SWG).		
	25		SAND, slight plasticity, saturated, brown, medium through coarse grained, trace clay with approx. 30% large (greater than 1") gravel (angular to sub-rounded), no odor, (SW).	1.1	495.6
			CLAYEY SAND, slight plasticity, saturated, brown, fine grained, cave-in from above, petroleum odor, (SC).	1.8	1726.8
			SAND, slight plasticity, saturated, brown (significantly stained), medium through coarse grained, trace clay with approx. 30% 1" gravel (rounded to sub-rounded), strong petroleum odor, (SW).		
			CLAYEY SAND, slight plasticity, saturated, brown, medium grained, up to 1/2" gravel (sub-rounded), petroleum odor, (SC).	1.0	1003.5
			CLAYEY GRAVEL, slight plasticity, saturated, brown (significantly stained), abundant (greater than 50%) gravel (angular) present greater than 1", strong petroleum odor, (GC).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

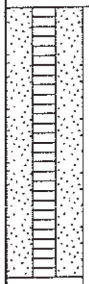
Approved by ______________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	**01/13/04** **01/14/04**	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-190**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ 22.31	33.5	NA	NA



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
		☒	SAND, non-plastic, saturated, brown (product stained), medium grained, trace clay, petroleum odor, (SP).	0.8	9999+
			SANDY GRAVEL, non-plastic, saturated, brown (product stained), petroleum odor, (GWS).		
		☒	CLAYEY SAND, slight plasticity, saturated, light brown, medium grained, cave-in from above, petroleum odor, (SC).	2.0	1705.8
			SANDY GRAVEL, non-plastic, saturated, jet black (significant product staining), medium grained, trace clay with abundant (approx. 50%) gravel (well-rounded) between 1/4" and 1", petroleum odor, (GWS).		
	35				
	40				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by ______________

Figure (sheet 3 of 3)

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

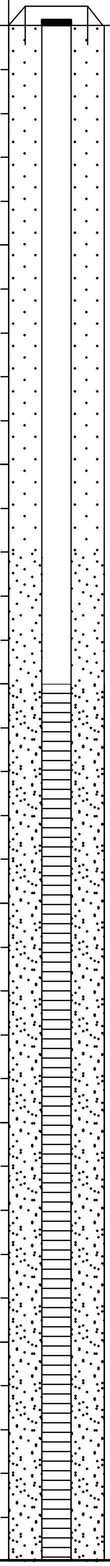
S-191 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **2/26/15** COMPLETED: **2/26/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **TD**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in): **8.25**
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy.							
			Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	0-12' bgs: Bentonite
10									10	
15									15	
20									20	
25									25	12-35' bgs: Sand 15-35' bgs: 30-slot PVC Screen
30									30	



Borehole terminated at 35 feet.

SECOR
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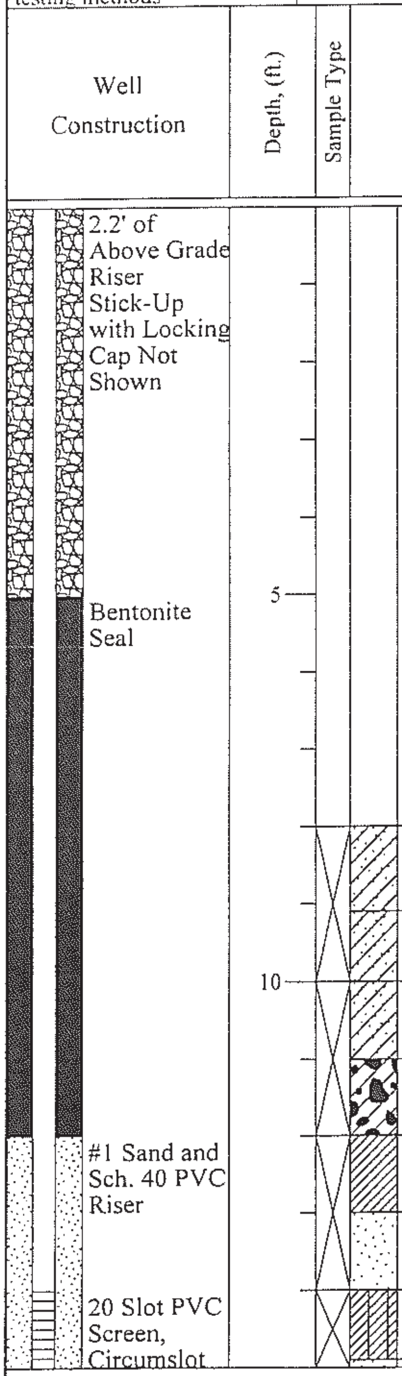
Logged By: JM
Dates Drilled: 01/13/04 01/13/04
Drilling Contractor: **Parratt-Wolff, Inc.**
Project Name: **Sunoco, Inc. Philadelphia Refinery, PA**
Method/Equipment: **Hollow Stem Auger Split Spoon**
Well Number: **S-191**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods
Boring Diam.(in.): 10.25
Surface Elev.(ft.):
Groundwater Depth (ft.): ▽ 22.61
Total Depth (ft.): 34.0
Drive wt.(lbs.): NA
Drop Dist.(in.): NA



Description	Recovery (feet)	PID Reading (ppm above background)
Soft dig interval; no samples.		
CLAYEY SAND, slight plasticity, moist, gray to brown, fine grained with less than 5% clay, petroleum odor, (SC).	1.6	1589
CLAYEY SAND, slight plasticity, moist, reddish brown, fine grained with less than 5% clay, up to 3/4" gravel (sub-rounded) and less than 1% red brick fragment inclusions, strong petroleum odor, (SC).		
CLAYEY SAND, slight plasticity, wet, reddish brown, fine grained, approx. 1" sub-rounded gravel at base, petroleum odor, (SC).	1.3	1792
CLAYEY GRAVEL, slight plasticity, wet, reddish brown to black (highly stained with green product discoloration), large (greater than 1") gravel wedged in sampling shoe, strong petroleum odor, (GC).		
SANDY CLAY, low plasticity, moist, brown, approx. 1/4" quartzite gravel (angular) at base, petroleum odor, (CL).	1.3	535
SAND, non-plastic, moist, yellow brown, medium through coarse grained, petroleum odor, (SP).		
SILTY CLAY, low plasticity, moist, reddish brown, trace sand and up to 3/4" gravel (angular), no odor, (CL-ML).	1.2	885

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by

Figure (sheet 1 of 3)

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	**01/13/04** **01/13/04**	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-191**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **22.61**	**34.0**	**NA**	**NA**

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			SAND, non-plastic, moist, yellow brown with color banding, medium through coarse grained, less than 1/2" gravel (sub-angular), no odor, (SP).		
			CLAYEY SAND, slight plasticity, moist, reddish brown, fine grained, cave-in from above, no odor, (SC).	1.3	706.9
			SAND, non-plastic, moist, yellow brown, medium grained, significant (approx. 20% to 30%) gravel (angular to sub-angular) up to 1/2", no odor, (SP).		
			No recovery.	0.0	
	20		SANDY CLAY, low plasticity, moist, brown to reddish brown, fine through medium grained, large (greater than 1" on edge) gravel (sub-rounded to sub-angular), no odor, (CL).	1.7	679
			SAND, non-plastic, moist, yellow brown to tan, medium grained, up to approx. 3/4" gravel (sub-rounded), no odor, (SP).		
∇			SANDY CLAY, slight plasticity, wet, brown with reddish brown at base, medium grained, up to 1/2" gravel (rounded), no odor, (CL).	1.6	803
			SAND, non-plastic, wet, tan with reddish brown and black (product streaking in discrete areas), medium grained, up to 3/4" gravel (sub-angular), petroleum odor, (SW).		
			SANDY CLAY, slight plasticity, saturated, brown, up to 1/2" gravel (rounded), strong petroleum odor, (CL).	1.2	1939
	25		SAND, non-plastic, saturated, black and brown (stained), medium grained, up to 1" gravel (rounded to well-rounded), petroleum odor, (SW).		
			SANDY CLAY, slight plasticity, saturated, brown, up to 1/2" gravel (rounded), petroleum odor, (CL).	1.8	1426
			SAND, non-plastic, saturated, black and brown (stained), medium grained, up to 1" gravel (rounded to well-rounded) and less than 10% red brick fragments, petroleum odor, (SW).		
			SANDY CLAY, slight plasticity, saturated, brown, up to 1/2" gravel (rounded), petroleum odor, (CL).	1.1	1430
			SAND, non-plastic, saturated, gray to black (highly stained), medium grained, up to 1" gravel (rounded to well-rounded), strong petroleum odor, (SW).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	01/13/04 01/13/04	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-191**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		⊽ 22.61	34.0	NA	NA

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			SAND, non-plastic, saturated, brown (significant staining), medium grained, up to 1" gravel (angular) present at approx. 40%, strong petroleum odor, (SW).	1.1	2864
			SAND, non-plastic, saturated, black (significant staining), medium grained, up to 1" gravel (angular) present at approx. 40%, strong petroleum odor, (SW).		
			SAND, non-plastic, saturated, black (significant staining), medium through coarse grained, coarse grained concentration is trace with up to 1" gravel (angular) present at approx. 20%, strong petroleum odor, (SW).	2.0	935
	35				
	40				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by ________________

Figure (sheet 3 of 3)

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

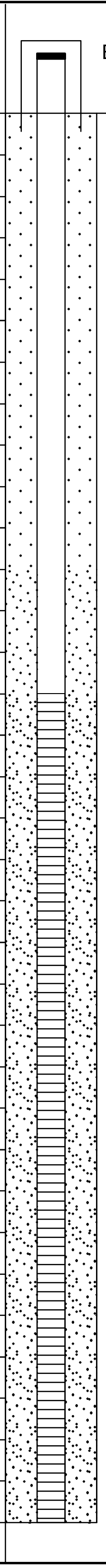
S-192 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **2/25/15** COMPLETED: **2/25/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **6**
LOGGED BY: **TD**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **34.0**
BOREHOLE DEPTH (ft): **34.0**
BOREHOLE DIA. (in): **8.25**
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			See original log for soil stratigraphy.							
			Well overdrilled to install 6" recovery well. Original well was 4".							
5									5	0-11' bgs: Bentonite
10									10	
15									15	
20									20	
										11-34' bgs: Sand 14-34' bgs: 30-slot PVC Screen
25									25	
30									30	
			Borehole terminated at 34 feet.							



SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	01/12/04 01/13/04	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-192**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		⊽ 22.8	33.4	NA	NA

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
2.3' of Above Grade Riser Stick-Up with Locking Cap Not Shown			Soft dig interval; no samples.		
	5				
Bentonite Seal		☒	SILT, non-plastic, moist, black, no odor, (ML).	0.8	400
			FILL, #57 stone.		
			SILT, non-plastic, moist, black to reddish brown, no odor, (ML).		
	10	☒	CLAYEY SAND, slight plasticity, moist, black and red, fine grained, up to 1" gravel (rounded) present at less than 3%, no odor, (SC).	1.5	322
#1 Sand and Sch. 40 PVC Riser		☒	CLAYEY SAND, slight plasticity, moist, black and red, fine grained, up to 1" gravel (rounded) present at less than 3%, no odor, (SC).	1.6	275
20 Slot PVC Screen, Circumslot			SAND, non-plastic, moist, brown, fine grained, up to 1/2" gravel (sub-rounded), strong petroleum odor, (SW).		
		☒	SAND, non-plastic, moist, reddish brown to tan, medium grained, gravel (both rounded and angular) present between 1/2" and up to more than 1" on edge, no	2.0	251

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by ____________

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

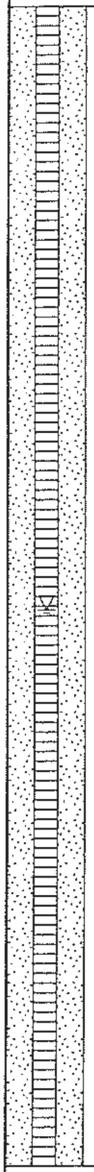
Figure (sheet 1 of 3)

SECOR

International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	01/12/04 01/13/04	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-192**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 22.8	33.4	NA	NA



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
		☒	odor, (SW).		
		☒	SAND, non-plastic, moist, brown to dark brown, fine grained, less than 10% medium grained sand and less than 1% angular gravel, no odor, (SP).	0.4	420
		☒	SAND, non-plastic, moist, dark brown, fine grained, petroleum odor, (SP).	0.7	9999+
			SILT, non-plastic, dry to moist, brown, small (less than 1/4") sub-angular gravel, petroleum odor, (ML).		
	20	☒	SILT, non-plastic, moist, brown, approx. 1/4" gravel (sub-angular to angular) inclusions with greater than 1" gravel at base of sampler, no odor, (ML).	1.6	770
		☒	SILT, non-plastic, moist, dark brown, approx. 1/4" gravel (sub-angular) inclusions, no odor, (ML).	1.1	643
			SAND, non-plastic, moist, brown, medium grained, no odor, (SP).		
	25	☒	SLIGHTLY CLAYEY SAND, non-plastic, saturated, brown, medium grained, up to 3/4" gravel (sub-rounded), petroleum odor, (SW).	1.0	1360
		☒	SLIGHTLY CLAYEY SAND, non-plastic, saturated, brown, medium grained, up to 3/4" gravel (sub-rounded), petroleum odor, (SW).	1.8	9999+
			GRAVEL, non-plastic, saturated, gray to black (stained with product), sub-rounded to rounded gravel with little fines, petroleum odor, (GW).		
		☒	SAND, very slight plasticity, moist, brown, medium grained, some (less than 5%) clay and up to 3/4" gravel (sub-rounded), no odor, (SW).	1.9	547
			SANDY GRAVEL, non-plastic, saturated, brown, greater than 1" sub-angular to sub-rounded gravel in medium grained sand matrix (less than 40%),		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by ____________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	01/12/04 01/13/04	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-192**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ 22.8	33.4	NA	NA

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			petroleum odor, (GWS). CLAYEY SAND, non-plastic, saturated, dark brown to gray (highly stained with product), medium grained, abundant (approx. 50%) gravel (sub-angular to sub-rounded) between 1/2" to 1", petroleum odor, (SC).	0.6	1816
			CLAYEY SAND, non-plastic, saturated, dark brown to gray (highly stained with product), medium grained, large (greater than 1") gravel wedged in sampling shoe yielded low recovery, petroleum odor, (SC).	0.1	161
	35				
	40				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by

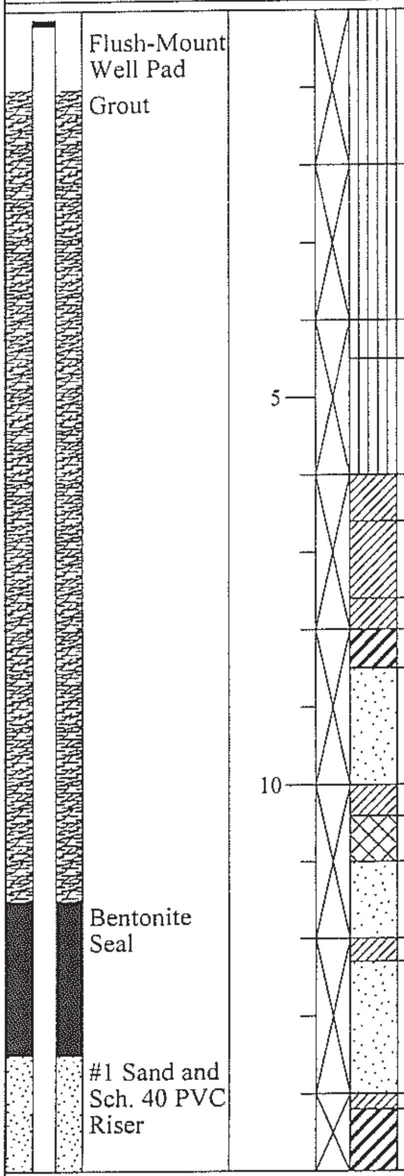
Figure (sheet 3 of 3)

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/04/03 12/04/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-193**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ 24.2	35.0	NA	NA



Description	Recovery (feet)	PID Reading (ppm above background)
SILT, non-plastic, moist, dark brown, roots present, no odor, (ML).	0.8	2.2
CLAYEY SILT, low plasticity, moist, light brown, red brick fragments present, no odor, (ML).	1.8	1.8
CLAYEY SILT, low plasticity, moist, light brown, red brick fragments and roots present, no odor, (ML). CLAYEY SILT, low plasticity, moist, light brown, sericite flakes visible, no odor, (ML).	2.0	0.3
CLAY, medium plasticity, very moist, mottled gray and tan, no odor, (CL). CLAY, medium plasticity, very moist, light tan, no odor, (CL). CLAY, medium plasticity, very moist, gray to green, no odor, (CL).	2.0	2.0
CLAY, high plasticity, saturated, green to gray, sharp contact with lower unit, no odor, (CH). SAND, non-plastic, moist, dark brown, fine grained, no odor, sharp contact with upper unit, (SP).	0.9	46.5
CLAY, low plasticity, wet, brown, no odor, (CL). FILL, red brick fragments. SAND, non-plastic, moist, gray to black (product stained), fine grained, petroleum odor, (SP).	0.8	36.9
CLAY, low plasticity, moist, light tan and yellow orange, petroleum odor, (CL). SAND, non-plastic, moist, black (product stained), fine grained, some brown banding at bottom 5", strong petroleum odor, (SP).	2.0	3034.7
SANDY CLAY, low plasticity, wet, light tan, no odor, (CL). CLAY, high plasticity, moist, light tan, very impermeable layer, no odor, (CH).	2.0	718.5

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by ____________

Figure

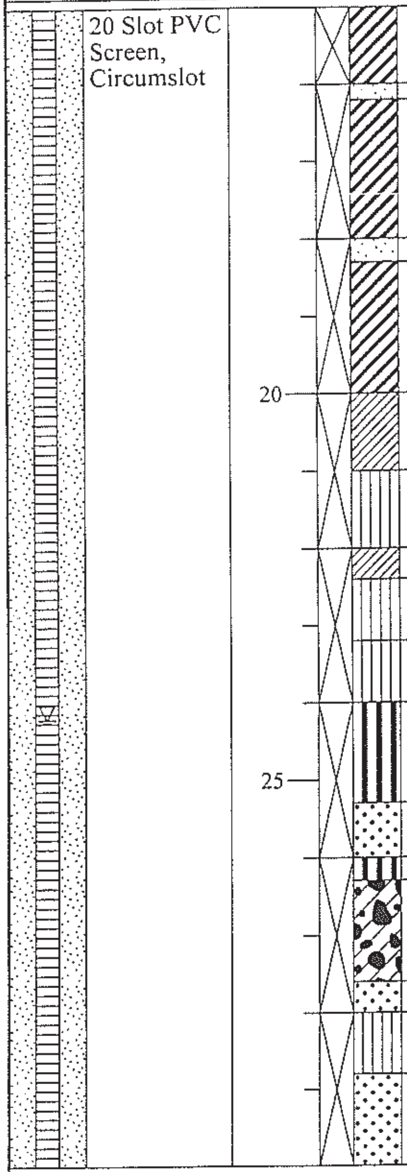
(sheet 1 of 3)

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/04/03 12/04/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-193**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 24.2	35.0	NA	NA



Description	Recovery (feet)	PID Reading (ppm above background)
SAND, non-plastic, wet, brown, fine grained, petroleum odor, (SP). CLAY, high plasticity, moist, light tan, no odor, (CH).	1.4	242.5
SAND, non-plastic, moist, brown to black, fine grained, up to 1/2" gravel (sub-rounded) on edge, petroleum odor, (SP). CLAY, high plasticity, moist, tan, no odor, (CH).	2.0	167.6
CLAY, low plasticity, moist, brown to reddish brown, slow grade to unit below, some petroleum odor, (CH). SILT, low plasticity, moist, dark reddish brown, slow grade from unit above, sub-angular gravel (quartzite) approx. 1%, petroleum odor, (ML).	2.0	38.7
SANDY CLAY, slight plasticity, moist, brown, petroleum odor, (CL). SILT, non-plastic, moist, dark reddish brown, up to 1/4" sub-angular to sub-rounded quartzite gravel, petroleum odor, (ML). SILT, low plasticity, moist, gray, distinct iron staining at base (approx. 2"), petroleum odor, (ML).	1.3	220.6
SILT, medium to high plasticity, moist, reddish brown, small (approx. 1/8") quartzite gravel inclusions (less than 1%), petroleum odor, (MH). GRAVELLY SAND, non-plastic, moist, light gray, medium grained, up to 1/4" pink and orange gravel (angular), petroleum odor, (SW).	1.3	1119.5
SILT, high plasticity, moist, reddish brown, petroleum odor, (MH). CLAYEY GRAVEL, low plasticity, moist, reddish brown, abundant gravel (rounded) up to 1/2", petroleum odor, (GC). GRAVELLY SAND, non-plastic, moist, light gray, coarse grained, petroleum odor, (SW).	2.0	1979.5
SILT, low plasticity, moist, bluish gray, sub-rounded gravel inclusions, petroleum odor, (ML). GRAVELLY SAND, non-plastic, wet, light gray with pink product staining, coarse grained, abundant gravel up to 1" on edge, petroleum odor, (SW).	0.8	961.3

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

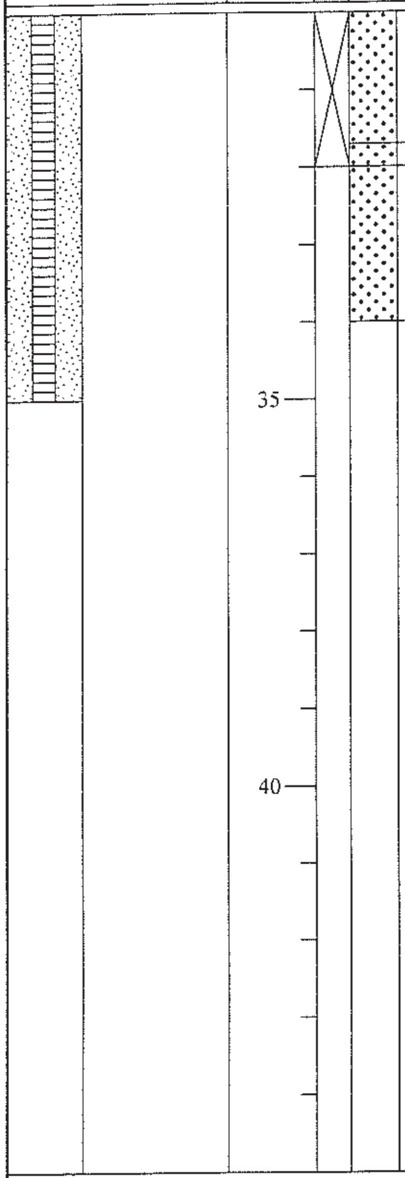
Approved by ____________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/04/03 12/04/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-193**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **24.2**	**35.0**	**NA**	**NA**



Description	Recovery (feet)	PID Reading (ppm above background)
GRAVELLY SAND, non-plastic, wet, reddish brown, coarse grained, trace silt and up to 3/4" sub-rounded gravel, petroleum odor, (SW).	1.5	1408.3
GRAVELLY SAND, non-plastic, wet, reddish brown, coarse grained, up to 1/2" rounded gravel, petroleum odor, (SW). GRAVELLY SAND, non-plastic, wet, reddish brown, coarse grained, up to 3/4" sub-rounded gravel, petroleum odor, (SW).	2.0	2058.3

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by ____________

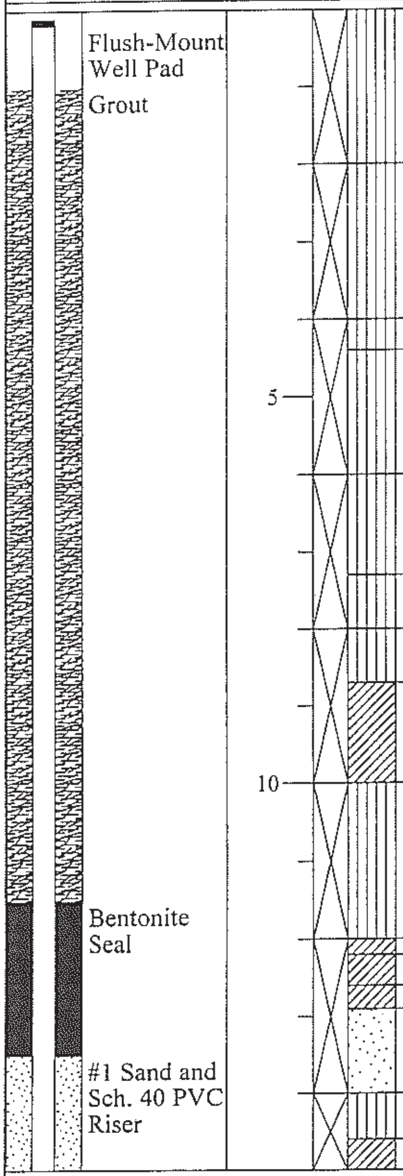
Figure (sheet 3 of 3)

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/03/03 12/04/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-194**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **24.7**	**30.0**	**NA**	**NA**



Description	Recovery (feet)	PID Reading (ppm above background)
SILT, non-plastic, moist, dark brown to black, red brick plugged sampler shoe, no odor, (ML).	0.2	6.5
SILT, non-plastic, moist, orange to brown, concrete fill plugged sampler shoe, no odor, (ML).	0.5	45.0
SILT, non-plastic, moist, dark brown, topsoil cave-in, no odor, (ML).	1.4	11.1
CLAYEY SILT, low plasticity, moist, yellowish orange, some roots present, no odor, (ML).		
CLAYEY SILT, low plasticity, moist, light brown, gradual grade to unit below, no odor, (ML).	2.0	21.2
CLAYEY SILT, low to medium plasticity, moist, light brown, gradual grade from unit above, no odor, (ML).		
CLAYEY SILT, low plasticity, moist, mottled gray and brown, petroleum odor, (ML).	1.4	1357.5
CLAY, low plasticity, moist, light gray, trace fine sand present, petroleum odor, (CL).		
SLIGHTLY CLAYEY SILT, low plasticity, moist, dark brown, sericite flakes and up to 1/2" rounded to sub-rounded gravel with small angular gravel (possibly fractured rock) at bottom of spoon, petroleum odor, (ML).	0.4	9999+
CLAY, low plasticity, moist, dark reddish brown, angular gravel present up to 1/8", petroleum odor, (CL).	2.0	9999+
CLAY, low to medium plasticity, moist, tan with some gray, less than 3% reddish brown angular gravel (1/8") present, petroleum odor, (CL).		
CLAY, low to medium plasticity, moist, gray blue, less than 3% reddish brown angular gravel (1/8") present, petroleum odor, (CL).		
SAND, non-plastic, moist, gray and brown, fine grained, slight petroleum odor (SP).	1.5	1583.5

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

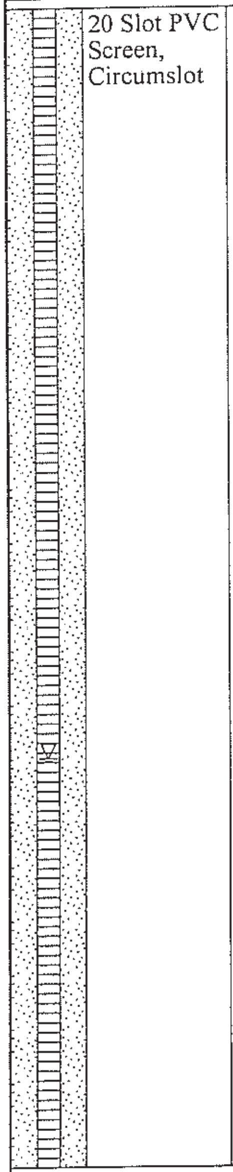
Approved by ____________

Figure (sheet 1 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/03/03 12/04/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-194**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **24.7**	**30.0**	**NA**	**NA**



Depth, (ft.)	Description	Recovery (feet)	PID Reading (ppm above background)
	CLAYEY SILT, low plasticity, moist, dark brown, up to 1/2" sub-angular gravels, petroleum odor, (ML).		
	SLIGHTLY SANDY CLAY, low plasticity, moist, light gray, petroleum odor, (CL).	2.0	9999+
	SAND, non-plastic, wet, black (product stained), fine grained, strong petroleum odor, (SP).		
	SAND, non-plastic, wet, black (product stained), fine grained, strong petroleum odor, (SP).		
	CLAY, medium to high plasticity, moist, cream to orange yellow, petroleum odor, (CH).	1.0	82.7
	CLAY, high plasticity, moist, cream to orange yellow, no odor, (CH).		
20	CLAY, high plasticity, moist, cream to orange yellow, slow grade to unit below, no odor, (CH).	1.3	5.9
	CLAY, low plasticity, moist, cream to orange yellow, slow grade from unit above, no odor, (CL).		
	CLAY, low plasticity, moist, light gray, sharp color change only from unit above, no odor, (CL).	2.0	9.1
	CLAY, low plasticity, moist, light gray, no odor, (CL).		
	CLAY, low plasticity, moist, greenish gray, sharp color change only from unit above, no odor, (CL).		
	CLAY, low plasticity, moist, brown, no odor, slow color change only from unit above, (CL).	2.0	31.9
	CLAY, low plasticity, moist, light gray, no odor, (CL).		
25	CLAY, high plasticity, moist, reddish brown, approx. 1% angular gravel up to 1/8", no odor, (CH).		
	SAND, non-plastic, moist, gray, fine grained, up to 3/4" quartzite rock inclusions (sub-angular), petroleum odor, (SW).		
	SAND, non-plastic, moist, light gray, medium grained, abundant gravel inclusions, petroleum odor, (SW).	1.4	518.7
	SAND, non-plastic, wet, grayish green, medium grained, abundant gravel approx. 1/8", petroleum odor, (SW).	1.0	1821.3
	SAND, non-plastic, wet, grayish green, fine grained, abundant gravel (well-rounded) approx. 3/4", petroleum odor, (SP).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

Approved by

Figure (sheet 2 of 3)

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/03/03 12/04/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-194**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ 24.7	30.0	NA	NA

Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
		☒	CLAY, high plasticity, saturated, brown, no odor, (CH).	1.7	539.7
			CLAY, high plasticity, saturated, green to gray, up to 3/4" sub-rounded gravel, no odor, (CH).		
			GRAVELLY SAND, non-plastic, saturated, light brown with red product staining toward bottom of spoon, fine grained, abundant gravel up to 1 1/2" on edge, strong petroleum odor, (SW).		
		☒	CLAYEY SAND, slight plasticity, saturated, gray to green, fine grained, petroleum odor, (SW).	2.0	1460.5
			SAND, non-plastic, saturated, gray to green, fine grained, abundant gravel, petroleum odor, (SW).		
	35				
	40				

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

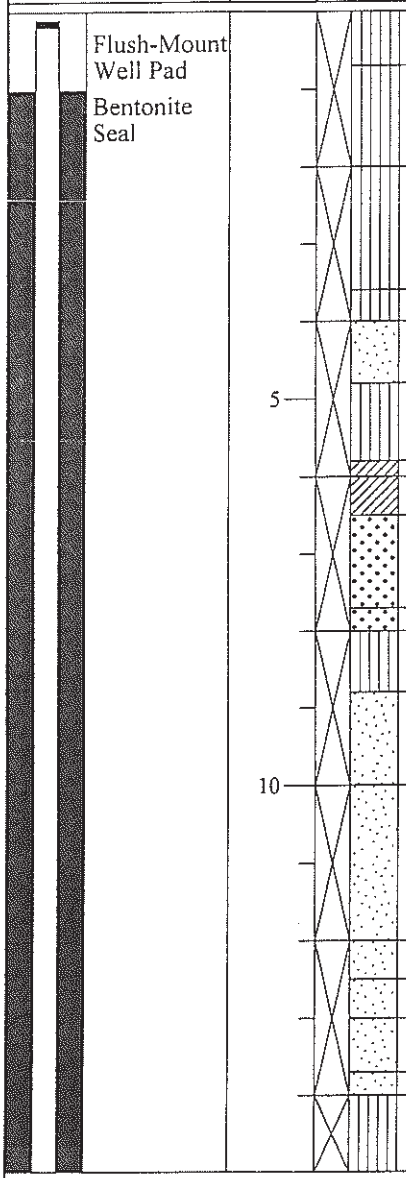
Approved by ____________

Figure (sheet 3 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/02/03 12/03/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-195**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **26.35**	**37.0**	**NA**	**NA**



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			SILT, non-plastic, moist, dark brown, some roots present, no odor, (ML).	2.0	0.0
			SILT, non-plastic, moist, brown, no odor, (ML).		
			SILT, non-plastic, moist, brown, no odor, (ML).	2.0	0.1
			SILT, non-plastic, saturated, brown, no odor, (ML).		
			SAND, non-plastic, saturated, brown, fine grained, no odor, (SP).	2.0	1.0
	5		CLAYEY SILT, low plasticity, moist, brown, some fine sand, no odor, (ML).		
			CLAY, low plasticity, moist, white to gray, no odor, (CL).	2.0	0.5
			CLAY, low plasticity, moist, light gray, no odor, (CL).		
			SAND, non-plastic, moist, brown, fine grained with sub-angular inclusions of fine gravel (approx. 1/4") on edge, no odor, (SW).		
			SAND, non-plastic, moist, brown, medium grained with small mica (muscovite) up to 1/8" on edge, angular, no odor, (SW).	1.8	0.0
			CLAYEY SILT, low plasticity, moist, brown, no odor, (ML).		
			SAND, non-plastic, moist, gray and white (salt and pepper texture), fine grained, petroleum odor, (SP).		
	10		SAND, non-plastic, moist, mottled with color banding ranging from dark brown to light tan, fine grained, petroleum odor, (SP).	1.2	0.2
			SAND, non-plastic, moist, yellow to brown, fine grained, no odor, (SP).	1.8	5.7
			SAND, non-plastic, moist, gray to brown, fine grained, no odor, (SP).		
			SAND, non-plastic, moist, light gray, fine grained, no odor, (SP).		
			SAND, non-plastic, moist, black (product stained), fine grained, petroleum odor, (SP).	1.7	0.6
			CLAYEY SILT, low plasticity, wet, mottled gray and brown, no odor, (ML).		

The substrata descriptions above are generalized representations and based upon visual/manual classification of cuttings and/or samples obtained during drilling. Predominant material types shown on the log may contain different materials and the change from one predominant material type to another could be different than indicated. Descriptions on this log apply only at the specific location at the time of drilling and may not be representative of subsurface conditions at other locations or times.

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

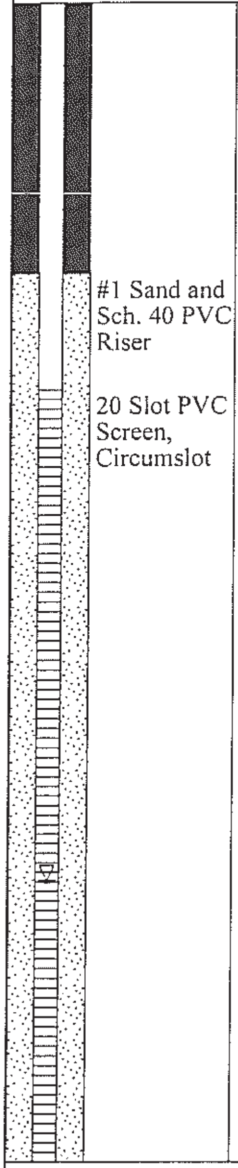
Approved by

Figure (sheet 1 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/02/03 12/03/03	Parratt-Wolff, Inc.	Sunoco, Inc. Philadelphia Refinery, PA	Hollow Stem Auger Split Spoon	S-195

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ 26.35	37.0	NA	NA



Depth, (ft.)	Description	Recovery (feet)	PID Reading (ppm above background)
	SAND, non-plastic, moist, pink and black (product stained), fine grained, petroleum odor, (SP). SAND, non-plastic, moist, pink and black (product stained), fine grained, up to 3/4" coarse gravel (well-rounded to sub-rounded), petroleum odor, (SW). SAND, non-plastic, moist, brown to black, fine grained, up to 1" angular rock (quartzite) inclusions, no odor, (SW).	1.3	0.5
	CLAYEY SILT, low plasticity, wet, brown, some angular (coarse) sand, no odor, (ML). SAND, non-plastic, moist, dark brown, medium grained, up to 3/4" coarse gravel (well-rounded to sub-rounded), petroleum odor, (SW).	1.5	2.3
20	CLAYEY SILT, low plasticity, wet, brown and gray to tan, no odor, (ML). SAND, non-plastic, moist, dark brown (product stained), coarse grained, up to 1/2" coarse gravel (sub-rounded), petroleum odor, (SW).	1.5	3.3
	SAND, non-plastic, moist, brown and black (product stained), fine grained, petroleum odor, (SP). SAND, non-plastic, moist, brown and black (product stained), medium through coarse (up to 1/8") grained, sub-angular, petroleum odor, (SP).	2.0	1.4
	SAND, non-plastic, moist, dark brown to black (product stained), fine grained, up to 1/4" coarse gravel (rounded), petroleum odor, (SW). SAND, non-plastic, wet, pink and brown (product stained), fine grained, up to 1/4" coarse gravel (rounded), petroleum odor, (SW).	1.2	0.9
25	CLAYEY SILT, low plasticity, moist, brown, no odor, (ML). SANDY SILT, low plasticity, moist, reddish brown, up to 1/2" sub-angular gravel, no odor, (ML).	0.8	3.7
	SILTY CLAY, low plasticity, saturated, light brown, no odor, (CL).	0.9	10.0

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

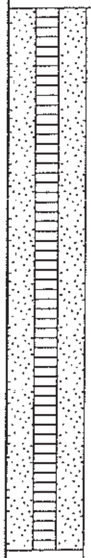
Approved by ______________

Figure (sheet 2 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
JM	12/02/03 12/03/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-195**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ 26.35	37.0	NA	NA



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			CLAYEY SILT, low to medium plasticity, saturated, brown and gray, rock plugged bottom 5" of spoon, no odor, (ML).	0.8	3.1
			SAND, non-plastic, saturated, brown, medium grained, angular, up to 3/4" coarse gravel (sub-rounded), rock with petroleum odor plugged bottom 5" of spoon, (SP).	1.4	287
			SAND, non-plastic, saturated, dark brown, medium grained, angular, up to 3/4" coarse gravel (rounded to sub-rounded quartzite), no odor, (SP).	1.9	56.3
	35		GRAVEL, non-plastic, saturated, dark brown, small grained, angular, up to 3/4" coarse gravel (rounded to sub-rounded quartzite), slight petroleum odor, (GW).		
	40				

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

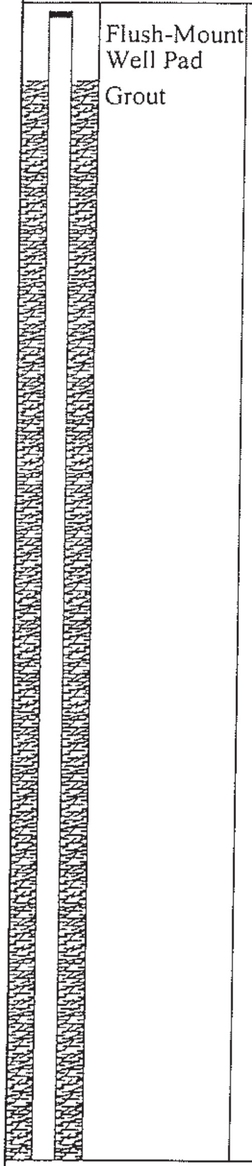
Approved by ____________

Figure (sheet 3 of 3)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	11/18/03 12/01/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-196**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 46.1	55.7	NA	NA



Depth, (ft.)	Description	Recovery (feet)	PID Reading (ppm above background)
	SILT, non-plastic, dry, black, little fine sand with pieces of slag, no odor, (ML). SILTY SAND, non-plastic, dry, brown, fine grained with some medium through coarse sand, no odor, (SM).	1.5	0.0
	SAND, non-plastic, dry, reddish brown, fine grained with some medium through coarse sand, little fine gravel and clay, no odor, (SP).	0.5	0.0
5	SAND, non-plastic, dry, black, fine through coarse grained, slag inclusions, no odor, (SW). SANDY CLAY, low plasticity, moist, light brown, fine grained, little medium through coarse sand with trace silt and fine gravel, no odor, (CL).	0.9	0.0
	SILT, non-plastic, dry, brown, saprolitic, no odor, (ML).	0.4	0.0
	SILT, non-plastic, dry, brown, saprolitic, no odor, (ML).	0.5	0.0
10	SILT, slight plasticity, moist, orange brown, trace clay and fine through medium sand, no odor, (ML).	0.7	0.0
	SILT, slight plasticity, moist, orange brown, trace clay and fine through medium sand, no odor, (ML). SILT, slight plasticity, moist, orange brown, some clay and fine through coarse sand, no odor, (ML).	1.6	0.0
	SILT, slight plasticity, moist, brown, little clay and trace fine through coarse sand, no odor, (ML).	1.3	0.0

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

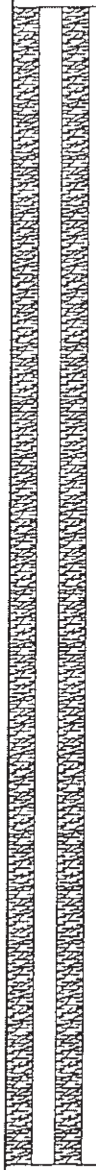
Approved by ____________

Figure (sheet 1 of 4)

SECOR
International Incorporated

Logged By: SM	Dates Drilled: 11/18/03 12/01/03	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc. Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger Split Spoon**	Well Number: **S-196**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 10.25	Surface Elev.(ft.):	Groundwater Depth (ft.): ∇ 46.1	Total Depth (ft.): 55.7	Drive wt.(lbs.): NA	Drop Dist.(in.): NA



Well Construction	Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
			SILT, slight plasticity, moist, brown and gray, little clay and trace fine through coarse sand, no odor, (ML).	1.5	0.0
			CLAY, low plasticity, moist, gray, some silt and trace fine sand, no odor, (CL).	1.2	0.0
	20		CLAY, low plasticity, moist, gray, some silt and trace fine sand, no odor, (CL).	0.5	0.0
			SILT, non-plastic, moist, gray and black, little fine sand and pieces of organic material, no odor, (ML).		
			FILL, pieces of brick, glass, and slag with trace dry, black silt.	0.8	0.0
	25		SAND, non-plastic, dry, black, fine through medium grained, inclusions of brick, coal, and slag, no odor, (SP).	1.2	0.0
			No recovery.	0.0	
			SANDY SILT, non-plastic, wet (base of spoon), black, fine grained, inclusions of brick, no odor, (MLS).	0.6	0.0

Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

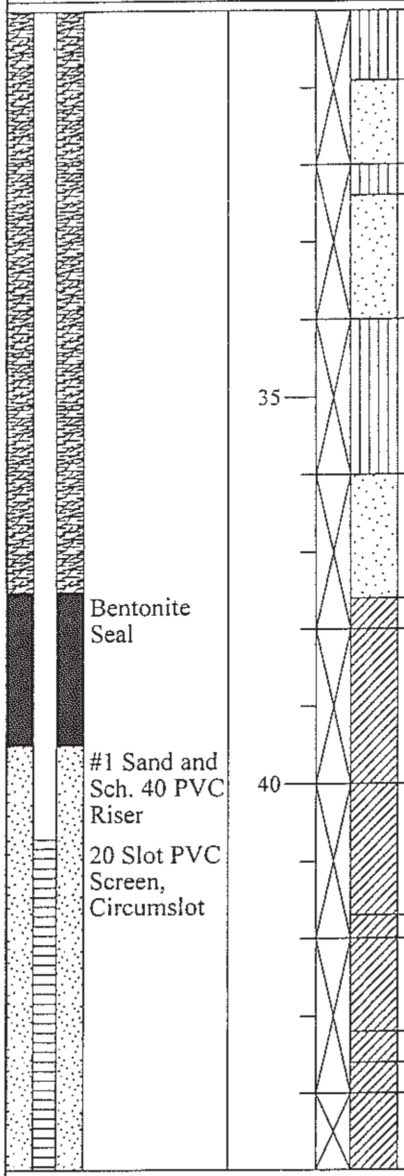
Approved by

Figure (sheet 2 of 4)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	11/18/03 12/01/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-196**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		⊻ **46.1**	**55.7**	**NA**	**NA**



Description	Recovery (feet)	PID Reading (ppm above background)
SILT, non-plastic, moist, gray, trace fine sand, no odor, (ML).	1.7	0.0
SAND, non-plastic, wet, gray, fine grained, no odor, (SP).		
CLAYEY SILT, slight plasticity, dry, gray, trace fine sand, no odor, (ML).	2.0	0.0
SAND, non-plastic, dry, gray, fine grained, no odor, (SP).		
SILT, slight plasticity, dry, tan, little clay, no odor, (ML).	2.0	0.0
SAND, non-plastic, moist to wet, gray, fine grained, little medium through coarse grained and little silt, no odor, (SP).	1.7	0.0
CLAY, low plasticity, moist, tan, some silt, no odor, (CL).		
CLAY, low plasticity, dry, tan, little silt, no odor, (CL).	1.7	0.0
CLAY, low plasticity, dry, tan and brown, trace silt, no odor, (CL).	2.0	0.0
CLAY, low plasticity, dry, light brown, trace silt, no odor, (CL).		
CLAY, low plasticity, dry, light brown, trace silt, no odor, (CL).	2.0	0.0
CLAY, low plasticity, dry, brown, trace silt, no odor, (CL).		
CLAY, low plasticity, dry, brown, little silt and trace fine sand, no odor, (CL).		
CLAY, low plasticity, dry, light gray (some staining from iron deposition and oxidation), trace silt, no odor, (CL).	2.0	0.0

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

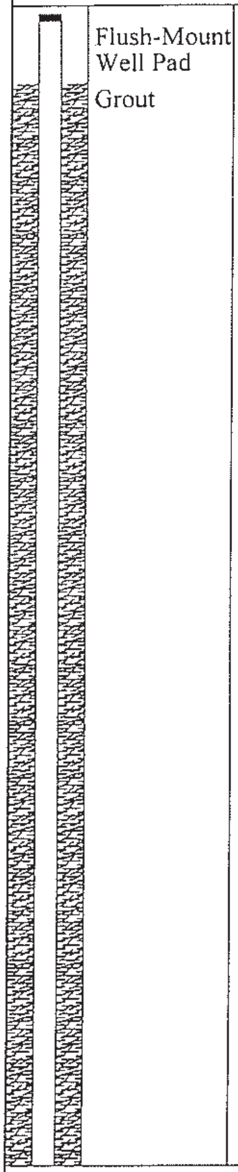
Figure (sheet 3 of 4)

SECOR
International Incorporated

Logged By: SM	Dates Drilled: 11/19/03 11/20/03	Drilling Contractor **Parratt-Wolff, Inc.**	Project Name: **Sunoco, Inc.** **Philadelphia Refinery, PA**	Method/Equipment: **Hollow Stem Auger** **Split Spoon**	Well Number: **S-197**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.): 10.25	Surface Elev.(ft.):	Groundwater Depth (ft.): ∇ 45.51	Total Depth (ft.): 55.0	Drive wt.(lbs.): NA	Drop Dist.(in.): NA

Well Construction



Depth, (ft.)	Sample Type	Description	Recovery (feet)	PID Reading (ppm above background)
		FILL, pieces of coal and slag with little dry, black silt.	1.3	
		FILL, pieces of coal and slag with little dry, black silt.	0.4	
5		SANDY CLAY, low plasticity, dry, brown, fine grained, trace medium through coarse sand, no odor, (CL).	1.2	
		SANDY CLAY, low plasticity, dry, brown, fine grained, trace medium through coarse sand, no odor, (CL). CLAY, low plasticity, dry, red, no odor, (CL). SILT, non-plastic, dry, brown, saprolitic, no odor, (ML).	0.8	
		No recovery, stone wedged in shoe of sampler.	0.0	
10		SILT, non-plastic, dry, brown, saprolitic, no odor, (ML).	0.4	0.0
		SILT, non-plastic, dry, brown, saprolitic, no odor, (ML). SILT, non-plastic, dry, gray, saprolitic, relict schistose texture, no odor, (ML).	2.0	0.0
		FILL, pieces of black, dry cinder.	0.8	0.0

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 1 of 4)

SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	11/19/03 11/20/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-197**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ 45.51	55.0	NA	NA

Depth, (ft.)	Description	Recovery (feet)	PID Reading (ppm above background)
	SILT, non-plastic, dry, gray, saprolitic, relict schistose texture, no odor, (ML).		
	SILT, non-plastic, dry, gray, saprolitic, relict schistose texture, no odor, (ML). FILL, pieces of black, dry cinder. SILT, non-plastic, dry, gray, saprolitic, relict schistose texture, no odor, (ML).	1.2	0.0
	SILT, non-plastic, dry, gray, saprolitic, relict schistose texture, no odor, (ML). CLAY, low plasticity, moist, brown, some fine sand, no odor, (CL). CLAY, low plasticity, moist, brown, trace fine through coarse sand and fine gravel, no odor, (CL).	1.0	0.0
20	CLAY, low plasticity, moist, brown, some fine sand, no odor, (CL). CLAYEY SILT, slight plasticity, moist, brown, trace fine gravel, no odor, (ML).	1.3	0.0
	FILL, pieces of black, moist cinder. CLAY, low plasticity, dry, reddish brown, no odor, (CL). FILL, pieces of black, moist cinder.	1.2	0.0
25	FILL, pieces of black, moist cinder.	1.0	0.0
	FILL, pieces of black, moist (and wet at base) cinder.	1.0	0.0
	FILL, pieces of black, wet cinder. SILT, slight plasticity, dry, gray to green, trace fine sand, no odor, (ML).	2.0	0.0

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

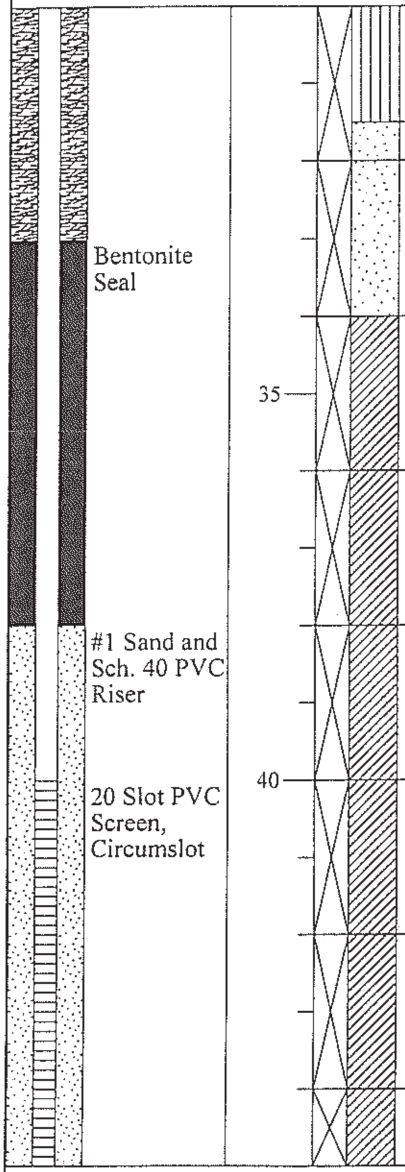
Log of Well

Approved by ____________

Figure (sheet 2 of 4)

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	11/19/03 11/20/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc. Philadelphia Refinery, PA**	**Hollow Stem Auger Split Spoon**	**S-197**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		▽ 45.51	55.0	NA	NA



Description	Recovery (feet)	PID Reading (ppm above background)
CLAYEY SILT, slight plasticity, moist, gray, no odor, (ML).	2.0	0.0
SAND, non-plastic, moist, brown and gray, fine grained, no odor, (SP).		
SAND, non-plastic, wet, brown and gray, fine grained, no odor, (SP).	1.5	0.0
CLAY, low plasticity, dry, pink and tan, little silt, no odor, (CL).	2.0	0.0
CLAY, low plasticity, dry, pink and tan, little silt, no odor, (CL).	0.4	0.0
CLAY, low plasticity, dry, tan, little silt, no odor, (CL).	2.0	0.0
SILTY CLAY, low plasticity, dry, tan and brown, no odor, (CL).	2.0	0.0
SILTY CLAY, low plasticity, dry, tan and brown, no odor, (CL).	2.0	0.0
SILTY CLAY, low plasticity, dry, gray, some fine sand, no odor, (CL).	1.5	0.0

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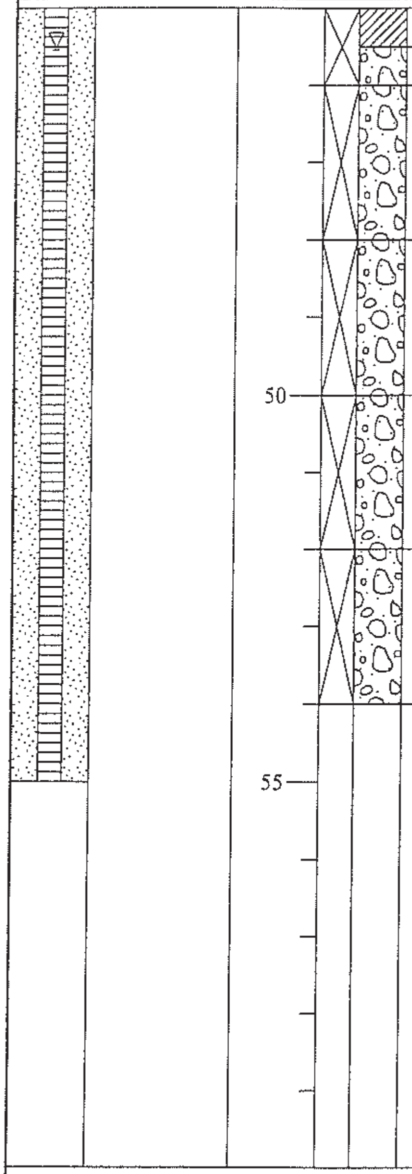
SECOR
International Incorporated

Logged By:	Dates Drilled:	Drilling Contractor	Project Name:	Method/Equipment:	Well Number:
SM	11/19/03 11/20/03	**Parratt-Wolff, Inc.**	**Sunoco, Inc.** **Philadelphia Refinery, PA**	**Hollow Stem Auger** **Split Spoon**	**S-197**

See "Legend to Logs" for sampling method, classifications and laboratory testing methods	Boring Diam.(in.):	Surface Elev.(ft.):	Groundwater Depth (ft.):	Total Depth (ft.):	Drive wt.(lbs.):	Drop Dist.(in.):
	10.25		∇ **45.51**	55.0	NA	NA



Description	Recovery (feet)	PID Reading (ppm above background)
SANDY GRAVEL, non-plastic, dry, gray, fine grained gravel and fine through coarse grained sand, slight petroleum odor, (GWS). SANDY GRAVEL, non-plastic, moist, gray and red, fine grained gravel and fine through coarse grained sand, petroleum odor, (GWS).	0.9	483
SANDY GRAVEL, non-plastic, wet, gray and red, fine grained gravel and fine through coarse grained sand, petroleum odor, (GWS).	1.3	567
SANDY GRAVEL, non-plastic, wet, gray and red, fine grained gravel and fine through coarse grained sand, petroleum odor, (GWS).	2.0	464
SANDY GRAVEL, non-plastic, wet, gray and red, fine grained gravel and fine through coarse grained sand, petroleum odor, (GWS).	1.8	377

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Project No. **62SU.01019.02** Date **December 2003 through January 2004**

Log of Well

BORING LOGS 26TH STREET.GPJ
LOG OF BOREHOLE

Approved by ____________

Figure (sheet 4 of 4)

Aquaterra Technologies, Inc.
Subsurface Log: S-198

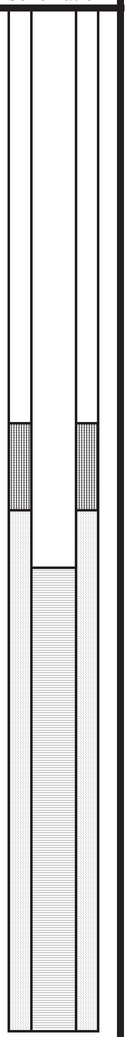
Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-198 **Log By:** M.B. Spancake **Date:** 3/8, 11,15/05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):**
Casing Diameter: 4 inch **Length:** 20.5 **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' bgs **Backfill:** 0'-15'
Screen Interval: 20'-35' **Cement/Grout Interval:**
Sand Pack Interval: 18'-35' **Bentonite Interval:** 15'-18'
Completion Details: 1.5' stick up **Sand Pack Type:** #2

□ = Backfill
■ = Cement/Grout
▩ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0					
	1.5-2			Gray clay matrix and rock fragments.	
	2-7			Soft dig to 7' BGS. Advance augers to 10' BGS and begin split spoons every 5'	
5					
10	10-12	NA	NA	Gray moist to wet sandy clay.	
15	15-17	595	NA	Gray sandy gravel, moist, slight clay content.	
20	20-22	363	NA	Gray sandy clay, slightly moist.	
25	25-27	NA	1.5	Coarse sand and gravel matrix, moist to wet towards bottom.	
30	30-32	1019	NA	Poorly sorted sandy gravel. Sand is coarse and medium gray in color.	
35				Well set at 35' and completed with a 3' stick-up.	

1.5-2 Sample interval submitted for laboratory analysis

Aquaterra Technologies, Inc.
Subsurface Log: S-199

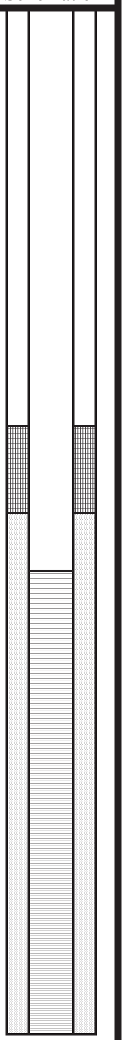
Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-199 **Log By:** M.B. Spancake **Date:** 10-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 25'
Casing Diameter: 4 inch **Length:** 21' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' bgs **Backfill:** 0'-15'
Screen Interval: 20'-35' **Cement/Grout Interval:**
Sand Pack Interval: 18'-35' **Bentonite Interval:** 15'-18'
Completion Details: 1' stickup **Sand Pack Type:** #2

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 7' BGS. Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5					
10	10-12	42	2	Gray fine clayey sand, wet, changing to brown and gray clay towards bottom.	
15	15-17	272	2	Brown gray clay in top 6" changing to a coarse sandy gravel. Gravel is small.	
20	20-22	657	1.5	Same as above changing to a brown silt, some clay. Rock fragment in bottom of spoon.	
25	25-27	672	1	Wet poorly sorted sandy coarse gravel. Reddish brown in color.	
30	30-32	627	1.75	Same as above.	
35				Lost 1' to cave in. Well set at 34'.	

1.5-2 Sample interval submitted for laboratory analysis

Aquaterra Technologies, Inc.
Subsurface Log: S-200

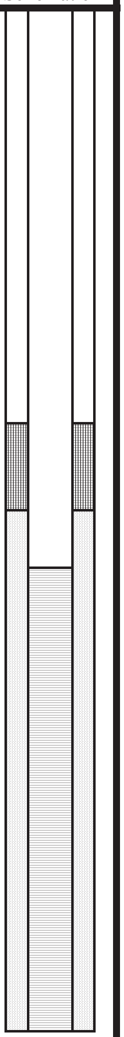
Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-200 **Log By:** M.B. Spancake **Date:** 16-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 25'
Casing Diameter: 4 inch **Length:** 20' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' bgs **Backfill:** 0'-15'
Screen Interval: 20'-35' **Cement/Grout Interval:**
Sand Pack Interval: 18'-35' **Bentonite Interval:** 15'-18'
Completion Details: Flushmount manhole **Sand Pack Type:** #2

☐ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5					
10	10-12	961	1.5	Black stained medium and coarse sandy gravel, wet. Changing to a brown clayey silt.	
15	15-17	NA	0	No recovery. Rock fragment and some gravel in shoe of spoon.	
20	20-22	869	1	Brown and reddish coarse sandy gravel, poorly sorted	
25	25-27	835	1.5	Moist to wet medium sand and poorly sorted gravel with brown silt and rock fragments.	
30	30-32	627	1.75	Wet poorly sorted coarse sandy gravel, brown in color. A Advance augers to 35' BGS and set well	
35				Well set at 35'.	

Aquaterra Technologies, Inc.
Subsurface Log: S-201

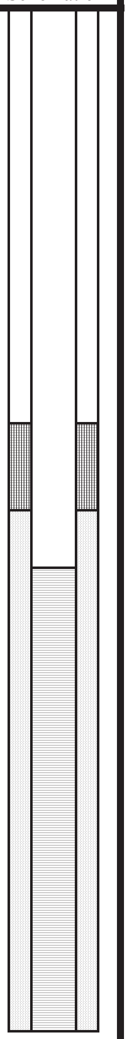
Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-201 **Log By:** M.B. Spancake **Date:** 17-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 25'
Casing Diameter: 4 inch **Length:** 20' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' bgs **Backfill:** 0'-15'
Screen Interval: 20'-35' **Cement/Grout Interval:**
Sand Pack Interval: 18'-35' **Bentonite Interval:** 15'-18'
Completion Details: Flushmount manhole **Sand Pack Type:** #2

☐ = Backfill
■ = Cement/Grout
▩ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5					
10	10-12	34	0.5	Wet gravel in a gray silt matrix, some clay content in the top of spoon.	
15	15-17	246	1.5	Moist poorly sorted gravel and coarse sand, brownish red in color.	
20	20-22	83	1	Brown clayey silt, some small gravel. Slightly moist.	
25	25-27	433	1.25	Wet brown coarse sandy gravel, poorly sorted.	
30	30-32	617	0.75	Same as above, some black staining towards bottom of spoon. Advance augers to 35' BGS and set well	
35				Well set at 35'.	

Aquaterra Technologies, Inc.
Subsurface Log: S-202

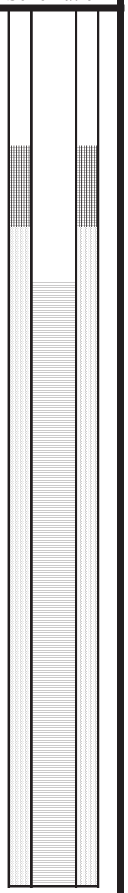
Project Name: Sunoco Philadelphia Refinery AOI - 1
Owner: Sunoco, Inc. (R&M)
Location: Philadelphia, PA
Permit No.:

Boring Number: S-202
Log By: M.B. Spancake
Date: 3/10 & 11/05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25'
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): 28'
Casing Diameter: 4 inch **Length:** 23'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Backfill: 0-15'
Screen Interval: 20'-35"
Cement/Grout Interval:
Sand Pack Interval: 18'-35"
Bentonite Interval: 15'-18'
Completion Details: 3-foot Stickup
Sand Pack Type: #2

☐ = Backfill
■ = Cement/Grout
▨ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin continuous split spoons	
5					
10	10-12	144	2	Brown and gray clay changing to a gray fine sandy clay, slightly moist.	
	12-14'	NM	NS	Not sampled	
	14-16'	847	1	Gray sandy clay changing to a fine gray sand, wet.	
15					
	16-18'	704	2	Wet gray sand and small gravel changing to a moist gray clay at 17' BGS	
	18-20'	6	2	Moist gray sandy clay changing to a tan and gray clay at 18.5' BGS. Changing to a brown clay at 19' BGS with some small gravel	
20	20-22	27	1.25	Moist brown clay changing to a poorly sorted sandy gravel, some red sandstone rock fragments present.	
	22-24	38	1	Poorly sorted sandy gravel, reddish brown in color, slightly moist.	
	24-26	371	1	Same as above.	
25					
	26-28	810	1	Moist to wet grayish red sand, poorly sorted gravel.	
	28-30	652	1	Wet poorly sorted reddish gray sand and small gravel.	
30	30-32	754	0.5	Same as above	
	32-34	759	1.5	Wet poorly sorted sandy gravel, reddish gray in color.	
35				Advance augers to 35' BGS Well set at 35' BGS.	

Aquaterra Technologies, Inc.
Subsurface Log: S-203

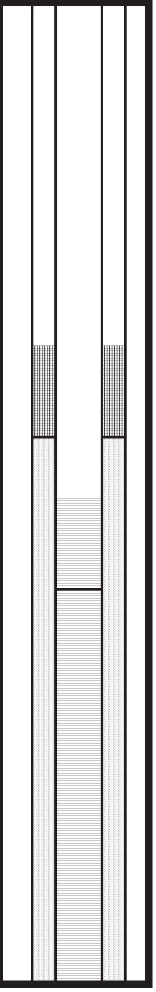
Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-203 **Log By:** M.B. Spancake **Date:** 22-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 25'
Casing Diameter: 4 inch **Length:** 20' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 32' bgs **Backfill:** 0'-12'
Screen Interval: 17'-32' **Cement/Grout Interval:**
Sand Pack Interval: 15'-32' **Bentonite Interval:** 12'-15'
Completion Details: 3' Stick up **Sand Pack Type:** #2

☐ = Backfill
■ = Cement/Grout
▩ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 8' BGS Advance augers to 10' BGS and collect spoons every 5'	
5					
10	10-12	NA	2	Gray clayey silt changing to a moist to wet gray fine sand	
15	15-17	NA	2	Moist gray silt changing to a gray and tan clay	
20	20-22	NA	1.25	Dark grayish brown silt with slight clay content	
25	25-27	NA	1	Orangish brown silt, slight clay changing to a wet gray sandy gravel.	
				Advance augers to 32' BGS and set well	
30	30-32	NA	NA	Same as above. Set well at 32' BGS.	

Note: PID malfunctioned therefore no readings were collected.

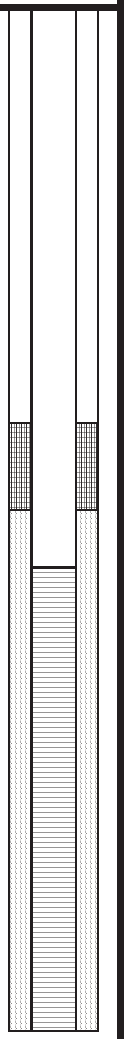
Aquaterra Technologies, Inc.
Subsurface Log: S-204

Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-204 **Log By:** M.B. Spancake **Date:** 10-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 26'
Casing Diameter: 4 inch **Length:** 23' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' bgs **Backfill:** 0'-16' □ = Backfill
Screen Interval: 20'-35' **Cement/Grout Interval:** ■ = Cement/Grout
Sand Pack Interval: 18'-35' **Bentonite Interval:** 16'-18' ▦ = Bentonite
Completion Details: 3' Stick up **Sand Pack Type:** #2 ░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5					
10	10-12	47	1.5	Gray sandy clay with a thin layer of fine gray sand, moist. Changing to a brown silty clay.	
15	15-17	12	1.25	Tan clay with slight orange mottling, slightly moist.	
20	20-22	2	2	Tan clay in top 9" changing to a dark gray clay	
25	25-27	953	1.25	Gray and tan clay in top 4" changing to a poorly sorted coarse sandy gravel, wet. Some pebble and brown silt.	
30	30-32	250	1	Wet coarse sandy gravel, gravel is larger and rock fragments present. Red sandstone fragment in bottom of spoon. Advance augers to 35' BGS.	
35				Well set at 35'.	

Aquaterra Technologies, Inc.
Subsurface Log: S-205

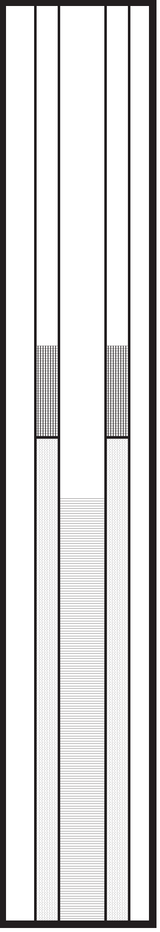
Project Name: Sunoco Philadelphia Refinery AOI - 1
Owner: Sunoco, Inc. (R&M)
Location: Philadelphia, PA
Permit No.:

Boring Number: S-205
Log By: M.B. Spancake
Date: 9-Mar-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25'
Screen Diameter: 4 inch **Length:** 20'
Slot Size: 0.020
Water Level (Init): 15'
Casing Diameter: 4 inch **Length:** 10'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 30' bgs
Backfill: 0'-5'
Screen Interval: 10'-30'
Cement/Grout Interval:
Sand Pack Interval: 8'-30'
Bentonite Interval: 5'-8'
Completion Details: 3' Stick up
Sand Pack Type: #2

□ = Backfill
■ = Cement/Grout
▨ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 8' BGS Advance augers to 10' BGS and collect spoons every 5'	
5					
10	10-12	24	0.25	Fine black stained sand, wood fragments and gravel, slightly moist	
15	15-17	287	0.75	Fine sand and brown silt with black staining, moist to wet.	
20	20-22	81	1.75	Brown coarse sand, wet. Brick fragments in top of spoon. Heavy staining. Changing to a gray clay at 21' BGS.	
25	25-27	240	0.75	Wet gray sandy gravel, some brown silt. Advance augers to 30' BGS and set well	
30		NA	NA	Set well at 30' BGS	

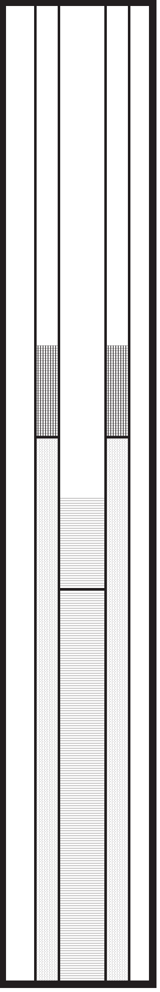
Aquaterra Technologies, Inc.
Subsurface Log: S-206

Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-206 **Log By:** M.B. Spancake **Date:** 9-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 25'
Casing Diameter: 4 inch **Length:** 20' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 32' bgs **Backfill:** 0'-12' ☐ = Backfill
Screen Interval: 17'-32' **Cement/Grout Interval:** ■ = Cement/Grout
Sand Pack Interval: 15'-32' **Bentonite Interval:** 12'-15' ▦ = Bentonite
Completion Details: 3' Stick up **Sand Pack Type:** #2 ░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 8' BGS Advance augers to 15' BGS and collect spoons every 5' Augers were advanced to 15' due to time constraints.	
5					
10	10-12	NA	NA		
15	15-17	40	2	Gray sandy clay in top 6", moist. Changing to a light gray and tan clay matrix, slight moisture.	
20	20-22	8	2	Same as above changing to a dark brown clayey silt matrix.	
				Augers starting "jumping" indicating gravel.	
25	25-27	741	1.25	Wet gray coarse sandy gravel, poorly sorted.	
				Advance augers to 32' BGS and set well	
30	30-32	NA	NA	Same as above. Set well at 32' BGS.	

Aquaterra Technologies, Inc.
Subsurface Log: S-207

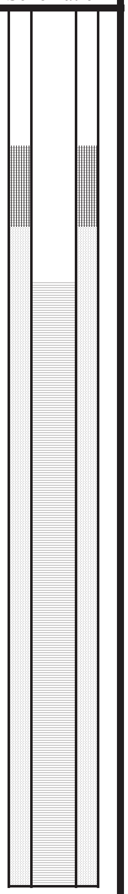
Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-207 **Log By:** M.B. Spancake **Date:** 8-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 24'
Casing Diameter: 4 inch **Length:** 18' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 30' bgs **Backfill:** 0-5'
Screen Interval: 10'-30' **Cement/Grout Interval:**
Sand Pack Interval: 8'-30' **Bentonite Interval:** 5'-8'
Completion Details: 3-foot Stickup **Sand Pack Type:** #2

☐ = Backfill
■ = Cement/Grout
▨ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin continuous split spoons	
5					
10	10-12	21	1.25	Gray stained fine sand, slight clay content. Moist	
	12-14'	33	1	Gray stained fine sand, moist. More clay content towards bottom.	
	14-16'	0	0.25	Gray sand and gravel, rock fragments. Moist to wet.	
15					
	16-18'	0	2	Gray sand in top 6" changing to a tan clay. Moist.	
	18-20'	0	1	Compact, dense tan clay. Slight moisture.	
20	20-22	0	1	Gray coarse sand and gravel, slight moisture.	
	22-24	0	1	Same, red dense clay in bottom of spoon. Dry	
	24-26	0	1	Brownish gray sandy gravel, some pebble. Moist to wet	
25					
	26-28	0	1	Same as above.	
	28-30	0	1	Same as above	
30	30-32	0	2	Brown silty sand and gravel, wet.	
	32-34	0	2	Same as above, gray sand in bottom 6"	
	34-36	0	1	Wet gray sand matrix changing to a moist gray sandy clay	
35					
	36-38	0	1.5	Gray clay with orange banding, some fine sand changing to a silt and clay matrix.	

Aquaterra Technologies, Inc.
Subsurface Log: S-208

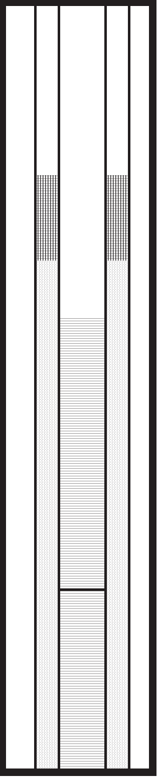
Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-208 **Log By:** M.B. Spancake **Date:** 9-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 12' **Slot Size:** 0.020 **Water Level (Init):** 20'
Casing Diameter: 4 inch **Length:** 15' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 25' bgs **Backfill:** 0-5'
Screen Interval: 10'-25' **Cement/Grout Interval:**
Sand Pack Interval: 8'-25' **Bentonite Interval:** 5'-8'
Completion Details: 3' Stick up **Sand Pack Type:** #2

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5					
10	10-12	32	1.25'	Medium sand and gravel in a brown silt matrix	
15	15-17	228	1	Same as above, slight moisture	
20	20-22	387	1.5	Wet gray sand and small gravel	
	23-25	97	1	Wet coarse tan sand and brown silt with small gravel and pebble. Rock fragment in bottom of spoon.	
25				Set well at 25' BGS	

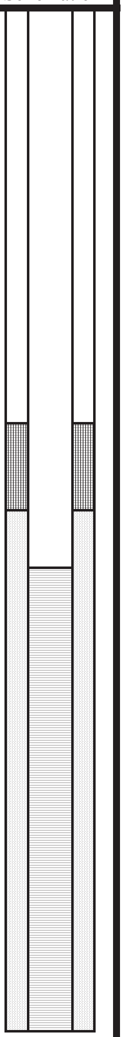
Aquaterra Technologies, Inc.
Subsurface Log: S-209

Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-209 **Log By:** M.B. Spancake **Date:** 10-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 25'
Casing Diameter: 4 inch **Length:** 23' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' bgs **Backfill:** 0'-15' □ = Backfill
Screen Interval: 20'-35' **Cement/Grout Interval:** ■ = Cement/Grout
Sand Pack Interval: 18'-35' **Bentonite Interval:** 15'-18' ▦ = Bentonite
Completion Details: 3' Stick up **Sand Pack Type:** #2 ░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5					
10	10-12	5	0.5	Brown silt and medium sand with small gravel and rock fragments	
15	15-17	7	0.75	Coarse sand and brown silt with gravel, red sandstone fragment in bottom of spoon	
20	20-22	82	1.25	Moist brown medium sand and silt with some small gravel. Some gray clay in top of spoon	
25	25-27	180	1	Wet coarse sandy gravel and pebble, some brown silt.	
30	30-32	131	1.5	Wet poorly sorted coarse sandy gravel with small pebble Advance augers to 35' BGS and set well	
35				Well set at 35'.	

Aquaterra Technologies, Inc.
Subsurface Log: S-210

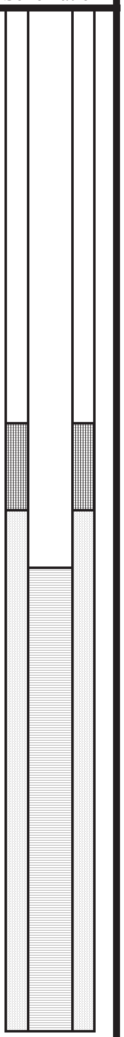
Project Name: Sunoco Philadelphia Refinery AOI - 1
Owner: Sunoco, Inc. (R&M)
Location: Philadelphia, PA
Permit No.:

Boring Number: S-210
Log By: M.B. Spancake
Date: 17-Mar-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25'
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): 25'
Casing Diameter: 4 inch **Length:** 23'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Backfill: 0'-15'
Screen Interval: 20'-35'
Cement/Grout Interval:
Sand Pack Interval: 18'-35'
Bentonite Interval: 15'-18'
Completion Details: 3' Stick up
Sand Pack Type: #2

☐ = Backfill
■ = Cement/Grout
▩ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5					
10	10-12	0	0.75	Moist gray silty clay	
15	15-17	0	2	Gray and brown fine to medium sand with slight clay content, moist. Rock fragment in bottom of spoon.	
20	20-22	884	1.75	Gray and brown fine sandy clay changing to a black stained coarse sandy gravel, moist.	
25	25-27	629	1	Wet brownish gray coarse sandy gravel.	
30	30-32	641	2	Wet poorly sorted coarse sandy gravel and pebble. Advance augers to 35' BGS and set well	
35				Well set at 35'.	

Aquaterra Technologies, Inc.
Subsurface Log: S-211

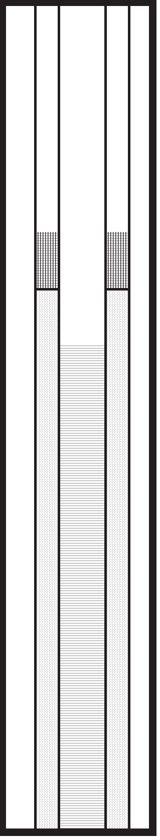
Project Name: Sunoco Philadelphia Refinery AOI - 1
Owner: Sunoco, Inc. (R&M)
Location: Philadelphia, PA
Permit No.:

Boring Number: S-211
Log By: M.B. Spancake
Date: 24-Mar-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25'
Screen Diameter: 4 inch **Length:** 12'
Slot Size: 0.020
Water Level (Init): 17'
Casing Diameter: 4 inch **Length:** 18'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 27' bgs
Backfill: 0-8'
Screen Interval: 12'-27'
Cement/Grout Interval:
Sand Pack Interval: 10'-27'
Bentonite Interval: 7'-10'
Completion Details: 3' Stick up
Sand Pack Type: #2

☐ = Backfill
■ = Cement/Grout
▨ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5					
10	10-12	238	0.5	Brown coarse sand, poorly sorted gravel and rock fragments	
15	15-17	550	1.25	Same as above, moist to wet at 17' BGS	
20	20-22	227	1	Large rock fragments in a coarse gray sand and small gravel matrix.	
25	25-27	115	0.5	Same as above, some brown silt present.	
				Set well at 27' BGS	

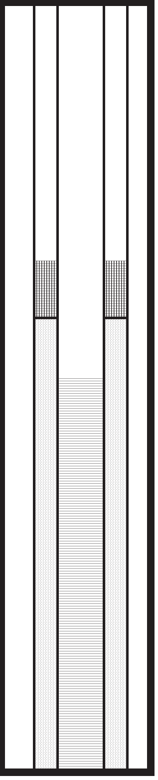
Aquaterra Technologies, Inc.
Subsurface Log: S-212

Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-212 **Log By:** M.B. Spancake **Date:** 18-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 12' **Slot Size:** 0.020 **Water Level (Init):** 20'
Casing Diameter: 4 inch **Length:** 15' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 25' bgs **Backfill:** 0-8' □ = Backfill
Screen Interval: 13-25' **Cement/Grout Interval:** ■ = Cement/Grout
Sand Pack Interval: 11-25' **Bentonite Interval:** 8'-11' ▦ = Bentonite
Completion Details: 2' Stick up **Sand Pack Type:** #2 ░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5					
10	10-12	77	1.5	Coarse sandy gravel matrix, reddish brown in color, dry.	
15	15-17	90	1	Reddish brown coarse sandy gravel, becoming moist towards bottom	
20	20-22	155	1.5	Wet coarse sandy gravel, reddish brown in color Advance augers to 25' BGS and set well	
25					

Aquaterra Technologies, Inc.
Subsurface Log: S-213

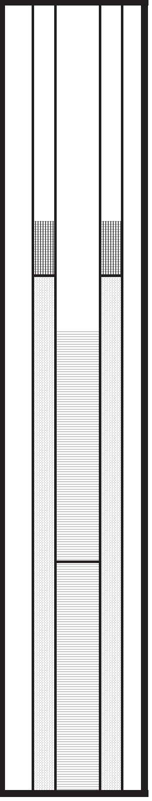
Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-213 **Log By:** M.B. Spancake **Date:** 24-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 12' **Slot Size:** 0.020 **Water Level (Init):** 17'
Casing Diameter: 4 inch **Length:** 18' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 27' bgs **Backfill:** 0-8'
Screen Interval: 12'-27' **Cement/Grout Interval:**
Sand Pack Interval: 10'-27' **Bentonite Interval:** 7'-10'
Completion Details: 3' Stick up **Sand Pack Type:** #2

☐ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5				Lithology not recorded. See boring log for S-211 for lithology information	
10	10-12				
15	15-17				
20	20-22				
25	25-27				
				Set well at 27' BGS with 3' Stick up	

Aquaterra Technologies, Inc.
Subsurface Log: S-214

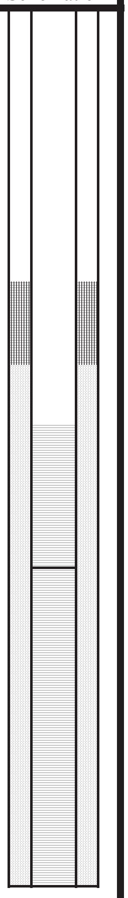
Project Name: Sunoco Philadelphia Refinery AOI - 1
Owner: Sunoco, Inc. (R&M)
Location: Philadelphia, PA
Permit No.:

Boring Number: S-214
Log By: M.B. Spancake
Date: 28-Mar-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25'
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): 17'
Casing Diameter: 4 inch **Length:** 18'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 30' bgs
Backfill: 0'-10'
Screen Interval: 15'-30'
Cement/Grout Interval:
Sand Pack Interval: 13'-30'
Bentonite Interval: 10'-13'
Completion Details: 3' Stick up
Sand Pack Type: #2

□ = Backfill
■ = Cement/Grout
▩ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 8' BGS Advance augers to 15' BGS and collect spoons every 5' Augers were advanced to 15' due to time constraints.	
5					
10	10-12	NA	1.25	Reddish brown coarse sand and poorly sorted gravel, moist.	
15	15-17	NA	1.5	Same as above, becoming wet at 17' BGS	
20	20-22	NA	0.75	Same as above, wet.	
25	25-27	NA	1	Same as above, slight clay content towards the bottom of spoon. Wet	
30	30-32	NA	1.75	Gray silty clay with some small gravel and coarse sand	
				Set well at 30' BGS with 3' Stick-up	

Note: PID malfunctioned therefore no readings were collected.

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

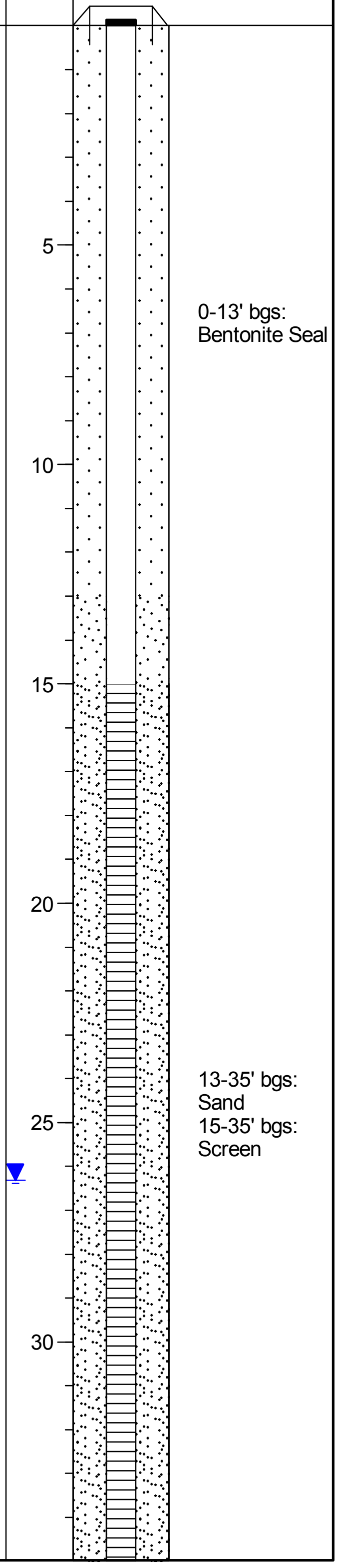
WELL / PROBEHOLE / BOREHOLE NO:
S-215 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **12/10/14** COMPLETED: **12/10/14**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT:

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **26.32**
WELL CASING DIA. (in): **4**
LOGGED BY: **SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			Well overdrilled due to damage / blockage in well. See original log for soil stratigraphy.							



Borehole terminated at 35 feet.

Aquaterra Technologies, Inc.
Subsurface Log: S-215

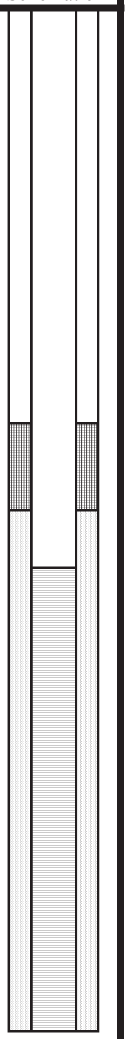
Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-215 **Log By:** M.B. Spancake **Date:** 11-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 25'
Casing Diameter: 4 inch **Length:** 23' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' bgs **Backfill:** 0'-15'
Screen Interval: 20'-35' **Cement/Grout Interval:**
Sand Pack Interval: 18'-35' **Bentonite Interval:** 15'-18'
Completion Details: 3' Stick up **Sand Pack Type:** #2

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' below ground surface and begin split spoons every 5 feet.	
5					
10	10-12	433	2	Brown and gray clayey silt changing to a fine gray sand with brown banding	
15	15-17	53	1.5	Brown moist clay and some small gravel changing to a gray sandy clay with small gravel.	
20	20-22	67	1	Poorly sorted coarse sandy gravel, reddish brown in color.	
25	25-27	1125	1.25	Reddish brown medium and coarse sand, some poorly sorted gravel. Moist to wet towards bottom of spoon.	
30	30-32	NM	2"	Gray and brown clay with medium sand and some small gravel. Rock fragment in shoe of spoon, wet.	
35				Well set at 35'.	

Aquaterra Technologies, Inc.
Subsurface Log: S-226

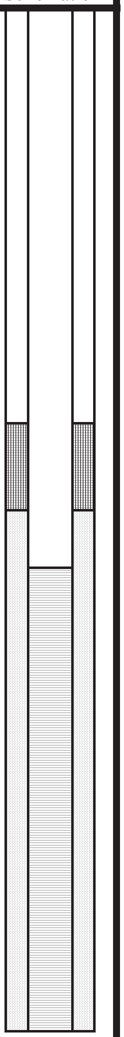
Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-226 **Log By:** M.B. Spancake **Date:** 17-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 25'
Casing Diameter: 4 inch **Length:** 23' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' bgs **Backfill:** 0'-15'
Screen Interval: 20'-35' **Cement/Grout Interval:**
Sand Pack Interval: 18'-35' **Bentonite Interval:** 15'-18'
Completion Details: 3' Stick up **Sand Pack Type:** #2

□ = Backfill
■ = Cement/Grout
▨ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 35' below ground surface and set well No lithology recorded due to proximity of well S-210.	
5				See S-210 well log for litholgy details.	
10	10-12				
15	15-17				
20	20-22				
25	25-27				
30	30-32				
35				Well set at 35'.	

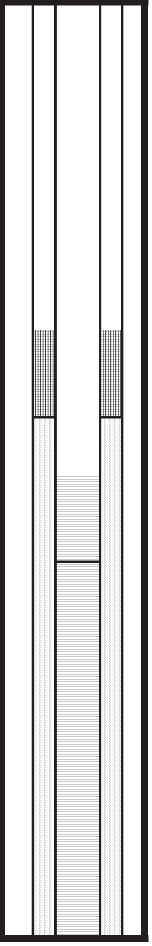
Aquaterra Technologies, Inc.
Subsurface Log: S-227

Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-227 **Log By:** M.B. Spancake **Date:** 21-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 25'
Casing Diameter: 4 inch **Length:** 20' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 32' bgs **Backfill:** 0'-12' □ = Backfill
Screen Interval: 17'-32' **Cement/Grout Interval:** ■ = Cement/Grout
Sand Pack Interval: 15'-32' **Bentonite Interval:** 12'-15' ▦ = Bentonite
Completion Details: 3' Stick up **Sand Pack Type:** #2 ░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 10' BGS and collect spoons every 5'	
5					
10	10-12	102 7.6	0.75	Moist brownish tan medium sand in top 3" changing to a brown silty clay	
15	15-17	0	1.5	Dry coarse sandy poorly sorted gravel, reddish brown in color.	
20	20-22	4	1.25	Same as above, moist to wet at bottom of spoon.	
25	25-27	734	1.5	Wet gray medium and coarse sand, pebble fragments and some small gravel.	
30	30-32	744	1.25	Same as above. Set well at 32' BGS.	

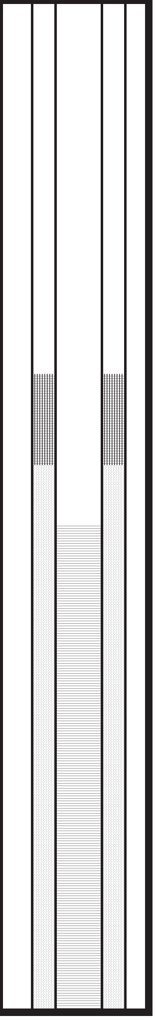
Aquaterra Technologies, Inc.
Subsurface Log: S-228

Project Name: Sunoco Philadelphia Refinery AOI - 1 **Owner:** Sunoco, Inc. (R&M)
Location: Philadelphia, PA **Permit No.:**

Boring Number: S-228 **Log By:** M.B. Spancake **Date:** 21-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** NA
Casing Diameter: 4 inch **Length:** 21' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 33' BGS **Backfill:** 0'-13' □ = Backfill
Screen Interval: 18'-33' **Cement/Grout Interval:** ■ = Cement/Grout
Sand Pack Interval: 16'-33' **Bentonite Interval:** 13'-16' ▨ = Bentonite
Completion Details: 3' Stick up **Sand Pack Type:** #2 ░ = Sand

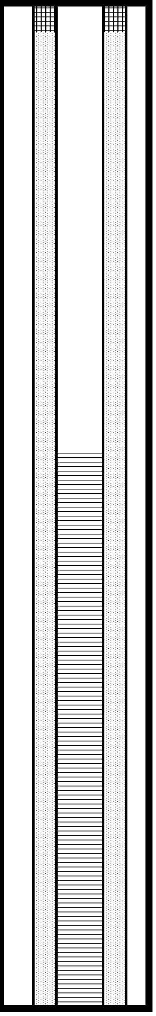
Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS Advance augers to 33' BGS and set well. No lithology recorded due to proximity of S-227	
5					
10	10-12				
15	15-17				
20	20-22				
25	25-27				
30	30-32				
				Set well at 33' BGS	

Aquaterra Technologies, Inc.
Subsurface Log: S-255

Project Name: Sunoco Philadelphia Refinery26th street **Owner:** Sunoco, Inc. (R&M)
Location: AOI 1 **Permit No.:**
Philadelphia, PA
Boring Number: S-255 **Log By:** K MARTIN **Date:** 7-Aug-07
Casing Elevation: N/A **Driller:** Total Quality Drilling **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 8' **Slot Size:** 0.020 **Water Level (Init):** 24'
Casing Diameter: 4 inch **Length:** 2' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** split spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' **Backfill:** NA ☐ = Backfill
Screen Interval: 15'-35' **Cement/Grout Interval:** NA ■ = Cement/Grout
Sand Pack Interval: 12'-35' **Bentonite Interval:** 0'-1' ▦ = Bentonite
Completion Details: pvc stickup **Sand Pack Type:** #2 ░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS	
5					
10	10'-12'	0		dry light brown clay	
	14'-16'	0		dry medium brown silty clay w/ occas. pebbles	
15					
	18'-20'	0		dry medium brown clayey sand	
20					
	23'-25'	0		dry medium brown clayey sand	
25					
	28-30	163		wet, poorly sorted, medium brown silt sand and gravel	
30					
	33-35	5.8		wet medium brown silty clay	
35					

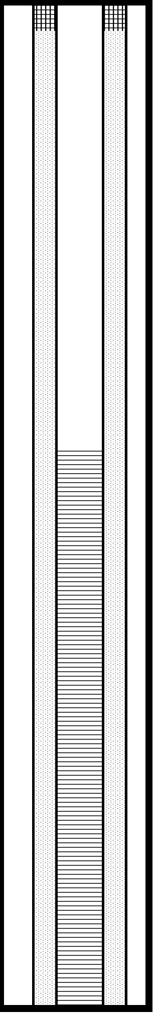
Aquaterra Technologies, Inc.
Subsurface Log: S-256

Project Name: Sunoco Philadelphia Refinery26th street **Owner:** Sunoco, Inc. (R&M)
Location: AOI 1 **Permit No.:**
Philadelphia, PA
Boring Number: S-256 **Log By:** K MARTIN **Date:** 7-Aug-07
Casing Elevation: N/A **Driller:** Total Quality Drilling **Borehole Dia:** 8.25'
Screen Diameter: 4 inch **Length:** 8' **Slot Size:** 0.020 **Water Level (Init):** 24'
Casing Diameter: 4 inch **Length:** 2' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** split spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' **Backfill:** NA □ = Backfill
Screen Interval: 15'-35' **Cement/Grout Interval:** NA ■ = Cement/Grout
Sand Pack Interval: 12'-35' **Bentonite Interval:** 0'-1' ▦ = Bentonite
Completion Details: pvc stickup **Sand Pack Type:** #2 ░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS	
5					
10	10'-12'	0		dry light brown clay	
	14'-16'	0		dry medium brown silty clay w/ occas. pebbles	
15					
	18'-20'	0		dry medium brown clayey sand	
20					
	24'-26'			moist reddish brown medium sand some gravel	
25					
	28-30			wet gray medium sand w/occas. small rounded gravel	
30		145			
	33-35	1.2		tan to brown wet clay	
35					



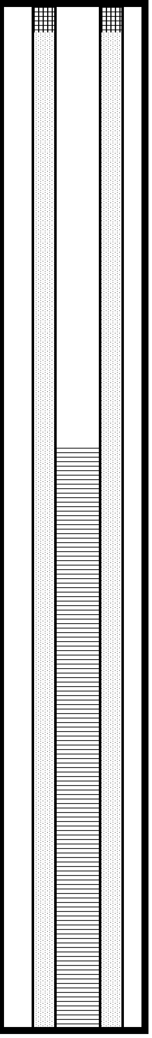
Aquaterra Technologies, Inc.
Subsurface Log: S-257

Project Name: Sunoco Philadelphia Refinery26th street **Owner:** Sunoco, Inc. (R&M)
Location: AOI 1 **Permit No.:**
Philadelphia, PA

Boring Number: S-257 **Log By:** K MARTIN **Date:** 14-Aug-07
Casing Elevation: N/A **Driller:** Total Quality Drilling **Borehole Dia:** 8.25"
Screen Diameter: 4 inch **Length:** 8' **Slot Size:** 0.020 **Water Level (Init):** 24'
Casing Diameter: 4 inch **Length:** 2' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** split spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' **Backfill:** NA □ = Backfill
Screen Interval: 15'-35' **Cement/Grout Interval:** NA ■ = Cement/Grout
Sand Pack Interval: 12'-35' **Bentonite Interval:** 0'-1' ▦ = Bentonite
Completion Details: Flushmount with an 8" manhole cover **Sand Pack Type:** #2 ░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS	
5					
10	10'-12'	0		dry light brown clay	
	14'-16'	0		dry medium brown silty clay w/ occas. pebbles	
15					
	18'-20'	0		dry medium brown clayey sand	
20					
	23'-25'	0		dry medium brown clayey sand	
25					
	28-30	49		wet, poorly sorted, medium brown silt sand and gravel	
30					
	33-35	2.4		wet, poorly sorted, medium brown silt sand and gravel	
35					

Aquaterra Technologies, Inc.
Subsurface Log: S-258

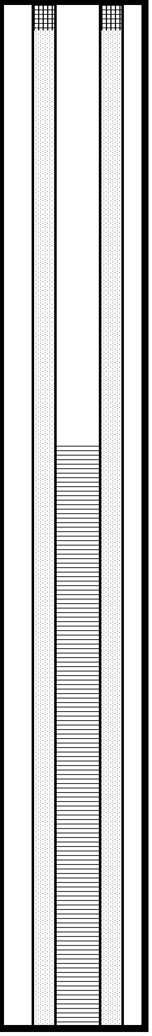
Project Name: Sunoco Philadelphia Refinery26th street **Owner:** Sunoco, Inc. (R&M)
Location: AOI 1 **Permit No.:**
Philadelphia, PA

Boring Number: S-258 **Log By:** K MARTIN **Date:** 15-Aug-07
Casing Elevation: N/A **Driller:** Total Quality Drilling **Borehole Dia:** 8.25"
Screen Diameter: 4 inch **Length:** 8' **Slot Size:** 0.020 **Water Level (Init):** 24'
Casing Diameter: 4 inch **Length:** 2' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** split spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' **Backfill:** NA
Screen Interval: 15'-35' **Cement/Grout Interval:** NA
Sand Pack Interval: 12'-35' **Bentonite Interval:** 0'-1'
Completion Details: Flushmount with an 8" manhole cover **Sand Pack Type:** #2

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS	
5					
10	10'-12'	0		dry light brown clay	
	14'-16'	0		dry medium brown silty clay w/ occas. pebbles	
15					
	18'-20'	0		dry medium brown clayey sand	
20					
	23'-25'	0		moist medium brown clayey sand	
25					
	28-30	25		wet, poorly sorted, medium brown silt sand and gravel	
30					
	33-35	4.7		wet, poorly sorted, medium brown silt sand and gravel	
35					

Aquaterra Technologies, Inc.
Subsurface Log: S-259

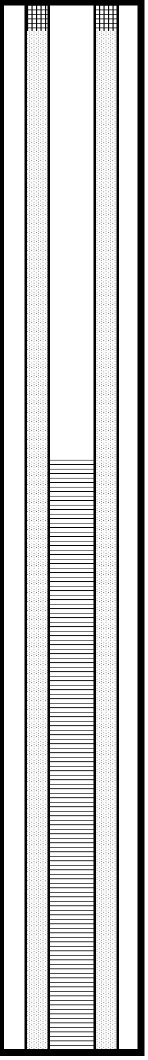
Project Name: Sunoco Philadelphia Refinery26th street **Owner:** Sunoco, Inc. (R&M)
Location: AOI 1 **Permit No.:**
Philadelphia, PA

Boring Number: S-259 **Log By:** K MARTIN **Date:** 13-Aug-07
Casing Elevation: N/A **Driller:** Total Quality Drilling **Borehole Dia:** 8.25"
Screen Diameter: 4 inch **Length:** 8' **Slot Size:** 0.020 **Water Level (Init):** 24'
Casing Diameter: 4 inch **Length:** 2' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** split spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' **Backfill:** NA
Screen Interval: 15'-35' **Cement/Grout Interval:** NA
Sand Pack Interval: 12'-35' **Bentonite Interval:** 0'-1'
Completion Details: Flushmount with an 8" manhole cover **Sand Pack Type:** #2

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS	
5					
10	10'-12'	0		dry light brown clay	
	14'-16'	0		dry medium brown silty clay w/ occas. pebbles	
15					
	18'-20'	0		dry medium brown clayey sand	
20					
	23'-25'	9		dry medium brown clayey sand	
25					
	28-30	102		wet, poorly sorted, medium brown silty sand	
30					
	33-35	12		wet, poorly sorted, medium brown silt sand and gravel	
35					

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Subsurface Log: S-260

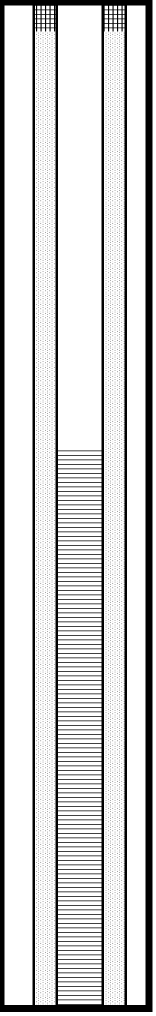
Project Name: Sunoco Philadelphia Refinery26th street **Owner:** Sunoco, Inc. (R&M)
Location: AOI 1 **Permit No.:**
Philadelphia, PA

Boring Number: S-260 **Log By:** K MARTIN **Date:** 9-Aug-07
Casing Elevation: N/A **Driller:** Total Quality Drilling **Borehole Dia:** 8.25"
Screen Diameter: 4 inch **Length:** 8' **Slot Size:** 0.020 **Water Level (Init):** 24'
Casing Diameter: 4 inch **Length:** 2' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** split spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' **Backfill:** NA
Screen Interval: 15'-35' **Cement/Grout Interval:** NA
Sand Pack Interval: 12'-35' **Bentonite Interval:** 0'-1'
Completion Details: Flushmount with an 8" manhole cover **Sand Pack Type:** #2

☐ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Soft dig to 10' BGS	
5					
10	10'-12'	0		dry light brown clay	
	14'-16'	0		dry medium brown silty clay w/ occas. pebbles	
15					
	18'-20'	0		dry medium brown clayey sand	
20					
	23'-25'	12		dry medium brown clayey sand	
25					
	28-30	204		wet, poorly sorted, medium brown sand and gravel	
30					
	33-35	2.2		wet, poorly sorted, medium brown sand and gravel	
35					

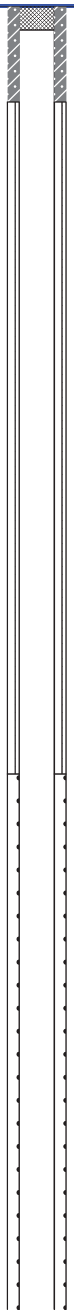
SUBSURFACE LOG: S-261D
AND WELL CONSTRUCTION : S-261

PROJECT: **Sunoco-Philadelphia Refinery**
SITE LOCATION: **AOI-1**
LOGGED BY: **Tiffani Doerr**
DATES DRILLED: **18 & 19 December 2007**
TOTAL BORING DEPTH: **66'**
BORING ELEVATION **25.485 feet**

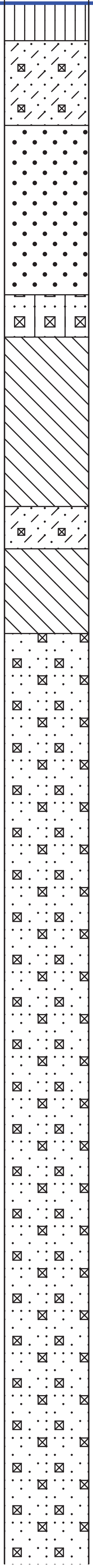
DRILLING CO.: **Parratt-Wolffe**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD: **Split Spoon**
SCREEN/RISER DIAMETER: **4-inch**
WELLBORE DIAMETER: **8-inch**
TOC (inner) ELEVATION: **27.412 feet (ASML)**

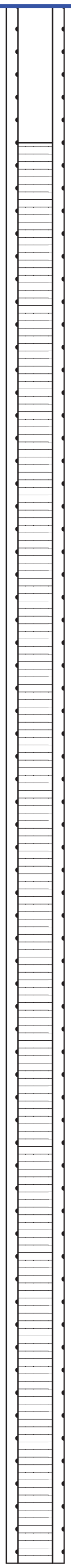
NOTE: Well S-261 drilled within 5 feet of boring S-261D. Screen=0.010 slot; "0" sand; 2' stickup finish. Screen (15'-30'); Riser (2' stickup - 15'); Sand (13'-30'); Bentonite (11'-13'); Grout (surface to 11')

Depth (feet)	Blow Counts	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
					Boring location pre-cleared by Mobile Dredge to 4'	
	4'-6'	0.0		Fill, brown slightly plastic sand with rock fragments, brick and cinders		
-5					Auger to 10'	
-10	10'-12'	0.0		Top 6" fill Laminated orange and gray, very slightly plastic stiff silt, no sand		
					Auger to 14'	



SUBSURFACE LOG: S-261D
AND WELL CONSTRUCTION: S-261





Depth (feet)	Sample Int	OVM (ppm)	LITHOLOGY	COMMENTS
	14'-16'	0.0	Sandy clay with round gravel to 15'. At 15.5', wet, orange loose silty sand with few gravels	Sample (14'-16') submitted for laboratory analysis
-15				
	16'-18'	0.0	Same, loose, wet sand to 17'	Sample (16'-17.5') submitted for laboratory analysis
			(17'-17.5') Gravel with sand and silt	
			(17.5'-18') Orange-gray clay	
	18'-20'	0.0	Orange and gray stiff clay, wet, with few gravels	Sample (18'-20') submitted for laboratory analysis
			At 19.5' Sandy clay with gravel, moist	
-20	20'-22'	2.5	(20'-21') Wet orange-gray mottled clay with few gravels	
			Sand and gravel, moist	Sample (21'-22') submitted for laboratory analysis
	22'-24'	109	Moist, brown sand and fine to coarse gravel of varying composition (mudstone, sandstone, quartzite)	Sample (22'-24') submitted for laboratory analysis
	24'-26'	1849	Same as above, saturated	Sample (24'-26') submitted for laboratory analysis
-25				
	26'-28'	436	Same as above	Sample (26'-28') submitted for laboratory analysis
	28'-30'	1635	Same as above with layers having less gravel, more med sand	Sample (28'-30') submitted for laboratory analysis
-30	30'-32'	722	Same as above, 31.5' - 32' less gravel more sand	Sample (30'-32') submitted for laboratory analysis

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SUBSURFACE LOG: S-261D
AND WELL CONSTRUCTION: S-261

Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
	32'-24'	1550		Same as above, sand and gravel to 33', less gravel, more sand 33'-34'	Sample (32'-34') submitted for laboratory analysis	
-35	34'-36'	877		Through shelby tube: top few inches are gravel, remainder looks like clay	Shelby Tube sample (34'-36') and laboratory sample	
	36'-36.5'	720		Gravel with sand	Sample (36'-36.5') submitted for laboratory analysis	
	36.5'-38'	7.7		Clayey sand to fine sandy clay	Sample (36.5'-38') accidentally discarded before collection	
	38'-40'	84.7		Med-coarse sand 20% gravel to 39' Medium sand, no gravel, 1-inch clay layer at 39'	Sample (38'-39') submitted for laboratory analysis	
-40	40'-42'	162		Medium sand with gravel in top 1-inch, clay lenses	Sample (40'-42') submitted for laboratory analysis	
	42'-44'	7.0			Shelby Tube sample (42'-44') and laboratory sample	
-45	44'-46'	4.0		Brown medium-fine sand, no gravel	Sample (44'-46') submitted for laboratory analysis	
	46'-48'	6.6		Same as above with sandy clay lenses	Sample (46'-48') submitted for laboratory analysis	
	48'-50'	6.1		Medium-coarse sand, thin sandy clay lenses with clay	Sample (48'-50') submitted for laboratory analysis	
-50	50'-52'	2.4		Brown, fine to med sand (bottom 4"-medium-coarse	Sample (50'-52')	

SUBSURFACE LOG: S-261D
AND WELL CONSTRUCTION: S-261

Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
				sand)	submitted for laboratory analysis	
	52'-54'	2.3		Fining upward sequence- medium-coarse sand with gravel fining upward to dark brown medium sand	Sample (52'-54') submitted for laboratory analysis	
	54'-56'	15.4			Shelby Tube sample (54'-56') and laboratory sample	
-55						
	56'-58'	16.6		Medium-coarse sand and gravel to 56' 4", grading into med sand with some gravel, dark brown	Sample (56'-58') submitted for laboratory analysis	
	58'-60'	176		Loose fine to med sandy clay. Bottom 4-inches coarse sand with fine gravels.	Sample (58'-60') submitted for laboratory analysis	
-60	60'-62'	33		Same clayey sand with fine gravel to 61.5	Sample (61.5'-62') submitted for laboratory analysis	
				At 61.5' gravels with sand, large red sandstone gravel in bottom of sample		
	62'-64'	5.6		Brown fine to med sand with occassional fine and coarse gravel	Sample (62'-64') submitted for laboratory analysis	
	64'-66'	70.2		Med to coarse sand and gravel	Sample (64'-66') submitted for laboratory analysis	
-65					Borehole complete to 66'	

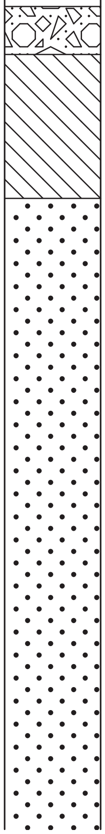
SUBSURFACE LOG: S-262D
AND WELL CONSTRUCTION : S-262

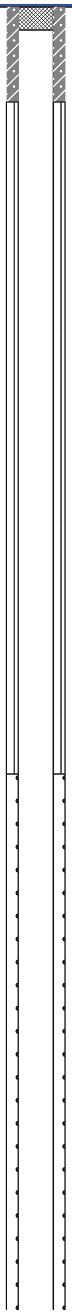
PROJECT: **Sunoco-Philadelphia Refinery**
SITE LOCATION: **AOI-1**
LOGGED BY: **Tiffani Doerr**
DATES DRILLED: **12 & 13 December 2007**
TOTAL BORING DEPTH: **65'**
BORING ELEVATION **17.559 feet**

DRILLING CO.: **Parrat Wolffe**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD: **Split Spoon**
SCREEN/RISER DIAMETER: **4-inch**
WELLBORE DIAMETER: **8-inch**
TOC (inner) ELEVATION: **19.443 feet (ASML)**

NOTE: Well S-262 drilled within 5 feet of boring S-262D. Screen=0.010 slot; "0" sand; 2' stickup finish. Screen (15'-30'); Riser (2' stickup to 15'); Sand (13'-30); Bentonite (11'-13'); Grout (surface to 11').

Depth (feet)	Blow Counts	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
					Boring location pre-cleared by Mobile Dredge to 4.5'	
					Perched water in hole at 3'	
-5	5'-7'	1735		Gravel (5'-5.5')	Sample (5'-7') submitted for laboratory analysis	
				Gray clay with some yellow-brown mottling, wet, very little fine sand; grades to silt with fine sand at bottom.		
					Auger to 7' to 10'	
-10	10'-12'	2900		Very slightly plastic fine sand to 11' 8"		
				Medium sand (11' 8" to 12')	Sample (11'8" -12') submitted for laboratory analysis	
					Auger 12' to 15'	





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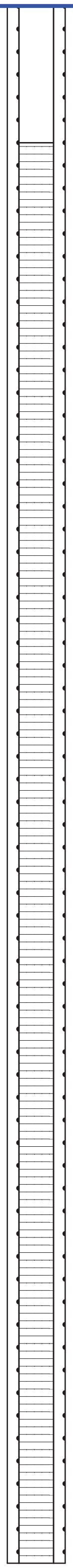
SUBSURFACE LOG: S-262D
AND WELL CONSTRUCTION: S-262

Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS
-15	15'-17'	2745		Coarse sand and 1" subround gravel. Large gravel at bottom of spoon (2")	Sample (16' -16.5') submitted for laboratory analysis
	17'-19'			Purple and gray-brown sand	Shelby Tube sample (17'-19') and laboratory sample
	19'-21'	1210		Saturated sand and gravel of variable colors.	Sample (19' -21') submitted for laboratory analysis
-20					
	21'-23'	3145		Same as above	Sample (21' -23') submitted for laboratory analysis
	23'-25'				Shelby Tube sample (23'-25')
-25	25'-27'	632		Same as above with few large gravels	Sample (25' -27') submitted for laboratory analysis
	27'-29'	1335		Same as above with medium-fine sand at botton 3"	Sample (27' -29') submitted for laboratory analysis
	29'-31'	266		Top 1-inch fissil shale (shattered cobble). 1" gravel with fine-med sand	
-30					
	31'-33'	318		Same to 32'	

WELL DIAGRAM



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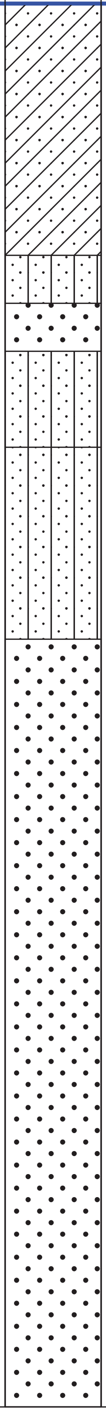
SUBSURFACE LOG: S-262D
AND WELL CONSTRUCTION: S-262

Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
				Medium-coarse sand with some gravel with large gravels at bottom	Sample (32' -33') submitted for laboratory analysis	
	33'-35'	222		Yellow-gray fine sand	Sample (33' -34') submitted for laboratory analysis	
		34.0		Yellow-gray silty clay to brown silty clay in bottom 6" with few very fine sands.	Sample (34' -35') submitted for laboratory analysis	
-35	35'-37'	119		Medium sand top 8-inches. Remainder of spoon is alternating layers of clay with 1-2 inch layers of fine sand.	Sample (35' -35.5') submitted for laboratory analysis	
		12.3				
	37'-39'	25.4		Dark brown silty clay with few fine sands	Sample (37' -39') submitted for laboratory analysis	
	39'-41'	23.8		Dark gray clay	Shelby Tube sample and laboratory sample (37'-39')	
-40						
	41'-43'	146		Dark brown-gray silty clay with few fine sands		
	43'-45'	250		Same as above with few thin (1"-2") layers of fine sand		
-45	45'-46'	18.2		Same as above, very stiff		
					Sample (46' -47') submitted for laboratory analysis	
	47'-49'	43.7		Stiff, dark gray silty clay with fine sand. Loose, saturated clay fine sand layer (47'6" - 47'10")	Sample (47' -49') submitted for laboratory analysis	
	49'-51'	7.8		Same as above, very silty, very stiff clay with fine sand.	Sample (49' -51') submitted for laboratory analysis	
-50						

SUBSURFACE LOG: S-262D
AND WELL CONSTRUCTION: S-262



Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
	51'-53'	1.4		Same as above	Sample (51' -53') submitted for laboratory analysis	
	53'-55'	6.4		Clayey silt with sand, plastic. Loose silty sand layer (53.5'-54')	Sample (53' -55') submitted for laboratory analysis	
-55	55'-57'	3.8		Same as above-clayey silt with sand	Sample (55' -57') submitted for laboratory analysis	
	57'-59'	13.3		Dark gray medium-fine sand with few round gravels. Large gravel at bottom, little bit of orange color.	Sample (57' -59') submitted for laboratory analysis	
	59'-61'				Shelby Tube sample (59'-61')	
-60						
	61'-63'	9.1		Medium dense, orange, medium to coarse grained sand. No gravel	Sample (61' -63') submitted for laboratory analysis	
	63'-65'	6.5		Same as above	Sample (63' -65') submitted for laboratory analysis Borehole complete to 65'	
-65						

Page 1 of 4

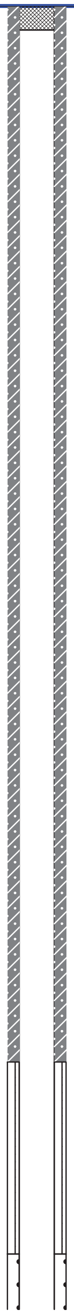
SUBSURFACE LOG: S-263D
AND WELL CONSTRUCTION : S-263

PROJECT:	**Sunoco-Philadelphia Refinery**	DRILLING CO.:	**Parratt-Wolffe**
SITE LOCATION:	**AOI-1**	DRILLING METHOD:	**Hollow Stem Auger**
LOGGED BY:	**Tiffani Doerr**	SAMPLING METHOD:	**Split Spoon**
DATES DRILLED:	**13 & 14 December 2007**	SCREEN/RISER DIAMETER:	**4-inch**
TOTAL BORING DEPTH:	**66'**	WELLBORE DIAMETER:	**8-inch**
BORING ELEVATION	**17.114 feet**	TOC (inner) ELEVATION:	**16.785 feet (ASML)**

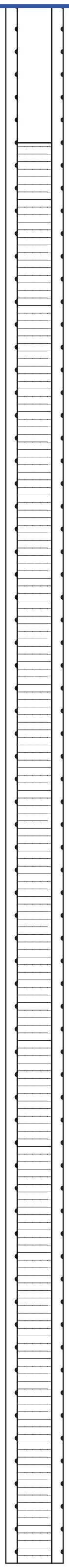
NOTE: Well S-263 drilled within 5 feet of boring S-263D. Screen=0.010 slot; "0" sand; flushmount finish. Screen (15'-30'); Riser (0'-15'); Sand (13'-30'); Bentonite (11'-13'); Grout (surface to 11')

Depth (feet)	Sample Int.	OVM (ppm)	USCS	LITHOLOGY	COMMENTS
0					
					Boring location pre-cleared by Mobile Dredge to 4'
-5	5'-7'	877	▧	Stiff dark gray clay with large chunk of wood (fill), saturated (water from dredging)	Sample (5'-7') submitted for laboratory analysis
			▧		Auger to 10'
-10	10'-12'	232	▧	Clay with organics, dark gray. Sheen on outside of spoon	Sample (10'-12') submitted for laboratory analysis
			▧		Auger to 16'

WELL DIAGRAM



SUBSURFACE LOG: S-263D
AND WELL CONSTRUCTION: S-263

Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
-15						
	16'-18'	232		Gravel and sand matrix	Shelby Tube sample (16'-18') and lab sample	
	18'-20'	261		Gravels of variable composition and size in clayey-sandy matirx, moist	Sample (18'-20') submitted for laboratory analysis	
-20	20'-22'	1147		Same as above	Sample (20'-22') submitted for laboratory analysis	
	22'-24'	1371		Same as above	Sample (22'-24') submitted for laboratory analysis	
	24'-26'	1516		Medium brown, Medium sand	Sample (24'-26') submitted for laboratory analysis	
				Sand with fine gravel.		
-25						
	26'-28'	1445		Same as above-sand and gravel (larger and more gravel at bottom of sample, less gravel and more sand at top-fining upward)	Sample (26'-28') submitted for laboratory analysis	
	28'-30'	1347		Mottled gray and orange clay, very little sand, saturated. Bottom 2" of spoon very fine light gray and orange sand	Sample (28'-30') submitted for laboratory analysis	
-30	30'-32'	1411		Same as above to 31'8".	Sample (30'-32') submitted for laboratory analysis	
				Medium coarse sand, no gravel, light brown		

SUBSURFACE LOG: S-263D
AND WELL CONSTRUCTION: S-263

Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
	32'-34'	1520		In shelby tube: looks like light brown, med coarse sand; product visible in air bubbles inside of tube (LNAPL).	Shelby Tube sample (32'-34') and lab sample	
-35	34'-36'	440		Soft clay with medium coarse sand, no gravel, saturated, light brown	Sample (34'-36') submitted for laboratory analysis	
	36'-38'	277		Light brown, med sand with few coarse sands, no gravel, saturated	Sample (36'-38') submitted for laboratory analysis	
	38'-40'	109		Light brown medium sand, no gravel	Sample (38'-40') submitted for laboratory analysis	
-40	40'-42'	55.3		Light brown med-coarse sand, medium dense	Sample (40'-42') submitted for laboratory analysis	
	42'-44'	101		Same as above, more orange in color in last 4" of spoon	Sample (42'-44') submitted for laboratory analysis	
-45	44'-46'	35.8		From tube look like same as above-bottom of tube was clay	Shelby Tube sample (44'-46') and lab sample	
	46'-48'	96.6		Light brown medium-coarse sand with fine sand at 47'-47.5'	Sample (46'-48') submitted for laboratory analysis	
	48'-50'	64.9		Light brown med-coarse sand, orange at bottom of spoon	Sample (48'-50') submitted for laboratory analysis	
-50	50'-52'	14.4		Orange brown med-coarse grained sand	Sample (50'-52')	

SUBSURFACE LOG: S-263D
AND WELL CONSTRUCTION: S-263

Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
					submitted for laboratory analysis	
	52'-54'	194		Same as above	Sample (52'-54') submitted for laboratory analysis	
	54'-56'	209		Same as above	Sample (54'-56') submitted for laboratory analysis	
-55						
	56'-58'	81.7		Same as above, very little gravel at bottom	Sample (56'-58') submitted for laboratory analysis	
				Same as above to 59.5		
	58'-60'	151			Sample (58'-59.5') submitted for laboratory analysis	
				At 59.5' sand; orange very weathered sandstone rock at bottom		
-60	60'-62'	154			Sample (60'-62') submitted for laboratory analysis	
				Same as above-orange brown med-coarse grained sand to 61.5		
	62'-64'	375		At 61.5' Orange coarse grained sand; few fine gravels (sub-angular) <1cm	Sample (62'-64') submitted for laboratory analysis	
				Orange, coarse sand with few small gravels ranging up to 2 cm		
	64'-66'	134		Sand	Shelby Tube sample (64'-66') and lab sample	
-65						
					Borehole complete to 66'	

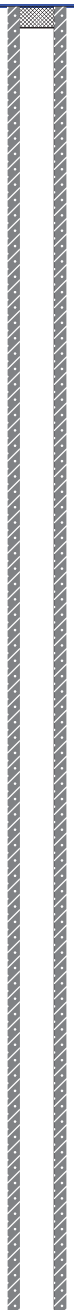
Aquaterra Technologies, Inc.

SUBSURFACE LOG: S-264D
AND WELL CONSTRUCTION : S-264D

PROJECT:	**Sunoco-Philadelphia Refinery**	DRILLING CO.:	**Parratt-Wolffe**
SITE LOCATION:	**AOI-1**	DRILLING METHOD:	**Hollow Stem Auger**
LOGGED BY:	**Tiffani Doerr**	SAMPLING METHOD:	**Split Spoon**
DATES DRILLED:	**19 & 20 December 2007**	SCREEN/RISER DIAMETER:	**4-inch**
TOTAL BORING DEPTH:	**82'**	WELLBORE DIAMETER:	**8-inch**
BORING ELEVATION	**25.097 feet (AMSL)**	TOC (inner) ELEVATION:	**26.63 feet**

NOTE: Well S-264D drilled within 5 feet of boring S-264D. Screen= 0.010 slot; "0" sand; 2' stickup finish. Screen (71'-81'); Riser (0'-71'); Sand (69'-81'); Bentonite (64'-69'); Grout (surface-64')

Depth (feet)	Sample Int.	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
0					Boring location pre-cleared by Mobile Dredge to 8'	
-5						
	8'-10'	0.3	▧	Gray silty clay with few orange laminations and some vey fine sand, slightly moist, no odors	No Sample	
-10			▧			
	14'-16'	37.2	▧	Same as above with large gravel in bottom of spoon	Sample (14'-16') submitted for laboratory analysis	



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SUBSURFACE LOG: S-264D
AND WELL CONSTRUCTION: S-264D

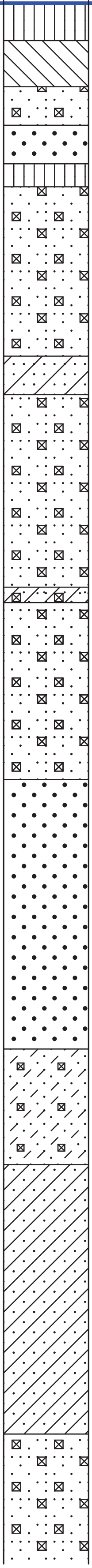
Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
-15						
	16'-18'	5.2		Med to coarse sand and gravel (variable size and color, gravels subrounded & subangular)	Sample (16'-18') submitted for laboratory analysis	
	18'-20'	6.9		In shelby tube: gravel appears to continue to 18.5 Gray clay with organics	Shelby Tube sample (18'-20') and laboratory sample	
-20	20'-22'	1.6		Same as 16'-18' interval	Sample (20'-22') submitted for laboratory analysis	
	22'-24'	28.6		Same as above, gravel and coarse sand. Top 1' less gravel/smaller gravel, green and red sandstone and quartzite frags	Sample (22'-24') submitted for laboratory analysis	
	24'-26'	115		Same as above, Larger gravels up to 2", bottom wet.	Sample (24'-26') submitted for laboratory analysis	
-25						
	26'-28'	1805		Same as above, wet, sheen visible on gravel surfaces.	Sample (26'-28') submitted for laboratory analysis	
	28'-30'	1810		Sand and gravel	Shelby Tube sample (28'-30') and laboratory sample	
-30	30'-32'	1262		Coarse sand with less gravel, color changing with depth (gray then orange then multicolored)	Sample (30'-32') submitted for laboratory analysis	
				(31.5'-32') Med-coarse sand, gray brown with occassional gravel		
	32'-24'	1560		Same as above, gray-brown, med to coarse sand with fne gravel	Sample (32'-34') submitted for laboratory analysis	
	34'-36'	1746		Same as above, bottom 4-inch with coarser gravels	Sample (34'-36') submitted for laboratory analysis	
-35						

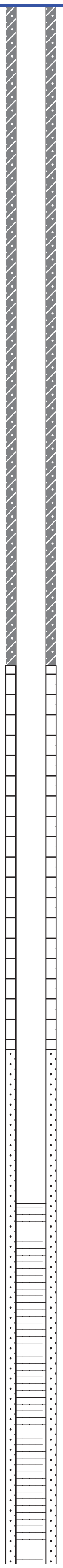
SUBSURFACE LOG: S-264D
AND WELL CONSTRUCTION: S-264D

Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
	36'-38'	1555		Same as above, less gravel	Sample (36'-38') submitted for laboratory analysis	
	38'-40'	1566		Same to 39.5	Sample (38'-40') submitted for laboratory analysis	
-40	40'-42'	829		Gray fine to med sand, no gravel. 2" caliche layer Same as above to 41'. Same as above, increased gravel content (41'-41.5') (41.5'-42') Orange & dark orange laminated clay then gray-orange clay at bottom, no sand.	Sample (40'-42') submitted for laboratory analysis	
	42'-44'	30.3		(42'-43') Fine sand layers with orange clay plug (43'-44') Orange clay w/ brown organic laminations in bottom 4"	Sample (42'-44') submitted for laboratory analysis	
-45	44'-46'	297		Brown medium coarse sand (45.5'-46') Light brown medium coarse sand with some gravel	Sample (44'-46') submitted for laboratory analysis	
	46'-48'	38.1		Medium to coarse sand with some gravel	Sample (46'-48') submitted for laboratory analysis	
	48'-50'	37.2		Light brown medium sand with occassional gravel	Sample (48'-50') submitted for laboratory analysis	
-50	50'-52'	291		Brown medium sand with occassional gravel, (51.5'-51.8') Reddish-brown plastic clay Very coarse medium sand and gravel	Sample (50'-52') submitted for laboratory analysis	
	52'-54'	3.4		Fine-med grained sand (fining grading upward sequence) to med-coarse sand with large gravel	Sample (52'-54') submitted for laboratory analysis	
-55	54'-56'	18.6		Medium sand to 55.3'	Sample (54'-56') submitted for laboratory analysis	

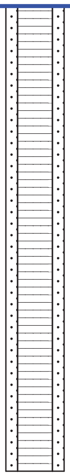
SUBSURFACE LOG: S-264D
AND WELL CONSTRUCTION: S-264D

Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
				Sandy silt to 55.9'		
	56'-58'	16.8		Reddish-orange silty clay	Sample (56'-58') submitted for laboratory analysis	
				Medium coarse sand with gravel (56.5' - 57'), Fine-med sand, gray color (57' - 57.5')		
				(57.5'-57.8') Reddish-brown sandy silt, gravel present at 57.8'		
	58'-60'	105		Medium to very coarse sand and gravel	Sample (58'-60') submitted for laboratory analysis	
-60	60'-62'	6.3		(60'-60.5') Clayey sand. (60.5'- 61') Medium to coarse sand with some gravel.	Sample (60'-62') submitted for laboratory analysis	
				(61'-62) Coarse to very coarse sand and gravel		
	62'-64'	33.3		(62.5'-63.5') Medium to coarse sand with very little gravel. At 63'-very sandy clay (2")	Sample (62'-64') submitted for laboratory analysis	
	64'-66'	216		Medium to coarse sand with some gravel	Sample (64'-66') submitted for laboratory analysis	
-65						
				(65.5'-66') Fine to medium sand		
	66-68'	6.1		Orange medium sand	Sample (66'-68') submitted for laboratory analysis	
	68'-70'	61.8		Spoon refusal at 69', gravel with clayey sand matrix at 68.5'-69'	Sample (68'-69') submitted for laboratory analysis	
					Auger to 70'	
-70	70'-72'	7.2		Same as above, saturated, less gravel to 70.5'	Sample (70'-70.5') submitted for laboratory analysis	
				Dark brown fine sandy clay		
	72'-74'	-		6-inch recovery: clayey sand to sandy clay to rock	No Sample	
	74'-76	15.5		Orange coarse sand with few gravel at top	Sample (74'-76') submitted for laboratory analysis	
-75						
				Milky white coarse sand and gray fine gravel		





SUBSURFACE LOG: S-264D
AND WELL CONSTRUCTION: S-264D

Depth (feet)	Sample Int	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL DIAGRAM
	76'-78'	27.6		6" recovery. Same as above, bottom 1-inch orange coarse sand and coarse gravel	Sample (76'-78') submitted for laboratory analysis	
	78'-80'	11.6		Coarse sand with gravel	Sample (78'-80') submitted for laboratory analysis	
				Coarse gravel with sand		
-80	80'-82'	25.6		Same as above, bottom 3-inches = round cobble with white sandy clay matrix	Shelby Tube sample (80'-82') and laboratory sample	
					Borehole complete to 82'	

Aquaterra Technologies, Inc.

MONITORING WELL LOG: S-269

PROJECT:	**Sunoco Philadelphia Refinery**	DRILLING CO.:	**Parratt Wolff Inc.**
SITE LOCATION:	**26th Street South**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:		SAMPLING METHOD:	**Split Spoon**
LOGGED BY:	**Shaun Sykes**	SCREEN/RISER DIAMETER:	**4"**
DATES DRILLED:	**8-27-08**	WELLBORE DIAMETER:	**8"**
TOTAL DEPTH:	**30'**	ELEVATION:	**-**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0						
-5				Cleared to 8'	Riser 0-10'	
				Fill observed during clearing activities, but depth of contact with native materials not determined.		
-10	276		Sligthly moist, light brown clayey fine sand, slightly to 13'			
	323					
	562					
	613		Moist fine brown/gray sand and			

Aquaterra
Technologies, Inc.

MONITORING WELL LOG: S-269

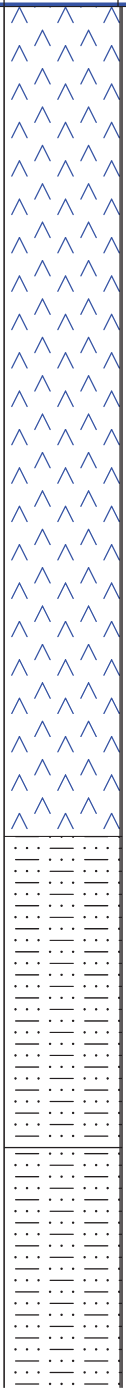
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
			gravel to 15.5'			
	622					
-15	573					
			Moist, fine light gray clayey sand to 16.5'			
	322					
			Gray/red sand and gravel to 17.5'			
	302					
			Moist, light gray clayey sand, compact			
	57.6		Gray/brown fine sand, trace clay and gravel, slightly moist			
	51.4		Orange-brown fine sand and gravel (mixed), slightly moist			
-20	65.6		Gray/light gray clayey fine sand and mixed gravels, slightly moist, slight odor		Screen 10-30'	
	49.7		Orange/yellow/brown fine sand and mixed gravels, trace clay, slightly moist			
	102		Red/brown fine sand and gravel, slightly moist			
			Gray/green/red/blue coarse sand and mixed gravels, wet			
	67.7					
	216		Same as above with blue and red tinted layers of fine sand, moist			
-25	327		Gold/dark brown medium sands, very moist, petroleum odors			
	215		Same with small gravels			
	205					
	117		Gray/brown fine clayey sand and trace small gravels, very moist to wet			
	102		Same as above (10" recovery)	Auger complete to 30'		
-30						

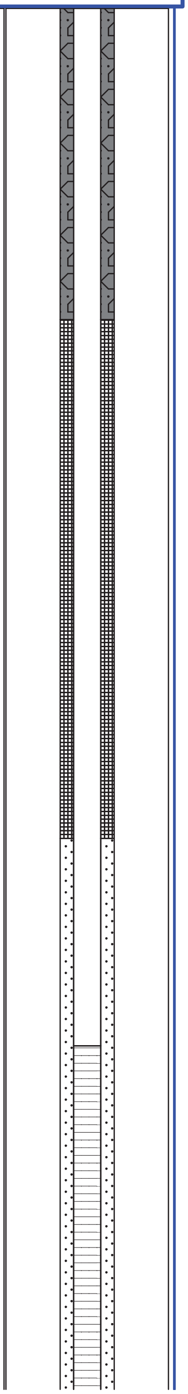
Aquaterra Technologies, Inc.

MONITORING WELL LOG: S-270

PROJECT:	**Sunoco Philadelphia Refinery**	DRILLING CO.:	**Parratt Wolff Inc.**
SITE LOCATION:	**26th Street South**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:		SAMPLING METHOD:	**Split Spoon**
LOGGED BY:	**Shaun Sykes**	SCREEN/RISER DIAMETER:	**4"**
DATES DRILLED:	**8-27-08**	WELLBORE DIAMETER:	**8"**
TOTAL DEPTH:	**30'**	ELEVATION:	**-**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0						
				Cleared to 8'		
-5				Water observed entering hole from approximately 4' below grade during clearing activities (constant ~1gpm)	Riser 0-10'	
				Fill observed to 8' in cleared hole. Coarse sand with gravel, wood, and much broken cinder block		
-10	356		Brown/black clayey fine sand and gravel, moist (6" recovery)			
	478		Compact, slightly moist,brown/red sandy silt to 14.5'			
	513					
	472					





MONITORING WELL LOG: S-270

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	356					
-15	782		Coarse sand and gravel, increasing sand content with depth, moist			
			Coarse sand and gravel to 23'			
	825					
	1215		Strong petroleum odors noted at 17'			
	1163					
	1172		Same as above, sand w/ reddish color			
-20	1065				Screen 10-30'	
	1345		Wet @ 21'			
	1271					
	1175		Medium reddish gray & white sands, some gravel, wet			
	1221					
-25	963					
	827					
	563					
	615		Same as above, shift to finer sands at 28'			
	421		Same as above, shift back to coarser sand, wet	Auger complete to 30'		
	315		Same, gravel at 29.5"			
-30						

PROJECT: **Philadelphia Refinery**
LOCATION: **Philadelphia, PA**
PROJECT NUMBER: **62SU.01095.05**

WELL / PROBEHOLE / BOREHOLE NO:
S-271 PAGE 1 OF 1

Stantec

DRILLING:	STARTED **7/29/08**	COMPLETED: **7/30/08**	
INSTALLATION:	STARTED **7/29/08**	COMPLETED: **7/30/08**	

DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **A-300**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):	EASTING (ft):
LATITUDE:	LONGITUDE:
GROUND ELEV (ft):	TOC ELEV (ft):
INITIAL DTW (ft): **NE**	BOREHOLE DEPTH (ft): **35.0**
STATIC DTW (ft): **23 7/29/08**	WELL DEPTH (ft): **35.0**
WELL CASING DIAMETER (in): **4**	BOREHOLE DIAMETER (in): **8**
LOGGED BY: **Frank Rooney**	CHECKED BY: **R Turner**

Time & Depth (feet) | Graphic Log | USCS | Description | Sample | Time Sample ID | Measured Recov. (feet) | Blow Count | Headspace PID (units) | Depth (feet) | Well Construction

Cleared Thursday, July 28, 2008

SAND WITH FINE GRAVEL; 10YR-5/6 yellowish brown; fine-grained; moist; subrounded

SAND WITH FINE TO COARSE GRAVEL; 5YR-2.5-1 black; fine-grained; moist; subrounded

SAND WITH FINE GRAVEL; 5YR-5/3 dark reddish brown; fine-grained; moist; subrounded

SAND WITH FINE GRAVEL; 5YR-3/1 dark gray; fine-grained; moist; subrounded

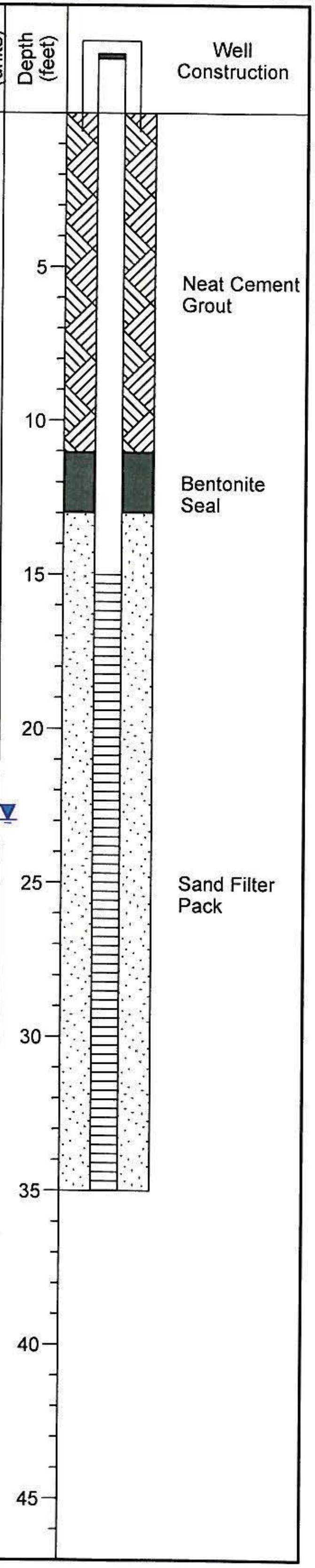
SAND WITH MEDIUM TO COARSE GRAVEL SOME MICA; 5YR-5/3 reddish brown; fine-grained; moist; subrounded

SAND WITH COARSE GRAVEL; 5YR-2.5/1 black; medium to coarse-grained; saturated; subrounded

SAND WITH COARSE GRAVEL; 5YR-5/3 reddish brown; medium to coarse-grained; saturated; subrounded

Hole terminated at 35 feet.

Time	Measured Recov. (feet)	Blow Count	Headspace PID (units)
1020	1.2	2 5 6 10	129 3253
1030	1.4	8 11 7 6	1334 100 151 5026
1045	1.2	12 15 14 10	- - 4448 1261
1050	1.2	8 4 5 8	- 557 1750 1249
1100	1.3	25 25 25 25	- - 3026 4937
1120	1.3	4 5 5 10	- 4310 1858 3552
1130	1.2	12 14 15 16	- 407 4029 4451
1135	1.6	15 16 25 50/0.4	- 2119 3767 3668
1140	1.3	7 19 23 24	- 1227 261 0
1220	0.6	11 18 25 23	- - - 2847
1230	1.5	15 18 23 25	- 614 812 3691
1250	1.7	7 8 13 15	3490 1850 3280 3385
1310	1.7	14 22 25 18	3219 3660 3161 3436
	2	25 15 - -	651 601



PROJECT: **Philadelphia Refinery**
LOCATION: **Philadelphia, PA**
PROJECT NUMBER: **62SU.01095.05**

WELL / PROBEHOLE / BOREHOLE NO:
S-272
PAGE 1 OF 1

DRILLING: STARTED **7/30/08**	COMPLETED: **7/30/08**	NORTHING (ft):	EASTING (ft):
INSTALLATION: STARTED **7/30/08**	COMPLETED: **7/30/08**	LATITUDE:	LONGITUDE:
DRILLING COMPANY: **Parratt Wolff**		GROUND ELEV (ft):	TOC ELEV (ft):
DRILLING EQUIPMENT: **A-300**		INITIAL DTW (ft): **NE**	BOREHOLE DEPTH (ft): **35.0**
DRILLING METHOD: **Hollow Stem Auger**		STATIC DTW (ft): **22 7/30/08**	WELL DEPTH (ft): **35.0**
		WELL CASING DIAMETER (in): **4**	BOREHOLE DIAMETER (in): **8**
SAMPLING EQUIPMENT: **Split Spoon**		LOGGED BY: **Frank Rooney**	CHECKED BY: **R Turner**

Description

Cleared Thursday, July 28, 2008

SAND; 10YR-5/1 gray with brown; fine-grained; moist

SAND WITH FINE GRAVEL; 10YR-3/2 very dark grayish brown with; fine-grained; moist; subrounded

CLAY WITH FINE GRAVEL; 10YR-6/3 pale brown; fine-grained; moist; rounded

SAND WITH FINE GRAVEL; 5YR-4/2 dark reddish gray; medium-grained; moist; angular

SAND WITH FINE GRAVEL; 10YR-4/3 brown; medium-grained; moist

SAND WITH COARSE GRAVEL; 10YR-3/3 dark brown; fine-grained; moist

SILT WITH SAND AND FINE GRAVEL; 10YR-3/4 dark yellowish brown; fine-grained; moist; slight petroleum odor; rounded

SAND WITH FINE GRAVEL; 2.5YR-3/2 dark red; fine to medium-grained; saturated; slight petroleum odor; subrounded

SAND WITH FINE GRAVEL; 10R-3/3 dark red with dark reddish brown; fine to medium-grained; moist; slight petroleum odor; subrounded

SAND WITH FINE GRAVEL; 10R-3/3 dark red; fine to medium-grained; moist; slight petroleum odor; subrounded

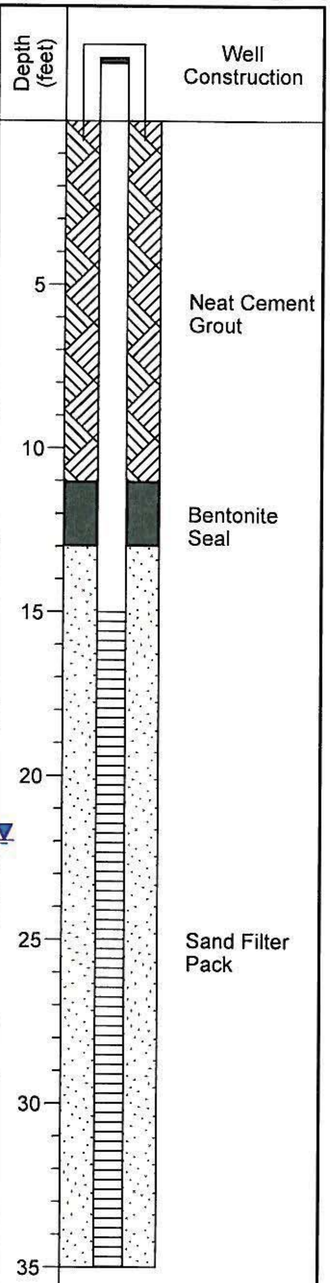
SAND WITH FINE TO MEDIUM GRAVEL; 10R-2.5/1 black; fine to medium-grained; moist; strong petroleum odor

SAND WITH FINE TO COARSE GRAVEL; 10R-3/1 dark reddish gray; fine to medium-grained; moist; slight petroleum odor; subangular

SAND WITH LITTLE FINE GRAVEL; 10YR-2/1 black to brown; moist; slight petroleum odor; subrounded

Hole terminated at 35 feet.

Time & Depth (feet)	Measured Recov. (feet)	Blow Count	Headspace PID (units)
5			
0930	1.8	14 10 10 15	0 4.6 0 0
10			
0950	1.8	6 7 11 20	0 0 0 0
1010	1.8	11 12 16 20	0 0 0 0
1020 15	1.4	20 30 36 20	- 0 0 0
1045	0.7	21 23 23 25	0 0 0 0
1100	0.3	8 16 20 23	0 0 0 0
20			
1120	1.6	10 26 36 35	- - 3697 3475
1130	2.0	37 37 34 33	664 3804 3779 3692
1140 25	1.8	16 20 32 37	- 149 1656 2167
1145	1.8	24 32 34 40	- 1940 828 3670
1200	1.9	34 26 28 33	- 1059 3296 3253
30			
1210	1.6	12 12 20 17	- 1177 3282 695
1220	1.4	1 1 1 8	481 3605 3486 4445
1230 35	2.0	1 1 - -	502 1836
40			
45			



PROJECT: **Philadelphia Refinery**
LOCATION: **Philadelphia, PA**
PROJECT NUMBER: **62SU.01095.05**

WELL / PROBEHOLE / BOREHOLE NO:
S-273 PAGE 1 OF 1

Stantec

DRILLING: STARTED **7/31/08** COMPLETED: **7/31/08**
INSTALLATION: STARTED **7/31/08** COMPLETED: **7/31/08**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **A-300**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon**

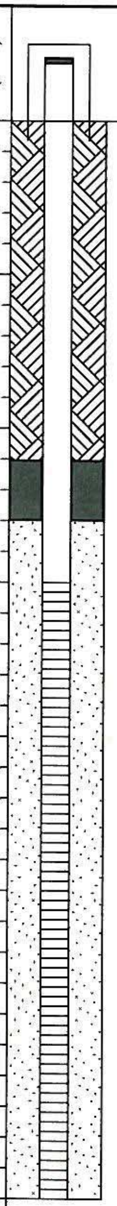
NORTHING (ft):
LATITUDE:
GROUND ELEV (ft):
INITIAL DTW (ft): **NE**
STATIC DTW (ft): **28 7/31/08**
WELL CASING DIAMETER (in): **4**
LOGGED BY: **Frank Rooney**

EASTING (ft):
LONGITUDE:
TOC ELEV (ft):
BOREHOLE DEPTH (ft): **35.0**
WELL DEPTH (ft): **35.0**
BOREHOLE DIAMETER (in): **8**
CHECKED BY: **R Turner**

Time & Depth (feet)	Description
	Cleared Thursday, July 28, 2008
0850	**CLAY**; GLEY 1-5/5G greenish gray with reddish brown; moist
0910	**CLAY**; GLEY 1-5/5G greenish gray with reddish brown; moist
0930	**CLAY**; 10YR-6/2 W/ 10YR-5/6 light brownish gray with yellowish brown; moist
0944	**CLAY**; 10YR-5/2 W/ 5YR-3/2 grayish brown with dark brown; moist
0950	**SAND WITH FINE TO COARSE GRAVEL** GLEY 1-5N greenish gray; fine to medium-grained; moist
1010	**SANDY CLAY**; 10YR-6/1 W/ 10R-6/8 gray with light red; moist
1030	**SAND WITH FINE TO COARSE GRAVEL** 10R-4/4, GLEY 2-4/5 PB, 7/5 PB pale red with dark blueish gray; fine to medium-grained; moist; slight petroleum odor; subrounded
1115	**SAND WITH FINE TO COARSE GRAVEL** 10R-4/4, 7.5YR-5/8, 7.5YR-3/3 pale red; fine to medium-grained; moist; slight petroleum odor
1150	Black; saturated; slight petroleum odor; subrounded
1200	**SAND WITH FINE TO COARSE GRAVEL** 7.5YR-3/2 dark brown to black; fine to medium-grained; moist; slight petroleum odor; subrounded
1220 35	**SAND WITH FINE TO MEDIUM GRAVEL** 7.5YR-3/2 dark brown; fine to medium-grained; moist; subrounded
	Hole terminated at 35 feet.

Time	Measured Recov. (feet)	Blow Count	Headspace PID (units)
0850	2.0	4 5 5 6	0 4.6 0 0
0900	2.0	4 8 10 10	0 0 0 0
0910	2.0	9 9 11 11	0 0 0 0
0930	1.3	4 7 9 9	- 0 0 0
0944	2.0	8 8 9 15	0 0 0 0
0950	2.0	15 27 22 24	0 0 0 0
1010	1.3	7 11 27 27	0 - - 1655
1030	1.0	28 29 22 22	2557 - - 3849
1045	1.7	22 34 37 24	4218 - 294 5340
1115	1.4	15 22 25 36	5219 - 0 165
1150	1.3	40 50/0.4 - -	4923 - - 6889
1200	1.5	20 24 32 36	6386 - 457 7058
1210	1.0	17 18 24 26	8800 - - 500
1220	2.0	17 18 - -	3208 - - 450

Well Construction



Neat Cement Grout

Bentonite Seal

Sand Filter Pack

PROJECT: **Philadelphia Refinery**
LOCATION: **Philadelphia, PA**
PROJECT NUMBER: **62SU.01095.05**

WELL / PROBEHOLE / BOREHOLE NO:

S-274 PAGE 1 OF 1

Stantec

DRILLING: STARTED **8/5/08**	COMPLETED: **8/5/08**	NORTHING (ft):	EASTING (ft):
INSTALLATION: STARTED **8/5/08**	COMPLETED: **8/5/08**	LATITUDE:	LONGITUDE:
DRILLING COMPANY: **Parratt Wolff**		GROUND ELEV (ft):	TOC ELEV (ft):
DRILLING EQUIPMENT: **A-300**		INITIAL DTW (ft): **NE**	BOREHOLE DEPTH (ft): **35.0**
DRILLING METHOD: **Hollow Stem Auger**		STATIC DTW (ft): **24 8/5/08**	WELL DEPTH (ft): **35.0**
		WELL CASING DIAMETER (in): **4**	BOREHOLE DIAMETER (in): **8**
SAMPLING EQUIPMENT: **Split Spoon**		LOGGED BY: **Frank Rooney**	CHECKED BY: **R Turner**

Time & Depth (feet)	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)
0910	☒		1.7	5 6 7 8	- 194 0 0
0920	☒		1.4	4 5 5 7	- 0 1088 1092
0935	☒		2.0	22 22 31 42	1954 662 4175 0
0950	☒		1.5	13 12 12 13	- 0 0 0
1000	☒		2.0	5 8 9 9	0 0 0 0
1015	☒		2.0	6 8 8 10	0 373 0 0
1030					
1045					
1055					
1115					
1130					
1145					
1200					
1215					

Description

Cleared Thursday, July 28, 2008

CLAY; GLEY 2-6/10B W/ 20% 10YR-5/8 blueish brown with yellowish brown; moist

CLAY WITH FINE GRAVEL; 2.5YR-7/1 light reddish gray; moist; slight petroleum odor; subrounded

CLAY WITH SILT; 10YR-7/1 W/ 40% 10YR-5/4 light gray with yellowish brown

CLAY; 10YR-4/2 dark grayish brown; moist

SAND; 10YR-6/2; fine to medium-grained; moist; slight petroleum odor

SAND WITH FINE TO MEDIUM GRAVEL; 10YR-3/4 dark yellowish brown; fine to medium-grained; moist; slight petroleum odor

SANDY CLAY WITH FINE TO COARSE GRAVEL; GLEY 2-6/5 PB blueish gray; moist; slight petroleum odor; subrounded

CLAYEY SAND WITH FINE TO MEDIUM GRAVEL; 2.5YR-2.5/4 & 5YR-2.5/1; fine to medium-grained; saturated; slight petroleum odor; subrounded

CLAYEY SAND WITH FINE TO COARSE GRAVEL; 10R-3/4 & 10YR-4/2 W/ 10% 10YR-8/2 dark red and dark gray; moist; slight petroleum odor; subrounded

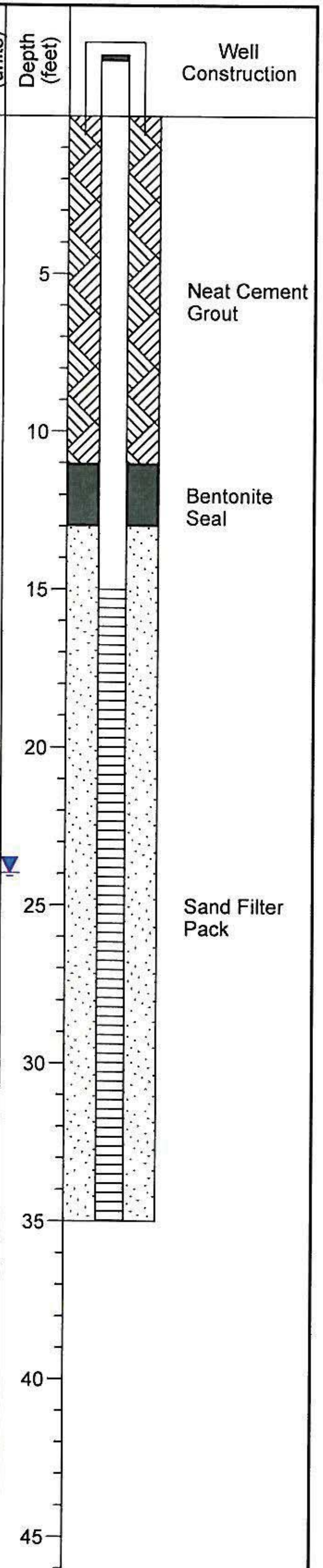
SAND WITH FINE TO COARSE GRAVEL; black; saturated; slight petroleum odor; subrounded

SAND WITH FINE TO COARSE GRAVEL; 10R-3/4 & 10R-3/2 dark red; fine to medium-grained; saturated; slight petroleum odor

SAND WITH FINE TO COARSE GRAVEL; 10YR-3/3 dark brown; fine to medium-grained; saturated; slight petroleum odor

CLAYEY SAND; 10YR-6/1 W/ 10YR-5/6; fine-grained; moist; slight petroleum odor

Hole terminated at 35 feet.



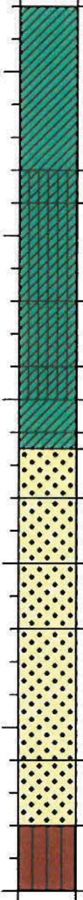
PROJECT: **Philadelphia Refinery**
LOCATION: **Philadelphia, PA**
PROJECT NUMBER: **62SU.01095.05**

WELL / PROBEHOLE / BOREHOLE NO:
S-275 PAGE 1 OF 1

DRILLING: STARTED **8/5/08** COMPLETED: **8/6/08**
INSTALLATION: STARTED **8/5/08** COMPLETED: **8/6/08**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **A-300**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LATITUDE:
GROUND ELEV (ft):
INITIAL DTW (ft): **NE**
STATIC DTW (ft): **23 8/5/08**
WELL CASING DIAMETER (in): **4**
LOGGED BY: **Frank Rooney**

EASTING (ft):
LONGITUDE:
TOC ELEV (ft):
BOREHOLE DEPTH (ft): **35.0**
WELL DEPTH (ft): **35.0**
BOREHOLE DIAMETER (in): **8**
CHECKED BY: **R Turner**



Description

Cleared Thursday, July 28, 2008

CLAY; GLEY 2-6/10B W/ 10YR-4/6 blueish gray with yellowish brown; moist

SILTY CLAY WITH MICA; 10YR-5/1 gray; moist

SILTY CLAY; GLEY2-6/10 W/ 10YR-4/6, 10YR-6/1 blueish gray with gray; moist

SILTY CLAY; 7.5YR-6/1 W/ 10YR-6/1 gray; moist

SILTY CLAY; 10YR-6/1, 10% 5/6 gray; moist

CLAY; 7.5YR-5/2 grayish brown; moist

CLAY WITH SILT AND MICA; 10YR-6/1 gray; moist

SAND WITH FINE GRAVEL; 10YR-4/8 dark yellowish brown; fine to medium-grained; moist; subrounded

SAND WITH FINE TO COARSE GRAVEL; 10YR-4/6, 10R-3/6, GLEY2-8/5 PB dark yellowish brown and dark red; fine to medium-grained; moist; slight petroleum odor; subrounded

SAND WITH FINE TO COARSE GRAVEL; 10R-3/4, 10YR-3/2 dark red and very dark grayish brown; fine to medium-grained; moist; slight petroleum odor; subrounded

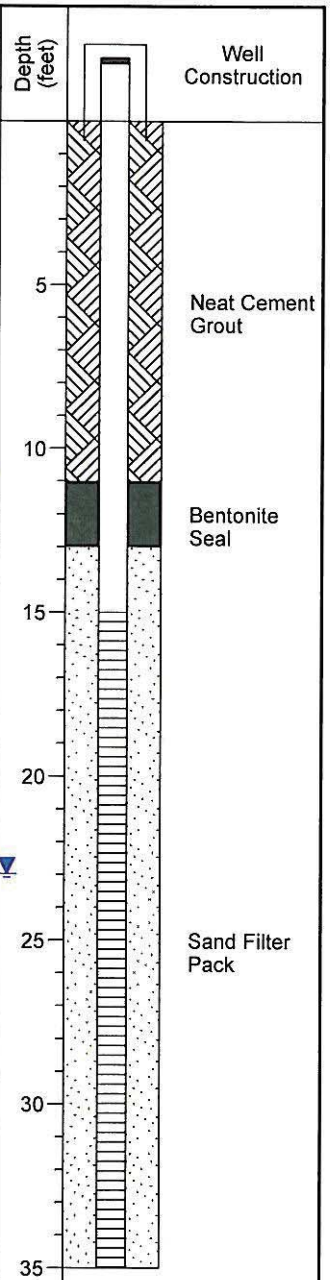
SAND WITH FINE TO MEDIUM GRAVEL; 10R-3/4, 10YR-3/2, 10YR-4/6 dark red and dark yellowish brown; fine to medium-grained; saturated; slight petroleum odor; subrounded

SAND WITH FINE TO COARSE GRAVEL; black; fine to medium-grained; moist; subrounded

SILT; 10YR-5/8, 10YR-6/2 yellowish brown and light brownish gray

Hole terminated at 35 feet.

Time & Depth (feet)	Measured Recov. (feet)	Blow Count	Headspace PID (units)
	2.0	3 7 11 13	0 980 0 0
	1.8	3 7 11 12	71 414 0 0
	2.0	9 10 14 17	0 0 0 0
	1.5	5 6 6 9	- 81 0 0
	2.0	12 13 10 8	0 0 0 0
	1.6	8 8 12 20	- 0 0 0
0800	1.2	50/0.4 - - -	- - 0 104
0815	1.6	17 29 39 50	- 4264 2644 4430
0830	1.7	28 32 32 36	- 540 3861 2891
0845	1.9	36 37 43 50/0.4	247 3036 4230 3573
0915	1.0	43 50/0.4 42 48	- - 4861 4937
0940	0.5	50/0.4 - 42 50/0.4	- - - 4831
0950	1.6	4 4 4 6	- 0 0 0
1000	2.0	7 5 - -	0 0



PROJECT: **Philadelphia Refinery**
LOCATION: **Philadelphia, PA**
PROJECT NUMBER: **62SU.01095.05**

WELL / PROBEHOLE / BOREHOLE NO:
S-276 PAGE 1 OF 1

Stantec

DRILLING: STARTED **8/12/08** COMPLETED: **8/12/08**
INSTALLATION: STARTED **8/12/08** COMPLETED: **8/12/08**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **A-300**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LATITUDE:
GROUND ELEV (ft):
INITIAL DTW (ft): **NE**
STATIC DTW (ft): **29 8/12/08**
WELL CASING DIAMETER (in): **4**
LOGGED BY: **Frank Rooney**

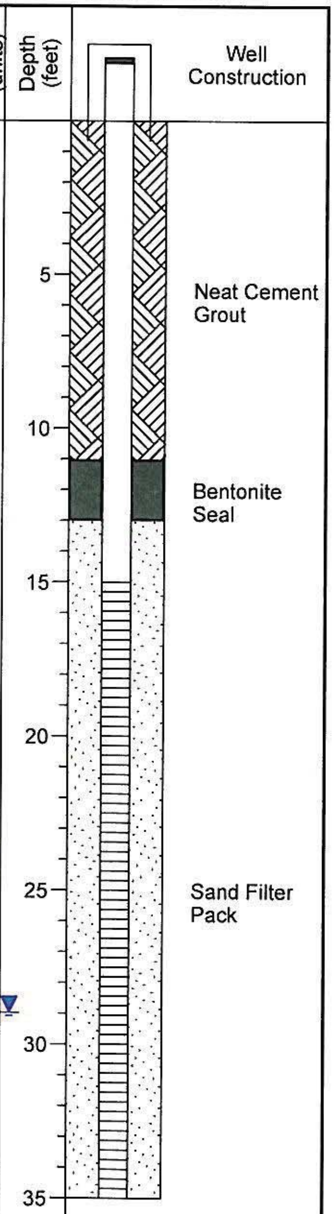
EASTING (ft):
LONGITUDE:
TOC ELEV (ft):
BOREHOLE DEPTH (ft): **35.0**
WELL DEPTH (ft): **35.0**
BOREHOLE DIAMETER (in): **8**
CHECKED BY: **R Turner**

Time & Depth (feet)	Graphic Log	USCS	Description
0			Cleared Thursday, July 28, 2008
8			**CLAY**; GLEY1-5/5 G, 10% 10YR-5/6 greenish gray with yellowish brown
14			**CLAY**; 10YR-6/1, 10% 10YR-5/6 gray with yellowish brown
16			**CLAY SOME SILT**; 5YR-6/1, 10YR-5/8 gray with yellowish brown
20			**SAND WITH FINE GRAVEL**; 10YR-4/6, GLEY 1-5/5 GY dark yellowish brown and greenish black; fine to medium-grained; subangular
			No recovery
			SAND WITH FINE GRAVEL FINE GRAVEL; 10R-3/3, 5YR-8/11 dark red and white; moist; slight petroleum odor
			SAND WITH FINE GRAVEL FINE TO COARSE GRAVEL; 2.5YR-4/3, 10YR-5/6 reddish brown and yellowish brown; moist; slight petroleum odor
			SAND WITH FINE TO COARSE GRAVEL FINE TO COARSE GRAVEL; 10YR-4/4 dark yellowish brown; moist; slight petroleum odor
			SAND WITH FINE TO COARSE GRAVEL FINE TO COARSE GRAVEL; 10YR-2/2 very dark brown; saturated; slight petroleum odor
			SAND WITH SILT AND FINE TO COARSE GRAVEL; 10YR-4/2 dark grayish brown; fine-grained; moist; slight petroleum odor
			SILT WITH MICA; 10YR-4/3 brown; moist; slight petroleum odor
			Hole terminated at 35 feet.

Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)
		1.8	2 2 3 9	- 120 0 0
		2.0	3 5 6 10	0 0 0 0
		2.0	10 12 15 16	0 0 0 0
		1.5	2 3 3 4	- 0 0 0
		2.0	8 9 10 7	0 0 0 0
		1.4	12 50/0.4 - -	- 208 0 0
		0.0	15 21 36 39	- - - -
		1.2	45 36 35 46	- - 8461 3945
		1.5	11 26 31 45	- - 3318 3942
		1.7	35 40 40 40	- 230 4623 4965
		0.5	50/.04 - - -	- - - 4345
		1.2	5 20 20 26	- - 4064 3886
		2.0	20 11 12 21	4219 4329 4344 4821
		2.0	9 10 - -	4788 4960 1404 0

Depth (feet)

Well Construction

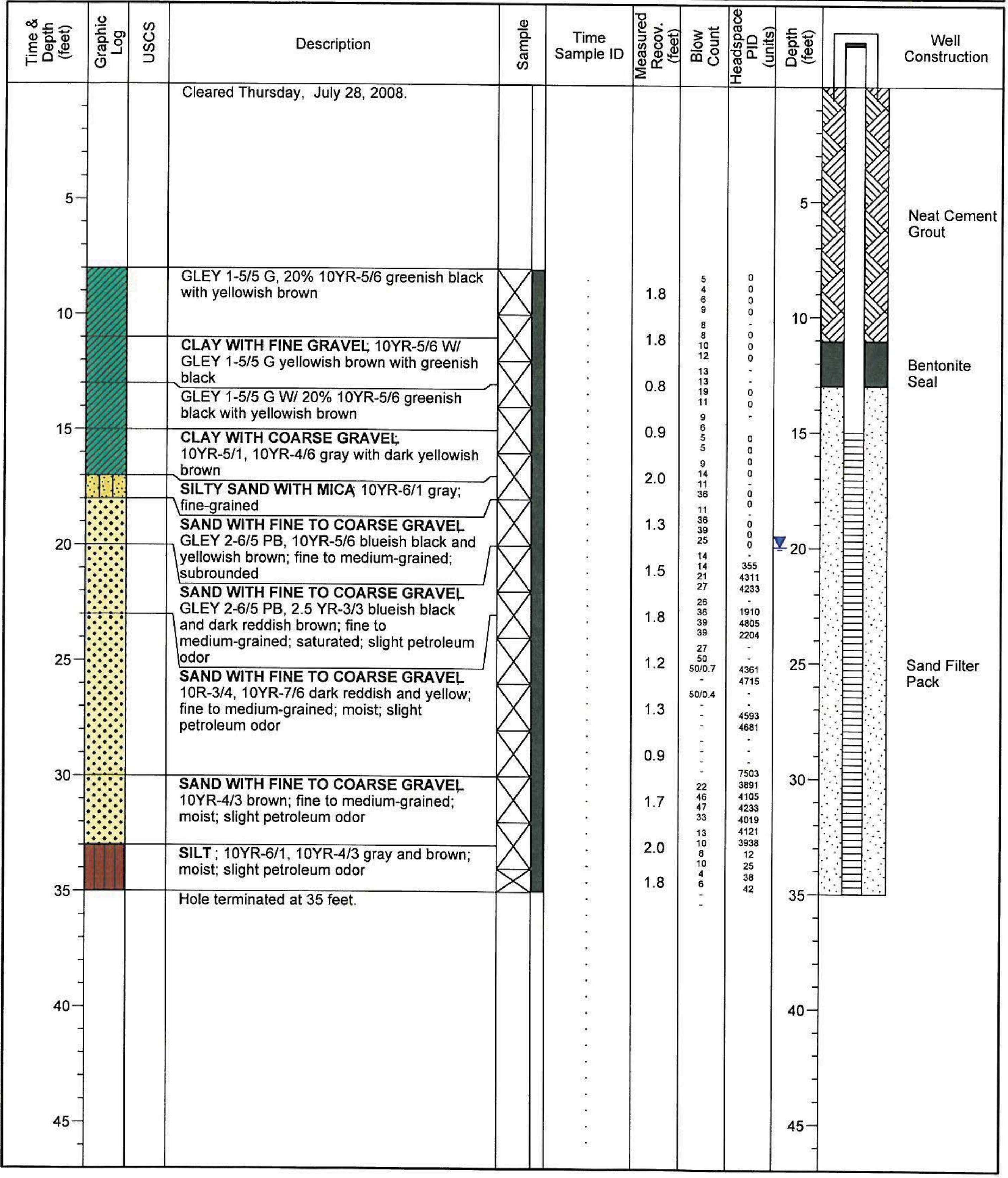


PROJECT: **Philadelphia Refinery**
LOCATION: **Philadelphia, PA**
PROJECT NUMBER: **62SU.01095.05**

WELL / PROBEHOLE / BOREHOLE NO:
S-277 PAGE 1 OF 1

Stantec

DRILLING: STARTED **8/13/08**	COMPLETED: **8/13/08**	NORTHING (ft):	EASTING (ft):
INSTALLATION: STARTED **8/13/08**	COMPLETED: **8/13/08**	LATITUDE:	LONGITUDE:
DRILLING COMPANY: **Parratt Wolff**		GROUND ELEV (ft):	TOC ELEV (ft):
DRILLING EQUIPMENT: **A-300**		INITIAL DTW (ft): **NE**	BOREHOLE DEPTH (ft): **35.0**
DRILLING METHOD: **Hollow Stem Auger**		STATIC DTW (ft): **20 8/13/08**	WELL DEPTH (ft): **35.0**
		WELL CASING DIAMETER (in): **4**	BOREHOLE DIAMETER (in): **8**
SAMPLING EQUIPMENT: **Split Spoon**		LOGGED BY: **Frank Rooney**	CHECKED BY: **R Turner**



Description	Measured Recov. (feet)	Blow Count	Headspace PID (units)
Cleared Thursday, July 28, 2008. GLEY 1-5/5 G, 20% 10YR-5/6 greenish black with yellowish brown **CLAY WITH FINE GRAVEL**; 10YR-5/6 W/ GLEY 1-5/5 G yellowish brown with greenish black GLEY 1-5/5 G W/ 20% 10YR-5/6 greenish black with yellowish brown **CLAY WITH COARSE GRAVEL**; 10YR-5/1, 10YR-4/6 gray with dark yellowish brown **SILTY SAND WITH MICA**; 10YR-6/1 gray; fine-grained **SAND WITH FINE TO COARSE GRAVEL**; GLEY 2-6/5 PB, 10YR-5/6 blueish black and yellowish brown; fine to medium-grained; subrounded **SAND WITH FINE TO COARSE GRAVEL**; GLEY 2-6/5 PB, 2.5 YR-3/3 blueish black and dark reddish brown; fine to medium-grained; saturated; slight petroleum odor **SAND WITH FINE TO COARSE GRAVEL**; 10R-3/4, 10YR-7/6 dark reddish and yellow; fine to medium-grained; moist; slight petroleum odor **SAND WITH FINE TO COARSE GRAVEL**; 10YR-4/3 brown; fine to medium-grained; moist; slight petroleum odor **SILT** ; 10YR-6/1, 10YR-4/3 gray and brown; moist; slight petroleum odor Hole terminated at 35 feet.	1.8 1.8 0.8 0.9 2.0 1.3 1.5 1.8 1.2 1.3 0.9 1.7 2.0 1.8	5 4 6 9 8 8 10 12 13 13 19 11 9 6 5 5 9 14 11 36 11 36 39 25 14 14 21 27 26 36 39 39 27 50 50/0.7 - 50/0.4 - - - - - - - 22 46 47 33 13 10 8 10 4 6 - -	0 0 0 0 - 0 0 0 - - 0 0 - 0 0 0 0 - 0 0 - 0 0 0 - 355 4311 4233 - 1910 4805 2204 - - 4361 4715 - - 4593 4681 - - - 7503 3891 4105 4233 4019 4121 3938 12 25 38 42

Aquaterra Technologies, Inc.

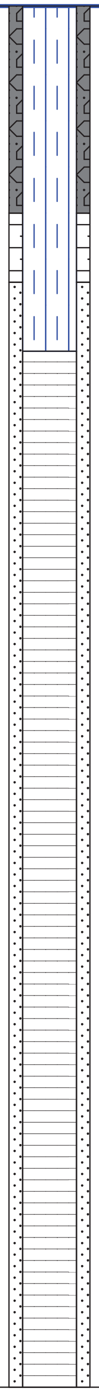
MONITORING WELL LOG: S-312

PROJECT: **Sunoco-Philadelphia Refinery**
SITE LOCATION: **AOI-2**
JOB NO.:
LOGGED BY: **S. Sykes**
DATES DRILLED: **4/28/10**
TOTAL DEPTH: **20'**

DRILLING CO.: **Parratt Wolff**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD: **Split Spoon**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **6"**
ELEVATION: **N/A**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
0				Hand cleared to 8'	
	0.0		50% Recovery - gravel, light brown to dark brown sandy silt, dry, no odor	Sample collected from (1'-2') submitted to the laboratory for analysis	
	0.0				
			Brown, sandy, clayey gravel, wet, no odors. Water @ 3'		5' PVC Riser Bentonite 3-4'
					Sand 4-20'
-5					
	357		Full recovery - Black/gray clayey (fine) sand, wet, strong odor		
	446				
-10	413		25% recovery - Same as above, gravel		15' PVC Screen
	376				
	263		BC=6-8-10-6, 25% recovery - black fine clayey sand, wet, strong odor		
	212				
	192		BC = 10-8-8-5, 25% recovery - same as above		
-15	201				
	276		BC = 10-6-10-8, 25% recovery - (16') same as above (17') black coarse sand and gravel, wet, strong odor		
	301				
	378		BC = 12-10-6-8, Full recovery - black coarse sand and gravel, wet, strong odor		
	291			Hollow stem auger terminal depth = 20'	
-20					

WELL DIAGRAM



Aquaterra Technologies, Inc.

MONITORING WELL LOG: S-388D

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **AOI-1**
JOB NO.:
LOGGED BY: **Tiffani Doerr**
DATES DRILLED: **12/3/13**
TOTAL DEPTH: **91' (boring); 82' (well)**

DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD: **Split Spoons**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **10" (HSA)**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0						
	5.6		Gravel, black sand & gravel, some wood/brick (fill)			
	175			Sample 0-2', laboratory analysis.		
	866					
	915		Dark gray clay/sandy clay, sl. moist changing to gray clay, strong odor.			
-5	973			Borehole cleared to 8' for utilities via backhoe		
	1025		Gray clayey sand, sl. moist, strong odor.			
	7.7		(1-1-8-5) Moist, mottled gray, silty fine sand w/ orange mottles. Few fine round gravels. 14" recovery.			
-10	7.9		(1-12-5-8) Same as above (SAA) w/ clay . (11-12' Red & brown angular gravels and f. sand). 13" recovery.			
	41.2					
	8.9		(10-14-14-18) Red-brown sand & gravel, multi-colored, heterogeneous f-m gravel, f-c sand, quartz, siltstone, sandstone. (Trenton gravel) 1.7' recovery.			
	3.6					
	3.0					
			(18-6-6-10) SAA; top 6" wet w/			

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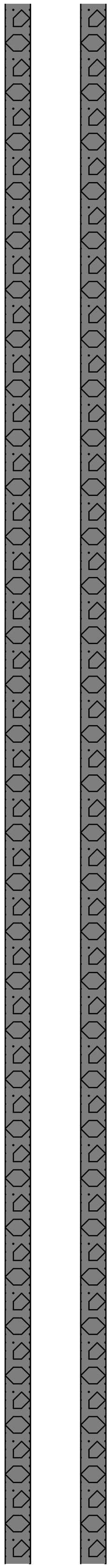
MONITORING WELL LOG: S-388D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
-15	69.1		clay (odors); bottom 4" sand. Full recovery.		Tremie Grout 0-65"
	18.7		(10-7-7-10) SAA f gravel, c sand. 1.4' recovery.		
	10.7				
	9.8		(9-4-15-27) SAA, lg gravels(f-c). 1.2' recovery.		
	47.1			Sample 19'-20', laboratory analysis.	
-20	1317		(14-42-50-13) 0.7' recovery, lg gravel (broken), qtz & ss.		
	12.8				
			(26-31-23-30) SAA. 12" recovery.		
	857				
			(4-8-16-29) wet, f-c gravel & sand, lg (>2" red ss gravel) 1.1' recovery.		
-25	456				
			(39-50) Saturated red-brown f-c sand & gravel. 0.9' recovery.		
	408				
			(5-14-15-17) Red, gray f-c sand w/ some f-c gravels. Clay lense at 29.5'. 1.3' recovery.		
	101				
-30			(6-11-16-15) Gray f-c sand & gravel, poorly sorted sub-round-sub angular. 1.4' recovery.		
	209				
	270		(10-11-13-14) SAA, gray f-c sand, some fine gravel. Full recovery.		

WELL DIAGRAM



MONITORING WELL LOG: S-388D

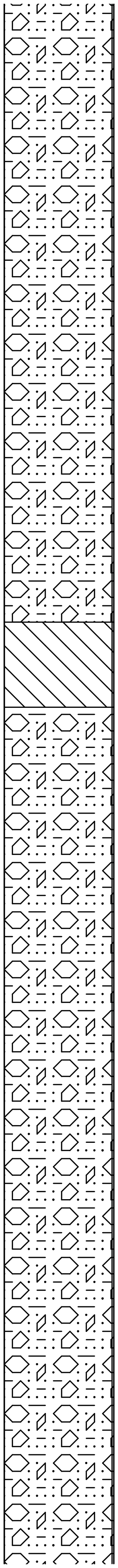
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	103					
	158		(2-1-2-3) Red/gray f-m sand, soft, trace f gravel (1.4' recovery)			
-35	340				4" PVC - Riser 0-72'	
			(11-14-5-3) SAA, lg qtz, f-c gravel (top 1'); plastic v. f sandy silt, red/gray clay at bottom (37'-38'). 22" recovery.			
	117					
	7.0		(3-2-4-9) gray/red f-m sand, gray f sandy clay; loose 39'-39.5'. 1.9' recovery.			
	2.2					
-40	1.4		(2-3-3-4) alt. layers (2-6") gray/brn f sand, c sand & sandy clay. Full recovery.			
	1.1					
	0.6		(4-4-6-7) Fining up sequence: med coarse sand - fine med sand - sandy clay. Full recovery.			
	0.6					
	0.8		(4-10-9-4) SAA			
-45	0.8					
	0.5		(5-5-7-18) SAA top 1' trace of gravel,med-coarse sand; bottom 1' fine sand gray/brown			
	0.1					
	0.1		(6-5-7-3) fine-coarse sand, trace round gravel, 1" clay lense. 1.3' recovery.			
	0.1					
-50			(3-6-6-9) gray/brown fine-med sand, broken red mudstone frags @ 51'. clay lense (<1"). 1.3' recovery.			
	0.0					

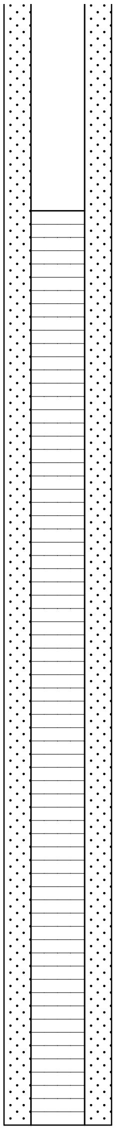
MONITORING WELL LOG: S-388D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
			(10-9-11-16) SAA, gray-brown f-c sand, 1 cm clay layer @53.5'. 12" recovery.			
	0.0					
			(9-8-8-6) SAA, no clay. 1' recovery.			
-55	0.0					
			(9-21-9-7) SAA w/ some sub-angular gravel. clay lense < 1cm at base. 1.2' recovery.			
	0.0					
			(6-11-13-26) red/gray sand & gravel. c sand & f-m gravel , f-m sand. gravels:qtz - semi round; mudstone & schist, frags weathered. 1.3' recovery.			
	0.0					
-60						
	0.0		(7-20-12-15) reddish gray fine-coarse sand w/ some fine-med gravel.			
	0.0		(16-27-35-25) Poorly sorted fine-coarse sand w some gravel, grayish brown. 0.9' recovery.			
			(11-26-31-34) Lg. red mudstone/ yellow sandstone, gravels @ base 4". Yellowish brown med-coarse sand w/ few gravels. 1.1' recovery.			
-65	0.0				Bentonite Slurry 65' - 69'	
	0.0		(28-24-33-36) Yellow brown fine-coarse sand w/ trace gravel. 1' recovery.			
			(50/0.2) No recovery. Auger to 69', can feel gravel.			
	0.0		(69-50/0.3) Brown-yellow sand & gravel (top 4"). Broken quartzite, gravel. 8" recovery.			

MONITORING WELL LOG: S-388D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-70	0.1				Sand 69' - 82'	
			(100/0.1) No recovery			
			(75-41-26-23) Lg red shale/mudstone gravel. 3" reddish-borwn fine-med sand (0.4' recovery).			
	0.0					
-75			(12-20-6-31) lt brn gray f sand (6"), red mudstone, orange-brn m sand. 1" orange/wht laminated v f sandy clay. quartz gravel in bottom. 1.5' recovery.			
	0.0					
					4" PVC - Screen 72' - 82"	
			(36-31-37-36) Top 1' gray white sandy clay. 4" white clayey gray sand w/ lg quartz gravel. Bottom 7" yellow med-coarse sand. 1.2' recovery.			
	0.0					
-80			(48-61-59-62) Lt brown fine sand, top 1.2', gravel w/ some sand, white/gray. Full recovery.			
			(23-20-62-78) SAA 0.9' recovery.			
	0.0			Well installed to 82' due to collapse and collaring in augers.		
-85			(15-35-52-78) white/gray med-coarse quartz sand w/ fines and fine multi-colored gravels. 1.1' recovery.			
	0.0					
			(48-25-44-53) SAA, gravels, fine-coarse, rounded. 0.7' recovery.			





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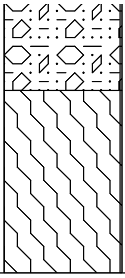
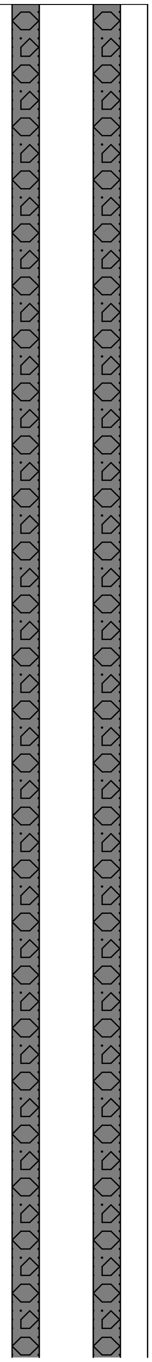
MONITORING WELL LOG: S-388D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-90			(28-9-24-8) yellow/gray banded saprolite. quartz grains and white/yellow clay. Sandy clay. Extremely weathered schist. 0.9' recovery.			

MONITORING WELL LOG: S-389D

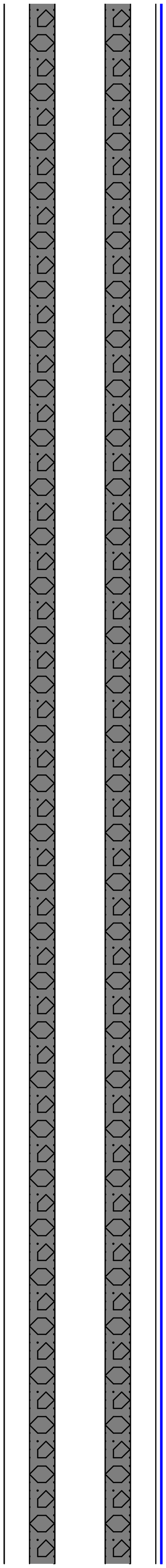
PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **AOI-1**
JOB NO.:
LOGGED BY: **Shaun Sykes/Tiffani Doerr**
DATES DRILLED: **12/9/13- 12/17/13**
TOTAL DEPTH: **86' (boring); 82' (well)**
DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger/Mud rotary**
SAMPLING METHOD: **Split Spoons**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **10" (HSA); 6" (Mud)**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0	12.2					
	135		Gravely, dark brn sand, silt, bricks, wood (fill).			
	161			Sample interval 0-2', 12/2/13 14:00		
-5	174		Dark brn/blk sandy silt, brick, sea shells, wood, blass bottles (fill). dry.	Borehole cleared to 8' for utilities via backhoe		
					4" PVC - Riser 0-72'	
	203		0.5' recovery. Brn/blk/gray fill, wood, some clay, large gravels, some sand.			
	11.3					
-10	13.5		0.3' recovery. SAA			
	14.7					
			0.3' recovery. m-c sand & mixed gravels (angular), some wood.			
	16.8					
			little recovery. m-c sand and lg angular gravels.			



MONITORING WELL LOG: S-389D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-15	32.3					
			0.7' recovery. Drk brn/blk f-m sand w/ mixed gravels, clay (10-20%), wet, odors.			
	165				4" PVC - Riser 0-72'	
			0.2' recovery. SAA			
	179					
-20	20.2		(5-7-14-18) Saturated black stained (sheen) gravel w/ some sand. Strong odors.		Tremie Grout 0-65'	
			(18-17-21-14) Sandy gravel w/ some clay * piece of metal screen in bottom of spoon. Recovery 0.7'; water (melted snow or surface water infiltration).			
	106					
				Sample interval 22' - 24', 12/11/13 8:30.		
	27.1		(5-10-15-19) Gray stained clayey f-c sand and gravel. Organics (wood) at top, strong odors.			
-25						
	55.8		(30-28-30-36) Med brown f-m sand and gravel. Some staining, 1.1' recovery, strong odors.			
	30.6		(11-32-41-24) SAA w/ f-c grayish brn; strong odors.			
-30	0.7		(7-11-3-5) Lt. gray plastic v. fine sandy silt. Top 2" gray/orange banded v. fine sandy clay. No odors.			
	0.5		(4-2-3-6) SAA w/o clay in top 2")			



MONITORING WELL LOG: S-389D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.0		(7-3-2-2) Lt Gray and orange v. fine sandy clay.			
-35					4" PVC - Riser 0-72'	
	0.0		(3-3-3-3) Dk. gray v. fine sandy clay.			
	4.1		(5-2-7-5) Lt gray sl plastic, f-m sand; slight chemical odor.			
-40	8.9		(3-3-8-7) SAA orange-gray in bottom 6"; same chemical odor (solvent?)			
	0.5		(5-5-6-9) Orangey-gray f-m sand, sl plastic. @ 43' dk orange & gray silty f-m sand. Same odor.			
	0.0		(2-2-2-4) Med brn sl plastic, silty fine sand, no odor.			
-45						
	0.0		(5-3-7-9) SAA. Overall med. brn color, gray/red/orange bands. Lower 0.4' fine sandy clay, med brn.			
	0.0		(6-4-5-11) SAA, 2" recovery.			
-50	0.0		(4-4-3-2) top 2" SAA. Reddish brown clay with few find sands.			

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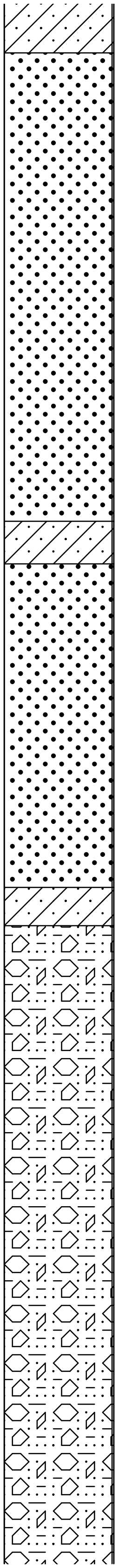
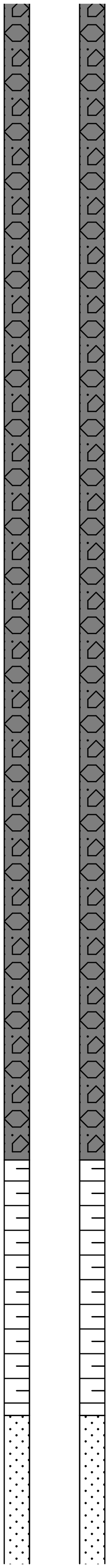
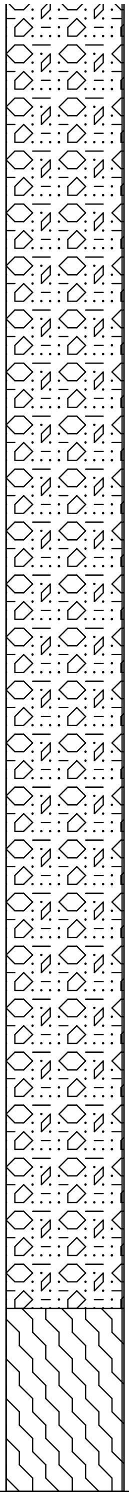
MONITORING WELL LOG: S-389D

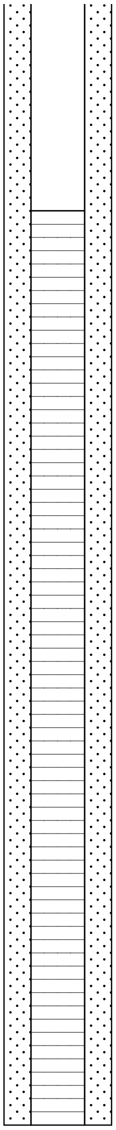




Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.0		(4-8-10-14) Reddish brn f-c sand, no clay; top 0.4'. Bottom 1.5' :Plastic fine red sand .			
	0.0		(7-8-7-9) 1.0' recovery. Top 0.4'; gray fine sl plastic sand. Bottom 0.6' ; same, reddish-brn.			
-55					4" PVC - Riser 0-72'	
	0.0		(8-4-5-5) 1.3' recovery. Same red f. sand w/ m-c sand & few f. gravel @ 57.7'. Red f. sandy clay @ 57.5'. Trace f. gravel & organics at bottom.			
	0.0		(1-3-7-6) 0.1' SAA. Lower 0.7': f-c sand and some f. gravel, reddish brn.			
-60	0.0		(2-10-13-10) 1.2' recovery. f-c reddish-brn sand, trace gravel. Gravel increasing toward bottom, clay lenses at bottom. Switch to mud rotary driiling.			
	0.0		(15-50-14-50) 1.0' recovery. Top 0.25': Red-brn f. sandy clay. Rest is med brn f-c sand and f-m gravel. semi-round poorly sorted.			
	0.0		(6-6-8-13) 1.1' recovery. Top 0.5': SAA Bottom 0.6': Med-brn fine sand.			
-65					Bentonite Slurry 65' - 68'	
	0.0		(16-13-14-12) 0.5' recovery. Med brn f-c sand & f-c gravel.			
	0.0		(8-11-12-17) 1.4' recovery. Top 0.5': Med brn f-c sand. Middle 0.5' C. sand & v. fine gravel. Lower 0.4': f. sand w/ lg gravel @ bottom.			

MONITORING WELL LOG: S-389D





Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-70	0.0		(15-26-33-20) 1.2' recovery. Top 0.5': Coarse sand & v. fine gravel. Bottom 0.7': gray-brn f-c gravel (>2") w/ some f-c sand.			
	0.0		(20-16-17-37) 1.7' recovery. Top 1.1': Med brn m-c sand w/ c. gravel @ base. Lower 0.6': Med brn f-m sand w/ few lg gravels @ base.		Sand 68' - 82'	
-75	0.0		(29-34-20-14) 1.3' recovery. Top 0.2': coarse sand & v fine gravel. Rest is lt gray coarse gravel w/ some sand and little clay. Bottom 1" lt gray m sand.			
	0.0		(9-11-15-16) 0.8' recovery. Lt gray f-m sand.		4" PVC - Screen 72' - 82'	
	0.0		(8-12-11-11) 0.9' recovery. Lt. gray m-c sand w/ trace gray qtz gravel.			
-80	0.0		(11-15-12-14) 1.0' recovery. SAA, top 0.3'. Next 0.4' graygreenish gray f sand. Bottom 0.3' gray sand & gravel. Lg gravel in tip.			
	0.0		(35-45-49-41) 1.3' recovery. Dk gray f-c sand & f-c gravel (qtz & qtzite). Tip of spoon: blk/gray biotite & qtz sand			
-85	0.0		(31-37-47-50) 1.0' recovery. Weathered Schist. Blk (biotite) & gray qtz sand, layered.			

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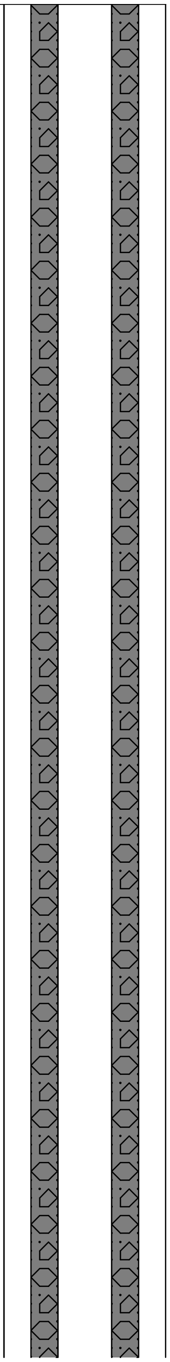
MONITORING WELL LOG: S-390D

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **AOI-1**
JOB NO.:
LOGGED BY: **Shaun Sykes/Tiffani Doerr**
DATES DRILLED: **12/18/13- 1/7/14**
TOTAL DEPTH: **92' (well); 94' (boring)**
DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger/Mud rotary**
SAMPLING METHOD: **Split Spoons**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **10" (HSA); 6" (Mud)**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
0	0.0				
	0.0		Gravely, dark brown/black sandy silt, dry brick fill.		
	0.0			Sample interval 0-2',	
			SAA		
-5	0.0		Orange brown sandy clay, moist.	Borehole cleared to 8' for utilities via backhoe	
	1.0		(WOH-3-3-5)1.5' recovery. Med Br CLAY, some fine sand, some gray mottling, moist, no petro-like odors.		
-10	1.8		(3-4-7-7)1.6' recovery. SAA to 11'. At 11' dk gray fine SAND, strong petro-like odor, petroleum staining.		
	55.1				
	198		(5-4-5-5)1.4' recovery. SAA top 0.5'. At 12.5' gray/orange mottled v. fine sandy CLAY.	Sample interval 12-12.5', 12/18/13, 1300.	
	6.1				
	0.9		(3-2-2-1)0.8' recovery. 0.3': Med br CLAY, some fine sand. 0.1': Lt gray sandy CLAY. Bottom 0.4': Dk gray loose f-m		

WELL DIAGRAM



MONITORING WELL LOG: S-390D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-15			SAND.			
	0.0		(1-1-1-1)full recovery. SAA with some f-m gravel to 16.5'. 16.5-18': Lt gray CLAY. soft.			
	0.0		(WOH/2)1.7' recovery. SAA to 19.5'. 19.5-20': Lt gray f-m sandy CLAY, trace v. fine gravel.			
-20			(WOH/2)full recovery. Lt gray CLAY, some silt and fine sand. Wood at base.		Tremie Grout 0-77'	
	0.6		(7-13-16-28)1.8' recovery. Top 0.5': Lt gray f-c SAND. 22.5-23': Lt gray f-m sandy CLAY. 23-24': Top 2" Gray/orange layered clayey SAND to Gray f-c SAND and f-m GRAVEL.			
	1.8					
	5.9			Wet at 24' bgs.		
-25			(8-9-14-14)0.9' recovery. Top 1": SAA. Med br f-c SAND and f-c Gravel, poorly sorted, petro-like odors.			
	2.4					
			(18-20-17-18)1.0' recovery. SAA - reddish gray (trenton gravel).			
	152		(12-19-16-33)1.0' recovery. SAA.	Sample interval 28-29', 12/19/13, 1000		
-30	72.9		(8-30-27-24)0.7' recovery. SAA.			
			(11-7-9-7) No recovery - large gravel in tip.			

MONITORING WELL LOG: S-390D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.4		(11-7-3-3)1.0' recovery.Top 1": SAA. Gray soft CLAY with orange layers, some fine sand. Bottom 1": Dk brownish gray silty CLAY.			
-35						
	0.1					
			(4-2-3-3)1.2' recovery. Dk brownish gray silty CLAY. Bottom 1": Gray clayey SAND.			
			(16-6-8-9) No recovery.			
-40						
	1.3		(6-4-5-6)1.5' recovery. Top half: reddish br f-m SAND. Bottom: SAND and CLAY, some m gravel, wet.			
	0.1		(7-6-6-9)0.8' recovery. Top half: SAA. Bottom: Reddish br clayey fine SAND.			
	0.0		(8-8-5-12)1.1' recovery. Top 0.1': Large GRAVEL. Middle 0.5': f-m SAND. Bottom 0.5': clayey SAND.			
-45						
			(10-16-14-18)1.2' recovery. Reddish br f-c SAND, no petro-like odor.			
	0.0		(4-2-5-8)1.5' recovery. Top 1': Reddish br f sandy CLAY. Bottom 0.5': Reddish br m-c SAND.			
-50	0.0		(4-6-8-11)1.1' recovery. SAA (sand), 0.5" clay lense.			

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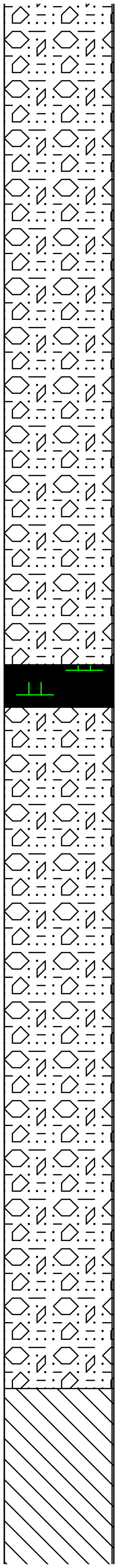
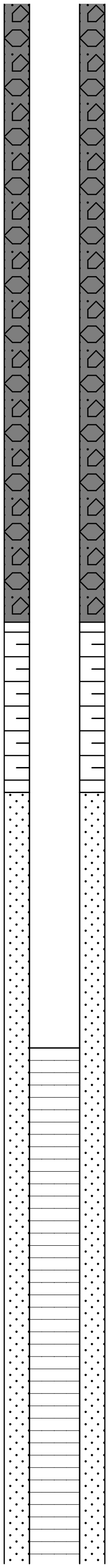
MONITORING WELL LOG: S-390D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.0		(7-11-11-11)1.2' recovery. SAA.			
	0.1		(21-10-9-10)0.7' recovery. Reddish br f-c SAND, some f-c gravel. 1" clay lense at top, solvent odor.			
-55					4" PVC - Riser 0-82'	
	1.1		(9-9-8-10)1.3' recovery. Top 0.4': f-c SAND with 1" clay lense. Bottom 0.9': f sandy CLAY with 1" orange brown f sand layer, solvent odor.			
	0.0		(8-8-10-15)1.5' recovery. Orange br f-c SAND, few clay nodules, few f gravel at base.	Switch to Mud Rotary Drilling at 58' bgs.		
-60	0.0		(15-13-11-12)1.2' recovery. SAA - f gravel increasing in size and frequency to 61.5'. Bottom 0.5': red br clayey f-m SAND.			
	0.0		(9-8-11-14)1.3' recovery. Med br f-m SAND. 2" clay plug @ 63'.			
	0.0		(18-15-14-12)1.1' recovery. SAA to 65' with few gravels at 65'. 65-66': Reddish br f-m SAND, few f-c gravel.			
-65						
	0.0		(10-17-13-9)0.8' recovery. Top 0.5': Med br f-m SAND. Bottom 0.3': f-c SAND, few f gravel.			
	0.0		(9-12-16-15)0.7' recovery. Med br f-c SAND and f-c GRAVEL.			

MONITORING WELL LOG: S-390D





Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-70	0.0		(39-41-30-29)1.0' recovery. Reddish gray f-c SAND and f-c multi-colored GRAVEL (green, blk, yellow, red).			
			(15-13-10-10) No recovery.			
	0.0		(16-15-42-24)0.6' recovery. SAA. Bottom 0.3': f-m SAND.			
-75						
	0.0		(9-8-9-11)1.1' recovery. Top 1": GRAVEL. Lt gray f-m SAND. 0.5': Peat layer at 77.5' (compacted leaves - leaf pattern visible). Bottom 0.5': Dk gray sandy CLAY at 78'.		Bentonite Slurry 77' - 79'	
	0.0					
			(9-14-16-21)1.5' recovery. Lt gray f-c SAND and dk gray f-m SAND, trace v. fine gravel.		Sand 79' - 92'	
-80	0.0		(16-19-18-17)0.8' recovery. Top 0.4': Lt gray f-c SAND (to 81' bgs). Bottom 0.4': f-c GRAVEL (up to 1"), some f-c sand. Green and white quartzite.			
	0.0		(25-33-23-17)0.8' recovery. SAA f-c GRAVEL, some sand. Green, gray with red mudstone in bottom.		4" PVC - Screen 82' - 92'	
	0.0		(33-40-33-17)1.1' recovery. Green f-c GRAVEL with f-c sand, loose at bottom.			
-85						
	0.0		(10-16-24-31)full recovery. 86-87.5': Lt gray CLAY. 87.5-88': Lt gray and red mottled CLAY.			
			(28-26-30-50/0.4)1.2' recovery. Red and gray CLAY, some f			

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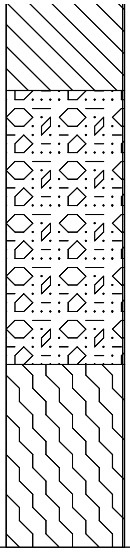
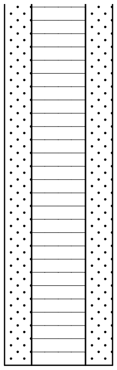
MONITORING WELL LOG: S-390D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.0		sand toward bottom of spoon. Bottom 6": Lt and dk gray m-c quartzite GRAVEL.			
-90	0.0		(33-27-30-31)1.0' recovery. Med gray f-c SAND, some gravel.			
	0.0		(20-29-40-43)full recovery. SAPROLITE (extremely weathered bedrock/schist), little grayish white clay matrix, mostly silver mica (muscovite).	Borehole terminated at 94' bgs.		





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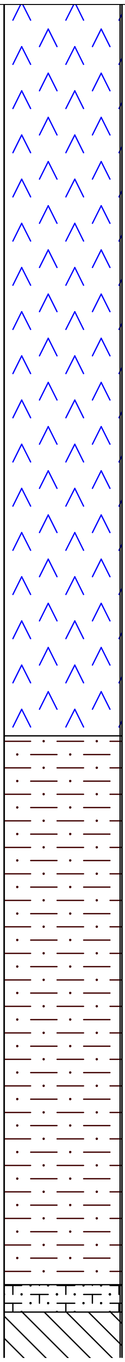
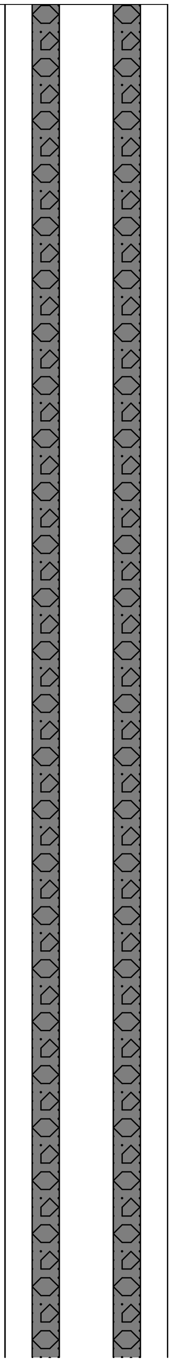
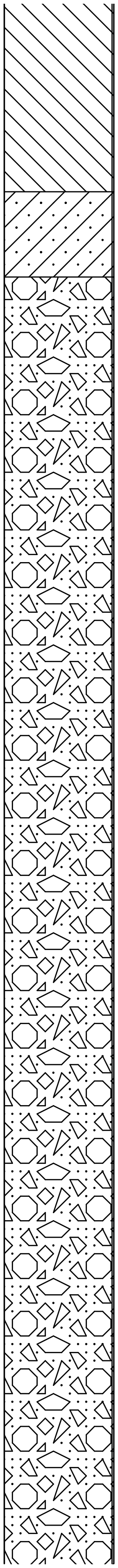
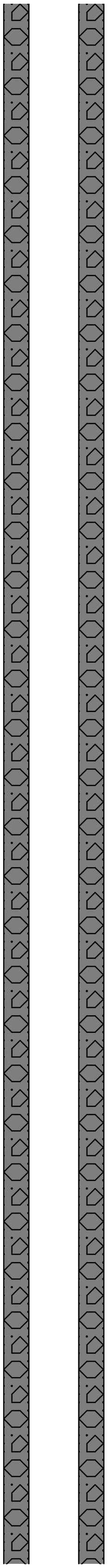
MONITORING WELL LOG: S-391D

PROJECT:	**Sunoco - Philadelphia Refinery**	DRILLING CO.:	**Parratt Wolff, Inc.**
SITE LOCATION:	**AOI-1**	DRILLING METHOD:	**Hollow Stem Auger/ Mud rotary**
JOB NO.:		SAMPLING METHOD:	**Split Spoons**
LOGGED BY:	**Shaun Sykes/Tiffani Doerr**	SCREEN/RISER DIAMETER:	**4"**
DATES DRILLED:	**12/9/13- 1/15/14**	WELLBORE DIAMETER:	**10" (HSA); 6"(Mud)**
TOTAL DEPTH:	**98' (well); 99.9' (boring)**	ELEVATION:	

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0	1281					
			Gravel, brown/black Sand , brick (Fill),Silt, strong odor, dry.	Soil sample collected at 0-2'.		
	1210					
			Black, dark gray Silty Sand, sl. moist, strong odor.			
	1370					
-5						
			Dark gray/black Sandy Clay, moist, strong odor.	Borehole cleared to 8' for utilities via backhoe		
	1238			Split spoon sampling started at 8'		
			Gray sand, trace Clay, moist, strong odor.			
	285					
			(4-4-5-6) 1.5' recovery. V. strong odors @ top, slight odors @ bottom. Native soil, Gray Silt, moist.			
	18.5					
-10	5.8		(3-4-5-7) 1.7' recovery. SAA to 11'			
	1104		Brn & gray layered silt w/ fine gray Sand lenses. Trace subround Gravel at base. High pid's in sand lenses only.			
	333			Soil sample collected at 11'-12'		
			(4-6-8-7) 0.5' recovery. Loose, saturated drk gray fine Sand.			
	3.3		(4-3-4-5) 1.2' recovery. Top 0.3' gray Silty v. fine Sand. Rest is orange and tan layered			

MONITORING WELL LOG: S-391D





Depth (feet)	OVM (ppm)	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
-15		(laminated) Clay, moist.		
	5.9	(4-2-5-13) 1.5' recovery. SAA to 17'.		
		@ 17' med brn, moist v. fine Sandy Clay w/ trace fine gravels. Tip of spoon is lt. brn med-coarse sand.		
	0.4	(33-50-50/0.4) Recovery most likely Clays from above, (very loose). Most likely pushed lg. gravel.		
-20		(34-41-48-25) No recovery.		
	167	(7-14-16-16) 1' recovery. Reddish brn f-c Sand w/ some f-m Gravel. (Trenton - top @ 18' most likely) Multi-colored hetereogeneous.		
	1094	(5-4-8-10) 1.5' recovery. Reddish-brn f-m Sand. No gravel.		
-25				
	687	@25.5' reddish brn f-c Sand w/ trace f. Gravel. Saturated @ ~25'.		
		(12-17-16-18) 1.2' recovery. SAA (f-c Sand w some fine Gravel) 1 lg. gravel in bottom.		
	327	(14-25-25-22) 1.2' recovery. SAA.		
		@29' f-c Sand & f-m Gravel (more & larger gravel)		
-30	588	(9-19-14-14) 1.4' recovery. SAA.		
	21.4	(13-16-17-14) 1.4' recovery. SAA (orangy brn, smaller gravels)		

MONITORING WELL LOG: S-391D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	4.1		(16-10-9-10) 1.1' recovery. SAA.			
-35						
	0.7		(8-9-19-17) 1.2' recovery. SAA to 37'. Same color, more & larger gravel, f-c sand, f-c gravel.			
	0.0		(26-8-5-4) 0.2' recovery. Very loose sandy GRAVEL with gray clay lense (possible fall in).			
-40	0.0		(WOH/2') Full recovery. Gray & orange laminated CLAY, trace f sand, very soft.			
	0.0		(WOH/2') Full recovery. SAA to 43' (no laminations) - solid tan color @ 43'.			
	0.4		(4-5-8-8) 1.4' recovery. Top 0.2': Dk gray f-c SAND. Next 0.5': Brownish gray clayey fine SAND. Next 0.3': Brownish gray f-c SAND. Bottom 0.4': Med brown f-m SAND, some clay.			
-45						
	3.7(sand) 0.0 (clay)		(8-10-10-10) Full recovery. SAA to 47.5'. Reddish brown CLAY, trace f sand.			
	0.0		(WOH-3-5-5) Full recovery. Reddish brown CLAY, little f sand, very soft.			
-50	0.0		(WOH/1.5') Full recovery. SAA to 51.5'. Reddish brown fine sandy CLAY, trace gravel.			

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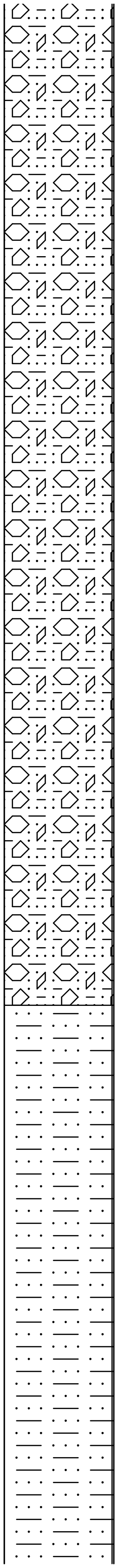
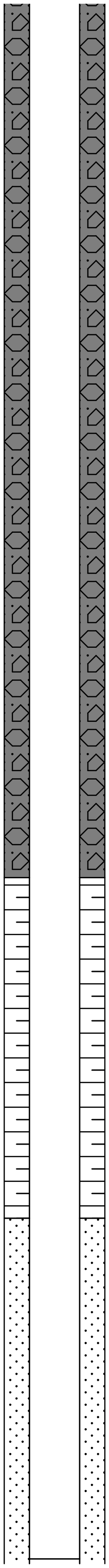
MONITORING WELL LOG: S-391D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.0		(6-5-6-6) Full recovery. SAA to 52.5'. Next 0.2': Red brown m-c SAND. Bottom 1.3': Reddish brown CLAY, trace f sand.			
	1.2		(WOH/2') Full Recovery. SAA.			
-55						
	0.0		(4-5-5-5) Full recovery. SAA to 57.5'. Reddish brown clayey f SAND.			
	0.0		(WOH/1'-7-6) Full recovery. Reddish brown (some gray zones) slightly micaceous CLAY, some f sand to 59.2'. Clayey f SAND from 59.2' - 60'.	Switched to mud rotary drilling.		
-60	0.0		(8-12-17-15) 1.5' recovery. SAA to 60.5'. Redish brown slightly micaceous f SAND, trace clay.		Tremie Grout 0 - 80'	
	0.0		(10-12-14-18) 1.6' recovery. SAA.			
	0.0		(14-24-28-29) 1.2' recovery. Reddish brown f-m SAND (coarse sand last 0.5').			
-65						
	0.0		(12-13-15-17) 1.4' recovery. SAA (f-c SAND, single clay lense approx. 1").			
	0.0		(10-15-14-18) 1.6' recovery. SAA (trace very fine gravels).			

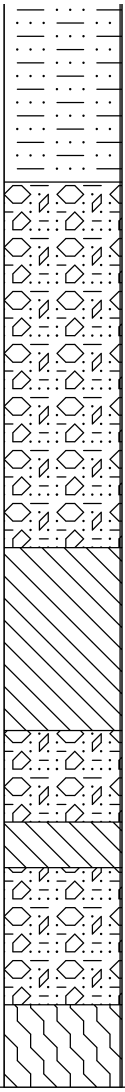
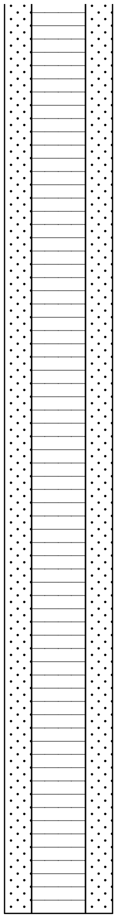
MONITORING WELL LOG: S-391D





Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-70	0.5		(13-18-19-15) 0.8' recovery. SAA (slight chemical odor).			
	0.3		(11-15-32-29) 0.9' recovery. Reddish brown f-c SAND with f-c gravel, very slight chemical odor.			
			(25-22-16-27) 0.5' recovery. Reddish brown f-c GRAVEL with f-c sand.			
-75						
	0.0		(31-33-36-38) 1.5' recovery. Reddish gray f-c GRAVEL (sandstone & quartz, broken & some decomposed gravel)			
	0.0		(27-35-60-40) 1.2' recovery. SAA.		4" PVC - Riser 0 - 88'	
-80	0.0		(30-28-16-15) 1.2' recovery. SAA to 81.5'. Next 0.2': Gray micaceous f-c SAND. Next 0.1': greenish gray micaceous v. fine sandy CLAY. Next 0.1': Dk brown laminated SILT (organics). Bottom 0.1': Gray micaceous clayey f SAND.		Bentonite Seal 80' - 84'	
	0.0		(7-11-12-14) 1.7' recovery. Alternating layers of 1-2" thick dk gray f micaceous SAND ; dk brown organics (leaf patterns visible) 1/4" - 1"; thin layers of dk brown silty CLAY, trace f sand.			
	0.0		(18-22-24-26) 1.8' recovery. SAA (thicker sand & clay layers).		Sand 84' - 98'	
-85						
	0.0		(5-9-13-20) Full recovery. SAA.			

MONITORING WELL LOG: S-391D

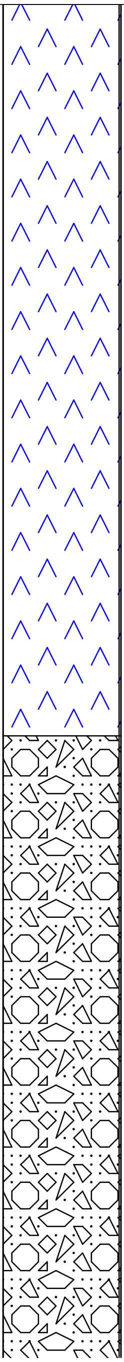
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.0		(16-21-20-29) 1.8' recovery. Top 1': brownish gray slightly micaceous f-m SAND. Bottom 1': SAA (clay, sand, organic layer).		4" PVC - Screen 88' - 98'	
-90	0.0		(13-15-26-31) 1.1' recovery. Grayish brown f-c SAND with f-m gravel.			
			(14-10-13-12) No recovery.			
	0.0		(12-5-5-9) Full recovery. Dark gray CLAY, some sand.			
-95						
	0.0		(8-13-49-50/4") Full recovery. Top 1': dk gray f-c SAND & f-m GRAVEL. Next 0.5': dk gray CLAY. Bottom 0.5': SAND & GRAVEL.			
	0.0		(42-20-36-50/0.4') 1.5' recovery. Top 1': dk gray f-c SAND & f-m GRAVEL. Bottom 1': Weathered SCHIST(black biotite & green chlorite).	Borehole terminated at 99.9' bgs.		

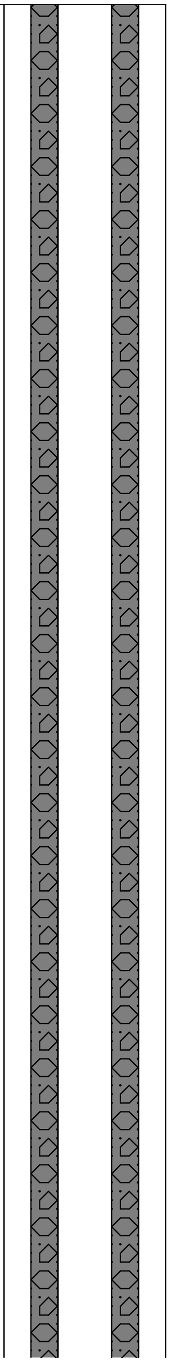
Aquaterra Technologies, Inc.

MONITORING WELL LOG: S-392D

PROJECT:	**Sunoco - Philadelphia Refinery**	DRILLING CO.:	**Parratt Wolff, Inc.**
SITE LOCATION:	**AOI-1**	DRILLING METHOD:	**Hollow Stem Auger/ Mud rotary**
JOB NO.:		SAMPLING METHOD:	**Split Spoons**
LOGGED BY:	**Shaun Sykes/Tiffani Doerr**	SCREEN/RISER DIAMETER:	**4"**
DATES DRILLED:	**1/9/14- 1/14/14**	WELLBORE DIAMETER:	**10" (HSA); 6" (Mud)**
TOTAL DEPTH:	**72' (well); 74' (boring)**	ELEVATION:	

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0	5.6					
	95.5		Gravel, green to black sand & silt, brick, wood (fill) dry.			
	156					
			SAA, very compact (fill) concrete.			
	163					
-5			Brown/green silty sand and rounded gravels, sl. moist, lg rocks/gravels, less silt with depth, mixed rounded gravels.	Borehole cleared to 8' for utilities via backhoe		
	12.6					
	33.6		(2-7-9-12) Moist 1' recovery. Fine - coarse sand w/ some fine-med gravel, lt. grayish brown. No odor.			
	0.0					
-10			(7-11-14-14) 1.7' recovery. SAA but fine-coarse gravel, multi-colored (red mudstone, gray qtz., yellow qtzite, some gravels, completely weathered) (Trenton).	Split spoon sampling started at 8'		
	0.0					
			(13-12-6-6) Full recovery. Slight odors, no pid. SAA to 13.5'. At 13.5' reddish gray plaster, v. fine sandy silt.			
	0.0					
			(3-4-8-8) 1.4' recovery. Reddish gray fine-coarse sand & fine-coarse gravel (SAA).			





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MONITORING WELL LOG: S-392D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-15	0.0					
	0.0		(8-12-14-11) 1.5' recovery. SAA. Inside of spoon v. moist @ 17'.			
	3.4			Soil sample collected at 17' - 18', as soil sample above water table.		
			(6-12-11-17) 0.5' recovery. WET, mostly 2 large gravels (broken). Lt gray sand in top of spoon.			
	10.9					
-20			(10-14-13-18) 1.2 recovery. Same sand & gravel.		4" PVC - Riser 0-62'	
	165					
	1361		(6-8-10-13) 1.3' recovery. SAA.			
-25	1286					
	1148		(11-9-7-6) 1.0' recover. SAA.			
			(5-5-5-5) 1.7' recovery. Top 0.4' gray fine-coarse sand, trace gravel (bottom of last unit). 0.5' orange clay w/ trace sands. 0.8' dk gray clay.			
	18.7					
-30	8.5		(2-2-2-3) 1.4' recovery. Top 0.4' orange clay w/ few sands. Bottom 1.0' gray clay w/ few sands (in thin layers ~#2).		Tremie Grout 0-55'	
	12.7					
			(3-3-3-3) 1.2' recovery. Same gray clay w/ few sand layers.			

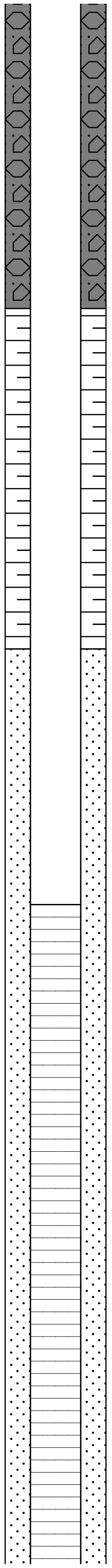
MONITORING WELL LOG: S-392D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	24.8					
			(2-2-3-3) Full recovery. SAA. Trace white/yellow clay bands.			
-35	32.3					
			(8-6-15-11) Full recovery. Top 0.3' SAA Sl more brown. Mid 1.4' brown fine-coarse sand, bottom 0.3' brn clay w/ sand.			
	24.2					
	19.2		(8-8-7-7) 1.3' recovery. Orange fine-coarse sand w/ 0.5" - 2" clay lenses.			
	6.2					
-40						
			(3-2-3-4) 1.2' recovery. Brown fine-corase sand layers w/ trace fine-med gravel w/ alt. layers of fine sandy clay. (~2" thick, gray at end).			
	3.4					
			(7-12-9-10) No recovery. Broken gravel gragments in spoon. Black/gray coarse gravel.			
	'-					
			(6-6-6-5) 1.1' recovery. Lt. gray fine-coarse sand w/ trace of gravel & trace clay lense.			
-45	2.1					
			(5-8-12-12) 1.3' recovery. Gray f-c sand, single 1" clay lense @ 47'. No gravel.			
	1.1		47'-48' Dark gray coarser sand.			
			(9-10-9-9) 1.2' recovery. Yellowish brown fine-med sand w/ trace fine gravel & trace clay lenses.			
	1.4					
-50						
			(3-7-9-9) 1.2' recovery. SAA - No clay tine-coarse sand.			
	3.8					

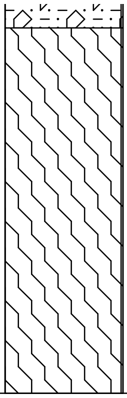
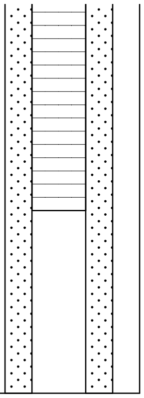
MONITORING WELL LOG: S-392D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
			(6-6-9-8) 0.9' recovery. SAA.		
			(5-8-8-8) 1.0' recovery. SAA - darker orange-brown.		
-55	1.5				Bentonite Seal 55' - 59'
	0.2		(8-13-27-24) 1.3' recovery. SAA to 57.5'. Last 0.5' fine-coarse gravel w/ f-c sand. No color change.		
	0.0		(31-43-48-49) 1.4' recovery. Yellowish brown find-coarse gravel (qtz or qtzite) w/ f-c sand.		
-60				Switch to mud rotary at 58'.	Sand 59' - 74'
	0.0		(17-14-12-31) 0.9' recovery. SAA - less and smaller gravel.		
	0.0		(25-30-18-19) Full recovery. SAA - f-c sand w/ some f-c gravel. V. stiff but loose and saturated @ 63' (~3" zone).		
			(15-19-21-42) 1.5' recovery. SAA to 64.5'		
-65	0.0		64.5' - 66' gray f-c sand w/ some f-m gravel. changes to brown toward bottom. Last 1" lt. tan lg gravel w/ little sand.		4" PVC - Screen 62' - 72'
	0.0		(21-19-25-17) 0.9' recovery. Tan f-c gravel w/ f-c sand. Qtzite gravels are brown & gray. Bottom 2" yellow laminated clay.		
	0.0		(24-38-36-25) 1.0' recovery. Top 2" same yellow clay w/ lg qtz gravel in it. Rest is yellow v.		

WELL DIAGRAM



MONITORING WELL LOG: S-392D

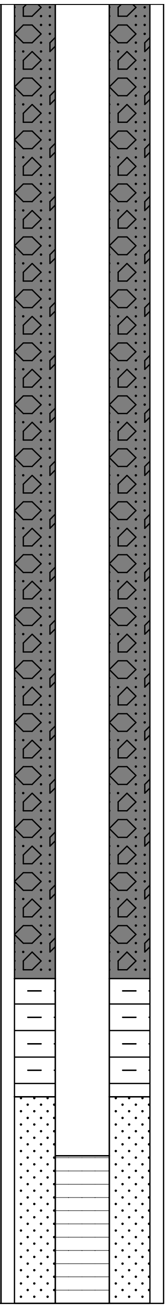
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-70			fine to med gravel w/ coarse sand. ~5% silt or clay creates yellow color (gravels are white/gray/pink qtz).			
	0.0		(9-11-14-18) Full recovery. Top 3" orange saprolite. Rest gray saprolite, dk gray muscorite w/ white clay matrix.			
				Borehole terminated at 74' bgs.		
			(16-41-36-46) Full recovery. SAA.			

Aquaterra Technologies, Inc.

MONITORING WELL LOG: S-396

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **AOI-1**
JOB NO.:
LOGGED BY: **Luke Mokrycki**
DATES DRILLED: **2/27/14**
TOTAL DEPTH: **44'**

DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD:
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **10"**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0 -5 -10 -15 -20 -25 -30 -35 -40			See S-389D well log for lithology.	Well installed adjacent to S-389D. Boring terminated.	4" PVC Riser 0 - 39' Tremie Grout 0 - 33' Bentonite Seal 33' - 37' Sand 37' - 44' 4" PVC Screen 39' - 44'	

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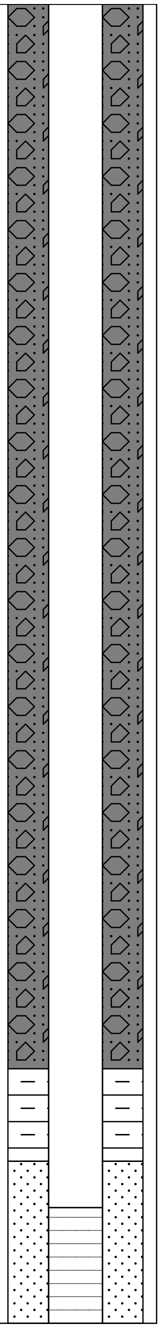
MONITORING WELL LOG: S-397

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **AOI-1**
JOB NO.:
LOGGED BY: **Luke Mokrycki**
DATES DRILLED: **3/4/14**
TOTAL DEPTH: **57'**

DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD:
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **10"**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
0			See S-390D well log for lithology.	Well installed adjacent to S-390D.	
-5					
-10					4" PVC Riser 0 - 52'
-15					
-20					Tremie Grout 0 - 46'
-25					
-30					
-35					
-40					
-45					Bentonite Seal 46' - 50'
-50					Sand 50' - 57' 4" PVC Screen 52' - 57'
-55				Boring terminated.	

WELL DIAGRAM



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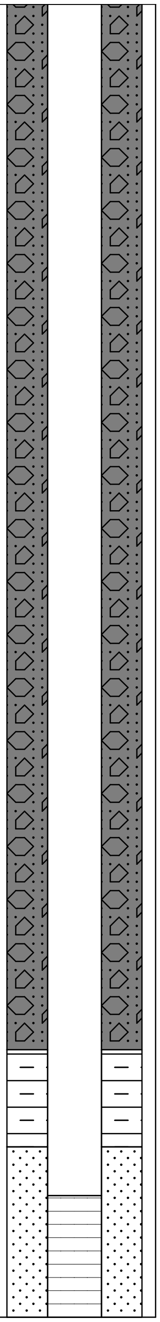
MONITORING WELL LOG: S-398

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **AOI-1**
JOB NO.:
LOGGED BY: **Luke Mokrycki**
DATES DRILLED: **3/5/14**
TOTAL DEPTH: **54'**

DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD:
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **10"**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0						
			See S-388D well log for lithology.	Well installed adjacent to S-388D.		
-5						
-10					4" PVC Riser 0 - 49'	
-15						
-20					Tremie Grout 0 - 43'	
-25						
-30						
-35						
-40						
					Bentonite Seal 43' - 47'	
-45						
					Sand 47' - 54'	
					4" PVC Screen 49' - 54'	
-50						
				Boring terminated.		

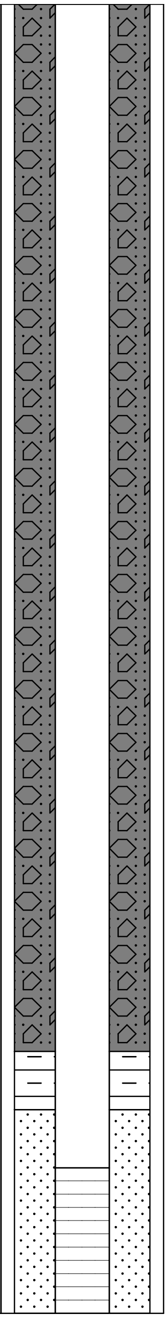
Aquaterra Technologies, Inc.

MONITORING WELL LOG: S-399

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **AOI-1**
JOB NO.:
LOGGED BY: **Luke Mokrycki**
DATES DRILLED: **3/6/14**
TOTAL DEPTH: **45'**

DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD:
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **10"**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			See S-392D well log for lithology.	Well installed adjacent to S-392D.		
-5						
-10					4" PVC Riser 0 - 40'	
-15						
-20					Tremie Grout 0 - 36'	
-25						
-30						
-35					Bentonite Seal 36' - 38'	
-40					Sand 38' - 45' 4" PVC Screen 40' - 45'	
-45				Boring terminated.		

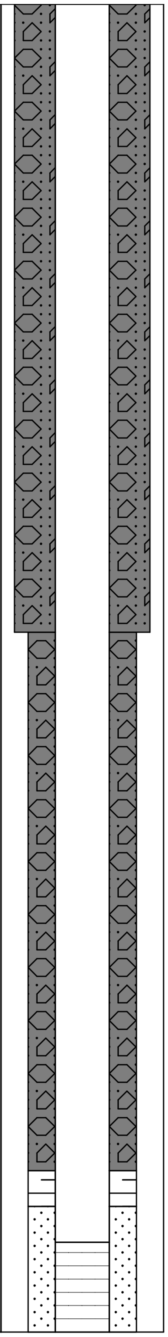


Aquaterra
Technologies, Inc.

MONITORING WELL LOG: S-400

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **AOI-1**
JOB NO.:
LOGGED BY: **Luke Mokrycki**
DATES DRILLED: **3/11/14**
TOTAL DEPTH: **74'**

DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger/Mud Rotary**
SAMPLING METHOD:
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **10" (HSA); 6" (Mud)**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			See S-391D well log for lithology.	Well installed adjacent to S-391D.		
-5						
-10					4" PVC Riser 0 - 74'	
-15						
-20					Tremie Grout 0 - 65'	
-25						
-30						
-35				Switched to Mud Rotary.		
-40						
-45						
-50						
-55						
-60						
-65					Bentonite Seal 65' - 67' Sand 67' - 74'	
-70				Boring terminated.	4" PVC Screen 69' - 74'	

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Aquaterra Technologies, Inc.

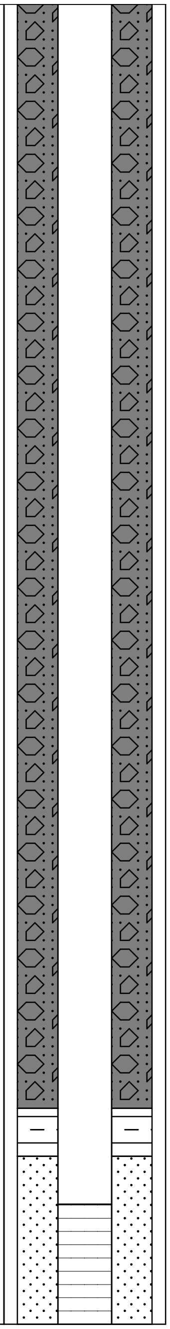
MONITORING WELL LOG: S-401

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **AOI-1**
JOB NO.:
LOGGED BY: **Luke Mokrycki**
DATES DRILLED: **3/13/14**
TOTAL DEPTH: **55'**

DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING METHOD:
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **10"**
ELEVATION:

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
0			See S-391D well log for lithology.	Well installed adjacent to S-391D.	
-5					
-10					4" PVC Riser 0 - 50'
-15					
-20					Tremie Grout 0 - 46'
-25					
-30					
-35					
-40					
-45					Bentonite Seal 46' - 48' Sand 48' - 55'
-50					4" PVC Screen 50' - 55'
-55				Boring terminated.	

WELL DIAGRAM



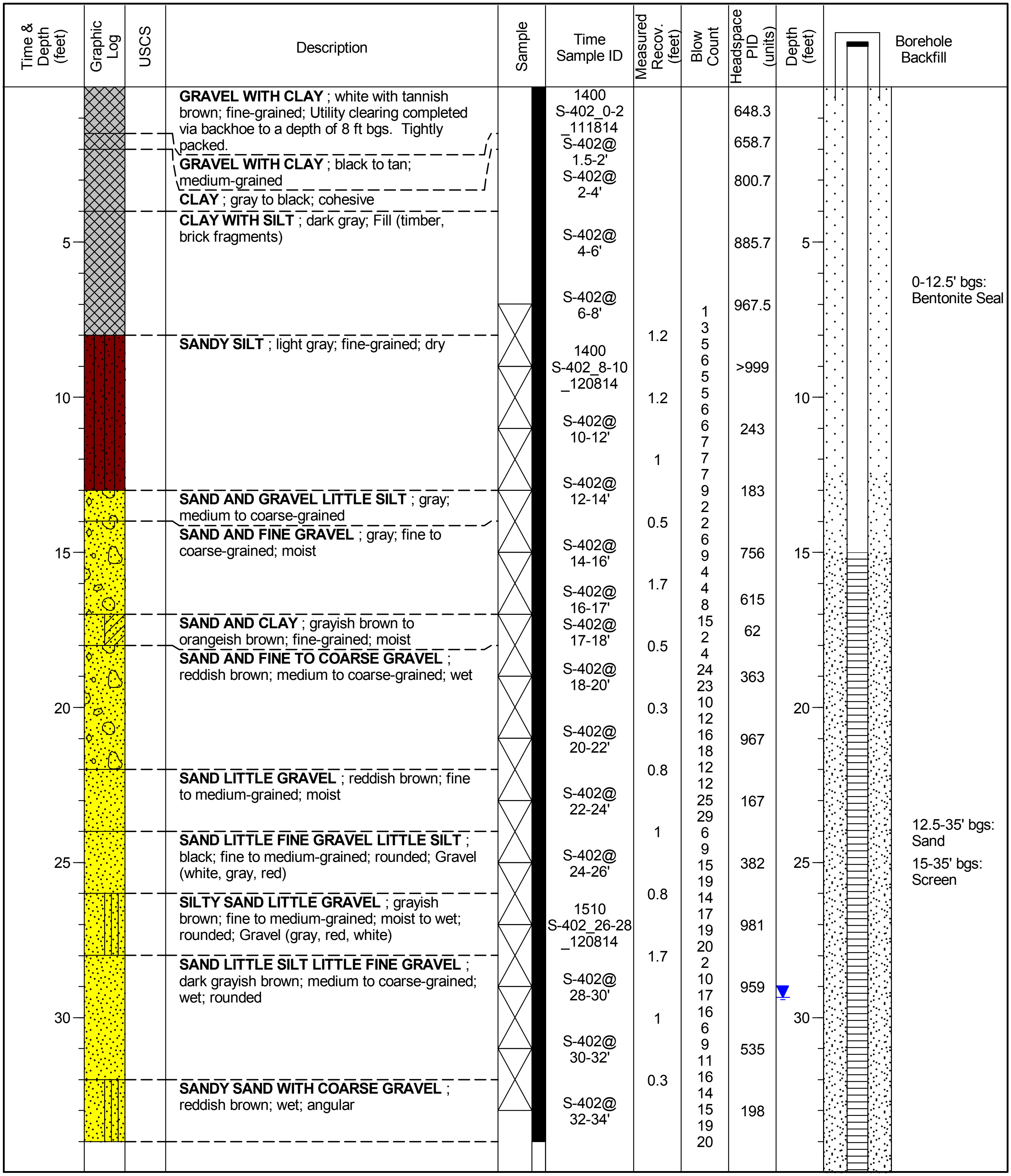
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:

S-402

PAGE 1 OF 1

DRILLING / INSTALLATION:	NORTHING (ft):	EASTING (ft):
STARTED **11/18/14** COMPLETED: **12/9/14**	LAT:	LONG:
DRILLING COMPANY: **Parratt Wolff**	GROUND ELEV (ft):	TOC ELEV (ft):
DRILLING EQUIPMENT: **Auger Rig**	INITIAL DTW (ft): **Not Encountered**	WELL DEPTH (ft): **35.0**
DRILLING METHOD: **HSA**	STATIC DTW (ft): **29.35**	BOREHOLE DEPTH (ft): **35.0**
SAMPLING EQUIPMENT: **Split Spoon**	WELL CASING DIA. (in): **4**	BOREHOLE DIA. (in):
	LOGGED BY: **LM/SS**	CHECKED BY:



Time & Depth (feet)	Description	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
	GRAVEL WITH CLAY ; white with tannish brown; fine-grained; Utility clearing completed via backhoe to a depth of 8 ft bgs. Tightly packed.	1400 S-402_0-2_111814			648.3		
	GRAVEL WITH CLAY ; black to tan; medium-grained	S-402@ 1.5-2'			658.7		
	CLAY ; gray to black; cohesive	S-402@ 2-4'			800.7		
5	**CLAY WITH SILT** ; dark gray; Fill (timber, brick fragments)	S-402@ 4-6'			885.7	5	
		S-402@ 6-8'	1.2	1 3 5 6	967.5		0-12.5' bgs: Bentonite Seal
	SANDY SILT ; light gray; fine-grained; dry	1400 S-402_8-10_120814	1.2	5 5 6 6	>999		
10		S-402@ 10-12'	1	7 7 7 9	243	10	
	SAND AND GRAVEL LITTLE SILT ; gray; medium to coarse-grained	S-402@ 12-14'	0.5	2 2 6 9	183		
15	**SAND AND FINE GRAVEL** ; gray; fine to coarse-grained; moist	S-402@ 14-16'	1.7	4 4 8 15	756	15	
	SAND AND CLAY ; grayish brown to orangeish brown; fine-grained; moist	S-402@ 16-17'			615		
		S-402@ 17-18'	0.5	2 4 24 23	62		
	SAND AND FINE TO COARSE GRAVEL ; reddish brown; medium to coarse-grained; wet	S-402@ 18-20'	0.3	10 12 16 18	363		
20		S-402@ 20-22'	0.8	12 12 25 29	967	20	
	SAND LITTLE GRAVEL ; reddish brown; fine to medium-grained; moist	S-402@ 22-24'	1	6 9 15 19	167		12.5-35' bgs: Sand
25	**SAND LITTLE FINE GRAVEL LITTLE SILT** ; black; fine to medium-grained; rounded; Gravel (white, gray, red)	S-402@ 24-26'	0.8	14 17 19 20	382	25	15-35' bgs: Screen
	SILTY SAND LITTLE GRAVEL ; grayish brown; fine to medium-grained; moist to wet; rounded; Gravel (gray, red, white)	1510 S-402_26-28_120814	1.7	2 10 17 16	981		
	SAND LITTLE SILT LITTLE FINE GRAVEL ; dark grayish brown; medium to coarse-grained; wet; rounded	S-402@ 28-30'	1	6 9 11 16	959	▼	
30		S-402@ 30-32'	0.3	14 15 19 20	535	30	
	SANDY SAND WITH COARSE GRAVEL ; reddish brown; wet; angular	S-402@ 32-34'			198		

Borehole terminated at 35 feet.

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
S-403 PAGE 1 OF 1

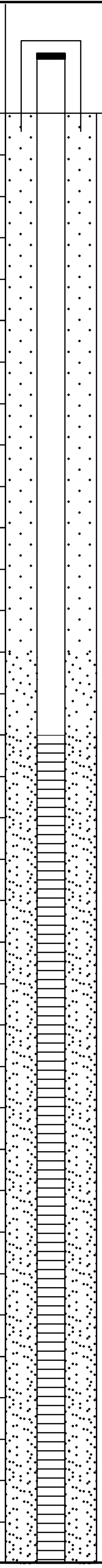
DRILLING / INSTALLATION:
STARTED **11/17/14** COMPLETED: **12/11/14**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **21.05**
WELL CASING DIA. (in): **4**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Description	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	SILTY CLAY WITH MEDIUM TO COARSE SAND ; black to orangeish brown; medium to coarse-grained; Utility clearing completed via backhoe to a depth of 8 ft bgs.	1100 S-403_0-2 _111814			208.7	
	CLAY WITH SILT ; black; loose	S-403@ 2-4'			247.2	
5	**CLAY** ; gray; very cohesive	S-403@ 4-6'			483.7	5
	CLAY ; gray and tan; Fill (timbers)	S-403@ 6-8'			654.3	
	SILTY SAND TRACE CLAY ; gray and brownish red; fine-grained; moist	1230 S-403_8-10 _121014	1.3	3 3 6 8	484	
10	**SANDY SILT** ; black to gray; fine-grained; moist to wet	S-403@ 10-12'	1	2 3 3 6	343	10
	SANDY CLAY WITH SILT ; orange and gray; fine-grained; moist; Compact.	S-403@ 12-14'	1	3 7 8 9	8	
15	**SILTY CLAY LITTLE ORGANICS** ; gray and brown; moist	S-403@ 14-16'	1.2	woh woh woh 2	43	15
		S-403@ 16-18'	1.3	2 3 2 6	16	
	SILTY CLAY TRACE ORGANICS ; gray and brown; moist to wet; Compact.	S-403@ 18-20'	1.5	8 9 15 18	8	
20	**SAND AND GRAVEL** ; red and brown; medium to coarse-grained; moist to wet; Gray, red, white, and green in color. Larger gravel with depth.	S-403@ 20-22'	0.8	2 10 12 14	346	20 ▼
		S-403@ 22-24'	0.7	50/2	914	
25		S-403@ 24-26'	0.5	6 20 23 5	589	25
		1500 S-403_26-28 _121014	1	12 10 8 9	918	
		S-403@ 28-30'	0.7	10 16 27 11	29	
30	**CLAY** ; orange and gray; moist to wet	S-403@ 30-32'	0.7	11 15 7 6	1	30
		S-403@ 32-34'	0.1	4 5 3 3	2	

Borehole Backfill



0-13' bgs:
Bentonite Seal

13-35' bgs:
Sand
15-35' bgs:
Sceen

Borehole terminated at 35 feet.

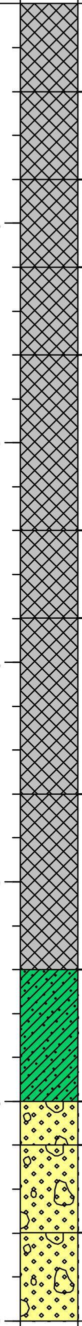
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
S-404 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **11/18/14** COMPLETED: **12/8/14**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

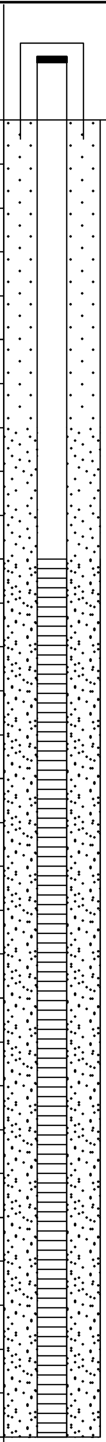
NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **11.35**
WELL CASING DIA. (in): **4**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **30.0**
BOREHOLE DEPTH (ft): **30.0**
BOREHOLE DIA. (in):
CHECKED BY:



Time & Depth (feet)	Description	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)
0-2	**SILT** ; black; loose; Utiity clearing completed via backhoe to a depth of 8 ft bgs.	0900 S-404_0-2 _111814			99.7
2-4	**SILT** ; black; Fill (bricks)	S-404@ 2-4'			103.8
4-6 (5)	**SILT** ; black; Fill (timber, concrete, rebar, bricks)	S-404@ 4-6'			149.6
6-8	**SILT** ; black; Fill (timber, bricks, concrete, black tar-like substance)	S-404@ 6-8'			269.7
8-10	**SAND LITTLE SILT** ; black; fine to medium-grained; moist; SPH/LNAPL on spoon.	S-404@ 8-10'	1.2	2 2 2 2	24
10-12 (10)		1200 S-404_10-12 _120514	0.5	2 2 2 2	50
12-14	**SAND LITTLE SILT** ; black and dark gray; fine-grained; moist to wet; Fill (wood pieces). SPH/LNAPL on spoon.	S-404@ 12-14'	0.3	2 1 2 2	13
14-16 (15)	**SAND** ; black; fine-grained; moist to wet; Fill (wood pieces).	S-404@ 14-16'	0.3	1 1 1 1	40
16-18		S-404@ 16-18'	0.3	2 1 1 1	45
18-20	**SAND SOME GRAVEL TRACE SILT** ; black and gray; fine to medium-grained; moist to wet; Fill (wood pieces).	S-404@ 18-20'	0.6	woh woh 1 1	14
20-22 (20)		S-404@ 20-22'	0.5	woh 3 3 3	18
22-24	**SANDY CLAY LITTLE ORGANICS** ; gray to orangeish brown; fine-grained; moist	S-404@ 22-24'	1	3 5 7 9	4
24-26 (25)	**SAND AND FINE GRAVEL** ; light gray; fine to coarse-grained; wet	1315 S-404_24-26 _120514	1	2 5 6 7	147
26-28	**SAND AND MEDIUM TO COARSE GRAVEL** ; gray and red; medium to coarse-grained; moist; angular; Colors gray, red, and white	S-404@ 26-28'	1.2	11 15 14 17	734
28-30	**SAND AND MEDIUM TO COARSE GRAVEL SOME CLAY** ; gray and red; medium to coarse-grained; Colors gray, red, and white	S-404@ 28-30'	1	16 15 30 44	34
30	Auger/spoon refusal Borehole terminated at 30 feet.		0	50/2	

Static water level (▼) at 11.35 ft.



Borehole Backfill

0-7' bgs: Bentonite Seal

7-30' bgs: Sand

10-30' bgs: Screen

GEO FORM 304 PHILLY AOI-1 LOGS NOV2014 THROUGH MAR2015.GPJ STANTEC ENVIRO TEMPLATE 010509.GDT 4/17/15

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

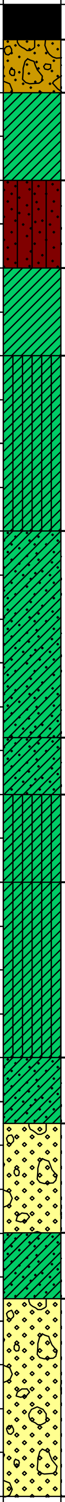
WELL / PROBEHOLE / BOREHOLE NO:
S-405 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **11/21/14** COMPLETED: **12/9/14**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

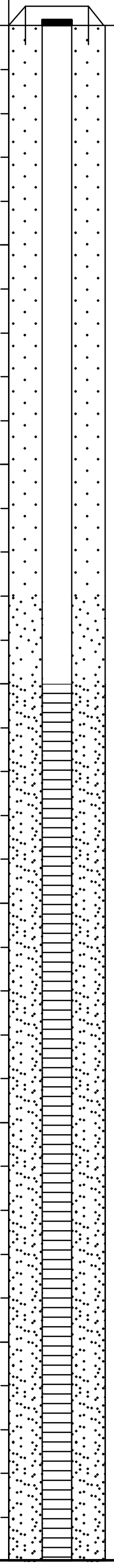
NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **20.16**
WELL CASING DIA. (in): **4**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **35.0**
BOREHOLE DIA. (in):
CHECKED BY:

Time & Depth (feet)	Description	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
	Asphalt. Utility clearing completed via backhoe to a depth of 8 ft bgs.					
	SANDY GRAVEL WITH SILT ; black; Base gravel.	0800 S-405_0-2 _112414			26.1	
	CLAY ; grayish green and dark tan	S-405@ 2-4'			65.1	
5	**SANDY SILT WITH FINE GRAVEL** ; black	S-405@ 4-6'			109.3	5
	CLAY ; blueish green to gray; moist; Cohesive.	S-405@ 6-8'			135	
	SILTY CLAY ; orangeish gray; moist	S-405@ 8-10'	1	3 2 3 4	0.0	
10		S-405@ 10-12'	0.1	3 6 5 5	0.0	10
	SANDY CLAY ; grayish brown; moist; Compact	1130 S-405_12-14 _120914	0.8	3 4 5 5	0.0	
15		S-405@ 14-16'	2	woh 1 2 3	0.0	15
	SANDY CLAY LITTLE SILT ; dark gray; fine-grained; moist	S-405@ 16-18'	2	3 3 3 4	0.0	
	SILTY CLAY TRACE SAND ; grayish brown to dark gray; moist	S-405@ 18-20'	1.7	woh 3 3 4	0.0	
20	**SILTY CLAY WITH FINE SAND LITTLE ORGANICS** ; gray to dark grayish brown; moist	S-405@ 20-22'	2	3 3 5 5	0.0	▼ 20
		S-405@ 22-24'	2	5 11 12 14	0.0	
25	**SANDY CLAY WITH ORGANICS** ; dark black to gray; fine-grained	1250 S-405_24-26 _120914	2	4 9 18 23	620	25
	SAND AND GRAVEL ; gray and red; fine to coarse-grained; wet; Gray, red, brown, and green in color. Mixed sand and gravel.	S-405@ 26-28'	1	8 11 15 24	618	
	SANDY CLAY LITTLE GRAVEL ; dark gray; wet	S-405@ 28-30'	1.5	5 14 50/1'	564	
30	**SAND AND GRAVEL TRACE CLAY** ; gray and reddish brown; wet	S-405@ 30-32'	1	woh 7 16 26	362	30
		S-405@ 32-34'	1	50/1'	173	



Borehole Backfill



0-13' bgs:
Bentonite Seal

13-35' bgs:
Sand
15-35' bgs:
Screen

Borehole terminated at 35 feet.

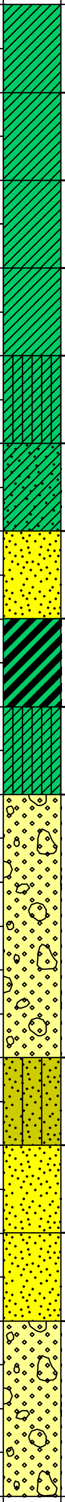
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

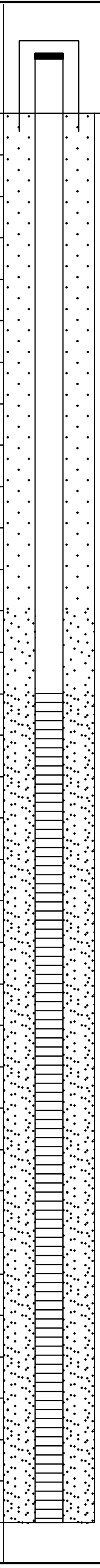
WELL / PROBEHOLE / BOREHOLE NO:
S-417 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **11/19/14** COMPLETED: **2/19/15**
DRILLING COMPANY: **Parratt Wolff**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **4**
LOGGED BY: **LM/SS**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **34.0**
BOREHOLE DEPTH (ft): **34.0**
BOREHOLE DIA. (in):
CHECKED BY:





Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
			CLAY ; dark brown and gray; Utility clearing completed via backhoe to a depth of 8 ft bgs.		0900 S-417_0-2 _111914			436.2		
			CLAY ; dark gray to reddish brown		S-417@ 2-4'			542.1		
5			**CLAY** ; dark grayish black to tannish brown		S-417@ 4-6'			988.3	5	
			CLAY ; black and dark gray		S-417@ 6-8'			1003.7		0-12' bgs: Bentonite
			SILTY CLAY ; orange and gray; moist	☒	S-417@ 8-10'	1		11.7		
10			**SANDY CLAY** ; gray; fine-grained; moist	☒	S-417@ 10-12'	2		170	10	
			SAND TRACE CLAY AND FINE GRAVEL ; gray; fine to medium-grained; moist; rounded	☒	1300 S-417_12-14 _021915	0.8		835.7		
15			**SILT AND CLAY** ; brown; moist	☒	S-417@ 14-16'	1		297	15	
			SILTY CLAY LITTLE SAND AND GRAVEL ; brown and gray; dry; rounded	☒	S-417@ 16-18'	1.5		48.6		
			SAND AND GRAVEL TRACE SILT ; orange and brown; fine to medium-grained; dry; rounded; White gravel.	☒	S-417@ 18-20'	2		56.8		
20				☒	S-417@ 20-22'	1		28.6	20	
				☒	S-417@ 22-24'	1		170.3		12-34' bgs: Sand 14-34' bgs: Screen
25			**SILTY SAND LITTLE FINE GRAVEL** ; brown; moist; Mixed gravel.	☒	S-417@ 24-26'	1.2		775	25	
			SAND LITTLE FINE GRAVEL ; brown with white; medium-grained; moist to wet; rounded; White gravel. Visible LNAPL.	☒	S-417@ 26-28'	1		660		
			SAND LITTLE FINE GRAVEL ; gray and brown; medium-grained; wet; Gray and white gravel.	☒	S-417@ 28-30'	1.2		727		
30			**SAND AND GRAVEL** ; gray; medium to coarse-grained; wet; rounded; Red, white, gray, and green mixed gravel.	☒	S-417@ 30-32'	2		760	30	
				☒	S-417@ 32-34'	2		336		
			Borehole terminated at 34 feet.							

PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

WELL / PROBEHOLE / BOREHOLE NO:
S-418 PAGE 1 OF 1

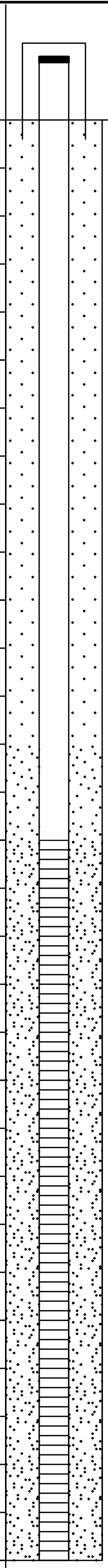
DRILLING / INSTALLATION:
STARTED **2/19/15** COMPLETED: **5/6/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **2**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **30.0**
BOREHOLE DEPTH (ft): **30.0**
BOREHOLE DIA. (in): **10**
CHECKED BY: **TD**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)
	🟩		**CLAY** ; brown and gray; Utility clearing completed to a depth of 8 feet bgs via backhoe.	■	1000 S-418 _ 0-2			70.1
	🟩		**CLAY** ; gray and tan	■	S-418@ 2-4'			35.5
5	🟩		**CLAY** ; blueish gray	■	S-418@ 4-6'			130.6
	🟥		**SANDY SILT** ; gray and brown	■	S-418@ 6-8'			529.8
	🟧		**SAND AND GRAVEL** ; fine to coarse-grained; moist; multicolored, poorly sorted	☒ ■	S-418@ 8-10'	1		12.2
10			No sample collected					
15	🟨		**SANDY GRAVEL WITH SILT** ; dark red and grayish brown; moist to wet	■	S-418@ 12-14' 0900 S-418 _14-16			500.3 1278
20 25 30			Borehole terminated at 30 feet.					

Borehole Backfill



0-13' bgs: Bentonite

13-30' bgs: Sand
15-30' bgs: PVC Screen

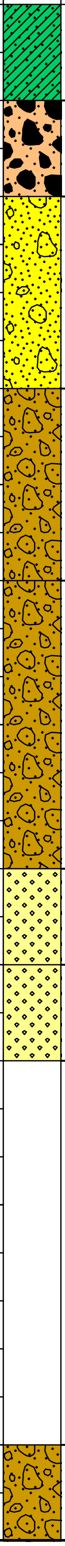
PROJECT: **Philadelphia Refinery**
LOCATION: **AOI-1**
PROJECT NUMBER:

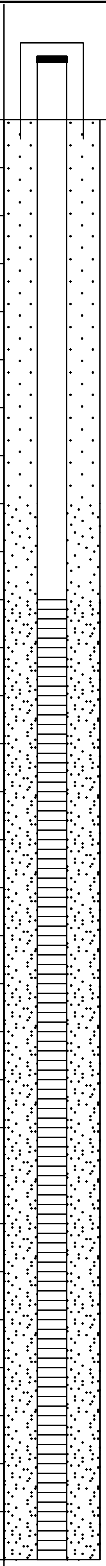
WELL / PROBEHOLE / BOREHOLE NO:
S-419 PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED **4/28/15** COMPLETED: **6/3/15**
DRILLING COMPANY: **Total Quality**
DRILLING EQUIPMENT: **Auger Rig**
DRILLING METHOD: **HSA**
SAMPLING EQUIPMENT: **Split Spoon**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **Not Encountered**
STATIC DTW (ft): **Not Encountered**
WELL CASING DIA. (in): **2**
LOGGED BY: **LM**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **30.0**
BOREHOLE DEPTH (ft): **32.0**
BOREHOLE DIA. (in): **10**
CHECKED BY: **TD**





Time & Depth (feet)	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Borehole Backfill
		SANDY CLAY WITH SILT AND GRAVEL ; brown and gray		0800 S-419 _0-2			899		
		SANDY GRAVEL ; dark brown; medium to coarse-grained		S-419@ 2-4'			190.3		
5		**SAND WITH GRAVEL** ; dark gray and brown; medium to coarse-grained; rounded; multicolored (dark gray, brown, and red)		S-419@ 4-6'			356	5	0-8' bgs: Bentonite
				S-419@ 6-8'			404.7		
		SAND AND GRAVEL ; fine to coarse-grained; saturated; (trenton gravel), multicolored	☒	S-419@ 8-10'	0.7		39.5		
10			☒	S-419@ 10-12'	0.7		132	10	
		SAND AND GRAVEL ; fine to coarse-grained; saturated to wet; large gravel (>2"0), hard augering (cobbles), not enough to sample 14-16' combined intervel 12-16'.	☒	S-419@ 12-14'	0.7		452		
15			☒	1340 S-419 _12-16	0.2		698	15	
			☒	S-419@ 16-18'	1		399		
		SAND ; brown; fine to coarse-grained; wet	☒	S-419@ 18-20'	1		373		8-30' bgs: Sand 10-30' bgs: PVC Screen
20		**SAND TRACE FINE GRAVEL** ; brown; fine to coarse-grained; wet	☒	S-419@ 20-22'	1		281	20	
25		Drill to 30 feet bgs. No additional spoons						25	
30		**SAND AND FINE TO MEDIUM GRAVEL** ; dark grayish brown; fine to coarse-grained	☒	S-419@ 30-32'			858.1	30	

Borehole terminated at 32 feet.

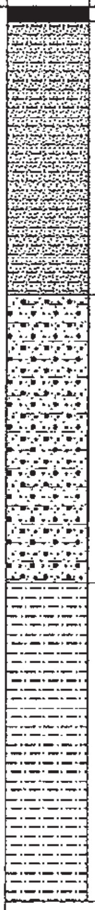
Handex®

Handex Of Maryland

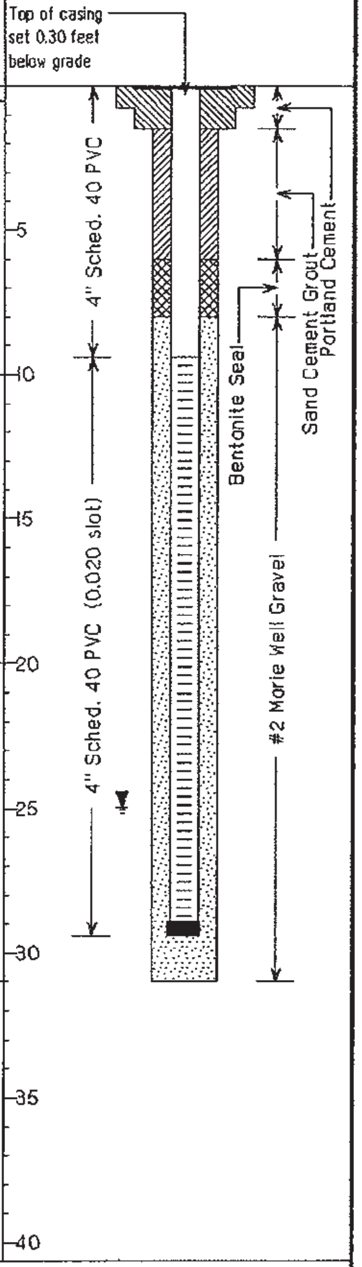
WELL LOG: MW-26

Permit #: *N/A*
Drill Date: *12/12/00*
Use: *Monitoring Well*
Location: *Sunoco Belmont Terminal, PA*
Owner Loc #:
Owner: *Sunoco, Inc*
Handex Loc #: *110535.032.T3045.900*
Owner Address: *3144 Passyunk Ave. Philadelphia, PA*
BORING - Depth: *31 ft.* Diameter: *10.25 in.*
Drilling Method: *Hollow Stem Auger*
CASING - Length: *9.4 ft.* Diameter: *4 in.*
Sampling Method: *N/A*
SCREEN - Length: *20 ft.* Diameter: *4 in.*
Static Water Level: *24.69 ft.* *(1/8/01)*
WELL - Depth: *29.4 ft.*

Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description
						ASPHALT
5						Black to dark green Silty SAND, moist
10 15						Dark brown Silty SAND with coarse Gravel, moist
20 25 30						Dark brown SILT, moist
35 40						File name: 11055528



Well Diagram



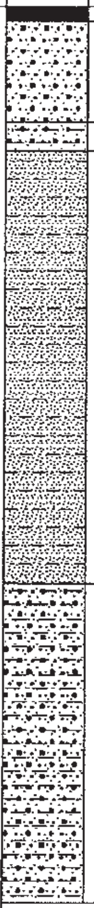
Geologist: David Leety
Driller: B.L. Myers Bros.

Handex®
Handex Of Maryland

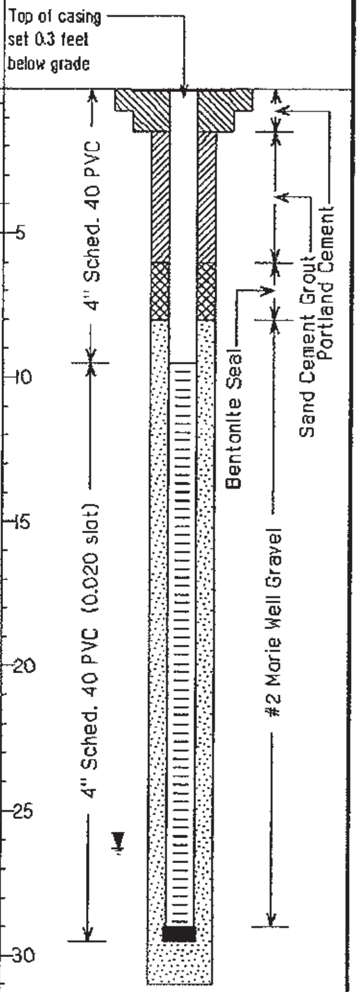
WELL LOG: MW-27

Permit #: *N/A*
Drill Date: *12/12/00*
Use: *Monitoring Well*
Location: *Sunoco Belmont Terminal, PA*
Owner Loc #:
Owner: *Sunoco, Inc*
Handex Loc #: *110535.032.T3045.900*
Owner Address: *3144 Passyunk Ave. Philadelphia, PA*
BORING - Depth: *31 ft.* Diameter: *10.25 in.*
Drilling Method: *Hollow Stem Auger*
CASING - Length: *9.5 ft.* Diameter: *4 in.*
Sampling Method: *N/A*
SCREEN - Length: *20 ft.* Diameter: *4 in.*
Static Water Level: *26.00 ft. (1/8/01)*
WELL - Depth: *29.5 ft.*

Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description
						ASPHALT
						Dark green to black fine SAND with medium Gravel, dry
5						Dark green to black fine SAND with some medium Gravel and Silt, wet
						Dark green Silty SAND, moist
10						
15						
20						Dark green Silty SAND with coarse Gravel, moist
25						
30						File name: 11055527
35						
40						



Well Diagram



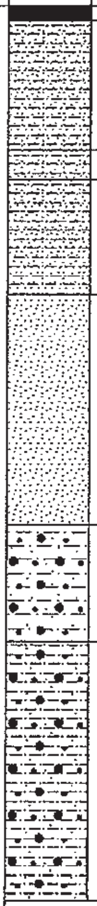
Geologist: David Leety
Driller: B.L. Myers Bros.

Handex Of Maryland

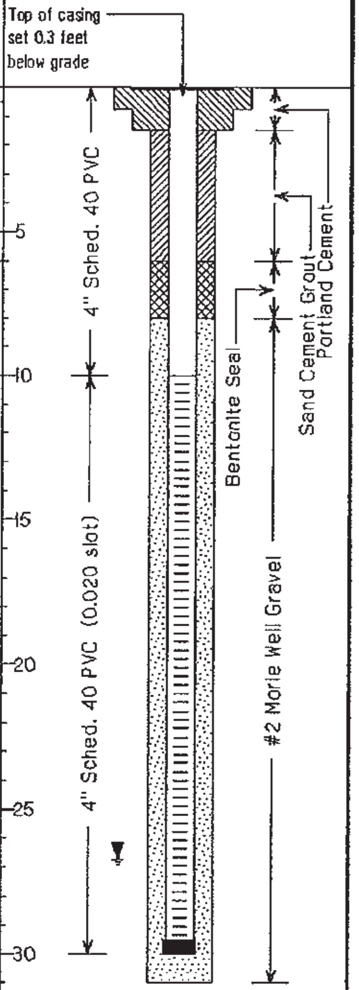
WELL LOG: MW-28

Permit #: *N/A*
Drill Date: *12/13/00*
Use: *Monitoring Well*
Location: *Sunoco Belmont Terminal, PA*
Owner Loc #:
Owner: *Sunoco, Inc*
Handex Loc #: *110535.032.T3045.900*
Owner Address: *3144 Passyunk Ave. Philadelphia, PA*
BORING - Depth: *31 ft.* Diameter: *10.25 in.*
Drilling Method: *Hollow Stem Auger*
CASING - Length: *10 ft.* Diameter: *4 in.*
Sampling Method: *N/A*
SCREEN - Length: *20 ft.* Diameter: *4 in.*
Static Water Level: *26.44 ft. (1/8/01)*
WELL - Depth: *30 ft.*

Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description
						ASPHALT
						Black and tan SAND and SILT, dry
5						Black and dark green Silty SAND, moist
						Light green Silty SAND, moist
10						Dark green fine SAND, very moist
15						
						Coarse GRAVEL with some Silty Sand, moist
20						
						Dark brown Sandy SILT with coarse Gravel, moist
25						
30						
						File name:11055528
35						
40						



Well Diagram



Geologist: David Leety
Driller: B.L. Myers Bros.

Handex®

Handex Of Maryland

WELL LOG: MW-29

Permit #: *N/A*

Drill Date: *12/11/00*

Use: *Monitoring Well*

Location: *Sunoco Belmont Terminal, PA*

Owner Loc #:

Owner: *Sunoco, Inc*

Handex Loc #: *110535.032.T3045.900*

Owner Address: *3144 Passyunk Ave. Philadelphia, PA*

BORING – Depth: *31 ft.*

Diameter: *10.25 in.*

Drilling Method: *Hollow Stem Auger*

CASING – Length: *10 ft.*

Diameter: *4 in.*

Sampling Method: *N/A*

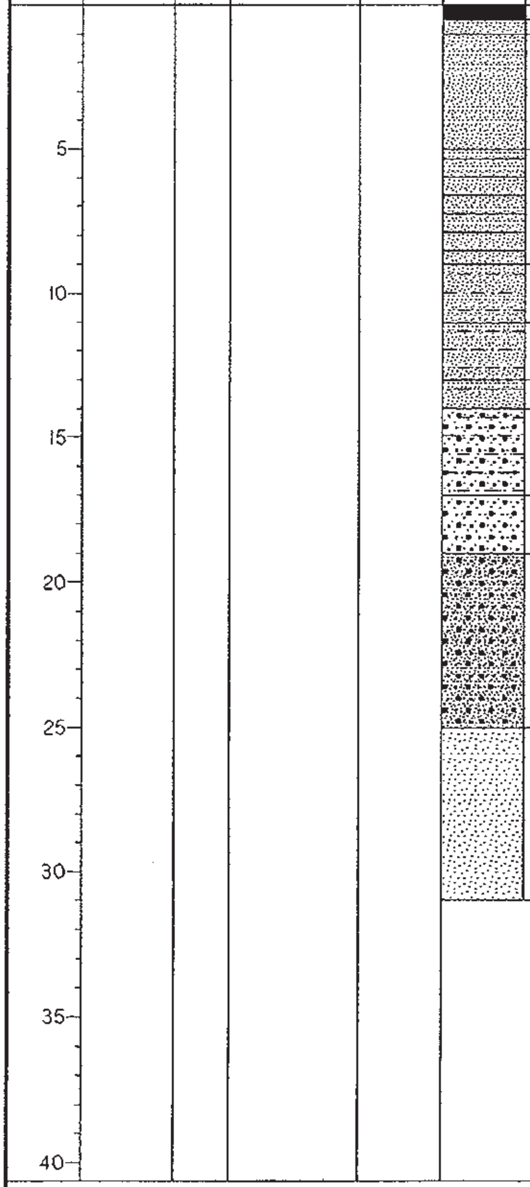
SCREEN – Length: *20 ft.*

Diameter: *4 in.*

Static Water Level: *26.19 ft. (1/8/01)*

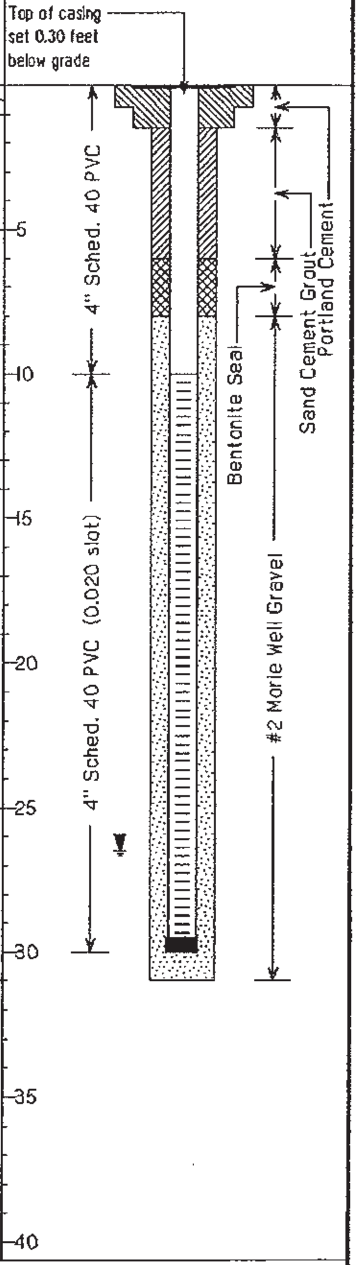
WELL – Depth: *30 ft.*

Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description
						ASPHALT
						Brown fine SAND
						Green fine to medium SAND
						Green Clayey fine SAND
						Light brown Silty fine SAND
						Gray Silty fine SAND
						Dark brown Silty fine SAND
						Dark brown Silty fine SAND with fine to medium Gravel
						Fine to medium GRAVEL with fine to medium Sand
						Brown fine to medium SAND with abundant fine Gravel, moist
						Brown medium SAND, wet



File name: 11055529

Well Diagram



Geologist: David Leety

Driller: B.L. Myers Bros.

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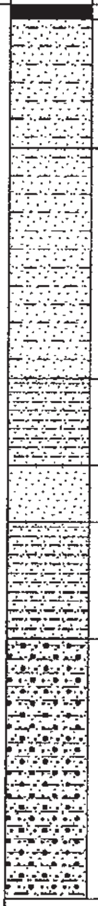
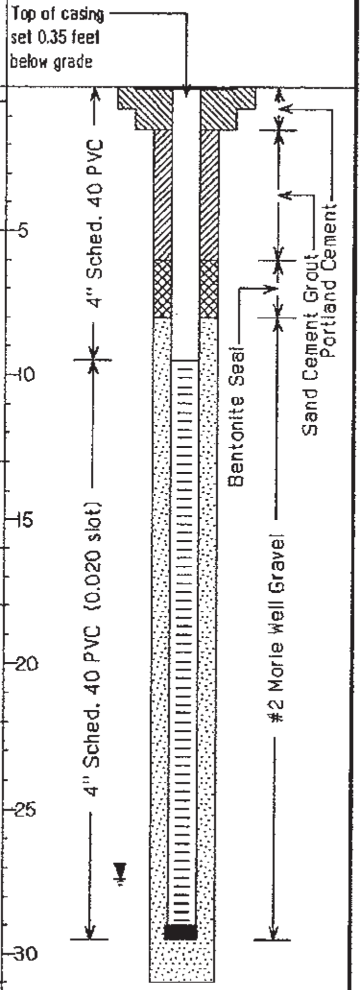
WELL LOG: MW-31

Permit #: *N/A*	Drill Date: *12/13/00*	Use: *Monitoring Well*
Location: *Sunoco Belmont Terminal, PA*		Owner Loc #:
Owner: *Sunoco, Inc*		Handex Loc #: *110535.032.T3045.900*
Owner Address: *3144 Passyunk Ave. Philadelphia, PA*	BORING - Depth: *31 ft.*	Diameter: *10.25 in.*
Drilling Method: *Hollow Stem Auger*	CASING - Length: *9.5 ft.*	Diameter: *4 in.*
Sampling Method: *N/A*	SCREEN - Length: *20 ft.*	Diameter: *4 in.*
Static Water Level: *27.05 ft. (1/8/01)*	WELL - Depth: *29.5 ft.*	

Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description	Well Diagram
						ASPHALT	
						Black Silty coarse SAND, dry	
5						Dark green Silty SAND, moist	
10							
15						Light green SAND and SILT, moist	
						Light green coarse SAND, wet	
20						Dark green SAND and SILT, moist	
25						Dark brown Silty SAND with coarse Gravel	
30							
						File name: 11055531	
35							
40							





Geologist: David Leety	Driller: B.L. Myers Bros.

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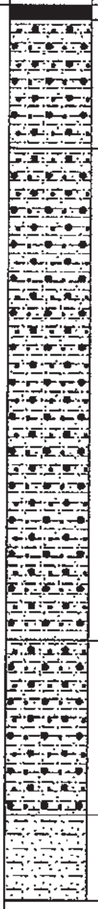
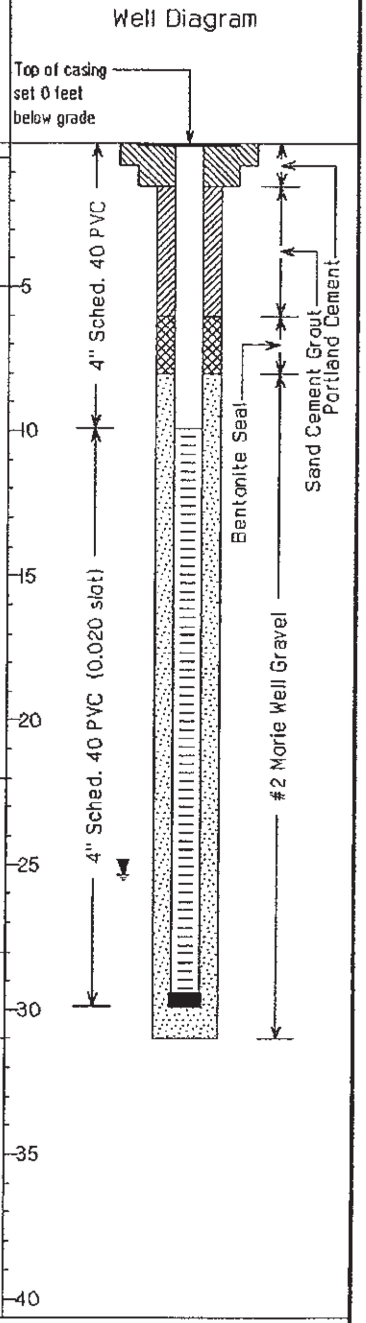
Handex Of Maryland

WELL LOG: MW-32

Permit #: *N/A*
Drill Date: *12/12/00*
Use: *Monitoring Well*
Location: *Sunoco Belmont Terminal, PA*
Owner Loc #:
Owner: *Sunoco, Inc*
Handex Loc #: *110535.032.T3045.900*
Owner Address: *3144 Passyunk Ave. Philadelphia, PA*
BORING - Depth: *31 ft.* Diameter: *10.25 in.*
Drilling Method: *Hollow Stem Auger*
CASING - Length: *9.9 ft.* Diameter: *4 in.*
Sampling Method: *N/A*
SCREEN - Length: *20 ft.* Diameter: *4 in.*
Static Water Level: *25.36 ft.* *(1/8/01)*
WELL - Depth: *29.9 ft.*

Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description
						ASPHALT
						Black Sandy SILT with coarse Gravel, dry
5						Black Silty SAND with coarse Gravel, very wet
10						
15						
20						
						Dark brown Silty SAND with coarse Gravel, moist
25						
						Dark brown coarse SAND with some Silt, moist
30						File name: 11055532
35						
40						





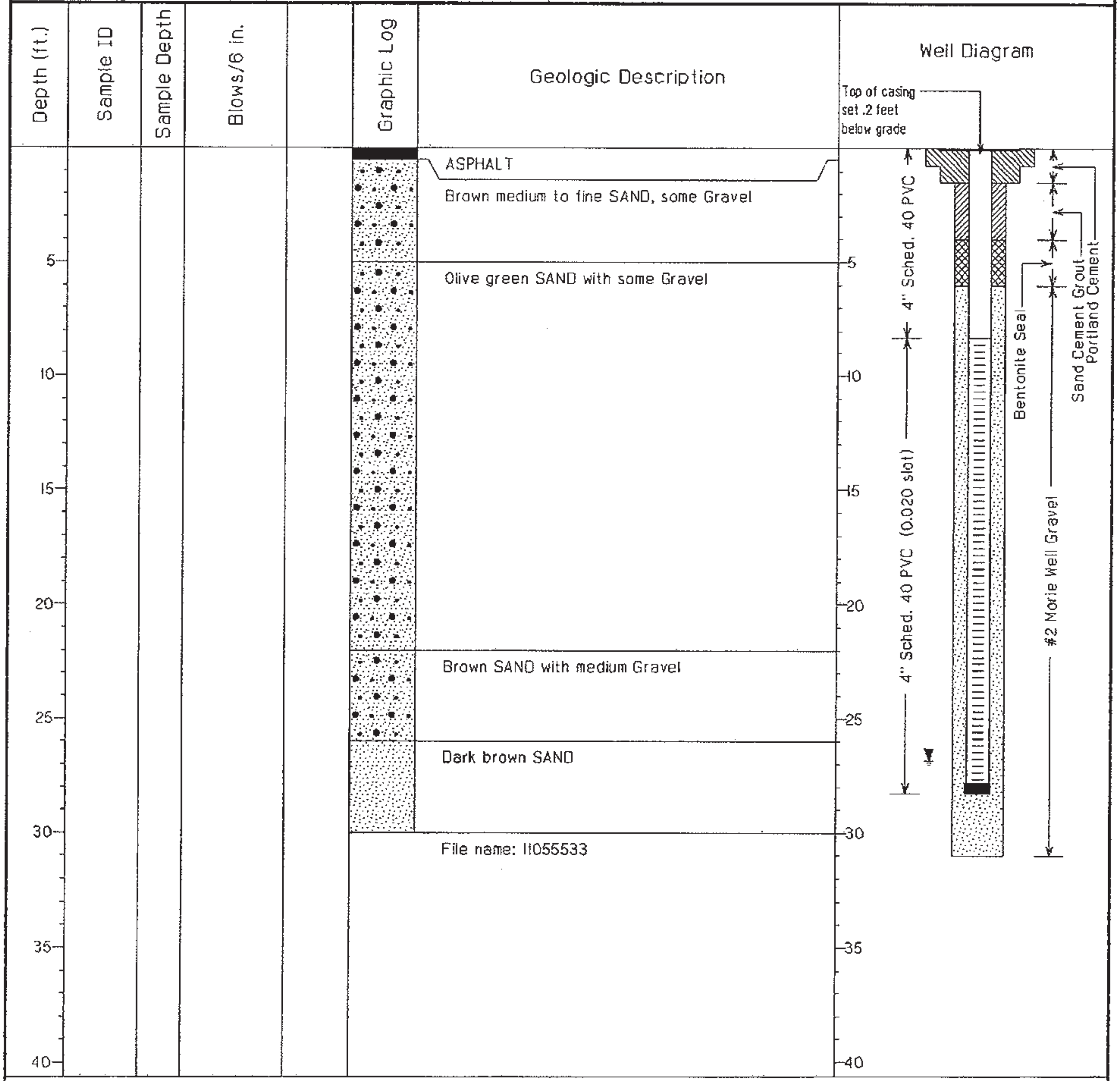
Geologist: David Leety
Driller: B.L. Myers Bros.

Handex®

Handex Of Maryland

WELL LOG: MW–33

Permit #: *N/A*
Drill Date: *12/12/00*
Use: *Monitoring Well*
Location: *Sunoco Belmont Terminal, PA*
Owner Loc #:
Owner: *Sunoco, Inc*
Handex Loc #: *110535.032.T3045.900*
Owner Address: *3144 Passyunk Ave. Philadelphia, PA*
BORING – Depth: *31 ft.* Diameter: *10.25 in.*
Drilling Method: *Hollow Stem Auger*
CASING – Length: *8.10 ft.* Diameter: *4 in.*
Sampling Method: *N/A*
SCREEN – Length: *20 ft.* Diameter: *4 in.*
Static Water Level: *26.64 ft. (1/8/01)*
WELL – Depth: *28.30 ft.*



ASPHALT

Brown medium to fine SAND, some Gravel

Olive green SAND with some Gravel

Brown SAND with medium Gravel

Dark brown SAND

File name: 11055533

Geologist: David Leety

Driller: B.L. Myers Bros.

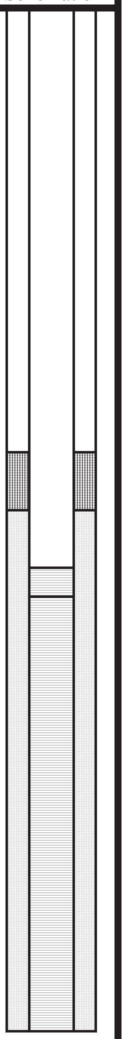
Aquaterra Technologies, Inc.
Subsurface Log: MW-35

Project Name: Sunoco Belmont Terminal
Owner: Sunoco, Inc. (R&M)
Location: 2700 W. Passyunk Ave
Philadelphia, PA
Permit No.:
Boring Number: MW-35
Log By: Brandee Blasi
Date: 31-Mar-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25"
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): 30'
Casing Diameter: 4 inch **Length:** 20'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Backfill: 0'-15'
Screen Interval: 20'-35'
Cement/Grout Interval: NA
Sand Pack Interval: 18'-35'
Bentonite Interval: 16'-18'
Completion Details: 10" Flushmount
Sand Pack Type: No. 2

□ = Backfill
■ = Cement/Grout
▨ = Bentonite
░ = Sand

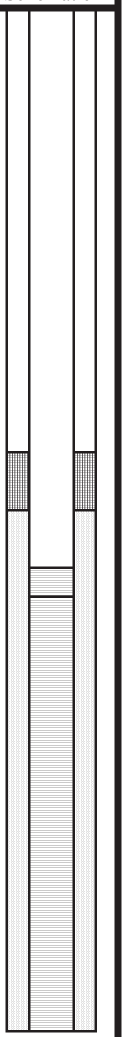
Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Hydroexcavate to 8' BGS	
5					
				Advance augers to 10' BGS and begin split spoons every 5'	
10	10-12	2.9	2	Gray-brown banded silt, compact, very moist	
15	15-17	0	2	Same as above to 16' BGS, changing to a red-brown gravel and sand, some rocks present, slighlty moist.	
20	20-22	0	2	Red-brown gravel and sand, slight moisture	
25	25-27	5.8	2	Red-brown gravel very coarse sand and gravel, slightly moist.	
30	30-32	1047	2	Black stained sand and gravel, wet. Sheen present on spoon.	
35				Well set at 35' and completed with a flushmount manhole cover	

Aquaterra Technologies, Inc.
Subsurface Log: MW-36

Project Name: Sunoco Belmont Terminal
Owner: Sunoco, Inc. (R&M)
Location: 2700 W. Passyunk Ave
Philadelphia, PA
Permit No.:
Boring Number: MW-36
Log By: Brandee Blasi
Date: 6-Apr-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25"
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): 30'
Casing Diameter: 4 inch **Length:** 20'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Backfill: 0'-15'
□ = Backfill
Screen Interval: 20'-35'
Cement/Grout Interval: NA
■ = Cement/Grout
Sand Pack Interval: 18'-35'
Bentonite Interval: 16'-18'
▨ = Bentonite
Completion Details: 10" Flushmount
Sand Pack Type: No. 2
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Hydroexcavate to 8' BGS	
5					
				Advance augers to 10' BGS and begin split spoons every 5'	
10	10-12	1847	2	Green-black stained clay and silt, slightly moist.	
15	15-17	2140	2	Green silty clay, slightly moist to 16' BGS. Changing to a tan clay, highly plastic. Slightly moist.	
20	20-22	1709	2	Same as above to 21' BGS, changing to a red-brown gravel and sand, moist.	
25	25-27	2790 2473	2	Red-brown gravel and sand to 26' BGS. Changing to a Brown silt with some clay, slightly moist.	
30	30-32	1091	2	Black stained sand and gravel, wet.	
35				Well set at 35' and completed with a flushmount manhole cover	

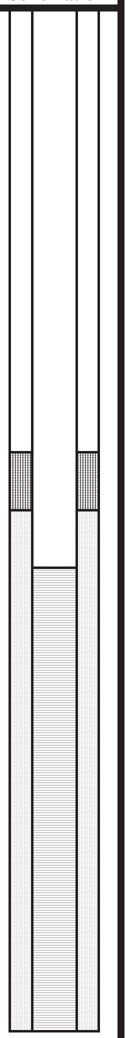
Aquaterra Technologies, Inc.
Subsurface Log: MW-37

Project Name: Sunoco Belmont Terminal
Owner: Sunoco, Inc. (R&M)
Location: 2700 W. Passyunk Ave
Philadelphia, PA
Permit No.:
Boring Number: MW-37
Log By: Brandee Blasi
Date: 7-Apr-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25"
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): NA
Casing Diameter: 4 inch **Length:** 20'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Backfill: 0'-15'
Screen Interval: 20'-35'
Cement/Grout Interval: NA
Sand Pack Interval: 18'-35'
Bentonite Interval: 16'-18'
Completion Details: 10" Flushmount
Sand Pack Type: No. 2

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Hydroexcavate to 8' BGS	
5					
				Advance augers to 10' BGS and begin split spoons every 5'	
10	10-12	NA	2	Black fill material, wet from rain	
15	15-17	NA	2	Brown sandy silt with rock fragments, gravel and brick material, moist.	
20	20-22	NA	2	Tan/red/brown sandy silt with some gravel present. Slightly moist.	
25	25-27	NA	0	No Recovery	
30	30-32	NA	0.25	Brown-red gravel and sandy silt, moist.	
35				Well set at 35' and completed with a flushmount manhole cover	

PID not working, therefore no measurements were collected

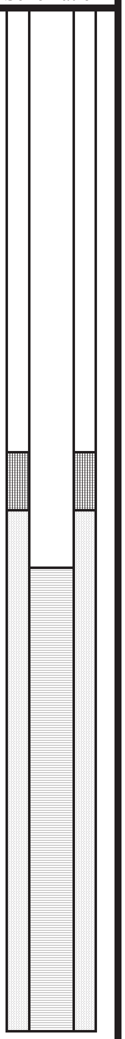
Aquaterra Technologies, Inc.
Subsurface Log: MW-38

Project Name: Sunoco Belmont Terminal
Owner: Sunoco, Inc. (R&M)
Location: 2700 W. Passyunk Ave
Philadelphia, PA
Permit No.:
Boring Number: MW-38
Log By: Brandee Blasi
Date: 6-Apr-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25"
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): 22-24'
Casing Diameter: 4 inch **Length:** 20'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Backfill: 0'-15'
Screen Interval: 20'-35'
Cement/Grout Interval: NA
Sand Pack Interval: 18'-35'
Bentonite Interval: 16'-18'
Completion Details: 10" Flushmount
Sand Pack Type: No. 2

☐ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Hydroexcavate to 8' BGS	
				Advance augers to 8' BGS and begin continuous split spoons every	
5					
	8-10'	10.9	0.25	Red-brown gravel and sand, slightly moist	
10	10-12	41.6	0.1	Same as above	
	12-14'	84.8	0.25	Same as above	
	14-16'	29.1	2	Same as above to 15' BGS. Changing to a	
15		245.6		Gray silt with some sand, slightly moist	
	16-18'	287	2	Red-brown sand and gravel, slightly moist. Clay lense from 16.5-17' BGS	
				Color banding from red-brown to tan to gray	
	18-20'	70.4	2	Red-brown sand and some gravel, slightly moist	
20	20-22	69.7	2	Same as above, gravel content increased with depth.	
	22-24'	9	2	Sand and gravel, wet.	
	24-26'	62.2	2	Coarse sand with small gravel, wet.	
25					
	26-28'	32.2	2	Sand and gravel, wet	
	28-30'	42.2	2	Brown-gray sand and gravel, wet.	
30	30-32	45.5	2	Same as above	
	32-34'	NA	2	No Recovery	
35				Well set at 35' and completed with a flushmount manhole cover	

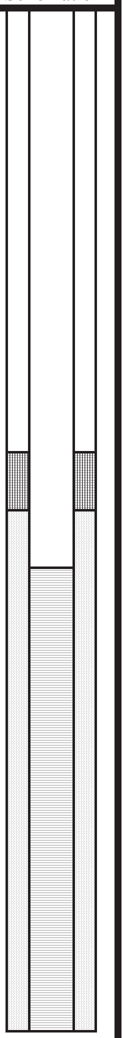
Aquaterra Technologies, Inc.
Subsurface Log: MW-39

Project Name: Sunoco Belmont Terminal
Owner: Sunoco, Inc. (R&M)
Location: 2700 W. Passyunk Ave
Philadelphia, PA
Permit No.:
Boring Number: MW-39
Log By: Brandee Blasi
Date: 5-Apr-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25"
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): 25-27'
Casing Diameter: 4 inch **Length:** 20'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Backfill: 0'-15'
Screen Interval: 20'-35'
Cement/Grout Interval: NA
Sand Pack Interval: 18'-35'
Bentonite Interval: 16'-18'
Completion Details: 10" Flushmount
Sand Pack Type: No. 2

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Hydroexcavate to 8' BGS	
5					
				Advance augers to 10' BGS and begin split spoons every 5'	
10	10-12	186.2	2	Red-brown gravel and sand, moist	
15	15-17	NA	0	No Recovery, rock fragment in shoe of spoon.	
20	20-22	373 337	2	Red brown sand and gravel, slightly moist. Change at 21.5' BGS to a red-brown silty clay, slightly moist	
25	25-27	264	2	Tan-poorly sorted gravel and sand, wet, sheen on sample.	
30	30-32	114	2	Red-brown poorly sorted gravel and sand, wet	
35				Well set at 35' and completed with a flushmount manhole cover	

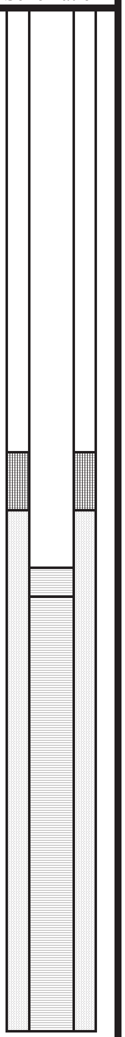
Aquaterra Technologies, Inc.
Subsurface Log: MW-40

Project Name: Sunoco Belmont Terminal
Owner: Sunoco, Inc. (R&M)
Location: 2700 W. Passyunk Ave
Philadelphia, PA
Permit No.:
Boring Number: MW-40
Log By: Brandee Blasi
Date: 5-Apr-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25"
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): 25-27'
Casing Diameter: 4 inch **Length:** 20'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Backfill: 0'-15'
Screen Interval: 20'-35'
Cement/Grout Interval: NA
Sand Pack Interval: 18'-35'
Bentonite Interval: 16'-18'
Completion Details: 10" Flushmount
Sand Pack Type: No. 2

□ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

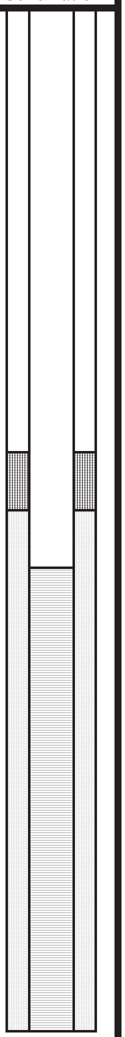
Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Hydroexcavate to 8' BGS	
5					
				Advance augers to 10' BGS and begin split spoons every 5'	
10	10-12	191	2	Red-brown-black sand and gravel, slightly moist	
15	15-17	90	2	Brown-gray silt with sand and gravel, slightly moist.	
20	20-22	NA	2	No Recovery	
25	25-27	92.3	2	Brown wet poorly sorted gravel and sand	
30	30-32	296	2	Brown-black sand and gravel, wet.	
35				Well set at 35' and completed with a flushmount manhole cover	

Aquaterra Technologies, Inc.
Subsurface Log: MW-41

Project Name: Sunoco Belmont Terminal **Owner:** Sunoco, Inc. (R&M)
Location: 2700 W. Passyunk Ave **Permit No.:**
Philadelphia, PA
Boring Number: MW-41 **Log By:** Brandee Blasi **Date:** 30-Mar-05
Casing Elevation: N/A **Driller:** Parrat Wolff **Borehole Dia:** 8.25"
Screen Diameter: 4 inch **Length:** 15' **Slot Size:** 0.020 **Water Level (Init):** 25-27'
Casing Diameter: 4 inch **Length:** 20' **Type:** PVC
Drilling Method: Hollow Stem Auger **Sample Method:** Split Spoon **Rig Type:** HSA Rig

Construction Details

Total Well Depth: 35' bgs **Backfill:** 0'-15' □ = Backfill
Screen Interval: 20'-35' **Cement/Grout Interval:** NA ■ = Cement/Grout
Sand Pack Interval: 18'-35' **Bentonite Interval:** 16'-18' ▨ = Bentonite
Completion Details: 10" Flushmount **Sand Pack Type:** No. 2 ░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Hydroexcavate to 8' BGS	
5					
				Advance augers to 10' BGS and begin split spoons every 5'	
10	10-12	537	2	Brown sand from 10-11' BGS changing to a red-brown gravel and sand matrix, moist.	
15	15-17	502	0.25	Brown gravel and sand, slightly moist. Rock fragment in shoe of spoon	
20	20-22	686	1	Brown gravel and sand, slighlty moist	
25	25-27	533	2	Coarse sand and poorly sorted gravel, red-brown in color. Wet.	
30	30-32	639	2	Same as above, black staining present	
35				Well set at 35' and completed with a flushmount manhole cover	

Aquaterra Technologies, Inc.
Subsurface Log: MW-42

Project Name: Sunoco Belmont Terminal
Location: 2700 W. Passyunk Ave
Philadelphia, PA
Boring Number: MW-42
Casing Elevation: N/A
Screen Diameter: 4 inch **Length:** 15'
Casing Diameter: 4 inch **Length:** 20'
Drilling Method: Hollow Stem Auger

Owner: Sunoco, Inc. (R&M)
Permit No.:
Log By: Brandee Blasi
Driller: Parrat Wolff
Slot Size: 0.020
Type: PVC
Sample Method: Split Spoon

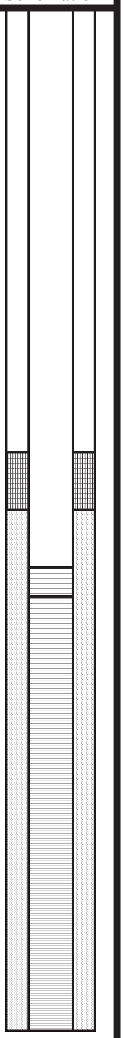
Date: 30-Mar-05
Borehole Dia: 8.25"
Water Level (Init): 20-22'
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Screen Interval: 20'-35'
Sand Pack Interval: 18'-35'
Completion Details: 10" Flushmount

Backfill: 0'-15'
Cement/Grout Interval: NA
Bentonite Interval: 16'-18'
Sand Pack Type: No. 2

☐ = Backfill
■ = Cement/Grout
▨ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0	0-2			Hydroexcavate to 8' BGS on 3/29/05	
				Asphalt and subangular base stone	
	2-4	277		Gray clay layer from 2-2.5' BGS changing to a small angular gravel matrix	
				with water entering borehole	
	4-6	NM		Gray clay with gravel and rock fragments.	
5					
	6-8	NM		Same. After soft dig was completed, the excavation filled up	
				with water to 3' BGS	
	8-10	NM		Advance augers to 10' BGS and begin split spoons	
10	10-12	583	2	Brown orange clay, highly plastic, moist changing to a dark brown/red	
		461		clay with gravel and sand, moist.	
	12-14	612	2	Dark brown orange clay with gravel and sand, slight moisture	
	14-16	624	0.5	Dark brown clay, highly plastic, moist. (wet black sand in spoon at the	
15				top, fall in material)	
	16-18	609	2	Reddish brown-gray compact clay, slight moisture with a sand lense in	
		629		the top of the spoon changing to a red-brown gravel and sand, moist	
	18-20	528	0.5	Red brown compact clay with some gravel and sand at 20' BGS. Slight	
				moisture	
20	20-22	534	0.25	Sand layer in top 1' changing to a red brown compact clay, slight moisture	
	22-24	569	0.25	Red brown compact clay, slightly moist	
				Soil sample collected for GeoTechnical analysis	
	24-26	679	2	Red-gray-brown compact clay in top 1' changing to a red-brown gravel	
25		345		and sand matrix, very moist	
	26-28	770	2	Red-brown gravel and sand matrix, very moist	
		926			
	28-30	615	2	Black stained gravel and sand very moist	
30	30-32	437	2"	Recovery in shoe of spoon only. Wet gravel and sand.	
	32-34	507	2	Wet gravel and sand matrix.	
35				Well set at 35' and completed with a flushmount manhole cover	

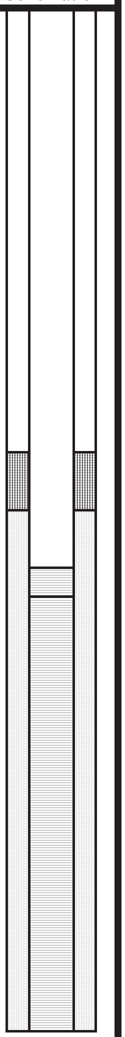
Aquaterra Technologies, Inc.
Subsurface Log: MW-43

Project Name: Sunoco Belmont Terminal
Owner: Sunoco, Inc. (R&M)
Location: 2700 W. Passyunk Ave
Philadelphia, PA
Permit No.:
Boring Number: MW-43
Log By: M. Brad Spancake
Date: 19-Apr-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25"
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): 27'
Casing Diameter: 4 inch **Length:** 20'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Backfill: 0'-15'
Screen Interval: 20'-35'
Cement/Grout Interval: NA
Sand Pack Interval: 18'-35'
Bentonite Interval: 16'-18'
Completion Details: 10" Flushmount
Sand Pack Type: No. 2

☐ = Backfill
■ = Cement/Grout
▦ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Hydroexcavate to 8' BGS	
5					
				Advance augers to 10' BGS and begin split spoons every 5'	
10	10-12	325	1.25	Moist greenish gray silty clay, some small gravel in top 3" Blowcount: 1-1-3-3	
15	15-17	46	1.5	Same as above to 15.5' BGS. Changing to a wet gray medium sand to 16.25' BGS. Changing to a moist to slightly moist reddish brown clay. Blowcount: 1-1-2-2	
20	20-22	36	1	Brownish orange silty coarse sand with poorly sorted gravel. Large rock fragment in shoe of spoon. Dry. Blowcount: 8-6-10-19	
25	25-27	145	1	Reddish brown coarse sand and gravel, slightly moist. Gravel is small. Black staining present in bottom 2" of spoon. Material is wet. Blowcount: 15-15-12-12	
30	30-32	298	1.75	Coarse brown sand in top 1' of spoon. Changing to a heavily black stained coarse sand. Blowcount: 8-14-14-15	
35	35-37	6.3	2	Tanish brown moist clay to 36.5' BGS. Changing to a moist gray fine sand for 3". Changing to a dark gray clay silt.	

Well set at 35' and completed with a flushmount manhole cover

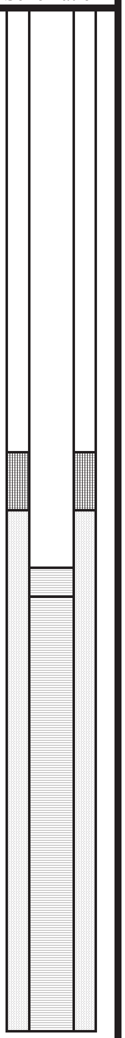
Aquaterra Technologies, Inc.
Subsurface Log: MW-44

Project Name: Sunoco Belmont Terminal
Owner: Sunoco, Inc. (R&M)
Location: 2700 W. Passyunk Ave
Philadelphia, PA
Permit No.:
Boring Number: MW-44
Log By: Brandee Blasi
Date: 1-Apr-05
Casing Elevation: N/A
Driller: Parrat Wolff
Borehole Dia: 8.25"
Screen Diameter: 4 inch **Length:** 15'
Slot Size: 0.020
Water Level (Init): 27'
Casing Diameter: 4 inch **Length:** 20'
Type: PVC
Drilling Method: Hollow Stem Auger
Sample Method: Split Spoon
Rig Type: HSA Rig

Construction Details

Total Well Depth: 35' bgs
Backfill: 0'-15'
Screen Interval: 20'-35'
Cement/Grout Interval: NA
Sand Pack Interval: 18'-35'
Bentonite Interval: 16'-18'
Completion Details: 10" Flushmount
Sand Pack Type: No. 2

☐ = Backfill
■ = Cement/Grout
▨ = Bentonite
░ = Sand

Depth (ft)	Sample Depth (ft)	OVM (ppm)	Amount of Recovery (ft)	Lithology	Well Schematic
0				Hydroexcavate to 8' BGS	
5					
				Advance augers to 10' BGS and begin split spoons every 5'	
10	10-12	579 21.6	2	Gray-green stained silt and some gravel, moist. Changing at 11' BGS to a red-orange compact silt, slight moisture.	
15	15-17	18.8	2	Red-brown-orange sand and gravel, slightly moist	
20	20-22	382	2	Red-brown silt, very moist	
25	25-27	522	2	Red-brown gravel and sand, moist. Black staining present at 27' BGS.	
30	30-32	574	2	Black stained sand and gravel, wet	
35				Well set at 35' and completed with a flushmount manhole cover	

OBSERVATION WELL DRILLING LOG

LOCATION:	Sunoco Belmont Terminal 26th Street and Passyunk Avenue Philadelphia, PA
DATE:	28 May 1998
GEOLOGIST:	John M. Zatyczyc, P.G.
DRILLER:	B. L. Myers Bros., Inc., Glenmoore, Pa.
METHOD:	8" Hollow Stem Auger HSA
IDENTIFICATION:	OW 18
CONSTRUCTION:	4" Galvanized Steel; 10' Solid Pipe; 20' 0.020" Slotted Galvanized Steel Screen
TOTAL DEPTH:	30 feet

DEPTH	DESCRIPTION	COMMENTS	OVM (ppm)
0 – 0.5'	Asphalt		
0.5' - 3'	Black silty, sand		
3' - 16'	Gray, silty, clay	Grab sample @ 5' Odor @ 5' Damp @ 5' Grab sample @ 10' Grab sample @ 15'	0.0 (5') 585 (10') 304 (15')
16' - 19'	Orange brown, clay	Hard drilling between 16' and 19' Damp @ 16'	
19' – 30'	Orange brown, silty, sandy clay	Grab sample @ 20' Grab sample @ 25'	734 (20') 1023(25')

OBSERVATION WELL DRILLING LOG

LOCATION:	Sunoco Belmont Terminal 26th Street and Passyunk Avenue Philadelphia, PA
DATE:	28 May 1998
GEOLOGIST:	John M. Zatyczyc, P.G.
DRILLER:	B. L. Myers Bros., Inc., Glenmoore, Pa.
METHOD:	8" Hollow Stem Auger HSA
IDENTIFICATION:	OW 19
CONSTRUCTION:	4" Galvanized Steel; 10' Solid Pipe; 20' 0.020" Slotted Galvanized Steel Screen
TOTAL DEPTH:	30 feet

DEPTH	DESCRIPTION	COMMENTS	OVM (ppm)
0 – 0.5'	Asphalt		
0.5' - 1'	Gray silt		
1' - 16'	Dark brown-black silt and gravel	Grab sample @ 5' Wet @ 6' Grab sample @ 10' Grab sample @ 15'	262 (5') 329 (10') 599 (15')
16' - 24'	Brown silty, clay	Grab sample @ 20'	546 (20')
24' – 30'	Brown, silty, sand and gravel	Grab sample @ 25' Grab sample @ 30'	803(25') 751(30')

OBSERVATION WELL DRILLING LOG

LOCATION: Sunoco Belmont Terminal
26th Street and Passyunk Avenue
Philadelphia, PA

DATE: 28 May 1998

GEOLOGIST: John M. Zatyczyc, P.G.

DRILLER: B. L. Myers Bros., Inc., Glenmoore, Pa.

METHOD: 8" Hollow Stem Auger HSA

IDENTIFICATION: OW 20

CONSTRUCTION: 4" Galvanized Steel; 10' Solid Pipe; 20' 0.020" Slotted Galvanized Steel Screen

TOTAL DEPTH: 30 feet

DEPTH	DESCRIPTION	COMMENTS	OVM (ppm)
0 – 0.5'	Grass cover		
0.5' - 4'	Gravel, brown silty clay, brick	Fill material	
4' - 8'	Orange brown, silty, sandy clay	Grab sample @ 5'	4.1 (5')
8' - 11	Brown silty, clay	Damp Grab sample @ 10'	12.4 (10')
11' - 18	Gray clay	Wet Grab sample @ 15'	12.4 (15')
18' – 22'	Orange brown clay, some sand	Grab sample @ 20'	95 (20')
22' – 30'	Orange brown, silty, sand and gravel	Grab sample @ 25' Grab sample @ 30'	170.8 (25') 7715 (30')

OBSERVATION WELL DRILLING LOG

LOCATION:
Sunoco Belmont Terminal
26th Street and Passyunk Avenue
Philadelphia, PA

DATE: 26 May 1998

GEOLOGIST: John M. Zatyczyc, P.G.

DRILLER: B. L. Myers Bros., Inc., Glenmoore, Pa.

METHOD: 10" Hollow Stem Auger HSA

IDENTIFICATION: RW 1

CONSTRUCTION: 4" Schedule 40 PVC; 20' Blank Pipe; 30' 0.020" Slot Screen

TOTAL DEPTH: 50 feet

DEPTH	DESCRIPTION	COMMENTS	OVM (ppm)
0 – 0.5'	asphalt		
0.5' - 2'	Gravel, cobble, gray silt	Fill material	
2' - 4'	Black sandy silt and gravel		
4' - 5'	Brown medium to coarse sand		
5' – 9'	Brown silty, sandy clay and gravel	Grab sample @ 5' Odor @ 5'	671 (5')
9' –23'	Gray silty, sand	Grab sample @ 10' Very wet @ 12' Grab sample @ 15' Grab sample @ 22'	979 (10') 785 (15') 1764 (22')
23' – 27'	Gravel and rock	Grab sample @ 25'	1264 (25')
27' – 33'	Brown sandy silt, gravel and rock	Grab sample @ 30' Strong odor @ 30'	1410 (30')
33' – 50'	Brown sandy silt	Grab sample @ 35' Grab sample @ 40' Grab sample @ 45' Grab sample @ 50' Odor between 35 and 50'	2077 (35') 1543 (40') 2161 (45') 1937 (50')

OBSERVATION WELL DRILLING LOG

LOCATION:	Sunoco Belmont Terminal 26th Street and Passyunk Avenue Philadelphia, PA
DATE:	27 May 1998
GEOLOGIST:	John M. Zatyczyc, P.G.
DRILLER:	B. L. Myers Bros., Inc., Glenmoore, Pa.
METHOD:	10" Hollow Stem Auger HSA
IDENTIFICATION:	RW 4
CONSTRUCTION:	4" Schedule 40 PVC; 20' Blank Pipe; 30' 0.020" Slot Screen
TOTAL DEPTH:	50 feet

DEPTH	DESCRIPTION	COMMENTS	OVM (ppm)
0 – 0.5'	asphalt		
0.5' - 6'	Black silt, ash, brick glass, swood chips	Fill material	
6' -22'	Black sandy silt and gravel	Wet @ 6' Odor @ 6' Grab sample @ 7' Grab sample @ 10' Grab sample @ 15' Very strong odor @ 17' Very wet @ 19' Grab sample @ 20'	572 (7') 1665 (10') 1598 (15') 2376 (20')
22' - 29'	Brown silty sand, gravel	Grab sample @ 25' Very wet 25'	2720 (25')
29' – 38'	Brown silty, sand	Grab sample @ 30' Grab sample @ 35' Very muddy	2336 (30') 2669 (35')
38' –50'	No cuttings	Soft @ 38'	

OBSERVATION WELL DRILLING LOG

LOCATION:	Sunoco Belmont Terminal 26th Street and Passyunk Avenue Philadelphia, PA
DATE:	28 May 1998
GEOLOGIST:	John M. Zatyczyc, P.G.
DRILLER:	B. L. Myers Bros., Inc., Glenmoore, Pa.
METHOD:	10" Hollow Stem Auger HSA
IDENTIFICATION:	RW 7
CONSTRUCTION:	4" Schedule 40 PVC; 20' Blank Pipe; 30' 0.020" Slot Screen
TOTAL DEPTH:	50 feet

DEPTH	DESCRIPTION	COMMENTS	OVM (ppm)
0 – 0.5'	Asphalt		
0.5' - 6'	Black silt, gravel	Fill material Odor @ 1' Grab sample @ 5'	20.8 (5')
6' - 13'	Brown, sandy silt and gravel	Odor @ 9' Grab sample @ 10'	115 (10')
13' - 50'	Brown, sandy silt and gravel	Grab sample @ 15'	170 (15')
		Very wet between 17' and 18'	
		Less wet @ 19'	
		Grab sample @ 20'	112 (20')
		Grab sample @ 25'	345 (25')
		Grab sample @ 30'	1296 (30')
		Grab sample @ 35'	1843 (35')
		Grab sample @ 40'	2522 (40')
		Grab sample @ 45'	2037 (45')
		Grab sample @ 50'	1806 (50'

RW-22

Handex®

Handex Of Maryland

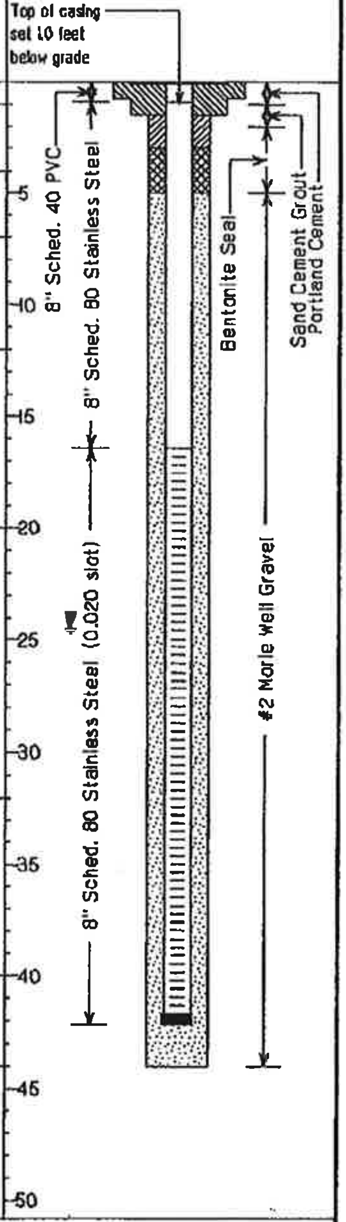
WELL LOG: MW-22

Permit #: *N/A*	Drill Date: *12/21/00*	Use: *Monitoring Well*
Location: *Sunoco Belmont Terminal, PA*		Owner Loc #:
Owner: *Sunoco, Inc*		Handex Loc #: *110535.032.T3045.900*

Owner Address: *3144 Passyunk Ave. Philadelphia, PA*	BORING - Depth: *44 ft.*	Diameter: *14.25 in.*
Drilling Method: *Air Rotary & Hollow Stem Auger*	CASING - Length: *0.92 / 15.47*	Diameter: *8 in.*
Sampling Method: *N/A*	SCREEN - Length: *25.8 ft.*	Diameter: *8 in.*
Static Water Level: *23.49 ft. (1/8/01)*	WELL - Depth: *42.19 ft.*	

Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description
						ASPHALT and CONCRETE
						FILL MATERIAL - Brick, Concrete with brown Sand
5						Brown and black SILT, SAND and GRAVEL, wet
						Brown and black SILT, SAND and GRAVEL, dry
10						Light brown SILT, SAND and GRAVEL, dry
15						
20						Brown SILT, SAND and GRAVEL, slightly moist
25						
30						Brown SILT and SAND, moist
35						
40						Brown SILT and SAND, wet
45						File name: 11055522
50						

Well Diagram



Geologist: David Leety	Driller: B.L. Myers Bros.

RW-23

Handex Of Maryland

WELL LOG: MW-23

Permit #: *N/A* | Drill Date: *12/20/00* | Use: *Monitoring Well*

Location: *Sunoco Belmont Terminal, PA* | Owner Loc #:

Owner: *Sunoco, Inc* | Handex Loc #: *110535.032.T3045.900*

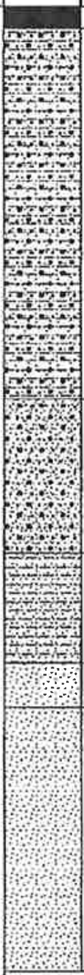
Owner Address: *3144 Passyunk Ave. Philadelphia, PA* | BORING - Depth: *44 ft.* Diameter: *14.25 in.*

Drilling Method: *Air Rotary & Hollow Stem Auger* | CASING - Length: *1.61 / 15.47* Diameter: *8 in.*

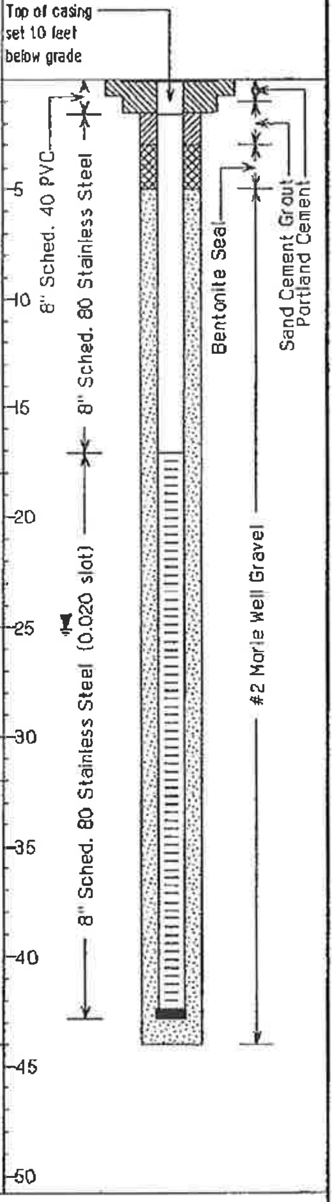
Sampling Method: *N/A* | SCREEN - Length: *25.8 ft.* Diameter: *8 in.*

Static Water Level: *24.10 ft.* *(1/8/01)* | WELL - Depth: *42.88 ft.*

Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description
						ASPHALT
5						Brown Silty SAND with fine to medium Gravel, moist
10						
15						
20						Light brown SAND with fine to medium Gravel
25						Light brown Silty SAND, moist
30						Brown SAND, NAPL saturated
35						Brown Sand, moist
40						
45						File name: 11055523
50						



Well Diagram



Geologist: David Leety | Driller: B.L. Myers Bros.

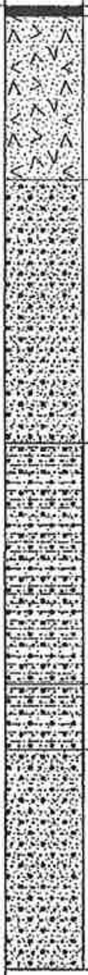
RW-24

Handex®

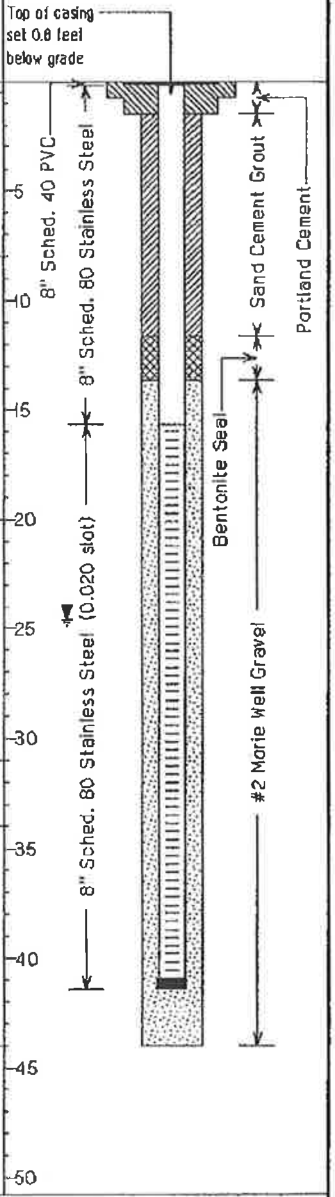
Handex Of Maryland

WELL LOG: MW-24

Permit #: N/A	Drill Date: 12/14/00	Use: Monitoring Well
Location: Sunoco Belmont Terminal, PA		Owner Loc #:
Owner: Sunoco, Inc		Handex Loc #: 110535.032.T3045.900
Owner Address: 3144 Passyunk Ave. Philadelphia, PA	BORING - Depth: 44 ft.	Diameter: 14.25 in.
Drilling Method: Air Rotary & Hollow Stem Auger	CASING - Length: 0.17 / 15.47	Diameter: 8 in.
Sampling Method: N/A	SCREEN - Length: 25.8 ft.	Diameter: 8 in.
Static Water Level: 24.02 ft. (1/8/01)	WELL - Depth: 41.44 ft.	

Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description
						ASPHALT
						Brown SAND with Fill material (Concrete, Brick, wood)
5						
						Brown SAND with fine to medium Gravel, dry
10						
15						
20						Brown Silty SAND with fine to medium Gravel, moist
25						
30						Brown Silty SAND with fine to medium Gravel, wet
35						Brown medium to coarse SAND with fine Gravel, moist
40						
						File name: 11055524
45						
50						

Well Diagram



Geologist: David Leety	Driller: B.L. Myers Bros.

RW-25

Handex®

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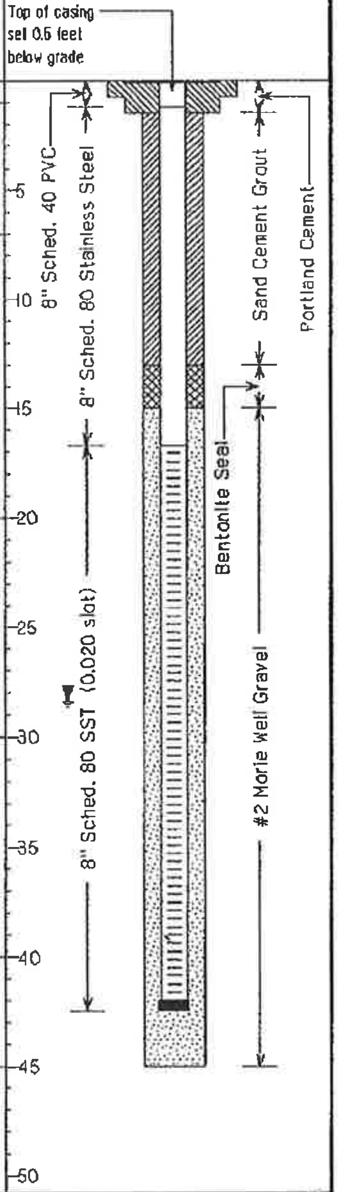
WELL LOG: MW-25

Permit #: *N/A*	Drill Date: *12/13/00*	Use: *Monitoring Well*
Location: *Sunoco Belmont Terminal, PA*		Owner Loc #:
Owner: *Sunoco, Inc*		Handex Loc #: *110535.032.T3045.900*
Owner Address: *3144 Passyunk Ave. Philadelphia, PA*	BORING - Depth: *45 ft.*	Diameter: *14.25 in.*
Drilling Method: *Air Rotary & Hollow Stem Auger*	CASING - Length: *1.23 / 15.47*	Diameter: *8 in.*
Sampling Method: *N/A*	SCREEN - Length: *25.8 ft.*	Diameter: *8 in.*
Static Water Level: *27.89 ft. (1/8/01)*	WELL - Depth: *42.5 ft.*	

Depth (ft.)	Sample ID	Sample Depth	Blows/6 in.		Graphic Log	Geologic Description
						ASPHALT and CONCRETE
5						Black Silty SAND with Fill material (Concrete, Bricks), dry
10						Black Silty SAND with medium Gravel, dry to slightly moist
15						
20						Brown to olive green, medium to coarse SAND, moist
25						
30						Brown SAND with fine to medium Gravel, moist
35						
40						Brown SAND, wet
45						File name: 11055525
50						

Well Diagram



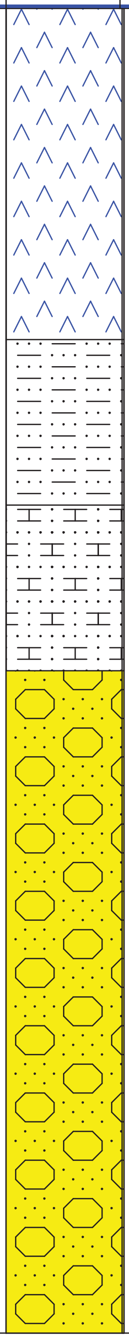
Geologist: David Leety

Driller: B.L. Myers Bros.

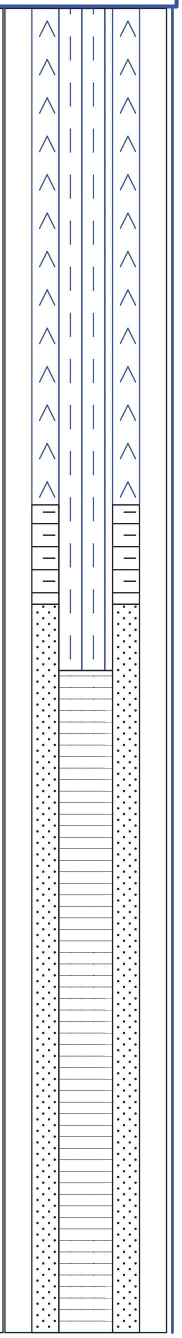
Aquaterra Technologies, Inc.

MONITORING WELL LOG: RW-26

PROJECT: **Sunoco Refinery**
SITE LOCATION: **Belmont Terminal**
JOB NO.: **11-102**
LOGGED BY: **Brad Spancake**
DATES DRILLED: **5-April-06**
TOTAL DEPTH: **40'**
DRILLING CO.: **Total Quality Drilling**
DRILLING METHOD: **8 1/4" Hollow Stem Auger**
SAMPLING METHOD: **Cuttings**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **8 1/4"**
ELEVATION: **-**



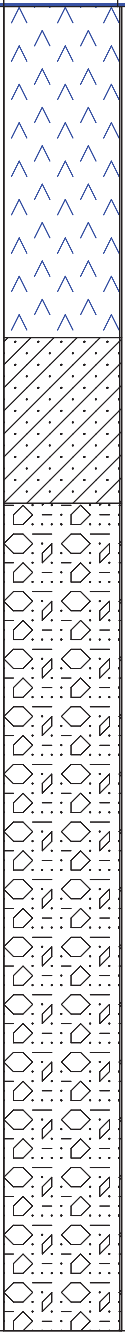
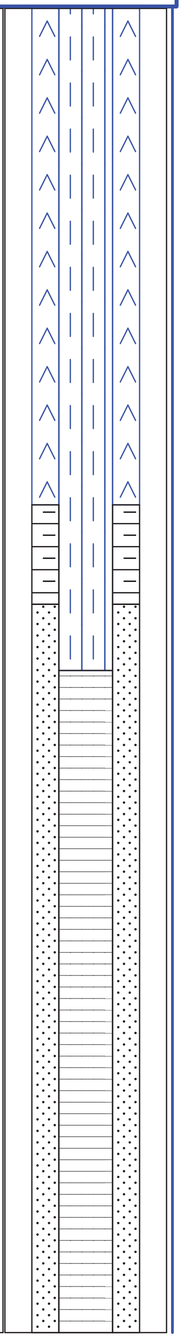
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0						
				Finished inside 2'x2' vault		
-5			Fill	Softdug with backhoe to 8'	Backfill 0-15'	
-10					PVC Riser 0-20'	
			Wet greenish-gray clayey sand, medium grained, chaning to brown clayey silt			
-15				Slight grinding at 15', grinding and jumping at 17'	Bentonite 15-18"	
			Brown clayey silt and pebbles, change to brown silt and pebbles			
-20						
			Same, change to reddish-brown coarse sandy gravel and pebbles			
-25					Sand 18-40'	
			Same, change to reddish brown coarse sand, small gravel @ 27', wet cuttings at 28', trace gravel	Water at 28'		
-30					PVC Screen 20-40'	
			Wet brownish gray, coarse sand and silt, trace gravel			
-35						
			Same	Drilling terminated at 40'		
-40						



Aquaterra Technologies, Inc.

MONITORING WELL LOG: RW-27

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Belmont Terminal**	DRILLING METHOD:	**8 1/4" Hollow Stem Auger**
JOB NO.:	**11-102**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Brad Spancake**	SCREEN/RISER DIAMETER:	**4"**
DATES DRILLED:	**5-April-06**	WELLBORE DIAMETER:	**8 1/4"**
TOTAL DEPTH:	**40'**	ELEVATION:	**-**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0				Finished inside 2'x2' vault Softdug with backhoe to 8'		
-5			Fill		Backfill 0-15'	
-10			Greenish gray clay changing to a greenish gray moist sandy clay @ 12', change to a clayey silt brown in color at 13'		PVC Riser 0-20'	
-15				Grinding at 16'	Bentonite 15-18"	
			Large pebbles grading to small pebbles and gravel in brown silt			
-20						
			Same, changing to reddish brown sandy silt with small gravel			
-25					Sand 18-40'	
			Reddish brown coarse sand and brown silt with small gravel			
-30					PVC Screen 20-40'	
			Same, wet			
-35						
			Same, more silt content	Drilling terminated at 40'		
-40						

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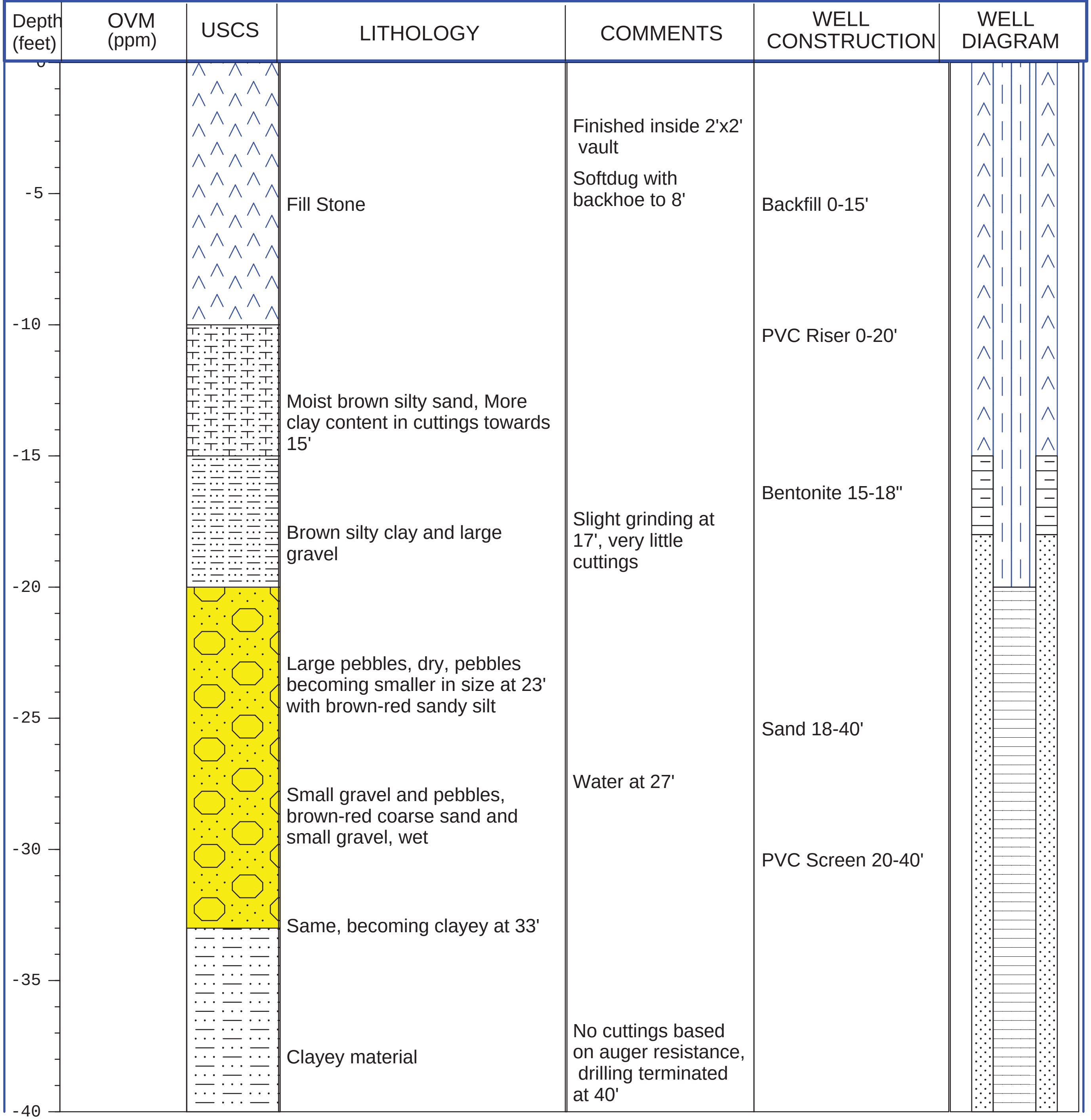
MONITORING WELL LOG: **RW-28**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **Belmont Terminal**
JOB NO.: **11-102**
LOGGED BY: **Brad Spancake**
DATES DRILLED: **4-April-06**
TOTAL DEPTH: **40'**

DRILLING CO.: **Total Quality Drilling**
DRILLING METHOD: **8 1/4" Hollow Stem Auger**
SAMPLING METHOD: **Cuttings**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **8 1/4"**
ELEVATION: **-**



Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0						
				Finished inside 2'x2' vault		
-5			Fill Stone	Softdug with backhoe to 8'	Backfill 0-15'	
-10					PVC Riser 0-20'	
			Moist brown silty sand, More clay content in cuttings towards 15'			
-15						
					Bentonite 15-18"	
			Brown silty clay and large gravel	Slight grinding at 17', very little cuttings		
-20						
			Large pebbles, dry, pebbles becoming smaller in size at 23' with brown-red sandy silt			
-25					Sand 18-40'	
				Water at 27'		
			Small gravel and pebbles, brown-red coarse sand and small gravel, wet			
-30					PVC Screen 20-40'	
			Same, becoming clayey at 33'			
-35						
			Clayey material	No cuttings based on auger resistance, drilling terminated at 40'		
-40						

Aquaterra Technologies, Inc.

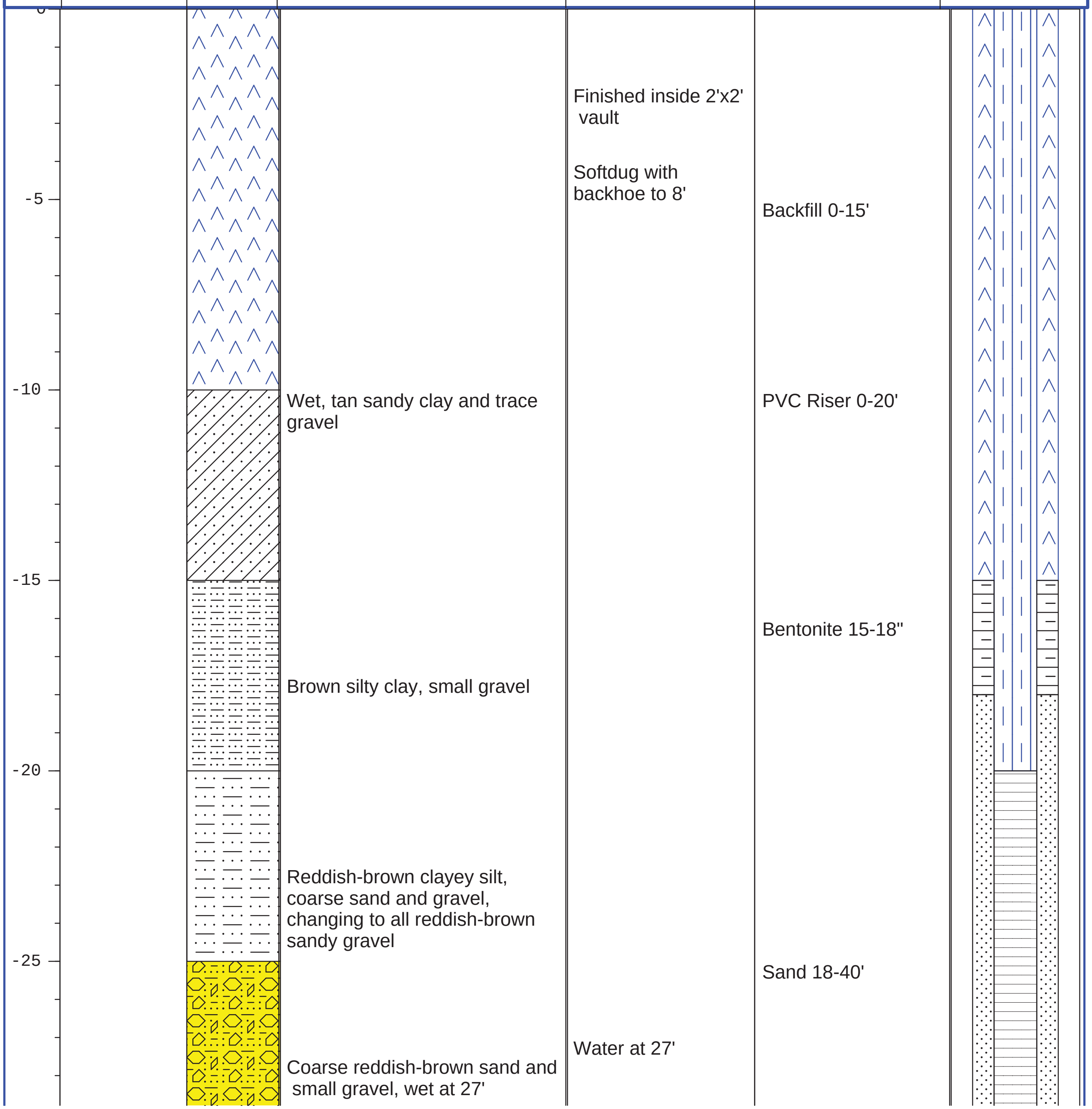
Page 1 of 2

MONITORING WELL LOG: RW-29

PROJECT: **Sunoco Refinery**
SITE LOCATION: **Belmont Terminal**
JOB NO.: **11-102**
LOGGED BY: **Brad Spancake**
DATES DRILLED: **11-April-06**
TOTAL DEPTH: **40'**

DRILLING CO.: **Total Quality Drilling**
DRILLING METHOD: **8 1/4" Hollow Stem Auger**
SAMPLING METHOD: **Cuttings**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **8 1/4"**
ELEVATION: **-**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM



Finished inside 2'x2' vault

Softdug with backhoe to 8'

Backfill 0-15'

Wet, tan sandy clay and trace gravel

PVC Riser 0-20'

Bentonite 15-18"

Brown silty clay, small gravel

Reddish-brown clayey silt, coarse sand and gravel, changing to all reddish-brown sandy gravel

Sand 18-40'

Water at 27'

Coarse reddish-brown sand and small gravel, wet at 27'

MONITORING WELL LOG: RW-29

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-30			Brown compact silt, coarse, heavy black stained sand and gravel lense (2" wide) at 31' (1.5' recovery)	Spoon samples collected 30-40' Sample taken for laboratory analysis at 31'	PVC Screen 20-40'	
			Reddish-brown silt with gray banding (0.5 ' recovery)			
-35			Reddish-brown compact silt with gray banding (2' recovery)			
			Gray fine sand, wet with brown silt lenses (2' recovery)	Drilling terminated at 40'		
			Wet, fine brown sand and silt (2' recovery)			
-40						

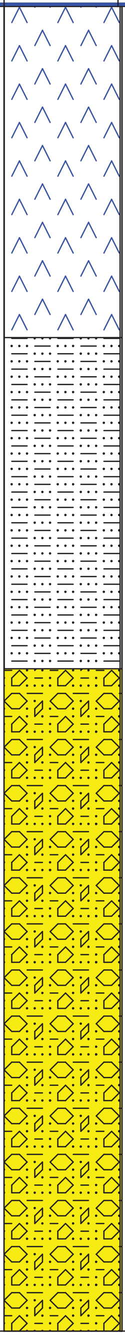
Aquaterra
Technologies, Inc.

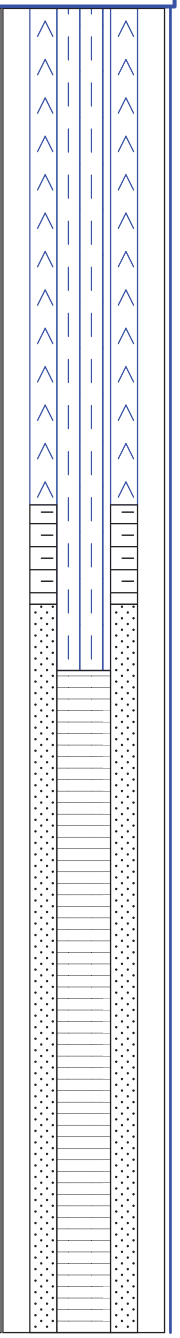
MONITORING WELL LOG: RW-30

PROJECT: **Sunoco Refinery**
SITE LOCATION: **Belmont Terminal**
JOB NO.: **11-102**
LOGGED BY: **Brad Spancake**
DATES DRILLED: **10-April-06**
TOTAL DEPTH: **40'**

DRILLING CO.: **Total Quality Drilling**
DRILLING METHOD: **8 1/4" Hollow Stem Auger**
SAMPLING METHOD: **Cuttings**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **8 1/4"**
ELEVATION: **-**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0						
				Finished inside 2'x2' vault Softdug with backhoe to 8'		
-5			Fill		Backfill 0-15'	
-10			Wet, tan silty clay and small gravel with coarse sand, change to moist brown tan clay at 13'		PVC Riser 0-20'	
-15						
				Grinding at 16', very few cuttings	Bentonite 15-18"	
			Brown clayey silt, trace coarse sand and gravel			
-20						
			Gravel of various sizes in reddish brown sand gravel			
-25					Sand 18-40'	
			Same, wet at 27'			
-30					PVC Screen 20-40'	
			Same			
-35						
			Same	Drilling terminated at 40'		
-40						



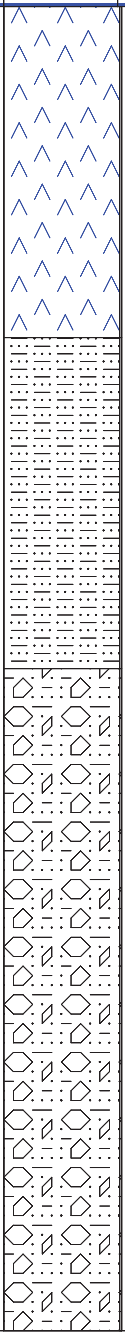


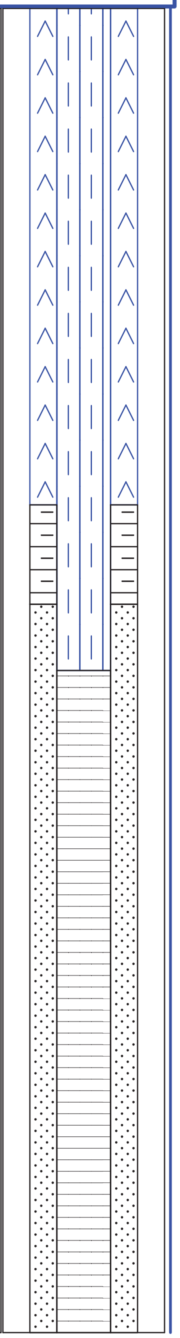
Page 1 of 1

Aquaterra Technologies, Inc.

MONITORING WELL LOG: RW-31

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Belmont Terminal**	DRILLING METHOD:	**8 1/4" Hollow Stem Auger**
JOB NO.:	**11-102**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Brad Spancake**	SCREEN/RISER DIAMETER:	**4"**
DATES DRILLED:	**7-April-06**	WELLBORE DIAMETER:	**8 1/4"**
TOTAL DEPTH:	**40'**	ELEVATION:	**-**





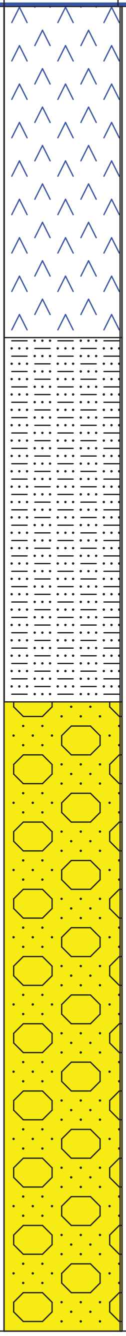
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0				Finished inside 2'x2' vault		
-5			Fill	Softdug with backhoe to 8' Perched water	Backfill 0-15'	
-10			Wet, tan clay and silt, some gravel		PVC Riser 0-20'	
-15			Wet, brown clayey silt, less moisture @ 17', grading to gray in color	Slight grinding at 19'	Bentonite 15-18"	
-20			Reddish-brown coarse sandy silt with gravel, dry			
-25					Sand 18-40'	
-30			Same		PVC Screen 20-40'	
-35				Drilling terminated at 40'		
-40						

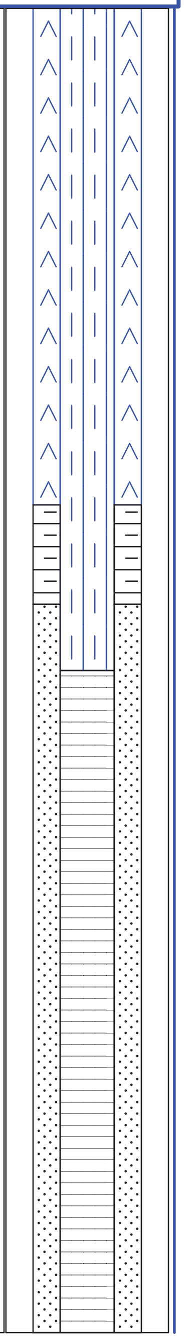
Page 1 of 1

Aquaterra Technologies, Inc.

MONITORING WELL LOG: RW-32

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Belmont Terminal**	DRILLING METHOD:	**8 1/4" Hollow Stem Auger**
JOB NO.:	**11-102**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Brad Spancake**	SCREEN/RISER DIAMETER:	**4"**
DATES DRILLED:	**6-April-06**	WELLBORE DIAMETER:	**8 1/4"**
TOTAL DEPTH:	**40'**	ELEVATION:	**-**





Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0				Finished inside 2'x2' vault Softdug with backhoe to 8'		
-5			Fill		Backfill 0-15'	
-10			Greenish gray clay changing to brown sandy silt, trace clay, moist at 12'. Sand less present at 13'		PVC Riser 0-20'	
-15					Bentonite 15-18"	
			Reddish brown silty clay, change to brown gray clay at 17'	Slight grinding at 19'		
-20						
			Same, change to brown gray silt and coarse sand, pebbles at 21'			
-25					Sand 18-40'	
			Same, change to pebble and gravel in gray coarse sand at 27', moist, wet at 28'	Water at 28'		
-30					PVC Screen 20-40'	
			Wet, reddish brown coarse sand and gravel	Heavier grinding at 31'		
-35						
			Wet, gray coarse sand and small gravel	Drilling terminated at 40'		
-40						

CALCULATION WORKSHEET Order No. 19116 (01-91)

PAGE ___ OF ___

CLIENT SUN PHILADELPHIA REFINERY

JOB NUMBER 26 th Street

SUBJECT Boring Logs for Recovery Well - Pilot Holes

BASED ON

DRAWING NUMBER

BY E. DZIEDZIC (GES)

CHECKED BY

APPROVED BY

DATE 5/4/94

DEPTH	GRAPHIC LOG Lith.		BLOWS	RECOVERY	PH-14 LITHOLOGY LOCATION: BELMONT TERMINAL ADJACENT TO S-75 (RW-400)	
13			8,13,12,22	8"	SAND - POORLY SORTED SAND AND GRAVEL STRONG ODORS, DRY	
15			13,18,9,12	15"	SAND - BROWN MED. GRAINED SAND, MOIST, ODOR, ½" GRAVEL LAYER IN MIDDLE OF SPOON	
17						
19						
21			17,23,25, 11	14"	SAND - POORLY SORTED SAND AND GRAVEL, MOIST, ODOR,	
23			27,34,50/5	13"	GRAVEL - POORLY SORTED MATRIX SUPPORTED PEBBLES, MULTI-COLORED, WET NAPL.	▽ INITIAL WATER @ 22 ft.
25			16,42,43,37	10"	GRAVEL - POORLY SORTED PEBBLES IN SAND MATRIX, WET, ODOR	
27			33,47,33, 50/5"	15"	SAND - POORLY SORTED SAND AND GRAVEL, WET, ODOR	
29			7,36,34,33	12"	SAND - POORLY SORTED SAND AND SMALL PEBBLES, NAPL STAINED, WET, ODOR	
31			12,36,44,33	11"	SAND - POORLY SORTED SAND AND SMALL PEBBLES, WET, ODOR	
33			30,37,34,27	10"	SAND - POORLY SORTED SAND AND GRAVEL, WET, ODOR,	
35			21,27,35,22	10"	SAND - POORLY SORTED SAND AND GRAVEL, WET, ODOR	
37			13,22,17,16	10"	SAND - COARSE SAND AND SMALL PEBBLES, WET, ODOR	
39			10,5,4,6	4"	CLAY - TAN SILTY CLAY, MOIST	
41			5,4,9,7	15"	SAND - DARK GRAY FINE-GRAINED SAND, MOIST	
43			10,7,11,12	8"	SAND - RED MEDIUM-GRAINED SAND,	
44			6,9,13,12	20"	CLAY - RED SILTY CLAY, MOIST	

GROUNDWATER & ENVIRONMENTAL SERVICES, INC.

DRILLING LOG

Project RW-INSTALLATION **Owner** SUN COMPANY, INC

Location PHILA. REFINERY **Permit No.** N/A

Well Number RW-400 **Total Depth** 39FT **Diameter** 10.25 ID

Casing Elevation N/A **Water Level: Initial** N/A **Static** N/A

Screen Dia. 6 INCH **Length** 15FT **Slot Size** 0.040 INCH

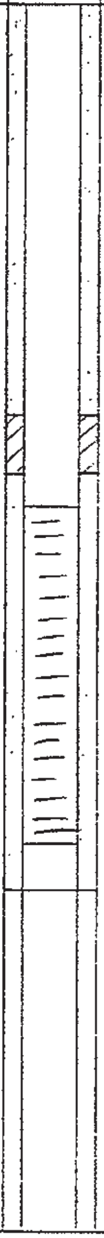
Casing Dia. 6 INCH **Length** 55FT **Type** PVC

Drilling Method AUGER **Sample Method** N/A

Completion Details 1FT PVC STICK-UP W/ LOCKING CHIMNEY PLUG

Driller HUNTINGDON-EMPIRE **Log By** N/A **Date** MAY 1994

Sketch Map

Depth (feet)	Sample No.	Well Const.	OVA (ppm)	Blow Count	Lithology
10 20 30 40 50					SAND PACK #2 TOP OF SAND 20.5FT. TOP OF BENTONITE 18FT TOP OF SCREEN 22FT BOTTOM OF SCREEN 37FT SCREEN STAINLESS STEEL VEE'WIRE

Page ________ of ________

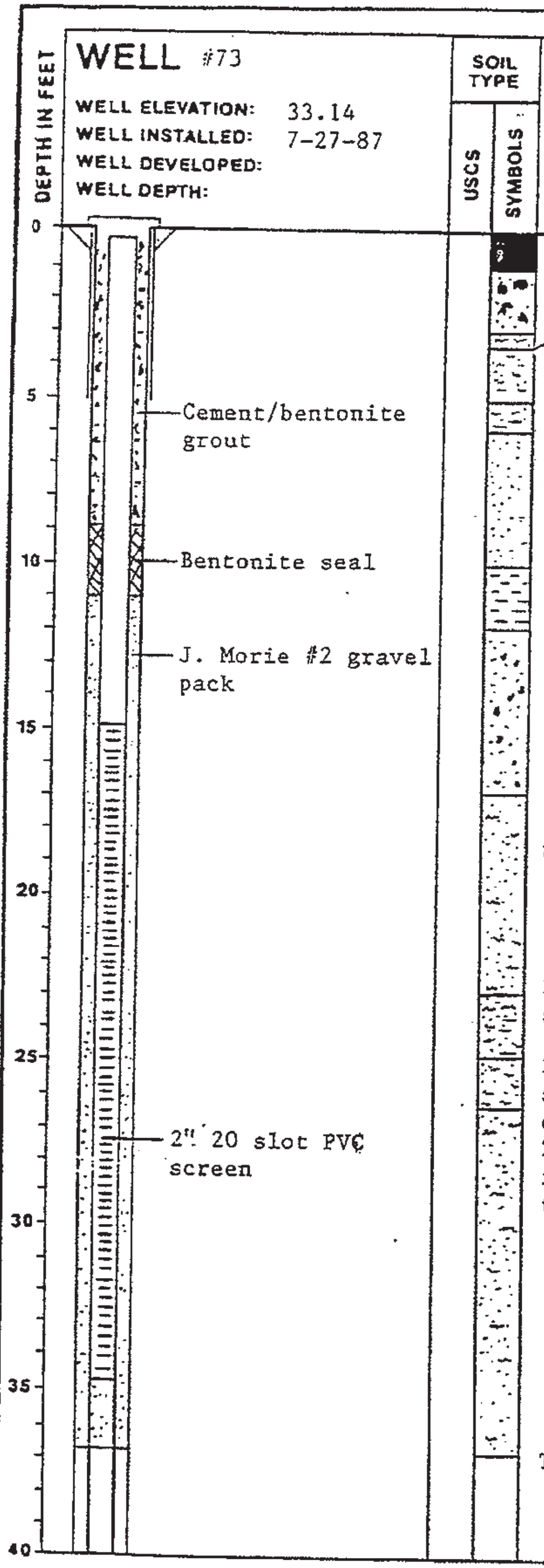
S-74

WELL #73

WELL ELEVATION: 33.14
WELL INSTALLED: 7-27-87
WELL DEVELOPED:
WELL DEPTH:

BORING

SURFACE ELEVATION:
DRILLING METHOD: Hollow Stem Auger
BORING DEPTH: 37.0



0.0 - 1.0 BLACK TOP
1.0 - 3.0 FILL
3.0 - 3.5 SILT: brown, sandy,
3.5 - 5.0 SILT: brown, sandy, clayey, wet, no ordor
5.0 - 6.0 SILT: brown, sandy, moist, no odor
6.0 - 10.0 SAND: light gray, silty, micaceous, wet, no odor
10.0 - 12.0 CLAY: gray, moist, no odor
12.0 - 17.0 SAND AND GRAVEL: brown, moist, no odor
17.0 - 23.0 SAND: variegated, fine to coarse, trace silt, moist, no odor
23.0 - 25.0 SILT: brown, sandy, micaceous, moist
25.0 - 26.5 SILT: brown, sandy, trace gravel, wet, no odor
26.5 - 37.0 SAND: variegated, fine to coarse, gravel and trace silt, wet, no odor

TOTAL DEPTH 37.0

SAMPLE DATA

		BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE
				1		
				2		
				3		
				4		
				5		

Drilled By Hardin-Huber
Logged By Peter J. Dougherty
Client Atlantic
Job No. 522-239-00
Page 1 Of 1

EEI ENGINEERING ENTERPRISES, INC.

NLW S-75

S.V.M. industries **geotechnical division inc.**
post office box 2 • huntingdon valley, pennsylvania
215-947-2555

Client ARCO
Project WELL INSTALLATION
Location SOUTH YARD, PHILADELPHIA, PA.
Project No.
Boring No. SM-36 Depth 31.0'
Elevation
Spoon Size Casing Size
Core Size Bit No.
Hammers:
Spoon, weight Drop
Drive, weight Drop
Date Started 3-19-85

Driller SB
Helper WGH
Inspector MC
Job No. 2890

Ground Water Data:
0 Hrs: WATER AT 27'6"
TOTAL PIPE : 33.0'

Date Completed 3-19-85

Depth	Casing Blows	STRATA CLASSIFICATION	Depth	SAMPLING DATA No.	Blows per 6"	REMARKS
		ASPHALT TOP .2'				
		MISCELLANEOUS FILL 5.0'				
		LIGHT TO MEDIUM GREY SILTY SAND 11.0'				PRODUCT ODOR VERY OBVIOUS
		REDDISH BROWN TO GREY SAND AND GRAVEL GRADING INTO MEDIUM SAND 31.0'				SATURATED WITH LIGHT PRODUCT.

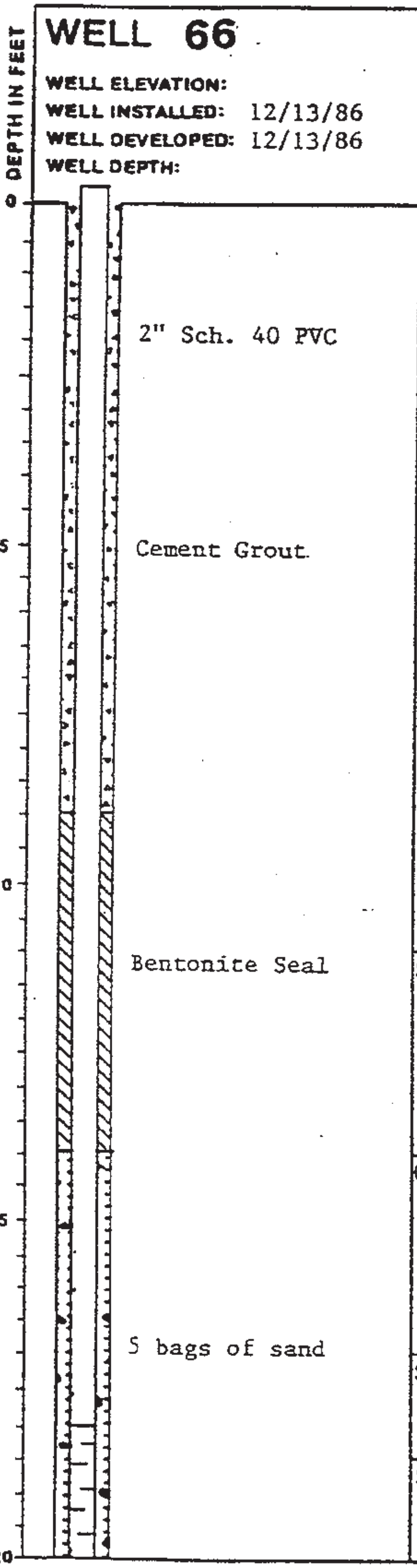
S-76.

WELL 66

WELL ELEVATION:
WELL INSTALLED: 12/13/86
WELL DEVELOPED: 12/13/86
WELL DEPTH:

BORING 66

SURFACE ELEVATION:
DRILLING METHOD: H.S.A.
BORING DEPTH:



SOIL TYPE USCS	DESCRIPTION	BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
	4" asphalt					
ML	SILT: HC odor (fill material) moist; black					
GM	FILL					
ML	No odor; slightly moist; gray, green					
SM	SANDY SILT: HC odor; moist; trace fine sand & gravel fill; gray, brown					
GM	GRAVELLY SILT: HC odor	4 15 25	75			S
SM	Silt to ½ gravel grading to bigger dry HC odor; multi	24 24 29	75			S
SM	SILTY SAND: fine to medium HC odor, slightly moist; tan	57				

Drilled by CVM Inc.
Logged by J. Garth
Client ARCO
Job No. 502-158-02
Page 1 of 2

EEI ENGINEERING ENTERPRISES, INC.

5-76

WELL 66 Cont.

BORING 66 Cont.

DEPTH IN FEET	USCS	DESCRIPTION	BLOWS	% RETAINED	SAMPLE NO.	SAMPLE DEPTH	SAMPLE TYPE
20	GP	GRAVELLY SAND: little silt; dry; multi; tan; HC odor	46 55 29 29	80			S
	ML	SILTY CLAY: trace fine sand; moist; HC odor; brown, gray	11 10				
	CL	Fine to medium sand; moist HC odor	10 10 13	100			S
25	CL	SILTY CLAY: wet, HC odor; little fine sand	6 10 31 35	80			S
			45	80			S
	SP	GRAVELLY SAND: fine to coarse ½" gravel; HC; wet; some silt + 3/4" gravel; tan	47 40 27				
		Water oil cut @ 28'					
30		Fine to coarse sand 3/4" (little) gravel and some silt	33 61 53 37	50			S
		some gravel; water saturated	N/S				
	SM	SILTY SAND: medium to coarse; saturated HC odor with silt; gray	28 45 49	100			S
	GM	SILTY GRAVEL: grading to ½" gravel with silt	75				
35		TD = 35'					
40							

ENGINEERING ENTERPRISES, INC.

Page 2 Of 2

PROJECT: **Sun FCU**
LOCATION: **Sunoco Belmont Terminal, Philadelphia, PA**
PROJECT NUMBER: **213402094.304.1001**

WELL / PROBEHOLE / BOREHOLE NO:
S-330 PAGE 1 OF 3

DRILLING / INSTALLATION:
STARTED **5/16/11** COMPLETED: **5/16/11**
DRILLING COMPANY: **Total Quality Drilling**
DRILLING EQUIPMENT: **Split Spoon**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **14**
STATIC DTW (ft): **27.01**
WELL CASING DIA. (in): **4**
LOGGED BY: **W. Rankin**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **36.0**
BOREHOLE DIA. (in): **10**
CHECKED BY: **A. Thomas**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			CONCRETE and ROAD BED Material.						
			Orange/brown, clayey SILT.		1240 FH-2 (1.5-2)				
5									5
					1345 FH-2 (6-6.5)				
10			Gray, silty SAND.		945 MW-330 (10-10.5) --		2	0.2 2.6	10
			Gray, sandy SILT.		-- -- --	1.25	3 4 5	4.3	
			Gray SILT with some fine sand.		-- --			0.9	
			No Recovery.			0	3 5 7 10		
			Gray SILT, saturated.		-- --			4.4	∇
			Reddish-brown SILT with some gray silt.		-- --		2 3	1.0	

Well Construction

PROJECT: **Sun FCU**
LOCATION: **Sunoco Belmont Terminal, Philadelphia, PA**
PROJECT NUMBER: **213402094.304.1001**

WELL / PROBEHOLE / BOREHOLE NO:
S-330 PAGE 2 OF 3

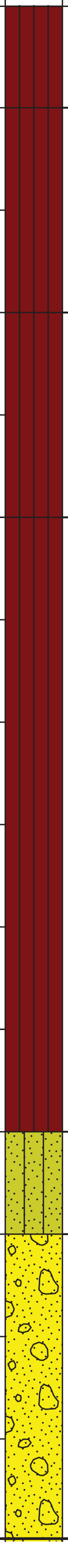
Stantec

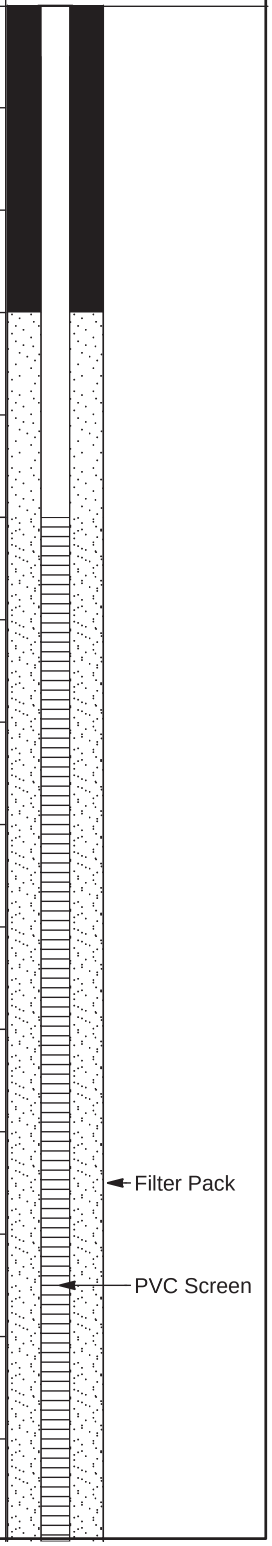
DRILLING / INSTALLATION:
STARTED **5/16/11** COMPLETED: **5/16/11**
DRILLING COMPANY: **Total Quality Drilling**
DRILLING EQUIPMENT: **Split Spoon**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **14**
STATIC DTW (ft): **27.01**
WELL CASING DIA. (in): **4**
LOGGED BY: **W. Rankin**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **36.0**
BOREHOLE DIA. (in): **10**
CHECKED BY: **A. Thomas**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Well Construction
					1000 MW-330 (15-15.5) --	0.83	3 4	0.8 0.4		
			Reddish-brown SILT with some gray silt and some gravel.		-- -- -- -- -- -- -- -- --	0.58	5 3 3 5	1.1 0.8 0.8 0.3		
			Gray SILT with some medium Gravel.		-- -- -- --	0.58	3 6 6 24	9.3 1.4		
20			Gray SILT with some coarse gravel.		1020 MW-330 (20-20.5) -- -- -- --	0.41	4 2 4 18	10.4 3.0	20	
					-- --	0.25	3 3 3 5	1.8		
25					1035 MW-330 (25-25.5)	0.33	1 2 3 5	0.9	25	
			Gray, silty SAND, saturated.		-- -- -- --			12.4 1.1		Filter Pack
			Coarse GRAVEL and fine and medium SAND.		1045 MW-330 (27-27.5)	1.5	2 3 12 33	148 239		PVC Screen
					-- -- -- -- -- -- -- -- -- --	0.58	1 1 2 1	200 201 80 3.6		





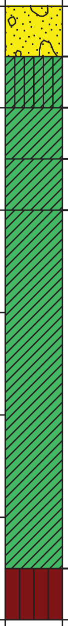
PROJECT: **Sun FCU**
LOCATION: **Sunoco Belmont Terminal, Philadelphia, PA**
PROJECT NUMBER: **213402094.304.1001**

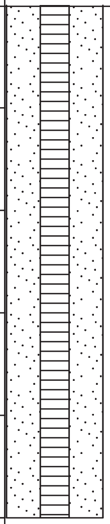
WELL / PROBEHOLE / BOREHOLE NO:
S-330 PAGE 3 OF 3

DRILLING / INSTALLATION:
STARTED **5/16/11** COMPLETED: **5/16/11**
DRILLING COMPANY: **Total Quality Drilling**
DRILLING EQUIPMENT: **Split Spoon**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **14**
STATIC DTW (ft): **27.01**
WELL CASING DIA. (in): **4**
LOGGED BY: **W. Rankin**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **36.0**
BOREHOLE DIA. (in): **10**
CHECKED BY: **A. Thomas**





Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Well Construction
					-- --			1.5		
			Brown, silty CLAY with some gravel.		-- --		4	0		
			Orange CLAY.		-- --	2	4 4	0.2		
			Orange-red CLAY.		-- --		5	0		
			Reddish-orange, silty CLAY with some sand and gravel, saturated.		-- --			3.5		
					-- --		3	1.6		
					-- --	2	3 5	0.1		
					-- --		7	1.8		
					-- --			0		
					-- --		3	1.8		
35					-- --	2	3 5	0.7	35	
			Black SILT, moist.		-- --		7	0.8		
			Borehole terminated at 36 feet.							
40									40	

PROJECT: **Sun FCU**
LOCATION: **Sunoco Belmont Terminal, Philadelphia, PA**
PROJECT NUMBER: **213402094.304.1001**

WELL / PROBEHOLE / BOREHOLE NO:
S-331 PAGE 1 OF 3

Stantec

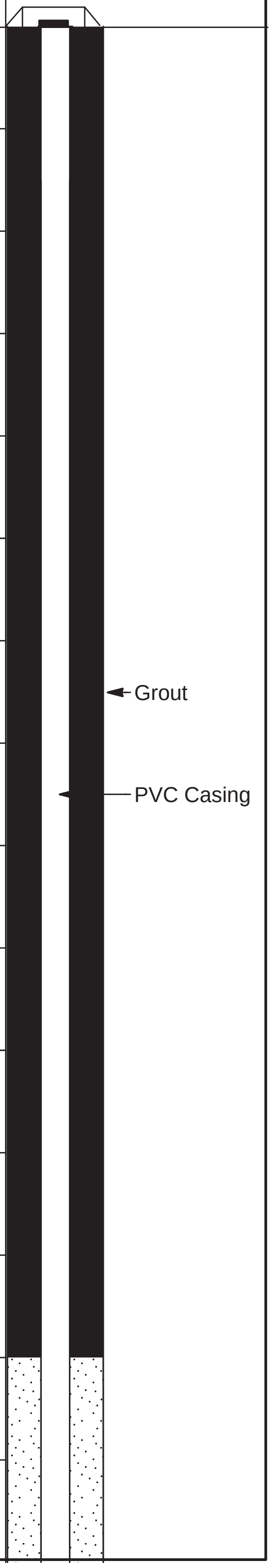
DRILLING / INSTALLATION:
STARTED **5/16/11** COMPLETED: **5/17/11**
DRILLING COMPANY: **Total Quality Drilling**
DRILLING EQUIPMENT: **Split Spoon**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **12**
STATIC DTW (ft): **28**
WELL CASING DIA. (in): **4**
LOGGED BY: **W. Rankin**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **36.0**
BOREHOLE DIA. (in): **10**
CHECKED BY: **A. Thomas**

Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
			Pre-cleared to 10'.						
5									5
10			Blueish-gray SILT.		1445 MW-331 (10-10.5) -- -- -- -- -- --	1.4	3 2 6 7	0.8 1.5 0 0	10
			Blueish-gray SILT, saturated.		-- -- -- -- -- -- --	1.8	4 3 6 6	0 0 0	▽
			Blueish-gray SILT, dry.		-- -- -- -- --		3 3	0 0 0	

Well Construction



PROJECT: **Sun FCU**
LOCATION: **Sunoco Belmont Terminal, Philadelphia, PA**
PROJECT NUMBER: **213402094.304.1001**

WELL / PROBEHOLE / BOREHOLE NO:
S-331 PAGE 2 OF 3

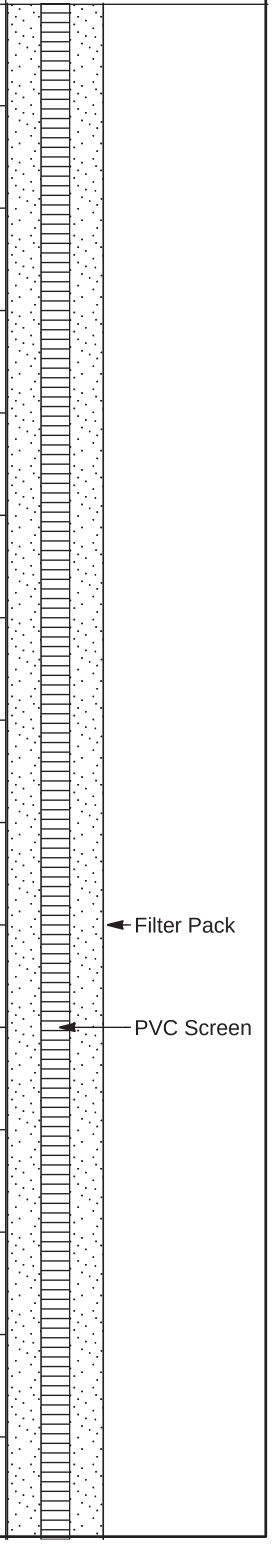
DRILLING / INSTALLATION:
STARTED **5/16/11** COMPLETED: **5/17/11**
DRILLING COMPANY: **Total Quality Drilling**
DRILLING EQUIPMENT: **Split Spoon**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **12**
STATIC DTW (ft): **28**
WELL CASING DIA. (in): **4**
LOGGED BY: **W. Rankin**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **36.0**
BOREHOLE DIA. (in): **10**
CHECKED BY: **A. Thomas**

Time & Depth (feet)	Description	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
		1455 MW-331 (15-15.5)	1.5	2 3	0 0	
	Blueish-gray SILT with some find and coarse gravel.		1.16	4 4 4 7	0 0 0 3.0	
	Blue-gray, sandy SILT.		2	3 4 4 7	0 0 0 0	
20	Blue-gray SILT, moist.	0740 MW-331 (20-20.5)	1.25	4 4 4 10	0 0 0 0	20
			0.83	3 3 3 5	0.1 0 0 0	
25		0800 MW-331 (25-25.5)	0.66	6 4 5 7	0.2 0.1 0.1 0.1	25
	Blue-gray, sandy SILT with some fine gravel, saturated.		2	2 2 2 5	0 0 0.2 0.2	
	Brown SAND with some fine and medium gravel.		0.83	2 2 2 4	1.0 1.0 0.3 0.3	

Well Construction



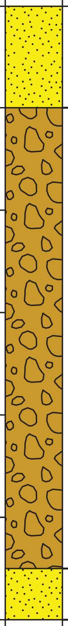
PROJECT: **Sun FCU**
LOCATION: **Sunoco Belmont Terminal, Philadelphia, PA**
PROJECT NUMBER: **213402094.304.1001**

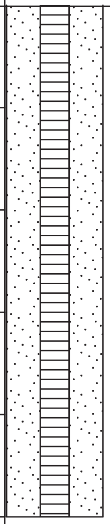
WELL / PROBEHOLE / BOREHOLE NO:
S-331 PAGE 3 OF 3

DRILLING / INSTALLATION:
STARTED **5/16/11** COMPLETED: **5/17/11**
DRILLING COMPANY: **Total Quality Drilling**
DRILLING EQUIPMENT: **Split Spoon**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **12**
STATIC DTW (ft): **28**
WELL CASING DIA. (in): **4**
LOGGED BY: **W. Rankin**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **36.0**
BOREHOLE DIA. (in): **10**
CHECKED BY: **A. Thomas**





Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Well Construction
			Brown, medium SAND with some silt.							
			Brown, coarse GRAVEL with some medium sand.			1.5	3 4 3 6			
						1.16	3 3 3 3			
35						1.58	3 3 3 3		35	
			Red, medium to fine SAND.							
			Borehole terminated at 36 feet.							
40									40	

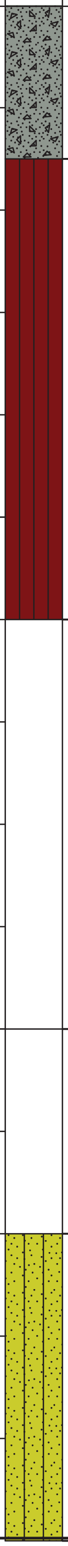
PROJECT: **Sun FCU**
LOCATION: **Sunoco Belmont Terminal, Philadelphia, PA**
PROJECT NUMBER: **213402094.304.1001**

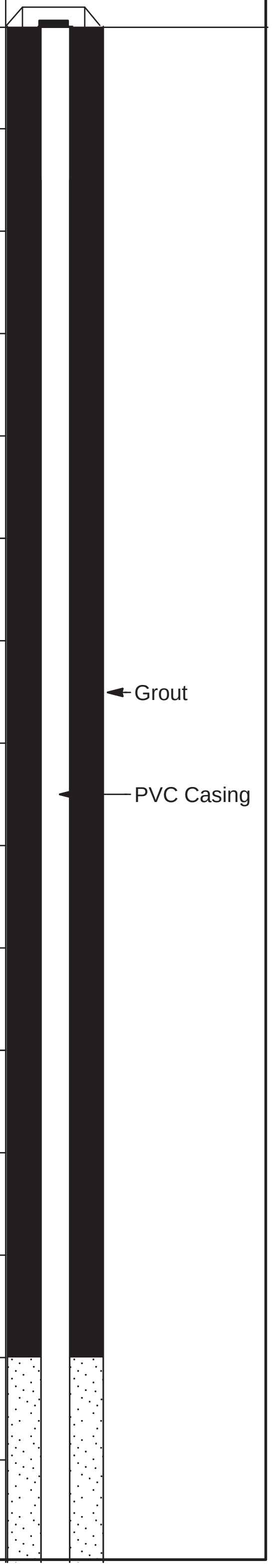
WELL / PROBEHOLE / BOREHOLE NO:
S-332 PAGE 1 OF 3

DRILLING / INSTALLATION:
STARTED **5/18/11** COMPLETED: **5/18/11**
DRILLING COMPANY: **Total Quality Drilling**
DRILLING EQUIPMENT: **Split Spoon**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **12**
STATIC DTW (ft): **26.46**
WELL CASING DIA. (in): **4**
LOGGED BY: **W. Rankin**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **36.0**
BOREHOLE DIA. (in): **10**
CHECKED BY: **A. Thomas**





Time & Depth (feet)	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)
		CONCRETE and ROAD BED Material.						
		Orange/brown, clayey SILT.						
				0945 FH-1 (3-3.5)				
5								5
				1045 FH-1 (6-6.5)				
10		Not Available.		-- -- -- -- -- -- -- --	1.75	2 2 2 1	0 0 0 0	10
		Dark gray, silty SAND, saturated.		0800 MW-332 (12-12.5) -- -- -- -- -- -- -- -- -- --	1.9	2 3 7 7 2 2	0 0 0 0 0 0	∇

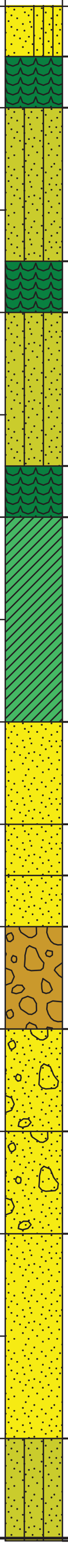
PROJECT: **Sun FCU**
LOCATION: **Sunoco Belmont Terminal, Philadelphia, PA**
PROJECT NUMBER: **213402094.304.1001**

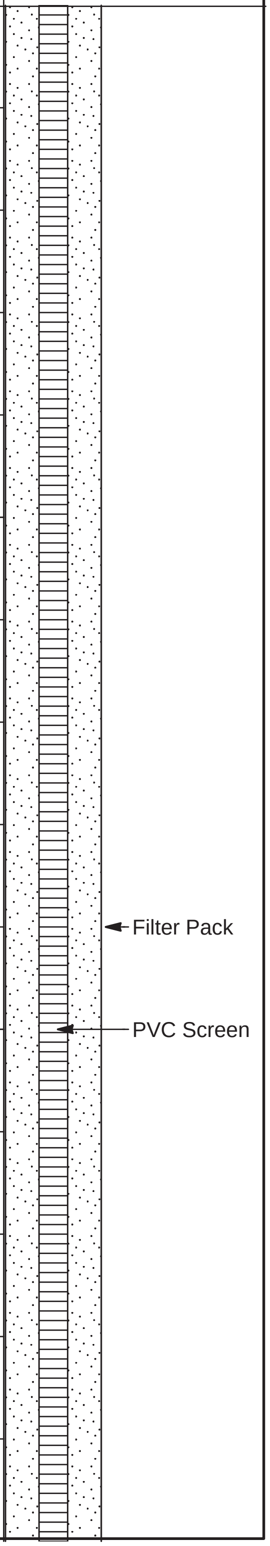
WELL / PROBEHOLE / BOREHOLE NO:
S-332 PAGE 2 OF 3

DRILLING / INSTALLATION:
STARTED **5/18/11** COMPLETED: **5/18/11**
DRILLING COMPANY: **Total Quality Drilling**
DRILLING EQUIPMENT: **Split Spoon**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon Auger**

NORTHING (ft):
LAT:
GROUND ELEV (ft):
INITIAL DTW (ft): **12**
STATIC DTW (ft): **26.46**
WELL CASING DIA. (in): **4**
LOGGED BY: **W. Rankin**

EASTING (ft):
LONG:
TOC ELEV (ft):
WELL DEPTH (ft): **35.0**
BOREHOLE DEPTH (ft): **36.0**
BOREHOLE DIA. (in): **10**
CHECKED BY: **A. Thomas**





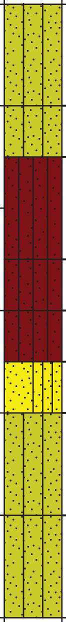
Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Well Construction
			Dark gray SILT and SAND, saturated. Dark brown, clayey SILT, saturated.		1000 MW-332 (15-15.5) -- --	1.6	5 5	0 0		
			Dark gray, silty CLAY, saturated. Dark brown, clayey SILT, saturated.		-- -- -- -- -- -- -- --	2	2 1 1 2	0 0 0 0		
			Dark brown, silty SAND, saturated. Orange-brown, clayey SILT, dry.		-- -- -- -- -- -- -- --	1.4	5 4 4 12	0 0 0 0		
20			Orange-red CLAY with little sand, dry.		1110 MW-332 (20-20.5) -- -- -- -- -- --	0.5	16 28 32 23	0 0 0 0	20	
			Gray, fine SAND, dry. Gray, fine SAND, brown sand horizon. Gray, fine sand medium SAND, dry.		-- -- -- -- -- -- -- -- --	1.6	5 9 17 20	0.5 0.2 0 9.9		
25			Red, silty, coarse GRAVEL. Orange and black, stratified SAND and GRAVEL.		-- -- -- 0800 MW-332 (25-25.5) --	1	3 6 28 17	1.2 0.4 0.9 5.8	25	Filter Pack PVC Screen
			Brown, coarse SAND and GRAVEL with some silt. Brown, coarse SAND with some silt, saturated.		-- -- -- 0840 MW-332 (26.5-27) -- --	1.16	15 18 17 26	388 960 485 356	▼	
			Dark brown, silty SAND with some medium gravel.		-- -- -- -- -- -- -- -- -- --	2	14 18 16 12	127 227 254 643		

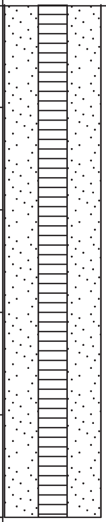
PROJECT: **Sun FCU**
LOCATION: **Sunoco Belmont Terminal, Philadelphia, PA**
PROJECT NUMBER: **213402094.304.1001**

WELL / PROBEHOLE / BOREHOLE NO:
S-332 PAGE 3 OF 3

DRILLING / INSTALLATION:
STARTED **5/18/11** COMPLETED: **5/18/11**
DRILLING COMPANY: **Total Quality Drilling**
DRILLING EQUIPMENT: **Split Spoon**
DRILLING METHOD: **Hollow Stem Auger**
SAMPLING EQUIPMENT: **Split Spoon Auger**

NORTHING (ft):	EASTING (ft):
LAT:	LONG:
GROUND ELEV (ft):	TOC ELEV (ft):
INITIAL DTW (ft): **12**	WELL DEPTH (ft): **35.0**
STATIC DTW (ft): **26.46**	BOREHOLE DEPTH (ft): **36.0**
WELL CASING DIA. (in): **4**	BOREHOLE DIA. (in): **10**
LOGGED BY: **W. Rankin**	CHECKED BY: **A. Thomas**





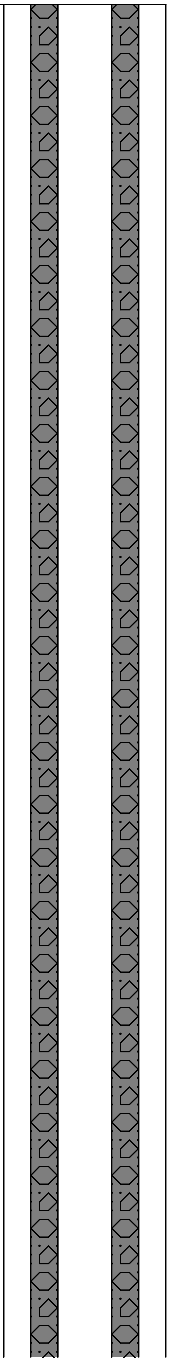
Time & Depth (feet)	Graphic Log	USCS	Description	Sample	Time Sample ID	Measured Recov. (feet)	Blow Count	Headspace PID (units)	Depth (feet)	Well Construction
			Dark brown, silty SAND with some coarse gravel.		-- --			34.8		
					-- --	2	12 13 16 24	227		
			Dark brown, silty SAND with little medium gravel.		-- --			867		
			Dark brown, sandy SILT with little medium gravel.		-- --			161		
					-- --			394		
			Dark brown, sandy SILT with little coarse gravel.		-- --	2	12 15 22 12	214		
			Dark brown, sandy SILT.		-- --			236		
			Brown SILT and fine SAND.		-- --			152		
			Dark brown, silty SAND with some medium gravel.		-- --			13.8		
					-- --	2	11 9 10 10	13.8		
35			Dark brown, silty SAND with little medium gravel		-- --			283	35	
					-- --			54.6		
			Borehole terminated at 36 feet.							
40									40	

MONITORING WELL LOG: S-393D

PROJECT: **Sunoco - Philadelphia Refinery**
SITE LOCATION: **AOI-1**
JOB NO.:
LOGGED BY: **Shaun Sykes/Tiffani Doerr**
DATES DRILLED: **1/27/14 - 2/19/14**
TOTAL DEPTH: **102' (well); 102.1' (boring)**

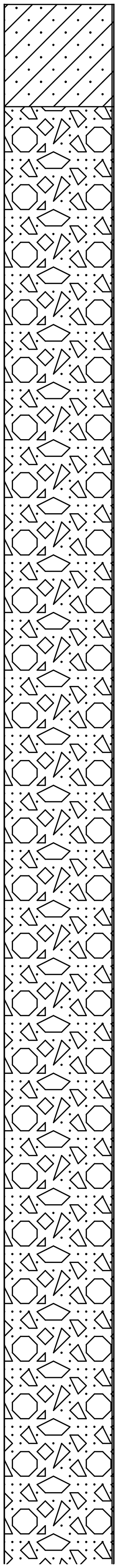
DRILLING CO.: **Parratt Wolff, Inc.**
DRILLING METHOD: **Hollow Stem Auger/ Mud rotary**
SAMPLING METHOD: **Split Spoons**
SCREEN/RISER DIAMETER: **4"**
WELLBORE DIAMETER: **10" (HSA); 6" (Mud)**
ELEVATION:

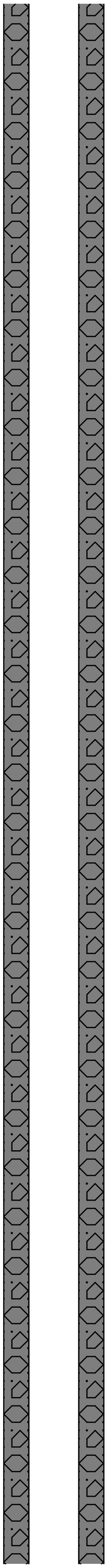
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0						
	0.0		Asphalt			
	37.6			Soil sample collected at 0-2'		
			Black sandy silt, brick, cinders, wood, glass, ash, dry (fill)			
	112					
	201		Same as above, dark gray - brown/black, dry			
-5				Borehole cleared to 8' for utilities via backhoe		
	897					
	9999		(1-2-2-2) 0.9' recovery. Moist fill, loose sand & gravel, cinders, wood, very strong odors			
-10	9999		(3-2-2-1) 0.5' recovery. Same as above (SAA)	Split spoon sampling started at 8'		
	9999		(5-4-4-7) 1.5' recovery. SAA to 13', @ 13' gray f-m sand w/ few light gray clay lenses (clay lenses have brown sand laminations)			
	9999		(2-3-3-5) 1.6' recovery. Top 0.4' SAA (gray/brow clay/sand layers), 14.8'-16' orange/brown	Soil sample collected at 14' - 15', as soil sample		



MONITORING WELL LOG: S-393D

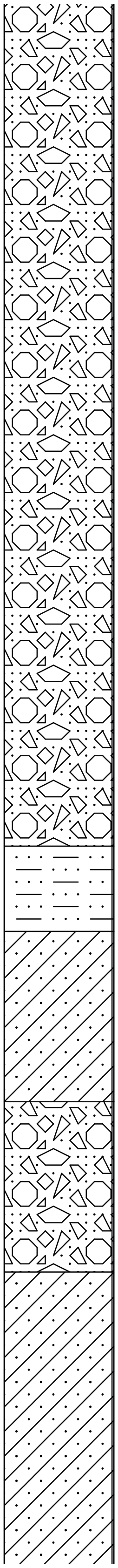
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-15			& red/brown clay w/ some fine sand	above water table.		
	1171		(29-19-32-37) 0.6' recovery. Gravel w/ some sand, multi-colored, heterogenous (green, orange, pink, gray, yellow). Some decomposed gravels			
	492		(9-13-16-18) 1' recovery. Multi-colored (SAA) sand w/ few f-c gravels			
-20	-		(6-20-22-22) No recovery		4" PVC - Riser 0-92'	
	-		(14-17-21-22) No recovery			
	534		(6-14-30-8) 0.5' recovery. 1 large gravel @ top w/ little sand 0.3' med brown plastic silt			
-25						
	1509		(14-9-29-22) 1.2' recovery. Top 0.3' - soft gray sandy clay. Bottom 0.9' - brown f-c sand w/ some f-c gravel			
				Soil sample collected at 27' - 28', as soil sample at water table.		
	836		(8-21-21-23) 1.1' recovery. Dark reddish brown f-c sand & f-m gravel, wet			
-30	746		(46-35-32-23) 0.7' recovery. f-c gravel w/ some f-c sand, wet		Tremie Grout 0-84'	
	296		(18-23-27-30) 1.2' recovery. Wet, SAA, equal f-c sand & f-c gravel			

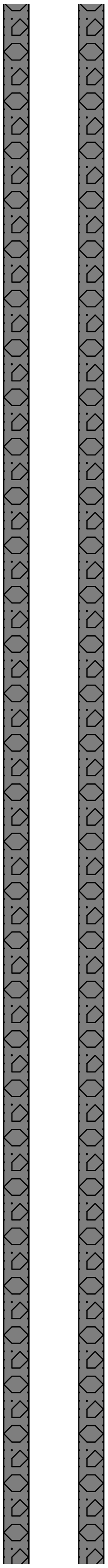




Aquaterra
Technologies, Inc.

MONITORING WELL LOG: S-393D





Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	1.6		(50/0.4') 0.4' recovery. f-c sand trace f gravel, black, wet, little odor			
-35						
	4.1		(5-15-13-12) 1.1' recovery. f-c gravel w/ f-c sand, black			
	0.4		(18-10-10-11) 1' recovery. SAA			
-40	85.1		(6-10-15-15) 0.9' recovery. Black stained f-c sand & f-c gravel			
	22.0		(12-11-7-10) 1.1' recovery. SAA top 0.4'. Bottom 0.9' - brown clayey f. sand grading to orange clay w/ little f. sand			
	-		(3-4-4-10) Full recovery. Med. gray fine sandy clay.			
-45						
	0.4		(6-6-11-12) 1' recovery. Reddish-gray f-m sand, trace f-m gravel			
	0.1		(4-5-6-6) Full recovery. Reddish brown clay w/ some f sand			
-50	0.1		(3-6-9-12) 1.5' recovery. Reddish brown clay w/ trace f. sand lenses and trace f. gravel			

Aquaterra
Technologies, Inc.

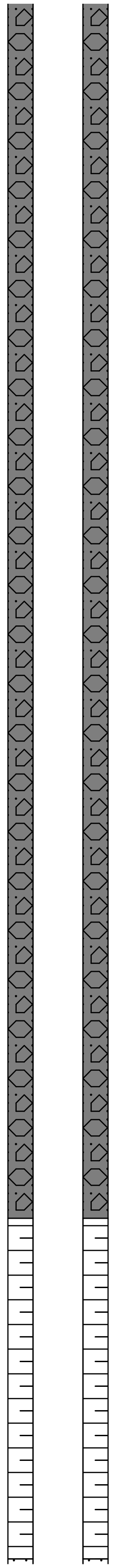
MONITORING WELL LOG: S-393D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.1		(12-13-12-11) Full recovery. SAA (no sand)			
	0.0		(3-6-7-8) 1.8' recovery. SAA - no sand/no gravel			
-55						
	0.0		(8-7-8-13) 1.6' recovery. SAA			
	0.0		(6-7-7-10) Full recovery. SAA - trace white silt inclusions			
-60	0.0		(6-6-5-7) Full recovery. SAA			
	-		(8-8-8-7) Full recovery. SAA, 63'-64' SAA but w/ little v. fine sand			
	1.2		(5-4-7-5) Full recovery. Medium brown v. fine sandy clay			
-65						
	0.4		(4-5-9-11) 1.5' recovery. SAA to 67' - @ 67' - same color, very fine sand, plastic (some clay)			
	1.3		(22-50-50/6") 0.9' recovery - top 0.4" SAA - bottom 0.5" - med. brown sand & gravel, m-c sand, f-c gravel, otz & quartzite (change @ 69')			

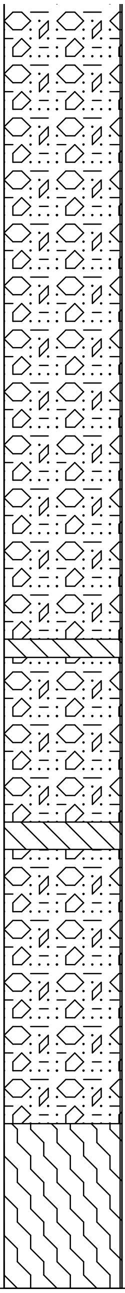
Aquaterra Technologies, Inc.

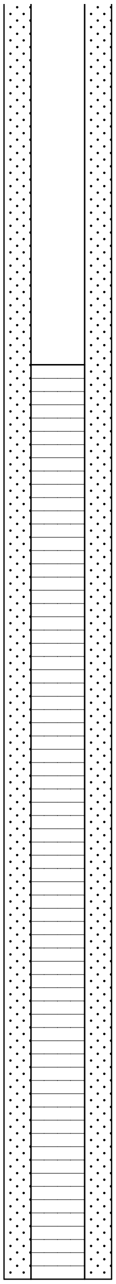
MONITORING WELL LOG: S-393D

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
-70	-		(50/0") No recovery - large quartzite gravel in nose of spoon			
	24.8		(29-47-50/6") 0.8' recovery - SAA, slight odor, hard drilling			
	36.1		(28-32-27-53) 0.7' recovery - SAA - bottom 0.2' yellow-brown color, slight odor			
-75						
	15.1		(31-48-37-26) 0.8' recovery. Top 0.2' - SAA (sand & gravel) - bottom 0.6' - tan f-c slightly micaceous sand w/ trace f gravel. Thm (0.5 cm), clay lense @ 78' (gray)			
	4.5		(24-27-26-17) 1.5' recovery. Same tan sand (f-m) yellow in last 0.2' - bottom 0.2' spoon gray f sand and dark brown peat layers			
	0.7					
-80	3.5		(12-18-16-20) 1.5' recovery. Gray f-m sand & few dark brown peat layers (peat is compacted leaves - max 1" thick)			
	0.4		(16-24-28-32) 1.7' recovery. SAA - top 1' all sand (sl. micaceous), bottom mostly peat			
	0.0					
	0.7		(7-14-21-18) 1.5' recovery. SAA		Bentonite Seal 84' - 88'	
-85						
	0.3		(17-29-30-15) 1.1' recovery. SAA - "peat" - organics, black & heavily degraded			



MONITORING WELL LOG: S-393D





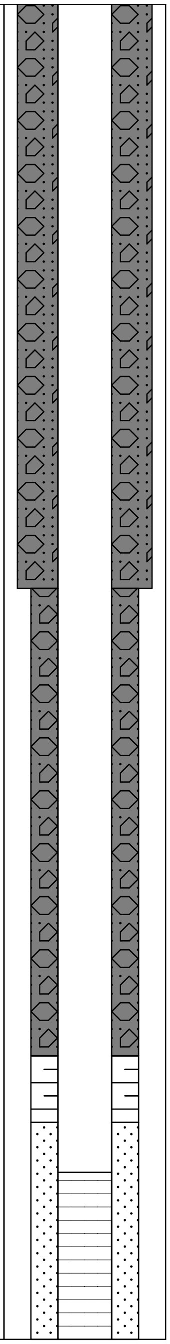
Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
	0.3		(27-28-347-41) 0.9' recovery. Gray f-c sand & f-c gravel. Round-subround quartz and quartzite gravels		Sand 88' - 102'	
-90	2.6		(1.2-11-16-25) 1.1' recovery. SAA heterogenous			
	-		(50/0.4) Few gravels in tip of spoon		4" PVC - Screen 92' - 102'	
-95	0.3		(11-32-42-19) 0.8' recovery - SAA top 0.3' - next 0.2' gray clay - bottom 0.3' gray f-c sand (no gravel)			
	0.1		(23-22-31-50/0.3) 1.3' recovery. Top 0.9' f-c sand & f-c gravel. Then 0.3' gray clay. Bottom 0.1' gray sand and gravel			
	0.2		(50/0.4') 0.4' recovery. Gray sand & gravel, f-c sand & f-c gravel (all quartz and quartzite but multicolored), large 2+" in base of spoon			
-100	-		(50/0.3') 0.3' recovery. Black mineral layer @ top 0.2', bottom 0.1' gray sand & gravel	Borehole terminated at 102.1' bgs.		
	0.0		(50/0.1') 0.1' recovery. Black/gray/white mottled - weathered schist			

MONITORING WELL LOG: S-394

PROJECT:	**Sunoco - Philadelphia Refinery**	DRILLING CO.:	**Parratt Wolff, Inc.**
SITE LOCATION:	**AOI-1**	DRILLING METHOD:	**Hollow Stem Auger/ Mud rotary**
JOB NO.:		SAMPLING METHOD:	
LOGGED BY:	**Shaun Sykes**	SCREEN/RISER DIAMETER:	**4"**
DATES DRILLED:	**2/20/14 - 2/21/14**	WELLBORE DIAMETER:	**10" (HSA); 6" (Mud)**
TOTAL DEPTH:	**80'**	ELEVATION:	

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
0					
-5			See S-393D well log for lithology.	Well installed adjacent to S-393D.	
-10					
-15					
-20					4" PVC - Riser 0 - 70'
-25					
-30					Tremie Grout 0 - 63'
-35				Switched to Mud Rotary.	
-40					
-45					
-50					
-55					
-60					
-65					Bentonite Seal 63' - 67' Sand 67' - 80'
-70					4" PVC - Screen 70' - 80'
-75					
-80				Boring terminated.	

WELL DIAGRAM



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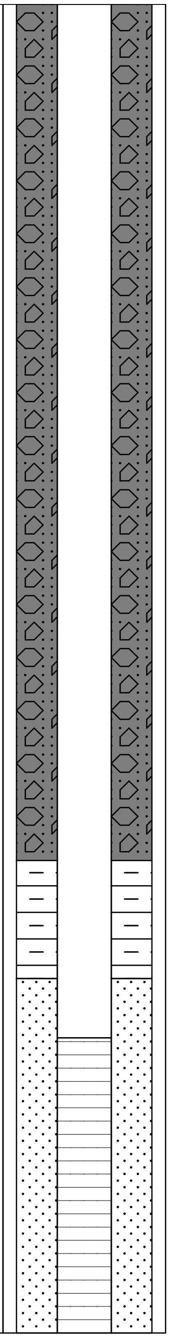
Aquaterra Technologies, Inc.

MONITORING WELL LOG: S-395

PROJECT:	**Sunoco - Philadelphia Refinery**	DRILLING CO.:	**Parratt Wolff, Inc.**
SITE LOCATION:	**AOI-1**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:		SAMPLING METHOD:	
LOGGED BY:	**Shaun Sykes**	SCREEN/RISER DIAMETER:	**4"**
DATES DRILLED:	**2/25/14**	WELLBORE DIAMETER:	**10"**
TOTAL DEPTH:	**45'**	ELEVATION:	

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION
0					
-5			See S-393D well log for lithology.	Well installed adjacent to S-393D.	
-10					4" PVC Riser 0 - 35'
-15					Tremie Grout 0 - 29'
-20					
-25					
-30					Bentonite Seal 29' - 33'
-35					Sand 33' - 45' 4" PVC Screen 35' - 45'
-40					
-45				Boring terminated.	

WELL DIAGRAM



APPENDIX D
LABORATORY ANALYTICAL REPORTS (CD-ROM)

Remedial Investigation Report
Area of Interest 1
Philadelphia Refinery Complex
Philadelphia, Pennsylvania
Philadelphia Refinery Operations,
a series of Evergreen Resources Group, LLC
3144 Passyunk Avenue, Philadelphia, Pennsylvania

APPENDIX E
LNAPL CONCEPTUAL SITE MODEL

Remedial Investigation Report
Area of Interest 1
Philadelphia Refinery Complex
Philadelphia, Pennsylvania
Philadelphia Refinery Operations,
a series of Evergreen Resources Group, LLC
3144 Passyunk Avenue, Philadelphia, Pennsylvania

LIGHT NON-AQUEOUS PHASE LIQUID CONCEPTUAL SITE MODEL AREA OF INTEREST 1

Philadelphia Refinery Complex
3144 West Passyunk Avenue
Philadelphia, Pennsylvania
PADEP Facility ID No. 780190

Prepared for:

Philadelphia Refinery Operations, a series of
Evergreen Resources Group, LLC

Prepared by:
Stantec Consulting Services Inc.

Stantec Project No. 213402434

August 2, 2016

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ACRONYMS AND ABBREVIATIONS

AMSL	Above mean sea level
AOI	Area of Interest
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BGS	Below ground surface
cm/s	Centimeters per second
CPT	Cone Penetrometer
CSX	CSX Transportation
EEI	Engineering Enterprises, Inc.
EEI	Engineering Enterprises, Inc.
EPA	U.S. Environmental Protection Agency
Evergreen	Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC
Facility	Philadelphia Refinery Complex
FFD	Fuel Fluorescence Detector
g/ml	Grams per milliliter
g/ml	grams per milliliter
ICF	ICF Consulting
LCSM	Conceptual Site Model
LDRM	LNAPL Distribution and Recovery Model
LIF	Laser induced fluorescence

LNAPL	Light Non-aqueous Phase Liquid
mg/l	Milligrams per liter
MTBE	Methyl-tertiary-butyl-ether
Mulry	Mulry and Cresswell Environmental, Inc.
PADEP	Pennsylvania Department of Environmental Protection
Q_0	LNAPL discharge rate
Q_w	Water discharge rate
RIR	Remedial Investigation Report
RCRA	Resource Conservation and Recovery Act
SCR	Site Characterization Report
Site	AOI 1 of the Philadelphia Refinery Complex
Stantec	Stantec Consulting Services Inc.
Sunoco	Sunoco Inc.
TFR	Total Fluids Recovery
T_n	LNAPL Transmissivity
Torkelson	Torkelson Geochemistry, Inc.
T_w	Aquifer transmissivity
ug/l	Micrograms per liter
USGS	U.S. Geological Survey
UV	Ultraviolet
ρ_r	LNAPL/Water Density Ratio

1.0 Introduction

Stantec Consulting Services Inc. (Stantec) has prepared this Light Non-aqueous Phase Liquid (LNAPL) Conceptual Site Model (LCSM) report on behalf of Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC (Evergreen), for Area of Interest (AOI) 1 (Site) at the Philadelphia Energy Solutions Refining and Marketing LLC (PES) Refining Complex (Facility). This LCSM includes analysis of subsurface data from areas adjacent to AOI 1 where available and beneficial to this study. The report describes the Site history, physical environment and contaminant fate and transport processes based upon current knowledge. The LCSM provides a basis upon which the investigation and response data may be understood, and from which appropriate corrective actions may be considered.

The purpose of the LCSM is to communicate Facility conditions with respect to subsurface impacts associated with historical petroleum releases within the general Site area. The impacts are described in terms of the release scenario, inferred source area, potential subsurface migration pathways, distribution of constituents of concern, and potential LNAPL receptors. The information presented in the LCSM is intended to establish a framework which allows Evergreen to make informed environmental management decisions regarding the Facility. Understanding current conditions is fundamental to the development of the LCSM and allows a platform for data extrapolations and prediction of future conditions. As new information becomes available, the LCSM should be modified, as necessary, to reduce uncertainties and improve the understanding of Site conditions.

2.0 Background

2.1 SITE SETTING

The Facility is located along the banks of the Schuylkill River in the City of Philadelphia, Philadelphia County, Pennsylvania (Figure 1). Portions of the Facility occupy both the eastern and western Schuylkill River banks. The Facility, which is located on industrial property, covers approximately 1,300 acres of land with access restricted by fencing and security measures. The area surrounding the Facility is characterized by a mixture of residential, commercial, and industrial properties. The Facility has operated, and is planned to continue operating, as an oil refinery, marketing terminal, and petrochemical complex

Sunoco Inc. (R&M) and the Pennsylvania Department of Environmental Protection (PADEP) entered into a Consent Order & Agreement (CO&A) in December 2003 with respect to the Facility. The CO&A included a Phase I Remedial Plan that divided the Facility into 11 AOIs (including AOI 1), and presented a prioritization of the AOIs based on specific risk factors.

AOI 1 occupies approximately 67 acres of the Facility in the northeast portion of the Point Breeze Process Area South Yard (Figure 2). Surrounding the AOI are the following properties/features:

- North: the Belmont Terminal beyond which is located Passyunk Avenue and Philadelphia Gas Works property

- East: 26th Street beyond which is located the CSX right-of-way, the Steen Property, the former Defense Supply Center Philadelphia (DSCP) site and the former Passyunk Homes complex

- South: Hartranft Street and the No. 4 Tank Farm of AOI 4

- West: 16th Street and the Point Breeze Process Area of AOI 2 beyond which is located the Schuylkill River.

2.2 SITE HISTORY

The following presents a detailed timeline of the history of LNAPL investigations and remediation at the Facility.

- 1860s
    - Atlantic Refining Company established an oil distribution center (Sunoco, 2007).
- Early 1900s
    - Crude oil processing began (Sunoco, 2007).
- 1940s
    - Full-scale gasoline production began (Sunoco, 2007).
- 1987

  - Potential source of hydrocarbon vapors within the 26th Street sanitary sewer were investigated. A pilot remedial system was tested and a report was completed. The investigation included the following (Engineering Enterprises, Inc. (EEI), 1987).
    - Installation of ten monitoring wells (67-76) (EEI, 1987).
    - Completion of LNAPL bail down tests at wells 71, 74, and 75 (EEI, 1987).
    - A pilot dual phase recovery test at wells PR-1 and PR-2. Extraction from the pilot recovery wells was continued for at least three months (EEI, 1987).
- 1992
  - ENSR completed a Resource Conservation and Recovery Act (RCRA) facility investigation for the Point Breeze Process Area (Sunoco, 2007).
- 1993
  - A consent order and agreement was established for the Point Breeze Processing Area (Sunoco, 2007).
- 1993
  - A revised consent order and agreement was established for the Point Breeze Processing Area and other areas of the Facility (Sunoco, 2007).
- 1995
  - A dual phase recovery system (RW-400 series wells) was installed in the northern part of the border between the Site and 26th Street (Secor, 2003).
- 1998
  - Hydrocarbon odors were reportedly encountered in the Shunk Street sewer, a combined storm and sanitary sewer line that crosses the Belmont Terminal property (Mulry and Cresswell, 1998a).
  - An investigation of the source(s) of the hydrocarbon odors was completed. The investigation included (Mulry and Cresswell, 1998a):
    - Installation of 19 borings which were converted into 14 monitoring wells (TWs and OWs), and five recovery wells (RW1, RW4, RW6, RW7, RW15).
    - Completion of LNAPL bail-down tests at wells OW3, RW6, and OW12
    - Completion of pumping tests at wells RW-6, RW-15, and OW-17.
    - Vacuum extraction testing at RW-6 and OW-17.
    - An extraction system was installed that included:
      - Dual phase extraction from wells RW1, RW4, and RW15;
      - Groundwater extraction from wells RW1, RW4, RW6, RW7, and RW15; and,
      - Soil vapor extraction at wells 3, 10, 12, 13, 16, 18, 19, and 20.
- 2000
  - A status report was completed which detailed Site activities related to investigation and remediation of the Shunk Street sewer including (Handex, 2000):
    - Groundwater and LNAPL recovery system data (RW-1, RW-4, RW-6, and RW-7);
    - LNAPL characterization sampling from six wells (RW-1, RW-4, RW-7, RW-15, S-75, and S-76); and
    - Combined Cone Penetration Test (CPT) and Fuel Fluorescence Detector (FFD) borings were completed at 22 locations within the Belmont Terminal

area of the Site to assist with delineation and assessment of petroleum impacts.

- 2001
    - Monitoring wells MW-21 through MW-34 were installed in the Belmont Terminal area (Handex, 2001a).
    - LNAPL samples were collected form the newly installed monitoring wells. The LNAPL samples were analyzed for API gravity and Sulfur. (Handex, 2001a).
    - Underground hydrocarbon pipelines between the loading rack and processing area were tightness tested. No leaks were detected; however, temporary above grade piping was installed in several locations.
    - LNAPL recovery tests were completed at six wells (MW-22, MW-23, MW-24, MW-26, MW-27, and MW-29) (Handex, 2001b).
    - Pumping tests were conducted at potential recovery wells MW-22 and MW-24 (Handex, 2001b).
- 2002
    - Aquaterra completed an investigation report for the Pollock Street sewer (Sunoco, 2007).
    - The Pennsylvania Department of Environmental Protection (PADEP) requested that Sunoco report actions taken related to off-site migration of LNAPL along the 26th Street border of the Site (Secor, 2003).
- 2003
    - Secor completed a remedial investigation report for the 26th Street border area. The report was focused on characterization of LNAPL along the Site border with 26th Street and evaluation of remedial options for LNAPL recovery including (Secor, 2003):
        - Installation of 12 monitoring wells (S-116 through S-127);
        - A groundwater pumping test of well RW-406. A manual pump was used to periodically remove LNAPL from the well during the test;
        - Slug testing at seven wells (S-43, S-86, S-116. S-120, S-122, S-127, and RW-406);
        - Redevelopment of the 400 series recovery wells;
        - Short duration capacity tests at RW-400 series wells (RW-402 through RW-405);
        - LNAPL bail down tests at monitoring wells S-50, S-98, S-100 and SCX-MW-5; and,
        - LNAPL characterization sampling from nine wells (S-50, S-88A, S-89, S-98, S-100, PZ-400, RW-401, RW-402, and CSX-MW-5).
    - The investigation concluded that the observed increases in LNAPL thickness were related to declining water table elevation during a prevailing drought in 2002 and that a Total Fluids Recovery (TFR) system at the RW-400 series wells would be more efficient at LNAPL recovery than dual phase
- 2004
    - Groundwater samples were collected from all accessible wells within AOI 1 which did not have measureable apparent LNAPL thickness (Sunoco, 2007).

  - Secor prepared a progress report for the 26th border area. The report documents additional activities completed including (Secor, 2004):
    - Installation of 19 wells on CSX property and on Site along the 26th street border area (S-179 through S-197);
    - Pumping tests at wells S-98, S-123, and S-125 (Secor, 2004);
    - Slug testing at wells S-193, S194, and S-195 (Secor, 2004); and,
    - Installation and operation of TFR pumps in the RW-400 series wells (Secor, 2004).
- 2005
  - LNAPL characterization analysis was completed on samples collected from 31 monitoring wells (Sunoco, 2007).
  - LNAPL and groundwater samples from two monitoring wells were analyzed for soil saturation parameters including density, tension, viscosity, and intrinsic permeability (Sunoco, 2007).
  - LNAPL/Soil saturation data was collected from one soil boring (adjacent to MW-42). Soil cores from this boring were photographed under white and ultra-violet light and analyzed for pore space phase saturation, porosity, grain size, Atterberg limits, total organic carbon, intrinsic permeability, and drainage capillary pressure (Sunoco, 2007).
  - Secor completed a progress report for the 26th Street border area (Sunoco, 2007).
  - Aquaterra installed monitoring wells in the Trenton Gravel (Intermediate) aquifer and the Lower Sand (Deep) aquifers. Aquaterra also collected shallow (less than two feet below grade) soil samples (Sunoco, 2007).
  - Sunoco Inc. (Sunoco) completed a Site Characterization Report (SCR) for AOI 1 (Sunoco, 2007).
  - Aquaterra completed an investigation regarding a potential leaking fire water line and groundwater mounding in the area of monitoring wells S-113 and S-126 (Sunoco, 2007).
- 2006
  - Sunoco Inc. (Sunoco) revised the Site Characterization Report for AOI 1 (Sunoco, 2007)
- 2007
  - Sunoco Inc. (Sunoco) revised the Site Characterization Report for AOI 1 (Sunoco, 2007)
- 2008
  - Monitoring wells MW-A through MW-G were installed at the Site under Stantec oversight.
  - A step drawdown test was completed at well S-185 and well capacity tests were completed at 19 wells (S-181 through S-192, MW-A through MW-F and MW-H).
- 2013
  - The Belmont Terminal recovery system was shut off in June.
- 2015
  - Groundwater recovery at the Belmont Terminal system was restarted in April and product recovery was restarted in June.

3.0 Geology/Hydrogeology

3.1 SITE GEOLOGY

Stantec (2016) has identified up to nine Coastal Plain deposits present at the Site overlying saprolitic schist and schistose bedrock. The deposits and their Site-specific characteristics are listed with increasing depth below (deposits may not be everywhere present across the Site):

- Anthropogenic Fill: present beneath the existing land surface at most locations in AOI 1 and has been identified to range in thickness from a thin veneer to a maximum of approximately 24 feet. The thickest fill generally correlates with and is reflective of the location of a former incised stream valley that once bisected AOI 1. The fill is generally heterogeneous in nature and is composed of an admixture of sand and gravel, mud, and anthropogenic debris included cinders, ash, bricks, cinder block, and metal.
- Recent (Holocene) alluvium: fine-grained, brown to brownish gray silt/clay with occasional lenses of sand and gravel that commonly grades with depth to include some sand; in places includes decomposing organic material; thickness ranges from a few feet to a maximum of approximately 20 feet.
- Pleistocene Trenton "gravel:" brown and reddish brown silty, clayey, poorly-sorted sand with gravel, including secondary sandy gravel and clay/silt lithologies in lenses; very heterogeneous unit; thickness ranges from approximately 6 feet to a maximum of approximately 30 feet.
- Cretaceous PRM upper clay unit: reddish yellow, brown, and brownish yellow clay/silt (commonly sandy and laminated); generally less than 10 feet thick and commonly only a few feet thick; not everywhere present beneath AOI 1.
- Cretaceous PRM upper sand unit: light gray to pale yellow, fine to medium-grained quartz sand with a trace to little silt but including muddy lenses; ranges in thickness from a few feet to a maximum of approximately 10 feet; not everywhere present beneath AOI 1 and generally associated with locations where the upper clay unit is present.
- Cretaceous PRM middle clay unit: medium to high plasticity red, white, and gray clay/silt with intercalating lenses of muddy sand; thickness ranges from greater than approximately 20 feet (where it may be vertically continuous with the lower clay unit) to less than 1 foot.
- Cretaceous PRM middle sand unit: brown and reddish yellow, silty, occasionally gravelly sand; up to 15 feet thick where present.
- Cretaceous PRM lower clay unit: gray, brown, and red clay/silt with sandy lenses; thickness generally less than one foot and not everywhere present beneath AOI 1.
- Cretaceous PRM lower sand unit: pale gray, pale yellow and white quartz sand coarsening with depth to white and varicolored sandy gravel and gravelly sand; common lenses of clayey sand and gravel; thickness ranges from approximately 20 feet to over 50 feet.

Bedrock is present beneath the Coastal Plain and/or fill deposits in AOI 1 and consists predominantly of variably-weathered mica schist. The bedrock surface is irregular and contains troughs. Beneath AOI 1, bedrock elevations range from approximately -55 feet [referenced to the North American Vertical Datum of 1988 (NAVD 88)] to -80 feet NAVD 88.

3.2 SITE HYDROGEOLOGY

Stantec (2016) indicates that the geologic framework present beneath AOI 1 supports the following hydrogeologic conditions:

- Two primary water bearing units have been identified beneath AOI 1 at the Philadelphia Refinery. In general, these are the water-table (unconfined) and a lower (semi-confined) aquifer. Their properties are as follows:

    1. *Unconfined aquifer*: primarily composed of saturated portions of the Trenton gravel; may also include the underlying PRM upper sand unit where present and where saturated, deeper portions of Holocene alluvium and fill; on average, the saturated thickness of the unconfined aquifer is approximately 10 to 15 feet; this zone is highly heterogeneous and as a result estimates of horizontal hydraulic conductivity vary from less than 1 ft/d to more than 600 ft/d; estimates of total porosity range from approximately 25% to 39%; estimates of total pore fluid saturation range from approximately 78% to 99%.
    2. *lower aquifer*: semi-confined aquifer primarily composed of the lower sand unit but also including portions of the middle sand unit where hydraulically connected; on average, the saturated thickness of the lower aquifer is approximately 25 to 50 feet; horizontal hydraulic conductivity is estimated to vary from approximately 123 ft/d to 151 ft/d; estimates of total sample porosity range from approximately 22% to 39%; estimates of total pore fluid saturation range from approximately 88% to 90%.

- 2014 and 2015 well gauging data indicates that unconfined aquifer groundwater flows to the southeast under a gentle hydraulic gradient (0.0007 ft/ft) in the northern portion of AOI 1 and seems to subtly mirror natural surface topography. South of that area, flow beneath AOI 1 and the former DSCP property appears to be dominated by groundwater movement towards an elongate depression in the water-table, centered along the eastern AOI 1 boundary at 26th Street. The pattern of unconfined aquifer groundwater flow near the Site suggests that infiltration into the 26th Street Intercepting Sewer, and potentially the Pollock Street/Packer Avenue Sewer, is occurring.

- 2014 and 2015 well gauging data indicates that lower aquifer groundwater flows to the southeast beneath Belmont Terminal, northern portions of the No. 1 Tank Farm, and in places off-Site under a hydraulic gradient of approximately 0.0009 ft/ft. Within the overall southeasterly groundwater flow regime present across the Site, the lower aquifer potentiometric surface appears disrupted and flow is concentric towards a depression along a portion of 26th Street. The patterns of groundwater flow suggest that infiltration into the 26th Street Intercepting Sewer is occurring.

- The middle clay unit appears to be laterally continuous beneath AOI 1 and create overall hydraulic separation between the unconfined and lower aquifers. Both the upper and lower clay units are interpreted to pinch out or have been truncated by erosion beneath areas of AOI 1.

- The middle and/or lower clay unit(s) thin and become intercalated with more sandy lithologies beneath southern AOI 1 and areas just east of that location.

- The hydraulic head potential between the unconfined and lower aquifers is generally positive or downward within AOI 1 and nearby proximity. An area of negative (upward) hydraulic head potential is present along 26th Street. Between those areas of opposing potential, an area of nearly equal hydraulic head is indicated, generally beneath southern AOI 1 and the former DSCP Property near the "breach" area identified by others. The pattern of flow potential suggests that the 26th Street Intercepting Sewer is receiving groundwater from the unconfined aquifer along a particular length of that sewer, and groundwater losses to the 26th Street Intercepting Sewer affect heads in the lower aquifer through upward recharge/vertical leakage to the unconfined aquifer, direct losses to the sewer, or both.

Table 1 of this LCSM presents a summary of hydrogeologic properties reported in historical reports for the AOI 1 unconfined aquifer. Stantec (2016) presents a more comprehensive summary of horizontal hydraulic conductivity values measured at the Facility.

4.0 LNAPL Mobility Assessment

This section discussed approaches, methods and results related to the evaluation of LNAPL mobility in the subsurface. The discussion of LNAPL mobility uses (1) observations over time of LNAPL distribution (2) dissolved plume characteristics, (3) an analysis of apparent LNAPL thickness, (4) LNAPL recharge to wells (bail-down testing), (5) physical and chemical laboratory analysis of the LNAPL and (6) theoretical estimates of LNAPL mobility supported by field and laboratory measurements to understand the potential mobility of the LNAPL body. The emerging consensus in technical approach to understanding LNAPL behavior is to use a combination of these methods to evaluate LNAPL mobility based on multiple lines-of-evidence.

The objective of the LNAPL mobility assessment was to evaluate if remaining LNAPL is residual, mobile, or migrating. In order to provide consistency across the industry ITRC has provided standard definitions for these terms in the document LNAPL Technology Selection for Achieving Project Goals (ITRC 2009).

Residual LNAPL represents LNAPL that is trapped in soil pores similar to water that cannot drain out of a sponge. Residual LNAPL is a consequence of porous media and capillary behavior. Below residual LNAPL saturation, LNAPL is discontinuous and immobile under the applied gradient. Residual LNAPL will not accumulate in a well installed across the LNAPL interval. Residual LNAPL saturations are higher for saturated conditions than in the vadose zone. As a result, a well may not exhibit LNAPL under high water-tables but may exhibit LNAPL under lower water-table conditions as a result of changes in water saturation resulting in a change in LNAPL residual saturation magnitude.

Mobile LNAPL is LNAPL that exceeds residual saturation. Mobile LNAPL, when combined with a gradient, is capable of moving laterally and/or vertically within the soil pore-space. If a well is placed in a location with mobile LNAPL present, LNAPL will accumulate in the well.

Migrating LNAPL is LNAPL that is observed to spread or expand laterally or vertically or otherwise result in an increased volume of the LNAPL extent (usually indicated by time-series data or observation). Migrating LNAPL has sufficient mobility at the pore-scale to cause expansion of the extent of the LNAPL. Mobile LNAPL includes migrating LNAPL, but not all mobile LNAPL is migrating LNAPL.

In unsaturated soils, the residual (immobile) LNAPL ranges from 5% to 20% of total pore volume, while in the saturated zone these concentrations are higher, with typical values ranging from 15% to 50% of total pore volume [U.S. Environmental Protection Agency (EPA), 1992].

Following a release LNAPL exhibits sufficient head to migrate down to the water-table and potentially below the water table as well as laterally from the source. In a near surface release, as the LNAPL migrates downward due to pressure and gravity, the quantity of mobile LNAPL decreases due to the residual oil left behind. If the amount of LNAPL spilled is small, all of the mobile LNAPL will eventually become exhausted in the vadose zone and the LNAPL will percolate no further. The column of LNAPL is immobile and never reaches the capillary fringe. However, as exhibited at the Site, if the pressure and quantity of LNAPL released per unit surface area is sufficient, mobile LNAPL will reach the capillary fringe above the water table. Once it has reached the water table the LNAPL will tend to spread out due to the buoyancy forces resulting from the density difference between the LNAPL and water. LNAPL continues to spread out until it is at residual saturation. Continued LNAPL plume expansion without an active release and with low LNAPL gradients is limited by capillary effects, LNAPL mass limitations and natural degradation processes. While vertical redistribution of LNAPL within the core of the plume can continue to occur, no further expansion of the LNAPL plume occurs when stability is achieved (Science Advisory Board for Contaminated Sites in British Columbia, 2006). Because some constituents of LNAPLs are slightly soluble in water, the constituents of LNAPL will slowly dissolve in accordance with their relative solubilities and be transported with the groundwater.

The LNAPL at the Site was evaluated using multiple-lines of evidence including evaluation of LNAPL distribution, trends, characteristics, and transmissivity. The approach also included determination of the LNAPL Mobility Term, LNAPL Pore Entry Pressure and use of the American Petroleum Institute (API) LNAPL Distribution and Recovery Model (LDRM).

4.1 LNAPL DISTRIBUTION

4.1.1 LNAPL Apparent Thickness

4.1.1.1 Introduction

A primary line of evidence for evaluation of LNAPL plume stability and mobility is observational data. If observational data indicates that the LNAPL and dissolved plumes are stable or shrinking, the potential for LNAPL mobility is low. LNAPL is deemed to be potentially migrating when:

- Fluid level gauging over time indicates that the apparent LNAPL thickness is increasing within monitoring wells in a manner not attributable to seasonal water-table fluctuations;

or

- LNAPL is identified in a portion of the monitoring well network that has historically lacked measureable LNAPL.

The accumulation of LNAPL in monitoring wells is a primary line of evidence used to evaluate the distribution of LNAPL in the subsurface. LNAPL may be able to flow through connected macropores in the subsurface under sufficient hydraulic head and saturation conditions. Assuming that a monitoring well is properly constructed and developed, the accumulation of LNAPL in the monitoring well may occur when the LNAPL fluid pressure is greater than the atmospheric pressure. However, even when LNAPL is observed in monitoring wells, the soil pores are generally not completely filled with LNAPL, rather this is merely an indication that LNAPL is locally present. In-well LNAPL thickness is not a reflection of the residual and entrapped saturations of LNAPL in the aquifer. The free-phase LNAPL that enters a monitoring well is usually only a small fraction of the LNAPL present in the aquifer (US EPA 2005). Due to this difference, the LNAPL thickness measured in a monitoring well is referred to as an apparent thickness.

Common misconceptions exist with regard to the in-well LNAPL thickness (ITRC 2009):

- The absence of LNAPL in a monitoring well does not mean that LNAPL is not present in the screened aquifer rather it is a reflection of the residual saturation,

- The presence of LNAPL in a monitoring well does not necessarily mean that the LNAPL plume is migrating or has the potential to migrate, and

- Apparent LNAPL thickness in a well is not a good predictor of the potential rate of recovery.

The thickness of LNAPL observed in the monitoring wells depends on a number of factors such as the geology and water table fluctuations. A falling water table for an unconfined system typically results in greater observed LNAPL thickness in the monitoring wells as a result of drainage from the unsaturated zone. The effect of a falling water table is more pronounced for coarse-grained than fine-grained soils.

Figures 4a through 4e present the historical extent of observed LNAPL apparent thicknesses for 1995 through 2015 in five year increments. Each map displays all of the wells that were gauged during that year and indicates which wells had observed LNAPL thickness. Figure 6 presents the maximum observed LNAPL thickness for each monitoring well over the period of record. Appendix I includes groundwater elevation and apparent LNAPL thickness hydrographs for Site wells.

4.1.1.2 Well Construction

Generally, submerged screens prevent LNAPL from entering a well. Review of well construction records for the Site identified 35 wells with screens that are regularly submerged. Of these wells, 18 are classified as being completed in the unconfined aquifer. These wells are listed in Table 2 and shown on Figure 3. Additionally, Figures 4 through 6 include symbology to indicate which wells have submerged screens. The wells with submerged screens were excluded from analysis during the LNAPL mobility assessment.

4.1.1.3 Trends

Numerous monitoring wells across the Site have been gauged for LNAPL over the course of the investigation and remediation history (Figures 4a through 4e). Hydrographs of AOI-1 wells (Appendix I) include groundwater elevation, LNAPL thickness, and well construction details. Figure 7 presents a graph of the cumulative deviation of precipitation from the long term average from 1980 to present based on weather data form the NOAA station located at the Philadelphia International Airport.

As indicated on Figure 7 and discussed in previous investigation reports, a long term drought occurred in the late 1990s and early 2000s in the area of the Site. As discussed above, a falling water table for an unconfined system typically results in greater observed LNAPL thickness in the monitoring wells as a result of drainage from the unsaturated zone. In 2002, increases in LNAPL apparent thickness were observed and LNAPL was found to occur at wells where it had not previously been observed. These changes were attributed to decreasing water levels associated with the prevailing drought conditions at the time (Secor, 2004).

Since 2008, precipitation has generally been higher than average. Identification of trends in groundwater elevations at the Site is complicated by the variations in pumping from active recovery systems. However, groundwater elevation in Site wells has generally increased or been stable since 2008.

At most AOI 1 locations where LNAPL has been observed, LNAPL apparent thicknesses through time have generally decreased. Over the period of record, LNAPL has been detected in 108 wells. In the first half of 2015 LNAPL was detected in only 46 wells. In some wells, apparent LNAPL thicknesses have decreased from greater than 10 feet to less than 1 foot (e.g., RW-401, RW-402). Since 2010, most wells have had stable or decreasing apparent LNAPL thicknesses. However, several wells have had increasing trends including wells S-100 and S-277 located in the 26th Street area. Several other wells have had long term stable or decreasing trends but have had increases in apparent LNAPL thickness since 2012 or 2013. These wells include wells S-203 located in the No. 1 Tank Farm area, as well as wells S-76 and S-77 located along the southern edge of the Belmont Terminal area.

A review of the apparent LNAPL thickness data over time suggests that the LNAPL plumes are not migrating, in general, because the vertical thickness of LNAPL observed in wells has not been increasing. In the 26th Street area near wells S-100 and S-277, increasing trends of apparent LNAPL thickness have recently been observed indicating LNAPL in this localized area may be migrating.

4.1.2 Aerial Distribution

Figures 4a through 4e present a historical summary of the aerial distribution of LNAPL over time broken up into five year intervals from 1995 to 2015. Each figure shows all of the wells gauged within the year indicated. Wells screened in the lower aquifer are not shown. Wells that had a measurable apparent thickness of LNAPL during a gauging event within the year indicated are shown. A different symbol is used to show wells where a sheen of LNAPL was observed (less than 0.01 feet). Wells where LNAPL was not observed but which had dissolved concentrations of benzene indicative of LNAPL were also symbolized (See Section 4.1.2.1 below for discussion of the criteria used to identify these wells). Figure 6 presents the maximum observed thickness for all of the wells that have historically been gauged at the Site within the period of record.

In 1995, 38 unconfined aquifer wells were gauged. LNAPL was detected in 15 wells with a maximum thickness of 11.12 feet at well RW-401. The LNAPL was detected along the southern edge of Belmont Terminal area (monitoring wells had not yet been installed in the northern area) and along the northern half of the 26th Street area. Dissolved concentrations of benzene indicative of LNAPL were detected at several locations in the southern half of the 26th Street area.

In 2000, 47 unconfined aquifer wells were gauged. LNAPL was detected in 22 wells with a maximum thickness of 4.34 feet at well RW-405. The LNAPL was detected in the same areas as in 1995.

By 2005, the monitoring well network had expanded significantly to include additional wells within the tank farms and along the 26th Street area. During the year, 99 unconfined aquifer wells were gauged. LNAPL was detected in 43 wells with a maximum thickness of 1.43 feet at well S-76. The LNAPL was encountered within the tank farm areas, along the southern edge of Belmont Terminal area, and along the northern and southern half of the 26th Street area. LNAPL was also detected in well S-100 located on CSX property. Dissolved concentrations of benzene indicative of LNAPL were detected at several locations in the southern half of the 26th Street area.

In 2010, 164 unconfined aquifer wells were gauged. LNAPL was detected in 53 wells with a maximum thickness of 2.04 feet at well S-76. LNAPL was encountered along the southern edge of the Shunk St. Sewer in the northern part of the Belmont Terminal area. LNAPL was also detected along the southern edge of the Belmont Terminal area, within the tank farm areas and within the 26Th Street area, and along the northern and southern half of the 26th Street area. Off Site, LNAPL was detected in wells S-100, S-193 and S-194 located on the CSX property.

Stantec completed LNAPL and groundwater elevation gauging events in February and May of 2015. During these events, 185 unconfined aquifer wells were gauged. LNAPL was detected in 47 wells with a maximum thickness of 3.98 feet at well RW-4. LNAPL was detected off-Site in wells S-100 and S-265 (sheen) located on CSX property. LNAPL was also detected in two new monitoring wells (S-402 and S-417) located southwest of the Belmont Terminal.

Based on review of the aerial extent of apparent LNAPL thickness data, observations suggest that the LNAPL plumes are not migrating. Fluid level gauging over time indicates that LNAPL has not been identified in a down-gradient portion of the monitoring well network that has historically lacked measureable LNAPL.

4.1.2.1 Dissolved concentrations of benzene indicative of LNAPL

Elevated concentrations of benzene approaching the effective solubility limit in water have been detected at the Site. Previous reporting (Sunoco, 2007) provided estimates of benzene solubility in a fuel/groundwater mixture. The EPA Temperature-Dependent Effective Solubility Calculator was used to estimate the effective solubility of benzene with gasoline (89 octane with low MTBE) and #2 diesel assuming a groundwater temperature of 12.5 degrees Celsius. The effective solubility of benzene with a gasoline LNAPL source was calculated to be 17.5 milligrams per liter (mg/l) and with a diesel source it was calculated to be 0.392 mg/l. LNAPL is expected to be present at saturation levels below the pore entry pressure at wells with dissolved concentrations of benzene near or above these concentrations in areas where gasoline or diesel are the suspected LNAPL source.

Figures 4a through 4e indicate wells where LNAPL was not detected that had dissolved concentration of benzene above these concentrations. These elevated concentrations have generally been detected in wells in or along the edge of known LNAPL plumes. However, they are not necessarily associated with LNAPL and could be indicative of a release of benzene (which is known to have been stored at the Site). The solubility of benzene in water is 1,780 mg/l at 25 degrees Celsius (USGS, 2006) which is approximately 100 times higher than the effective solubility of gasoline at 12.5 degrees Celsius. A release of pure benzene would have a higher solubility in groundwater than the effective solubility of benzene with a gasoline or diesel source.

4.1.2.2 Fuel Fluorescence Detector (FFD) Data

The vertical distribution of LNAPL at the neighboring Belmont Terminal area was investigated using 22 combined CPT and FFD borings in 2000 (Handex, 2000a). An FFD sensor is a type of laser induced fluorescence (LIF) tool:

> *"..a fuel fluorescence detector…projects ultraviolet light through a sapphire window onto the soil as the tool is being advanced into the ground. If hydrocarbons are present they absorb the ultraviolet (UV) light and emit energy in the form of fluorescent light. This light passes back through the sapphire window and is collected by a fiber optic cable and transmitted to two photo-multipliers in the FFD probe… One half of the signal is filtered to remove wavelengths below 280 nm and above 450 nm while the other half is filtered to remove wavelengths below 450 nm and above 575 nm. The fluorescence response signal for gasoline and fuel oil (diesel) range hydrocarbons is observed in the 280 to 400 nm wavelength range. The fluorescence response from heavier compounds such as creosote and coal tar residuals are observed at longer wavelengths, primarily impacting the photo-multiplier equipped with the long pass filter (only allowing 450nm to 575nm wavelength range of light to pass)." (Handex, 2000a)*

The CPT/FFD report is included as Appendix II which includes boring logs, a site map and a 3D interpolated model of the FFD response.

Reportedly all of the hydrocarbons encountered at the Site using the FFD detector had more response in the longer wavelength fraction of the signal. The borings completed at the Site ranged from 21 to 53 feet below ground surface (BGS). The CPT data indicates that the Site was underlain by sand and gravelly sand to approximately 30 feet BGS. Generally the primary sand layer was underlain by a fine-grained mix of sand, clayey silt and clay.

Elevated FFD signals were encountered in all of the borings except for CPT-19 and CPT-20. They were also detected in two distinct elevation intervals. A shallow zone of hydrocarbons was encountered between 10 to 30 feet above mean sea level (AMSL) or 5 to 20 feet BGS. The shallow hydrocarbons were generally detected in the loading rack area between the loading racks and the main parking lot. Unconfined aquifer groundwater elevation in the neighboring Belmont Terminal area has generally been encountered at approximately three to six feet AMSL. This pattern is consistent with a historic LNAPL release that migrated through the vadose zone due to pressure and gravity and subsequently was redistributed at the water table in accordance with the capillary pressure curve for the geologic formation.

A deeper zone of hydrocarbons was encountered between 5 to 10 feet below mean sea level or 20 to 35 feet below grade. The deeper hydrocarbons were generally detected south of the loading racks, south of the main parking lot and just south of the main entrance. The FFD responses indicated potential chemical differences between the shallow and deeper zones of hydrocarbons. The deeper hydrocarbons are located below the water table.

Beginning in the late 1940s and ending in the early 1970s significant quantities of water were pumped from the lower aquifer in the vicinity of the Facility. The U.S. Geological Survey (USGS) has modeled drawdown during that period and estimated that water levels near the Facility may have been drawn down to approximately six feet below mean sea level between 1969 to 1978 (Schreffler, 2001 Pg. 44). LNAPL present in the Belmont Terminal area during this period of significant pumping may have migrated through the vadose zone to the level of the drawn-down water table. When pumping ceased and aquifer water levels recovered, residual LNAPL may have been present at the lower elevation.

4.1.2.3 LNAPL Delineation

LNAPL at the Site has been delineated to the north by the Shunk Street Sewer which bisects the northern part of the Belmont Terminal area. Previous reporting (Mulry and Cresswell, 1998a) indicated that the sewer intersects the water table and may act as a barrier to northern migration of LNAPL from that area. To the west and south, the Site is bordered by other AOIs at the Facility (Figure 1). To the east, LNAPL is present off-Site on CSX property and was detected in 2015 in off-Site wells S-100 and S-265 (Figure 4e). The eastern extent of LNAPL at S-265 is delineated by well S-197. The extent of LNAPL at S-100 is delineated to the north by S-197, to the south by S-101 and to the east by wells on the DSCP property.

4.2 LNAPL SOURCE

The sources of the LNAPL at the Site are equivocal. Numerous potential sources have historically been present at the Site. Plumes from various sources appear to have co-mingled at the Site. The submerged LNAPL at the Belmont Terminal was likely released prior to the early 1970s and appears chemically different than the source(s) of the shallow hydrocarbons at the Belmont Terminal (Section 4.1.2.2).

LNAPL characterization samples have indicated a wide range of weathering from “severe” to “un-weathered” (Table 3). Figure 8b presents a map of the LNAPL weathering based on the LNAPL characterization samples. The symbolization indicates the weathering of the relatively youngest LNAPL sub-type for each sample. LNAPL sub-types that were described as un-weathered or slightly weathered were generally located within or along the southern border of the Belmont terminal area and were generally characterized as gasoline or middle distillates. This indicates that the most recent LNAPL releases are located within, and along the southern border of, the Belmont Terminal. The area that includes the most recent LNAPL releases also generally coincides with the locations of the Belmont Terminal total fluids recovery systems.

4.3 LNAPL CHARACTERIZATION

Various petroleum products have been stored and distributed within AOI 1. The LNAPL plumes at the Site are expected to be made up of various combinations of these products. Numerous tests have been completed to characterize the LNAPL at the Site. The results of the tests are summarized on Table 3, Figure 7 and are discussed below.

26th Street, 1998

The Sunoco 26th Street Border Investigation report from 2003 references LNAPL samples collected in 1998 from wells S-100, RW-401, RW-402 and PZ-400. Although the details of these analyses are not available, the results were reported to be similar to samples collected from these wells in 2002, however, the LNAPL sample from PZ-400 was reported to include less diesel range material in 1998 than in 2002 (Secor, 2003).

Belmont Terminal, 2000

In 2000, LNAPL samples from wells RW-1, RW-4, RW-7, RW-15, S-75, and S-76 were collected and submitted to Torkelson Geochemistry, Inc. (Torkelson) for analysis. Torkelson completed gas chromatography analysis of the samples as well as testing for density and lead (Handex, 2000b).

The four "RW" wells are located along the southern edge of the Shunk Street Sewer in the Belmont Terminal area. LNAPL from the "RW" wells was described as golden in color. LNAPL characterization samples from these wells were described as being similar to each other and had elevated methyl-tertiary-butyl-ether (MTBE) peaks. Torkelson characterized the "RW" samples as being motor fuel from the same source in close proximity to the wells (Handex, 2000b).

Well S-75 is located within the southeast corner of the Belmont terminal area along 26th street. Torkelson characterized the sample from S-75 as being composed of a moderately to severely weathered mixture of gasoline and another hydrocarbon distillate (Handex, 2000b).

Well S-76 is located along the southern edge of the Belmont terminal area. Torkelson characterized the sample from S-76 as being composed of a un-weathered to moderately weathered mixture of gasoline and another hydrocarbon distillate (Handex, 2000b) (2000.09.29).

Belmont Terminal, 2001

In 2001, LNAPL samples from monitoring wells MW-25 through MW-32 were collected and submitted to the Sunoco Refinery Quality Control Laboratory for analysis of density and sulfur. These well are all located within the Belmont Terminal area (the well name for MW-22 through MW-24 has since changed to RW-22 through RW-24). The sample from MW-31 was not run for density due to insufficient sample volume. The results were reported to indicate that the LNAPL was a light gasoline range product. The density of most of the samples was similar (average of 0.78 grams per milliliter (g/ml), however, it was lower for the samples from MW-22 and MW-23 (average of 0.76 g/ml). Additional samples were collected from several of the wells to be analyzed by a simulated distillation analysis. However, the result of the additional analysis is not available in the historical records for the Site (Handex, 2001a).

26th Street, 2002

In 2002, LNAPL samples were collected from wells S-50, S-88A, S-98, S-100, RW-401, RW-402, PZ-400, andCSX-MW-5 and submitted to ICF Consulting (ICF) for gas chromatographic analysis and interpretation. These wells are located within AOI1 along the border with 26th Street, except for CSX-MW-5 with is located on CSX property approximately 270 feet east of S-179.

The samples from S-100, RW-401, RW-402 and PZ-400 were reported to be composed of a mix of gasoline and diesel. The analysis indicated that the sample from S-98 was composed primarily of weathered gasoline with trace diesel range hydrocarbons. The samples from S-89 and CSX-MW-5 were reported to be a heavily degraded mix of gasoline and diesel.

The samples were compared to a sample previously collected from the DSCP plume (located east of the Facility) and found to be composed of distinct materials from the LNAPL samples collected at the Site (Secor, 2003).

AOI 1 2004 and 2005

In 2004, LNAPL samples were collected from nine wells located in AOI 1. Additionally, in 2005 LNAPL samples were collected from 28 wells within AOI 1. The samples were submitted to Torkelson for characterization and the results of both rounds of sampling were reported in the 2007 SCR report for AOI 1 (Sunoco, 2007, Appendix III). The results indicated that the LNAPL samples were composed of mixtures of various hydrocarbon types. Based on the ratio of these components, the LNAPL samples were grouped into four general LNAPL types including: lube oil, gasoline/middle distillate, gasoline, and light end feed stock (Sunoco, 2007).

AOI 1 2016

In 2015, LNAPL was observed in AOI 1 monitoring well S-417 where it had not previously been observed. Stantec collected one LNAPL sample from that well and submitted the sample to Pace Analytical Energy Services (Pace) for characterization. According to Pace, the LNAPL collected from monitoring well S-417 is most likely extremely-weathered gasoline, potentially containing a relatively small amount of diesel.

LNAPL/Groundwater Tension Samples

In 2005, groundwater and LNAPL samples were collected from two wells (MW-42 and S-198) near the southern edge of the Belmont Terminal/AOI 1 boundary and one well located in AOI 4 (S-34). In addition to density, these samples were analyzed for tension parameters (interfacial and surface), and viscosity. These Site specific values were compared to literature values. The literature values were found to be conservative and were applied to other wells when calculating specific LNAPL volume and relative permeability of LNAPL.

Spatial Distribution of Generalized LNAPL Types

Petroleum refinery streams and products are complex mixtures of hydrocarbons. These products may be categorized by boiling point into gases, distillates (light, middle, and heavy) and residuum (IFRF, 2016). Light distillates include liquid petroleum gas (LPG), gasoline, and naphtha.

Middle distillates include kerosene, jet fuel, diesel fuels, and light fuel oils. Heavy distillates include fuel oil and heavy atmospheric gas oil. Residuum includes waxes and asphalts.

Table 3a summarizes available, historical and recent LNAPL characterization results. The results have been grouped into the following four generalized LNAPL types: Light Distillates, Mixes of Light/Middle Distillates, Middle Distillates, and Residuum. In general most of the LNAPL samples collected from AOI-1 (excluding Belmont Terminal) were characterized as a mixture of light and middle distillates. The LNAPL characterization results and generalized LNAPL types are further discussed below.

- Light Distillates: The samples grouped into the light distillate category included samples that were characterized to be more than 90 percent gasoline, heavy virgin naphtha or reformed light naphtha. The light distillate samples had an average viscosity of 0.67 centipoise and an average density of 0.78 g/ml.

- Mixes of Light/Middle Distillates: The samples grouped into the light/middle distillate category included samples that were characterized to be intermediate mixes of light and middle distillate products. The light/middle distillate samples had an average viscosity of 0.85 centipoise and an average density of 0.80 g/ml.

- Middle Distillates: The samples grouped into the middle distillate category included samples that were characterized to be more than 60 percent middle distillate or that included significant proportions of coker naphtha mixed with middle distillate. The middle distillate samples had an average viscosity of 3.72 centipoise and an average density of 0.83 g/ml.

- Heavy Distillates: The sample from S-126 was characterized as lubricating oil and was categorized as a heavy distillate. The sample from S-126 had a viscosity of 5.8 centipoise and a density of 0.9 g/ml.

Figures 8a and 8b present the location, generalized LNAPL type, and degree of weathering for the LNAPL characterization samples included in Table 3a. The overall distributions of the generalized LNAPL types identified are discussed below.

In the Belmont Terminal area, most of the LNAPL samples have been categorized as light distillate or mixes of light and middle distillate. However, three samples (from wells MW-33, OW-17, and S-76) were classified as middle distillates.

Within the middle section of the 26th Street area, most of the LNAPL samples have been categorized as middle distillate or as a mix of light and middle distillate. The northern and southern sections of the 26th Street area include samples that have been classified as light distillate (S-81 to the north and S-50 to the south).

4.4 SITE-SPECIFIC LNAPL TRANSMISSIVITY ESTIMATES

Traditionally, remediation success of LNAPL has been defined by the reduction of LNAPL thickness, as measured in wells at a site. More recent publications suggest a better metric of LNAPL remediation is to examine LNAPL transmissivity to infer mobility and recoverability (ASTM, 2013; ITRC, 2009: EPA, 2003). Historical LNAPL baildown tests and records of LNAPL and groundwater recovery ratios were used to provide LNAPL transmissivity estimates for the Facility and are discussed in detail below. Historical LNAPL transmissivity estimates were compared to recent estimates for the Site.

4.4.1 LNAPL Baildown Tests

The API LNAPL Transmissivity Workbook: A Tool for Baildown Test Analysis Users Guide, (API, 2012) provides a tool for performing analysis for LNAPL baildown data. The analysis included protocols to adapt slug test analyses developed by Bouwer and Rice (1976), Cooper and Jacob (1946), and Cooper, Bredehoeft and Papadopulos (1967) to estimate LNAPL transmissivity.

The LNAPL baildown test induces a gradient that results in the flow of LNAPL into a monitoring well. Flow is induced by rapidly removing a known volume of LNAPL from a monitoring well without removing significant water from the well and measuring the recovery of the water-LNAPL and air-LNAPL interfaces.

The rate of LNAPL flow into the well is a function of LNAPL saturation, permeability of the surrounding formation to LNAPL, physical properties of the LNAPL (density, viscosity, interfacial tension between LNAPL and water), and the magnitude of the initial hydraulic gradient toward the well developed during the LNAPL baildown testing. LNAPL transmissivity values determined from baildown testing are representative of the LNAPL transmissivity of the formation in the vicinity of the well being tested under conditions existing at the Site at the time of the test. This is an important consideration as conductivity and transmissivity values obtained from baildown testing may vary in the same location during periods of high and low water elevations in an unconfined aquifer.

LNAPL baildown tests were completed at wells within AOI 1 between 1987 and 2003. The objective and evaluation methods for LNAPL baildown tests have changed since the completion of these tests. Historically the tests were completed to estimate LNAPL recovery rates. The data required to perform the analysis did not consistently include LNAPL and groundwater drawdown data and was generally limited to LNAPL thickness over time. As discussed above, the current API method is used to estimate LNAPL transmissivity and relies on LNAPL flow rates in addition to LNAPL and groundwater drawdown. The tests completed in 2001 did include sufficient data to be able to re-evaluate the tests using the API Tool for Baildown Test Analysis (API, 2012). The results of the historic baildown tests and re-evaluations are discussed in detail below and are summarized in Table 4, and output of the API Tool for Baildown Test Analysis (API, 2012) workbooks are included in Appendix III.

1987

In 1987, LNAPL baildown tests were completed in wells 71, 74 and 75 located within the 26th Street area. The results were reported in the 26th Street Pilot Remedial Recovery Investigation completed by EEI in 1987 (EEI, 1987) (1987.12.21). Reported data from the tests was limited to graphs of the LNAPL thickness during recovery which is insufficient for estimating LNAPL transmissivity using the API workbook.

The LNAPL thickness in well 74 reportedly recovered to its original value within 90 minutes and was determined to be a candidate for active recovery. However, the graph of this test was cut off at 50 minutes. Prior to the test, well 74 had a static LNAPL thickness of approximately 2.05 feet. At the start of the test there was approximately 0.3 feet of LNAPL left in the well. Measurements of LNAPL thickness continued for approximately 50 minutes, at which time the LNAPL thickness had recovered by 57% to 1.3 feet.

Prior to LNAPL removal for the baildown test, well 71 had a static LNAPL thickness of approximately 3.9 feet. At the start of the test there was approximately 0.95 feet of LNAPL left in the well. Measurements of LNAPL thickness continued for approximately 50 minutes, at which time the LNAPL thickness had recovered by 22% to 1.6 feet.

Prior to the test, well 75 had a static LNAPL thickness of approximately 1.4 feet. At the start of the test, most of the LNAPL had apparently been removed from the well. Measurements of LNAPL thickness continued for approximately 54 minutes, at which time the LNAPL thickness had recovered by 53% to 0.75 feet.

1997

In 1997, LNAPL baildown tests were completed at TW3, RW6, and OW12 in the Belmont Terminal. The results were reported in the Free Product Delineation Along Shunk St. Sewer Report completed by Mulry and Cresswell Environmental, Inc. (Mulry) in 1998 (Mulry, 1998). Depth to product and depth to water readings were included in the report. Details of the tests and efforts to estimate LNAPL transmissivity from the historical data are discussed below.

Two tests were completed at well RW6. Prior to the first test, well RW6 had a static LNAPL thickness of approximately 0.89 feet. At the start of the test there was approximately 0.01 feet of LNAPL left in the well. Measurements of LNAPL thickness continued for approximately 240 minutes, at which time the LNAPL thickness had recovered by 6% to 0.06 feet.

The second test at RW6 was completed the next day with significantly different results. The static LNAPL thickness was 0.73 feet and the LNAPL was bailed down to 0.02 at the start of the test. Measurements of LNAPL thickness continued for approximately 240 minutes, at which time the LNAPL thickness had recovered by 66% to 0.49 feet. The data from the second test was re-evaluated using the API Tool for Baildown Test Analysis (API, 2012). The analysis assumed that RW6 was a 2-inch diameter well prior to being over-drilled. The test data indicated that the LNAPL in the well may have been perched. The estimated LNAPL transmissivity (T_n) value at RW-6 on November 18, 1997 is 0.13 ft^2/day.

One test was completed at well TW3 (also historically referred to as OW3). Prior to the first test, well TW3 had a static LNAPL thickness of approximately 0.31 feet. At the start of the test there was approximately 0.01 feet of LNAPL left in the well. Measurements of LNAPL thickness continued for approximately 270 minutes, at which time the LNAPL thickness had recovered by 17% to 0.06 feet. The length of the test was insufficient to be able to accurately estimate T_n using the API Tool for Baildown Test Analysis. However the results do indicate that the T_n value was less than of 0.1 ft^2/day at TW-3 on November 17, 1997.

One test was completed at well OW12. Prior to the first test, well OW12 had a static LNAPL thickness of approximately 0.57 feet. At the start of the test there was approximately 0.09 feet of LNAPL left in the well. Measurements of LNAPL thickness continued for approximately 60 minutes, at which time the LNAPL thickness had recovered by 15% to 0.16 feet. The duration of the test was insufficient for use of the API Tool for Baildown Test to estimate T_n.

2001

In 2001, LNAPL baildown tests were completed at monitoring wells MW-22, MW-23, MW-24, MW-26, MW-27 and MW-29 near the Belmont Terminal southern boundary with AOI 1. The results were reported in a letter report dated June 6, 2001 (Handex, 2001b). The results from MW-23 and MW-24 were not included in the report because changes in the groundwater elevation during recovery precluded use of the analysis method used at the time. Reported data from the tests was limited to graphs of the LNAPL thickness during recovery which is insufficient for estimating LNAPL transmissivity using the API workbook. Additionally, the tests were run for a maximum of 30 minutes. However, during that time the LNAPL thickness increased by a significant amount. The rate of recovery of LNAPL thickness for MW-22, MW-26, MW-27, and MW-29 was 0.01, 0.06, 0.25, and 0.02 feet per minute. Additionally, the average initial LNAPL recovery rate for the wells was estimated as 49.02, 53.40, 282.57, and 63.27 gallons per day respectively.

2003

In 2003, LNAPL baildown tests were completed at monitoring wells S-50 (No. 2 Tank Farm), S-98 (off-Site), and S-100 (off-Site) along 26th Street (wells S-50 and S-98 were historically referred to as MW-50 and MW-98). Additionally, a baildown test was completed at monitoring well CSX-MW-5 located across 26th Street from the Facility on CSX property. CSX-MW-5 is located approximately 270 feet east of S-179. The results of the LNAPL baildown tests were reported in a remedial investigation report dated January 31, 2003 (Secor, 2003). Graphs of the raw depth to product and depth to groundwater readings were included in an appendix to the report.

Well S-50 had a static LNAPL thickness of approximately 1.03 feet prior to removal of 0.75 gallons of LNAPL. At the start of the test, there was approximately 0.2 feet of LNAPL left in the well. Measurements of LNAPL thickness continued for approximately 50 minutes, at which time the LNAPL thickness had recovered by 28% to 0.43 feet. The data from the test was re-evaluated using the API Tool for Baildown Test Analysis. A T_n value of 0.87 ft^2/day was estimated using the Bouwer and Rice method (B&R, 1976) and a T_n value of 1.26 ft^2/day was estimated using the

Cooper and Jacob method (C&J, 1946). A good fit to the data was not found with the Cooper, Bredehoeft and Papadopulos method (CB&P, 1967). An average T_n value of 1.07 ft^2/day was estimated based on the two methods for S-50 in 2003. It should be noted that because LNAPL recovery was limited during the duration of the test, this T_n estimate is uncertain and the data was filtered to remove records that did not fit the trend of decreasing discharge with decreasing drawdown.

Well S-98 had a static LNAPL thickness of approximately 0.57 feet prior to removal of 3 gallons of LNAPL. At the start of the test, there was approximately 0.06 feet of LNAPL left in the well. Measurements of LNAPL thickness continued for approximately 45 minutes, at which time the LNAPL thickness had recovered by 110% to 0.62 feet. The data from the test was re-evaluated using the API Tool for Baildown Test Analysis, and an average T_n value of 25.5 ft^2/day was estimated for S-98 in 2003.

Well S-100 had a static LNAPL thickness of approximately 0.61 feet prior to removal of 2 gallons of LNAPL. At the start of the test, there was approximately 0.14 feet of LNAPL left in the well. Measurements of LNAPL thickness continued for approximately 209 minutes, however, the LNAPL thickness in the well was stable within 12 minutes at 0.26 feet. The results of the test indicate that the LNAPL in the well was not in equilibrium with the formation prior to the start of the test. The data from the test was re-evaluated using the API Tool for Baildown Test Analysis, and an average T_n value of 91.3 ft^2/day was estimated for S-100 in 2003. However there was poor agreement between the methods with a standard deviation of 91.2 ft^2/day.

Well CSX-MW-5 had a static LNAPL thickness of approximately 0.63 feet prior to removal of 0.13 gallons of LNAPL. At the start of the test, there was approximately 0.14 feet of LNAPL left in the well. Measurements of LNAPL thickness continued for approximately 41 minutes, at which time the LNAPL thickness had recovered by 36% to 0.31 feet. The data from the test was re-evaluated using the API Tool for Baildown Test Analysis. Given the short duration of the test and limited LNAPL volume removed at the start of the test, the results of the analysis are uncertain. An average T_n value of 4.6 ft^2/day was estimated for CSX-MW-5 in 2003.

4.4.2 Water-Enhanced LNAPL Recovery

LNAPL transmissivity may also be estimated using discharge data from LNAPL/groundwater recovery systems. This estimation method is applicable even when the total recovery rate is variable or the system experiences periods of down time. The analysis assumes that LNAPL and groundwater are pumped from a well using a single or dual pumping system. The analysis assumes that the discharge rate is sufficiently low to prevent significant smearing of the LNAPL. When the skimming drawdown is small relative to the water extraction induced drawdown, the following equation can be used to determine LNAPL transmissivity (ASTM, 2013 and Charbeneau, 2007):

$$T_n = \frac{Q_0 T_w \rho_r}{Q_w}$$

Where:

T_n = LNAPL transmissivity
Q_0 = LNAPL discharge rate
Q_w = water discharge rate
T_w = Aquifer transmissivity
ρ_r = LNAPL/Water Density Ratio

Records of LNAPL and groundwater recovery ratios from facility total fluid extraction wells were reviewed. System status reports for the Belmont Terminal and 26th Street systems as well as several historical pilot testing reports have included LNAPL/groundwater recovery ratios. LNAPL transmissivity estimates from these data sources are discussed in detail below and summarized in Tables 5a and 5b.

System Status Reports

The semi-annual system status reports for the Facility include total fluids recovery system operational data from the 26th Street and Belmont Terminal Areas. The earliest records available are from 2003 and 1999 for the 26th Street and Belmont Terminal Area systems, respectively. These reports include recovery totals of LNAPL and groundwater.

The Belmont Terminal recovery system consists of the Loading Rack system (RW-4 and RW-21 through RW-25) and the Frontage Road system (RW-15 and RW-26 through RW-32). The Belmont Terminal system operational data is available from 1999 through present.

Figure 2-7 of the Remedial Investigation Report (RIR) summarizes the results of aquifer tests completed at the Facility (Stantec, 2016). Table 1 of this report summarizes the results of aquifer tests completed in AOI-1. Hydraulic conductivity estimates for the Site range from 0.009 ft/day based on a slug test completed at S-194 (Secor, 2004) to 617 ft/day based on a slug test completed at TW-218 (IST, 1998). A pumping test was completed at RW-2 (AOI-3) in 1997 (IST, 1998). The results indicated that regional hydraulic conductivity values in the unconfined aquifer at the Facility may range from approximately 434 to 460 ft/day. The 2007 Site Characterization Report listed a geometric mean value for hydraulic conductivity in AOI 1 of 24 ft/day which is consistent with literature values for coarse-grained sand (Heath, 1983) but is low compared to the results of the RW-2 pumping test.

Well logs and CPT borings completed in the Belmont Terminal area indicated the presence of significant sand and gravel in the saturated zone. Review of well logs for the Belmont Terminal recovery system wells indicated an average saturated thickness of approximately 15 feet. To be conservative when estimating the LNAPL transmissivity for the Belmont Terminal area, a value of 450 ft/day was used for the hydraulic conductivity of the unconfined aquifer. Assuming a saturated thickness of 15 feet yields an estimated transmissivity of water of 6,750 ft^2/day.

Table 5a presents annual average LNAPL transmissivity for the wells included in the recovery system during the period of record. Figure 9 shows the annual average LNAPL transmissivity values plotted on a semi-logarithmic scale. Generally the T_n values of the Belmont Terminal recovery system have decreased logarithmically from a high of 670 ft^2/day in 2000 to 0.2 ft^2/day in the first half of 2015.

The 26th Street Sewer Area (26th Street North) Total Fluids Recovery System consists of 14 total fluids recovery wells (14 wells on-Site along 26th Street) which discharge directly to a refinery process sewer. Because the system discharges directly to a controlled sewer the volume of recovered LNAPL is no longer measured. Separate records of LNAPL and groundwater recovery rates from this system are available from 2003 through 2006. In 2006, no LNAPL was recovered from the system. The average LNAPL Transmissivity values for the 26th Street recovery system decreased from a high of 109 ft^2/day in 2004 to less than 0.001 ft^2/day in 2006 (the last year LNAPL recovery rates were measured for the system) (Table 5a).

It should be noted that the LNAPL transmissivity estimates based on system performance data represent an average value for the wells included in the system and individual wells may have higher or lower LNAPL transmissivity if measured separately. Although the LNAPL transmissivity values estimated with this method are sensitive to the transmissivity of water used in the calculation, there is a clear decreasing trend in the aggregate LNAPL transmissivity and LNAPL recovery from these systems.

Historical Pilot Tests

Historical reports for AOI 1 were reviewed for LNAPL and groundwater recovery data. Several recovery system pilot test reports were identified which included sufficient information to allow for estimation of T_n for several wells. To facilitate comparison with T_n values estimated from system recovery records, same values for T_w consistent with values used in the previous section (345 ft^2/day for 26th Street area, and 360 ft^2/day for Belmont Terminal area). These additional estimated historical values for T_n are discussed below and are summarized in Table 5b.

Well S-84 (PR-1) was installed in the 26th Street area as part of a pilot remediation system. LNAPL and groundwater were pumped form the well at a combined flow rate of approximately 7.5 gallons per minute for six days in the fourth quarter of 1987. Based on the results of the pilot testing and estimated values for T_w and ρ_n, the estimated LNAPL transmissivity at S-84 in 1987 is 26.3 ft^2/day. Comparison of this estimated value with the values estimated from system operation data from 2003 to 2006 is consistent with a decreasing trend in T_n over time.

Startup testing of the initial Belmont Terminal System was completed in 1998. The initial system included groundwater pumping from wells RW4, and RW7, soil vapor extraction from eight wells and dual phase groundwater and LNAPL recovery from wells RW-1, RW-4, and RW-15 (using a two-pump system). The startup recovery rates for these wells (between September 17, 1998 and December 31, 1998) were reported in the Shunk Street Sewer Remediation Project report (Mulry and Cresswell, 1998b). LNAPL transmissivity values for RW-1, RW-4 and RW-15 in 1998 were estimated to be 10.24, 6.45 and 45.69 ft^2/day respectively. These values are consistent with the decreasing trend in T_n for the Belmont Terminal wells from 1999 through present as discussed above.

Wells RW-1, RW-4, RW-6, and RW-7 were operated in 2000 (Handex, 2000b). The LNAPL totalizer at well RW-4 stopped working at the end of March so extraction volumes used to estimate T_n were through the first quarter of 2000. For wells RW-1, RW-6 and RW-7, the T_n estimate is based on extraction volumes for the entire year. Estimated values of T_n ranged from a high of 21.84 ft^2/day at RW-4 to a low of less than 0.001 ft^2/day at RW-6.

Pilot testing was completed at wells RW-22 and RW-24 (MW-22 and MW-24) in Aril and May, 2001 (Handex, 2001b). Estimated values of T_n for these wells in 2001 were 26.2 and 2.51 ft2/day respectively. These values are consistent with the T_n value estimated for the entire Belmont Terminal system in 2001 of 4.7 ft^2/day.

Groundwater and LNAPL was pumped from wells RW-405 and RW-406 in 2002. Estimated values of T_n for these wells in 2001 were 5.01 and 3.5 ft^2/day respectively. These values are consistent with the T_n values observed for the entire 26th Street system in 2003 and 2004.

4.4.3 LNAPL Transmissivity Trends

LNAPL transmissivity values can be interpreted as a reflection of LNAPL mobility and can serve as a remediation performance metric, which is irrespective of in-well LNAPL thickness. The minimum LNAPL transmissivity for practicable product recovery (when recovery is the only goal for a remediation project) has been suggested to be approximately 0.1 to 0.8 ft^2/day (ITRC, 2009). Historic data is representative of wells at one point in time. To provide multiple lines of evidence regarding historic LNAPL transmissivity values at the Facility, historic measurements of water-enhanced LNAPL recovery rates were evaluated.

This historic data from the 1990's and early 2000's have indicated that most of the wells tested or selected for LNAPL recovery had values of LNAPL transmissivity suggesting practicable recovery (as high as 91.3 ft^2/day). Values of T_n have decreased significantly since the 1990s and early 2000s. The most recent estimates of T_n for the Facility are based on combined recovery system flow rates. These values have been consistently below the range of potentially recoverable LNAPL since 2009 for the 26th Street system and since 2005 for the Belmont Terminal system. However, it should be noted that estimates based on combined recovery system flow rates represent an average and there may be wells in the system with values of LNAPL transmissivity that are still within the potentially recoverable range.

The estimated LNAPL transmissivity for the recovery systems demonstrate a lack of LNAPL recoverability irrespective of the LNAPL thickness remaining. Lower T_n values can potentially be achieved; however, technologies other than hydraulic and pneumatic recovery technologies would typically need to be employed to recover the additional LNAPL. Further lowering of T_n in the system wells would be difficult and can be inefficient; that is, it would take very long to marginally reduce T_n without much benefit in terms of reduction of LNAPL mass, migration potential, risk, or longevity. It should be noted that the LNAPL transmissivity estimates based on system performance data represent an average value for the wells included in the system and individual wells may have higher or lower LNAPL transmissivity if measured separately.

4.5 LNAPL MOBILITY TERM

The LNAPL Mobility Term is a site-specific evaluation of LNAPL mobility based on intrinsic permeability, LNAPL viscosity, and relative permeability. Sale (2001) introduced an LNAPL "Mobility Term" defined as:

$M_o = 100\ k_{ro}k_i /\ \mu_o$

Where:

- M_o = mobility term in cubic centimeter seconds per gram (cm^3s/g);
- The factor of 100 appearing in this expression converts meters to centimeters in the viscosity units;
- K_{ro} = LNAPL relative permeability, permeability based upon a function of the relative saturation, in this case an extremely conservative approach is considered with a relative permeability of 1;
- K_i = intrinsic permeability (square centimeters [cm^2]) = $1.62x10^{-6}$ cm^2, estimated based upon conservative estimate of representative hydraulic conductivity of the unconfined aquifer near the Site (450 ft/day - RW-2 aquifer test results) (IST, 1998); and
- μ_o = dynamic viscosity for LNAPL, (cP) =0.587 cP [the minimum measured value of LNAPL from recovery well RW-23 at neighboring Belmont Terminal) (Sunoco, 2007)].

Thus, the Facility-specific Mobility Term for this Site can be estimated as follows:

- $M_o = 100\ (1)(1.62x10^{-6})\ /\ 0.587 = 2.76x10^{-4}\ cm^3s/g$

If the LNAPL "Practical Limit of Mobility (PLM)" defined using a Mobility Term is less than $1x10^{-7}$ cm^3s/g, then LNAPL can be presumed to be effectively immobile (Golder, 2008). The term is heavily influenced by the value of intrinsic permeability for which estimates can vary over orders of magnitude. Based upon the conservative estimation of the LNAPL mobility term, the mobility of some of the LNAPL encountered at the Site is above the practical limit of mobility.

4.6 LNAPL PORE ENTRY PRESSURE EVALUATION

LNAPL occurrence in a monitoring well does not necessarily imply that LNAPL is able to move in the formation. LNAPL must overcome a finite pore entry pressure before it can penetrate water-filled pores and flow laterally (Charbeneau, 2007). The head required to exceed the pore entry pressure is referred to as the displacement head (ITRS 2009).

A multiphase model can be used to estimate the displacement head, assuming Brooks-Corey soil characteristics. The Brooks-Corey water retention model assumes that a minimum capillary pressure must be applied before the interface between the wetting and non-wetting fluids is displaced from the largest pore spaces (air/water displacement head) (Charbeneau, 2003).

Generally, if the thickness of the LNAPL in the monitoring well is greater than the Brooks-Corey displacement head, then the free-phase LNAPL is potentially mobile. If there are monitoring wells near the periphery of the LNAPL plume where the LNAPL in-well thickness is less than the displacement head, then the free-phase LNAPL is theoretically unable to migrate laterally beyond these monitoring wells.

The observed monitoring well LNAPL thickness necessary for LNAPL to flow laterally into a porous medium can be described by the equation:

$$b_n[\text{crit}] = \left(\frac{\sigma nw}{(1-\rho r)\sigma aw} + \frac{\sigma an}{\rho r\ \sigma aw}\right)\frac{hd}{\sigma aw}$$

where:

- b_n[crit] = minimum LNAPL thickness in monitoring well for LNAPL to penetrate the formation (LNAPL apparent thickness; m);
- σ_{nw} = LNAPL/water interfacial tension (dynes/cm);
- σ_{an} = Air/LNAPL interfacial tension (dynes/cm);
- σ_{aw} = Air/water interfacial tension (dynes/cm);
- ρ_r = relative LNAPL density (density of LNAPL/density of water); and,
- h_d = displacement pressure head also known as bubbling pressure head (meters (m))

Table 6 presents a summary of LNAPL pore entry pressure calculations for the Facility for monitoring wells with LNAPL thickness greater than 0.5 feet in 2015. Interfacial tension values based on literature values (Sunoco, 2007) were used in the calculation. Literature values for h_d based on soil type are provided in the API Publication 4729 (Charbeneau, 2003) and range from a low of 0.55 meters for sand to a high of 2.0 for silty clay. Table 6 presents a summary of critical LNAPL pore entry pressure calculations using a conservative h_d value for sand.

The calculated critical pore entry pressure for monitoring wells with 2015 LNAPL thickness greater than 0.5 feet ranged from 0.34 to 0.51 feet with an average of 0.38 feet. For the wells evaluated, the observed LNAPL thickness was greater than the critical pore entry pressure indicating that the LNAPL observed at these wells may be mobile.

4.7 LNAPL MOBILITY MODELING

Similar to groundwater, LNAPL in the subsurface only moves under Darcy's Law, and thus movement is a function of the relative permeability based upon saturation and porous media characteristics, LNAPL density, and LNAPL viscosity. Using the American Society for Testing and Materials (ASTM) guidance, LNAPL pore velocities less than $1\text{x}10^{-6}$ centimeters per second (cm/s) indicate LNAPL in the formation is functionally immobile. When pore velocity exceeds this criterion, it is an indication that LNAPL is potentially mobile at the pore scale and capable of moving vertically and laterally within the formation.

Site-specific LNAPL mobility can be characterized through the use of site data and advanced LNAPL mobility calculations and models presented in the API Interactive LNAPL guide (2004, API). The approach is additionally referenced as a component of site management/characterization in a 2005 EPA document titled A Decision Making Framework for Cleanup of Sites Impacted with Light Non-Aqueous Phase Liquids.

Plume velocities were calculated as part of the 2007 Site Conditions Report (Sunoco, 2007). The 2007 estimates are similar the revised estimates provided herein. For wells that had apparent LNAPL thicknesses greater than 0.5 in the 2007, the calculated plume velocities ranged from $1.14\text{x}10^{-4}$ cm/s to $3.16\text{x}10^{-2}$ cm/s with an average velocity of $5.74\text{x}10^{-3}$ cm/s. The highest calculated plume velocities in the 2007 estimate were located near the Belmont Terminal area or were located close to recovery wells in the 26th Street area.

Stantec used the API Interactive guide and calculation tools to update the 2007 estimates by modeling the distribution and recovery of LNAPL at the Site. The model calculates an expected LNAPL saturation and corresponding LNAPL relative permeability based on input of the physical properties of the product and aquifer matrix and assumed water/LNAPL saturation conditions in the aquifer. Soil capillary pressure characteristics are assumed to follow the van Genuchten model for relating fluid saturation to capillary pressure. Modeled LNAPL saturation and relative permeability are used to calculate an estimated pore velocity.

The following input parameters are required:

- Site characteristics (e.g. soil type, LNAPL thickness, plume distribution);
- Fluid characteristics (e.g. LNAPL and water density, air-water-LNAPL interfacial tensions); and
- Aquifer characteristics (e.g. porosity, soil capillarity parameters, irreducible water saturation, and residual LNAPL saturation).

LNAPL mobility modeling was completed for 18 wells that had apparent LNAPL thicknesses greater than 0.5 feet in the first half of 2015. Table 7 summarizes the input parameters for and results of the model. Input values for soil properties were based on a conservative estimated hydraulic conductivity of 450 ft/day as discussed in section 4.4.2. These values were compared to API default values for the soil type at the water table for each well and found to be conservative.

The groundwater hydraulic gradients used in the LNAPL mobility modeling were 0.0035 feet per foot and 0.01 feet per foot. The higher gradient value (0.01) was used for wells located near the 26th Street Intercepting Sewer where the gradients appear to be steeper (Section 3.2) and the lower value (0.0035) was used as a conservative value for the other wells included in the model. Site specific values for LNAPL density and viscosity were used in the model. For wells that have not had LNAPL analytical results for these parameters the value used was a Site specific average of samples from other wells with a similar generalized LNAPL type (Table 3b). Interfacial tension values are based on literature estimates for the generalized LNAPL type (Table 3c).

Based on the above input parameters, the model calculated plume velocities ranged from 1.0×10^{-4} cm/s to 5.5×10^{-3} cm/s with an average velocity of 2.5×10^{-3} cm/s. Figure 10 presents a map of the plume velocity estimates. The calculated range and location of the higher plume velocities is similar to the reported values in the 2007 Site Conditions Report (Sunoco, 2007).

ASTM suggests that LNAPL seepage velocities less than 1×10^{-6} cm/s indicate that the LNAPL is functionally immobile. Calculated values for the wells included in the analysis were greater than the limit of functional mobility. Based on this criterion, the model results indicate that the plume may be able to migrate at its leading edge.

4.8 LNAPL DISTRIBUTION AND RECOVERY MODEL (LDRM)

The API LNAPL Distribution and Recovery Model (LDRM) was used to estimate the thicknesses of total, mobile and recoverable LNAPL present at each of the wells included in the model (Table 8). Additionally, saturation profile graphs were produced and are included in Appendix IV.

The model was run for each of the 18 wells that contained more than 0.5 feet of apparent LNAPL thickness during the first half of 2015. Model input parameters and results are summarized in Table 8. The model was run using a variable LNAPL residual saturation with an f-factor of 0.3 (Charbeneau, 2007). Model input parameters for fluid characteristics were the same as those used in the LNAPL mobility modeling discussed in section 4.7. Model input parameters for soil characteristics were estimated using two metrics for hydraulic conductivity, including values derived from regional pumping test data and values derived from API defaults based on soil type near the capillary fringe at each well.

Boring logs for the wells included in the LDRM model were reviewed where available to evaluate soil type near the capillary fringe. Soil parameters for the LDRM were based on API default values for the soil type near the capillary fringe for each well. Boring logs were not available for wells S-100 and PZ-404. For these wells, the soil type used was based on review of boring logs for other wells located within the proximity of S-100 and PZ-404. For 10 of the 18 wells included in the LDRM model, the boring logs described the soil type near the capillary fringe as being a mix of sand and gravel. The API default value for coarse-grained sand was used for modeling these wells.

It is important to note that migration of LNAPL in the subsurface is strongly influenced by the characteristics of the soil within the interval of LNAPL saturation. Because LNAPL saturation is typically highest at and just above the water table, the characteristics of the soil near the capillary fringe are more applicable to LNAPL modeling than are the soil characteristics of the overall saturated aquifer thickness. As discussed in this LCSM, a conservative hydraulic conductivity estimate for the saturated portion of the unconfined aquifer at the Facility may be 450 ft/day. This value is based on large-scale aquifer testing results and as such may be representative of the saturated zone as a whole, but may not accurately represent soil properties at all locations modeled for the reasons described (particularly when considering the lithologic heterogeneity of the Trenton "gravel" deposits that comprise the bulk of unconfined aquifer sediments at the Site). For this reason, the LDRM model results presented in Figure 11 display LNAPL transmissivity values based on well-specific soil types. Table 8 displays both LNAPL transmissivity estimates for comparative purposes.

Based on the input parameters used, the LDRM model calculated LNAPL transmissivity values ranging from 0.01 ft^2/day to 20.17 ft^2/day with an average velocity of 4.5 ft^2/day. Figure 11 presents a map of the LDRM estimated LNAPL transmissivity values. The calculated range and location of elevated plume velocities is similar to the reported values in the 2007 Site Conditions Report (Sunoco, 2007).

As discussed in section 4.4, the minimum LNAPL transmissivity for practicable product recovery has been suggested to be approximately 0.1 to 0.8 ft^2/day (ITRC, 2009). The 18 wells evaluated with the LDRM were those with greater than 0.5 feet of apparent LNAPL thickness in 2015. Of these 18 wells, 15 have LNAPL transmissivity values within the practicably recoverable range, two wells are in the not practicably recoverable range (MW-26, and S-76), and one well (S-276) has LNAPL transmissivity values along the limit of practicable recoverability.

5.0 Summary and Conclusions

This report documents the LNAPL CSM for AOI 1 of the Philadelphia Refinery Complex. The objective of the LNAPL mobility assessment was to evaluate if remaining LNAPL is residual, mobile, or migrating. As discussed above, residual LNAPL represents LNAPL that is trapped in soil pores, mobile LNAPL is LNAPL that exceeds residual saturation, and migrating LNAPL is LNAPL that is observed to spread or expand. Mobile LNAPL includes migrating LNAPL, but not all LNAPL indicated to be mobile is migrating. The following summarizes key elements of the LNAPL CSM utilizing data gathered from literature review, field investigations, laboratory analyses, and remediation efforts.

- Numerous LNAPL characterization samples collected from the Site by Stantec and others have identified the presence of several variably-weathered product mixtures in the subsurface at AOI 1. The variation in LNAPL characteristics is indicative of multiple product releases at different times with subsequent co-mingling of plumes. A mixture of light and middle distillate is the most common product type encountered at the Site. For the purposes of this LNAPL CSM, the characterized LNAPL samples have been generalized into four groups listed below:

    - Light Distillates
    - Mixture of Light and Middle Distillates
    - Middle Distillates
    - Residuum

- A review of apparent LNAPL thickness data through time suggests that LNAPL plumes at the Site are not migrating, in general, because the vertical thickness of LNAPL has not been increasing. In the 26th Street area near offsite well S-100 and No. 1 Tank Farm well

S-277, increasing trends in apparent LNAPL thickness have recently been observed indicating that LNAPL in this area may be migrating.

- Review of the aerial extent of apparent LNAPL thickness through monitoring well observations suggests that overall, AOI 1 LNAPL plumes are not migrating because fluid level gauging over time indicates that LNAPL has not been identified in a down gradient portion of the monitoring well network that has historically lacked measureable LNAPL.

- LNAPL has recently been identified in new AOI 1 wells located southwest of the Belmont Terminal (S-402 and S-417). The extent and mobility of LNAPL in this area has not previously been defined. These wells are not down-gradient of any known LNAPL plumes based on 2014/2015 water-table elevations and inferred groundwater flow directions. An LNAPL sample collected from well S-417 in 2016 was characterized as severely-weathered gasoline (possibly containing a small proportion of diesel) which is generally consistent with the results of the two closest LNAPL characterization samples (S-77 and S-78) which were previously characterized as light and middle distillates.

- Off-Site LNAPL is present on the CSX property located east of AOI 1 based on observations at well S-100. An increasing trend in LNAPL apparent thickness has recently been observed at well S-100. The extent and potential source(s) of LNAPL on the CSX property may not be fully delineated. Groundwater flow direction based on 2014/2015 water-table elevations is south/southwest along 26th Street.

- Combined CPT and FFD borings were completed offsite at the Belmont Terminal in 2000. The FFD results indicated that hydrocarbons were present in two distinct depth intervals. The deeper interval is currently submerged. The submerged LNAPL may have migrated to deeper depths prior to the mid-1970s when regional water levels were lowered by significant groundwater pumping from the lower and possibly other aquifers.

- Site specific values of LNAPL transmissivity have been estimated from historical LNAPL baildown tests, and LNAPL/groundwater recovery ratios. The results indicate a decreasing trend with current values below or approaching the limit of practicable recovery. Estimates of historical LNAPL transmissivity values were generally greater than 1 ft^2/day and as high as 35 ft^2/day. The most recent estimates of average LNAPL transmissivity for the Belmont Terminal and 26th Street total fluids recovery systems are less than 0.01ft^2/day. The recent estimates are based on average extraction rates for each remedial system operating as a whole. LNAPL transmissivity may be higher at individual wells included in or near each system. For AOI 1, LNAPL baildown testing of system wells could be used to facilitate future optimization of the 26th Street remedial system.

- A conservative value for the Site-specific Mobility Term was calculated to be 2.76×10^{-4} cm^3s/g which is above the practical limit of mobility.

- The critical pore entry pressure was estimated for wells that had greater than 0.5 feet of apparent LNAPL thickness in the first half of 2015. The estimated critical pore entry pressure thicknesses ranged from 0.34 to 0.55 feet with an average of 0.38 feet. For the wells evaluated, the observed LNAPL thickness was greater than the critical pore entry pressure indicating that the LNAPL observed at these wells may be mobile.

- ASTM suggests that LNAPL seepage velocities less than $1x10^{-6}$ cm/s are indicative of functionally immobile LNAPL. Plume velocities were calculated as part of the 2007 Site Conditions Report (Sunoco, 2007). For wells that had apparent LNAPL thicknesses greater than 0.5 feet in 2007, the calculated plume velocities ranged from $1.14x10^{-4}$ cm/s to $3.16x10^{-2}$ cm/s with an average velocity of $5.74x10^{-3}$ cm/s.

- As a part of this LNAPL CSM, plume velocity calculations were updated for wells with greater than 0.5 feet of apparent LNAPL thickness in the first half of 2015. Model calculated plume velocities ranged from $1.0x10^{-4}$ cm/s to $5.5x10^{-3}$ cm/s with an average velocity of $2.5x10^{-3}$ cm/s.

- Most recent LNAPL transmissivity estimates presented in this report are from combined LNAPL system extraction rates. Individually, some 26th Street remedial system wells may have LNAPL transmissivity values within the practicable recovery range. LNAPL baildown tests completed at system wells could be used to facilitate optimization of the 26th Street total fluids recovery system.

- The API LDRM model was run for wells with greater than 0.5 feet of apparent LNAPL thickness in the first half of 2015. The LDRM model indicates that LNAPL in 15 to 16 of the 18 wells evaluated was within the range of practicable recoverability. Up-to-date well specific LNAPL transmissivity estimates for these wells could be used to further calibrate the LDRM model and prepare it for future use in simulating potential recovery methods along 26th Street.

Site-specific values of LNAPL transmissivity based on groundwater recovery ratios indicate that overall, LNAPL at AOI 1 is below the lower limit of practicable recovery. However, pore entry pressure, mobility modeling and LDRM evaluations indicate that areas of potentially mobile and practicably recoverable LNAPL are still present at the Site. In general, based upon the multiple lines of evidence presented above, LNAPL observed at the Site appears to be stable or decreasing (not migrating) as a whole and to be immobile at most locations along the plume front. However, LNAPL may be mobile and migrating near offsite well S-100 and No. 1 Tank Farm well S-277 where increasing trends in apparent LNAPL thickness have recently been observed.

The results of this LNAPL mobility assessment may be used to focus additional testing and to facilitate recovery system optimization. As additional site-specific LNAPL data becomes available it may be used to update and calibrate the LNAPL mobility evaluations presented in this AOI 1 LNAPL CSM.

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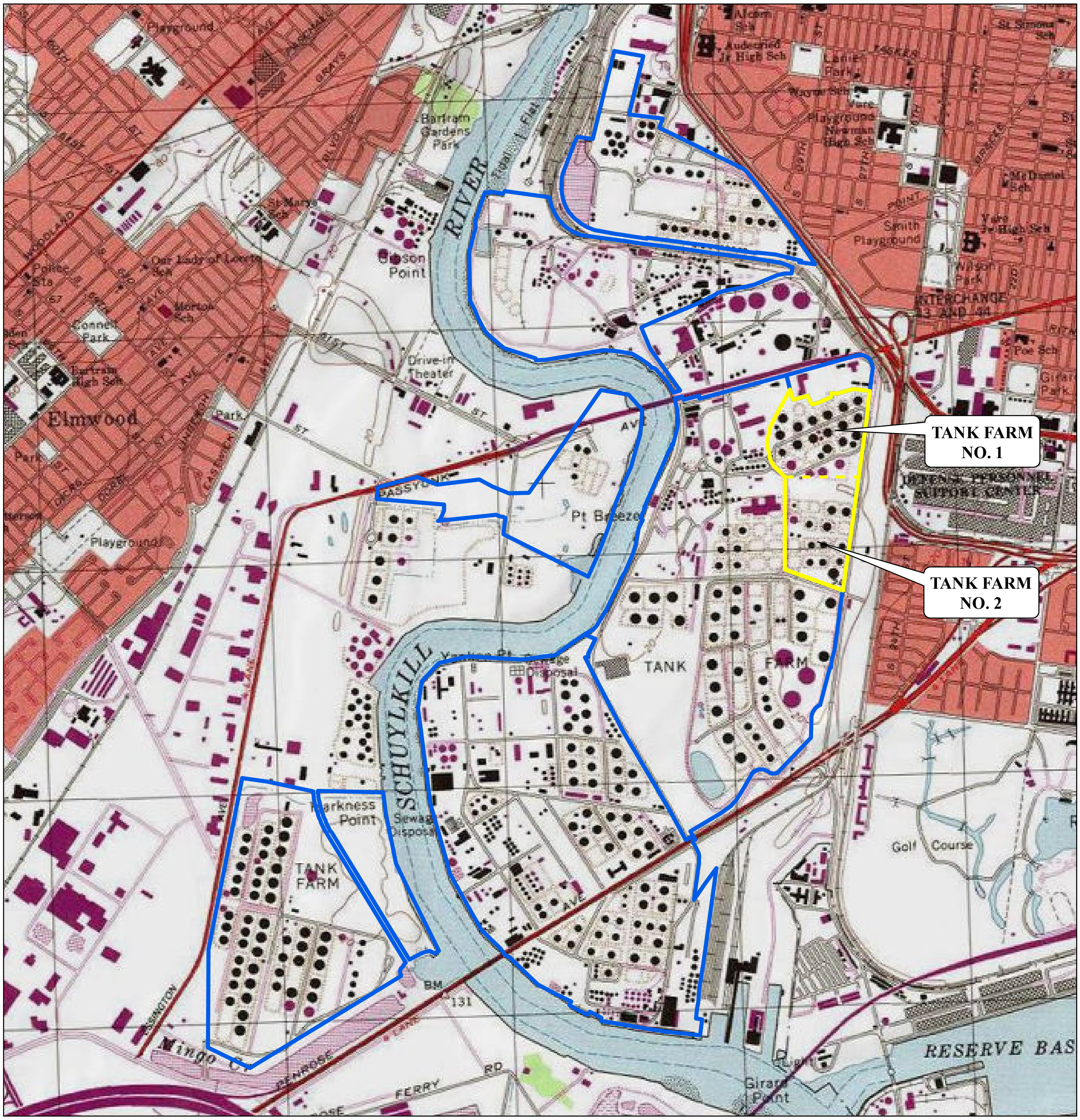
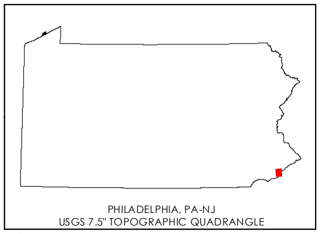
FIGURES

Light Non-aqueous Phase Liquid (LNAPL) Site Conceptual Model (LCSM)
Area of Interest 1

PHILADELPHIA REFINERY COMPLEX
PHILADELPHIA, PENNSYLVANIA
PHILADELPHIA REFINERY OPERATIONS,
A SERIES OF EVERGREEN RESOURCES GROUP, LLC
3144 PASSYUNK AVENUE, PHILADELPHIA, PENNSYLVANIA





PHILADELPHIA, PA-NJ
USGS 7.5" TOPOGRAPHIC QUADRANGLE

LEGEND

🟨 AREA OF INTEREST (AOI) 1 BOUNDARY

🟦 PHILADELPHIA REFINERY COMPLEX

0 1,100 2,200 Feet
1:26,400 (at original document size of 8.5x11)

N

Stantec

EVERGREEN

Notes
1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Source: Stantec, Evergreen Resources Management
3. Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed

Project Location
City of Philadelphia,
Pennsylvania

213402434
Prepared by GWC on 12/9/2015
Technical Review by JKD on 2/3/2016
Independent Review by ADK on 3/8/2016

Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Figure No.
1

Title
AOI 1 - SITE LOCATION MAP

Legend

- OFFSITE MONITORING WELL - FORMER DSCP, PASSYUNK HOMES, STEEN, AND CSX PROPERTIES
- FACILITY MONITORING WELL (AREAS OUTSIDE OF AOI 1)

AOI 1 MONITORING WELL (INCLUDING A PORTION OF OFFSITE WELLS MONITORED BY STANTEC)

HYDROSTRATIGRAPHIC UNIT

- UNCONFINED AQUIFER
- LOWER AQUIFER
- MIDDLE CLAY UNIT AQUITARD
- UNKNOWN SCREEN SETTING OR SCREENED IN FILLED STREAM VALLEY
- POLLOCK STREET HORIZONTAL WELL (AOI 2)

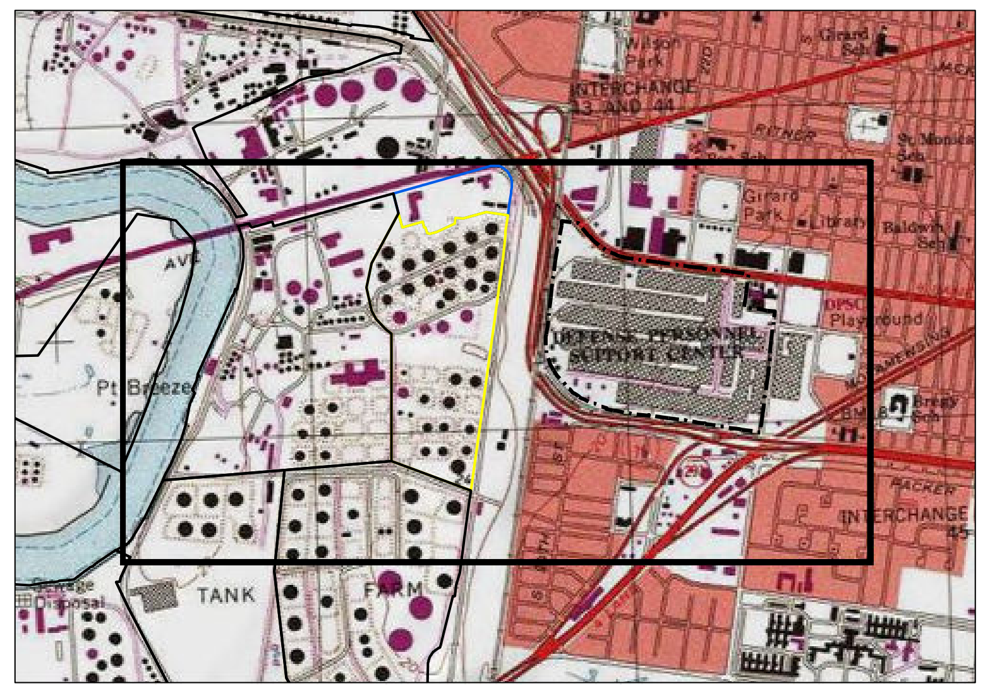
- APPROXIMATE LOCATION OF PHILADELPHIA WATER DEPARTMENT SEWER
- ▨ REMEDIATION SYSTEMS DESIGNATED AS CURRENTLY ACTIVE
- ▨ REMEDIATION SYSTEMS DESIGNATED AS INACTIVE
- ☐ AREA OF INTEREST (AOI) 1
- ☐ BELMONT TERMINAL
- ☐ AREA OF INTEREST (AOI)
- ☐ FORMER DEFENSE SUPPLY CENTER PHILADELPHIA (DSCP) PROPERTY

0 225 450
Feet
1:2,700 (At original document size of 24x36)

N

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
   North American Vertical Datum of 1988 (NAVD 88)
2. Data Sources: Stantec and Defense Logistics Agency (DLA)
3. Aerial & Topo Copyright:© 2013 National Geographic Society, i-cubed
   Image courtesy of USGS Earthstar Geographics SIO © 2016 Microsoft Corporation
   Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation



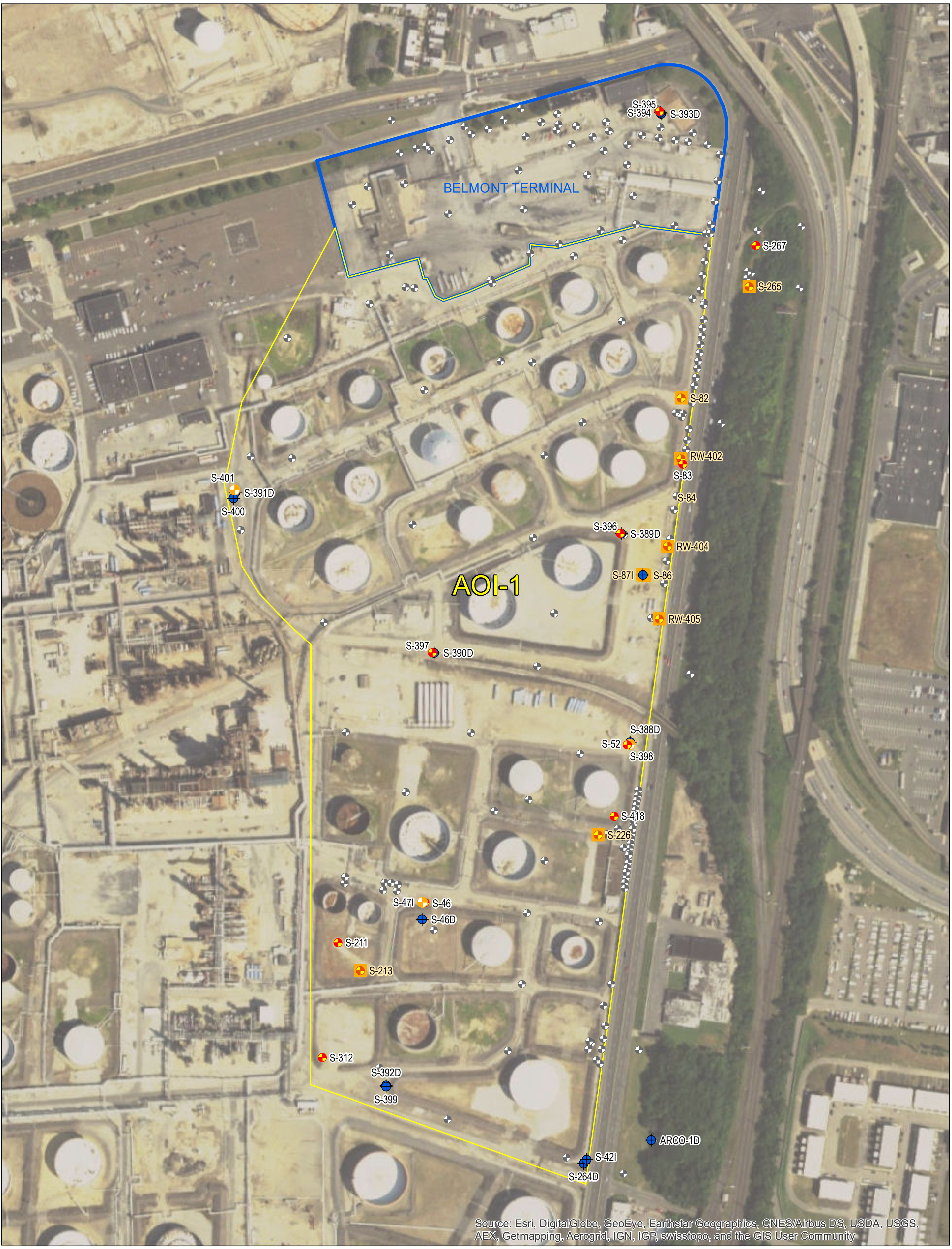
Project Location
City of Philadelphia,
Pennsylvania

213402434
Prepared by GWC on 2/3/2016
Technical Review by JKD on 2/3/2016
Independent Review by ADK on 3/8/2016

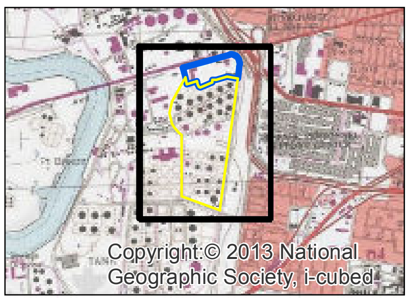
Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS
PHILADELPHIA REFINERY COMPLEX
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Figure No.
2

Title
AREA OF INTEREST (AOI) 1 SITE PLAN



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


Copyright:© 2013 National Geographic Society, i-cubed

Legend

MONITORING WELL WITH SUBMERGED SCREEN
HYDROSTRATIGRAPHIC UNIT

●	UNCONFINED AQUIFER WELL
●	UNCONFINED AQUIFER WELL WITH LNAPL PRESENT
⊕	LOWER AQUIFER WELL
⊕	LOWER AQUIFER WELL WITH OCCASIONAL SHEEN PRESENT
●	MIDDLE CLAY UNIT AQUITARD
●	MONITORING WELL LOCATION (UNSUBMERGED SCREEN)
☐	AREA OF INTEREST (AOI) 1
☐	BELMONT TERMINAL

0 150 300 Feet
1:3,500 (at original document size of 11X17)

N

Notes
1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: Stantec

Figure No.
3

Title
SUBMERGED SCREEN WELL LOCATION MAP

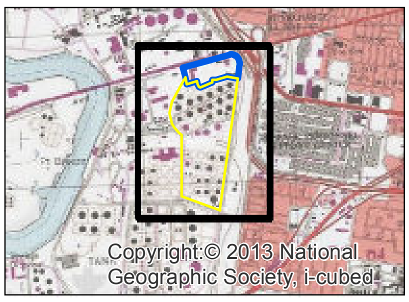
Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

213402434
Prepared by AAH on 2015-12-07
Technical Review by PRB on 2015-12-07
Independent Review by ADK on 2016-08-02

V:\2134\active\213402434\03_data\hydrogeology\nested_wells\mxds pdfs\LCSM\Figure 4A (LNAPL Extent and Benzene distribution in 1995)[2016-08-02]11x17.mxd   Revised: 2016-08-02 By: aklingbeil

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Copyright:© 2013 National Geographic Society, i-cubed

Legend

Unconfined Aquifer Wells Sampled or Guaged in 1995

- ⊞ LNAPL not present / benzene not sampled for
- ◕ LNAPL not present / benzene < 392
- ● LNAPL not present / benzene 392 - 17,500
- ● LNAPL not present / benzene > 17,500
- ⊙ LNAPL Sheen Present
- ◑ LNAPL Present

- ◕ Monitoring Well Location
- — Area of Interest 1 (AOI 1)
- — Belmont Terminal

0 150 300 Feet

1:3,500 (at original document size of 11X17)

N

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: Stantec

Figure No.
4A

Title
LNAPL EXTENT AND BENZENE DISTRIBUTION IN 1995

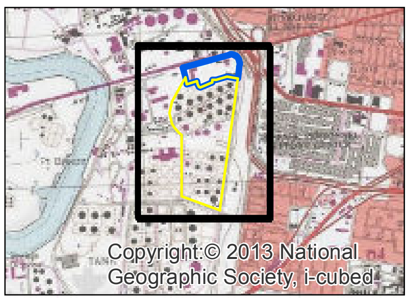
Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

2132402434
Prepared by AAH on 2015-12-07
Technical Review by PRB on 2015-12-07
Independent Review by ADK on 2015-08-02

V:\2134\active\213402434\03_data\hydrogeology\nested_wells\mxds pdfs\LCSM\Figure 4B (LNAPL Extent and Benzene distribution in 2000)(2016-08-02)11x17.mxd Revised: 2016-08-02 By: aklingbeil

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



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Legend

Unconfined Aquifer Wells Sampled or Guaged in 2000

- ▨ LNAPL not present / benzene not sampled for
- ◒ LNAPL not present / benzene < 392
- 🟢 LNAPL not present / benzene 392 - 17,500
- 🟣 LNAPL not present / benzene > 17,500
- ◉ LNAPL Sheen Present
- ◑ LNAPL Present

- ◒ Monitoring Well Location
- — Area of Interest 1 (AOI 1)
- — Belmont Terminal

1:3,500 (at original document size of 11X17)

Figure No.
4B

Title

LNAPL EXTENT AND BENZENE DISTRIBUTION IN 2000

Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

2132402434
Prepared by AAH on 2015-12-07
Technical Review by PRB on 2015-12-07
Independent Review by ADK on 2015-08-02

Notes

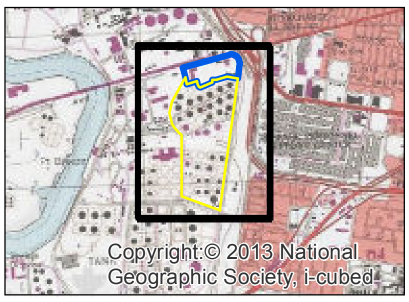
1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: Stantec

Stantec

EVERGREEN

V:\2134\active\213402434\03_data\hydrogeology\nested_wells\mxds pdfs\LCSM\Figure 4C (LNAPL Extent and Benzene distribution in 2005)(2016-08-02)11x17.mxd   Revised: 2016-08-02 By: aklingbeil

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Legend

Unconfined Aquifer Wells Sampled or Guaged in 2005

- ▣ LNAPL not present / benzene not sampled for
- ◐ LNAPL not present / benzene < 392
- 🟢 LNAPL not present / benzene 392 - 17,500
- 🟣 LNAPL not present / benzene > 17,500
- ⊙ LNAPL Sheen Present
- ◑ LNAPL Present

- ◐ Monitoring Well Location
- ― Area of Interest 1 (AOI 1)
- ― Belmont Terminal

0 150 300
Feet
1:3,500 (at original document size of 11X17)
N

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: Stantec

Figure No.
4C

Title
LNAPL EXTENT AND BENZENE DISTRIBUTION IN 2005

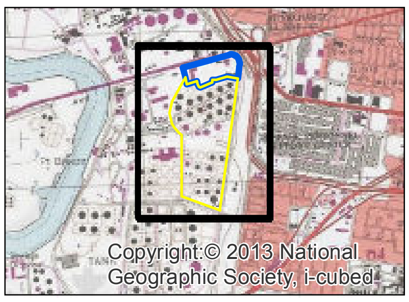
Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

2132402434
Prepared by AAH on 2015-12-07
Technical Review by PRB on 2015-12-07
Independent Review by ADK on 2015-08-02

Stantec
EVERGREEN

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Legend

Unconfined Aquifer Wells Sampled or Guaged in 2010

- ▣ LNAPL not present / benzene not sampled for
- ◕ LNAPL not present / benzene < 392
- ● LNAPL not present / benzene 392 - 17,500
- ● LNAPL not present / benzene > 17,500
- ◉ LNAPL Sheen Present
- ◐ LNAPL Present

- ◕ Monitoring Well Location
- Area of Interest 1 (AOI 1)
- Belmont Terminal

0 150 300
Feet
1:3,500 (at original document size of 11X17)

N

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: Stantec

Figure No.
4D

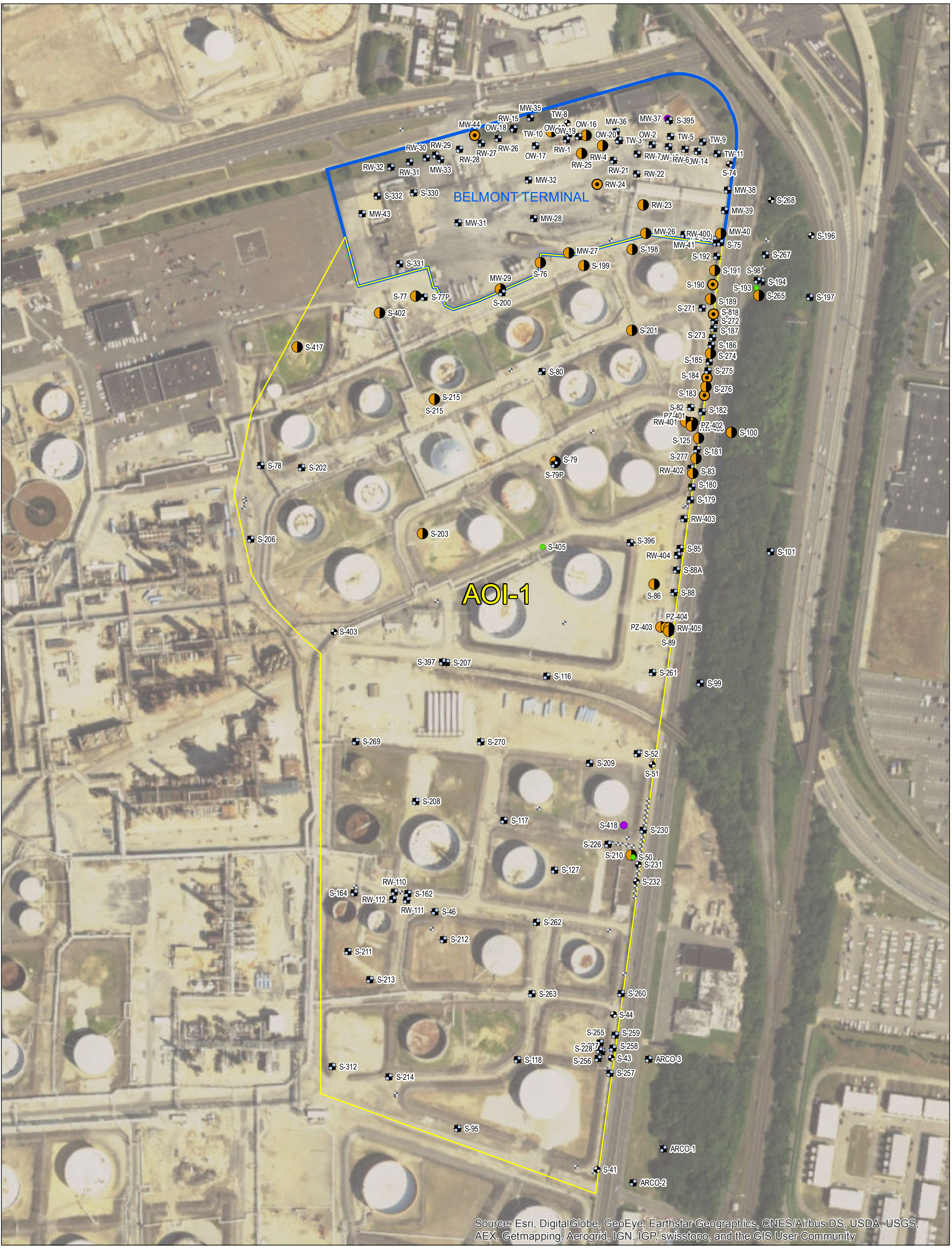
Title
LNAPL EXTENT AND BENZENE DISTRIBUTION IN 2010

Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

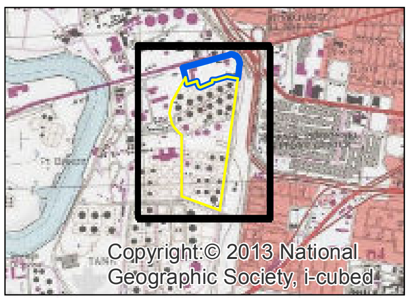
Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

2132402434
Prepared by AAH on 2015-12-07
Technical Review by PRB on 2015-12-07
Independent Review by ADK on 2015-08-02

V:\2134\active\213402434\03_data\hydrogeology\nested_wells\mxds pdfs\LCSM\Figure 4E (Maximum LNAPL Thickness and Benzene distribution in 2015)(2016-08-02)11x17.mxd   Revised: 2016-08-02 By: aklingbeil



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community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Legend

Unconfined Aquifer Wells Sampled or Guaged in 2015

⊞	LNAPL not present / benzene not sampled for
◕	LNAPL not present / benzene < 392
●	LNAPL not present / benzene 392 - 17,500
●	LNAPL not present / benzene > 17,500
⊙	LNAPL Sheen Present
◐	LNAPL Present
◕	Monitoring Well Location
🟨	Area of Interest 1 (AOI 1)
🟦	Belmont Terminal

0 150 300 Feet

1:3,500 (at original document size of 11X17)

N

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: Stantec

Figure No.
4E

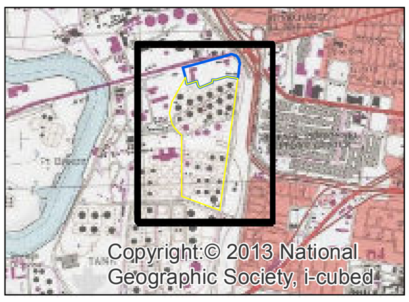
Title

LNAPL EXTENT AND BENZENE DISTRIBUTION IN 2015

Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

2132402434
Prepared by AAH on 2015-12-07
Technical Review by PRB on 2015-12-07
Independent Review by ADK on 2015-08-02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Legend

●	MONITORING WELL (SUBMERGED SCREEN)
●	MONITORING WELL (LNAPL OBSERVED)
○	MONITORING WELL (LNAPL NOT OBSERVED)
🟨	AREA OF INTEREST (AOI) 1
🟦	BELMONT TERMINAL

0 150 300
Feet
1:3,600 (at original document size of 11X17)
N

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: Stantec
3. Well labels denote apparent LNAPL thickness as measured in feet using an interface probe.

Figure No.
5

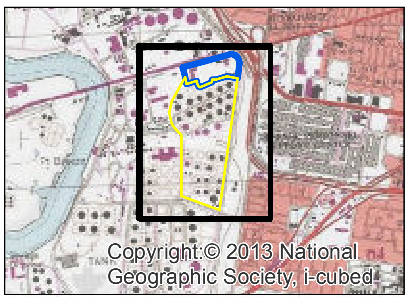
Title
MAY 2015 APPARENT LNAPL THICKNESS

Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

213402434
Prepared by AAH on 12/7/2015
Technical Review by PRB on 12/7/2015
Independent Review by ADK on 3/8/2016

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



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Legend

MONITORING WELL
HYDROSTRATIGRAPHIC UNIT
- ● UNCONFINED AQUIFER WELL
- ▣ UNCONFINED AQUIFER WELL (SUBMERGED SCREEN)
- ◐ MONITORING WELL LOCATION

- ▭ AREA OF INTEREST (AOI) 1
- ▭ BELMONT TERMINAL

0 150 300
Feet
1:3,500 (at original document size of 11X17)
N

Figure No.
6

Title
MAXIMUM OBSERVED APPARENT LNAPL THICKNESS (PERIOD OF RECORD)

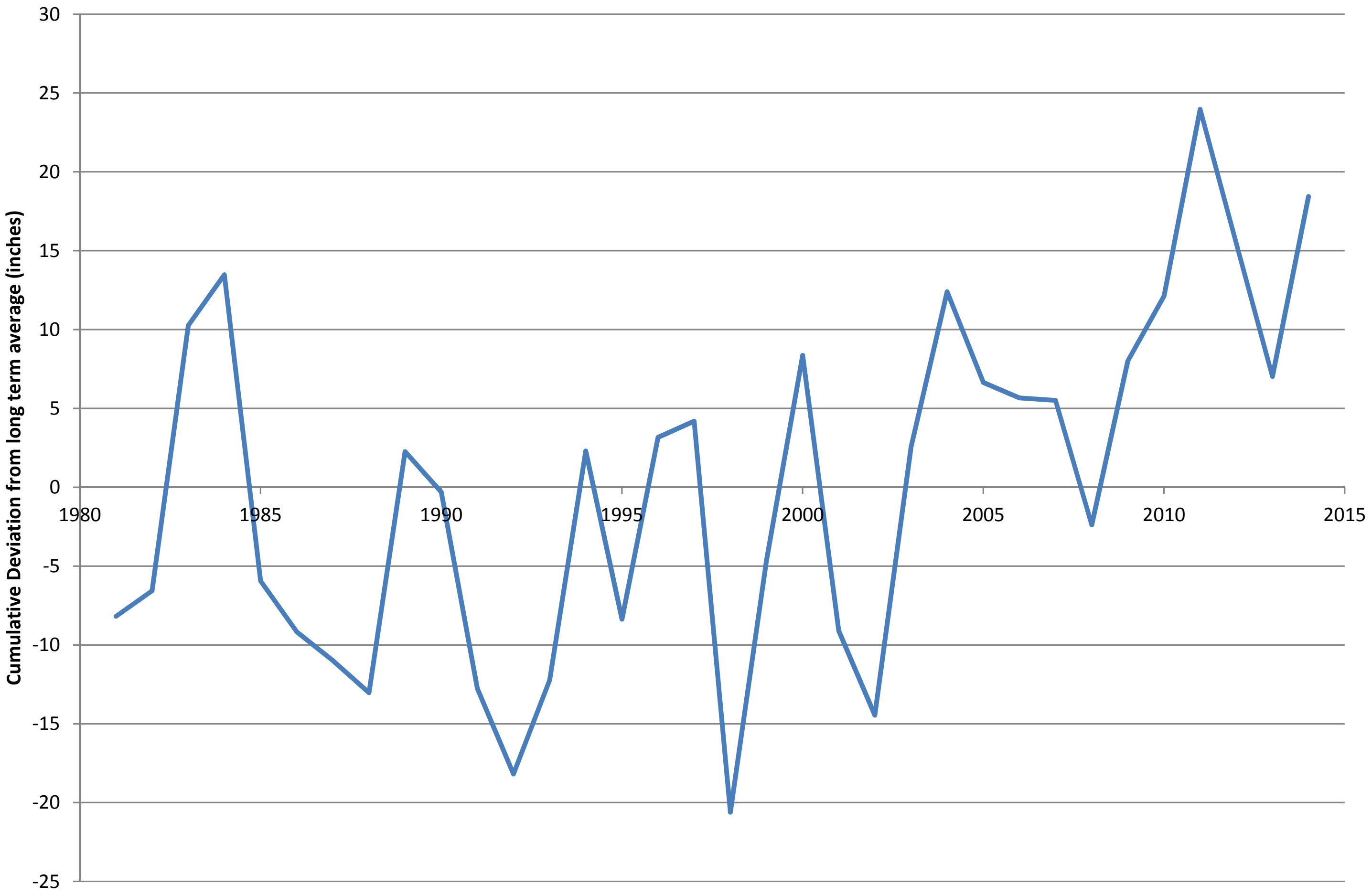
Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

213402434
Prepared by AAH on 2015-12-07
Technical Review by PRB on 2015-12-07
Independent Review by ADK on 2015-08-02

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: Stantec



Client/Project

Philadelphia Refinery Complex
LNAPL Site Conceptual Model (LCSM)

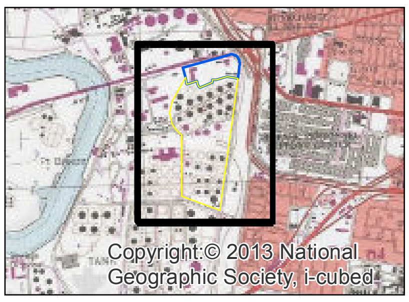
Figure/Well No.

7

Title

Precipitation Cumulative Deviation from Long Term Average

Weather data from the NOAA Station at Philadelphia International Airport, Pennsylvania.



Legend

GENERALIZED LNAPL

⊙	LIGHT DISTILLATE
△	LIGHT/MIDDLE DISTILLATE
▣	MIDDLE DISTILLATE
⬟	HEAVY DISTILLATE
◆	NA
▭	AREA OF INTEREST (AOI) 1
▭	BELMONT TERMINAL

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: See Table 3 for additional detail.

0 150 300
Feet
1:3,600 (at original document size of 11X17)

N

Figure No.
8A

Title
SUMMARY OF AVAILABLE LNAPL SAMPLE DATA – AOI 1 AND BELMONT TERMINAL

Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

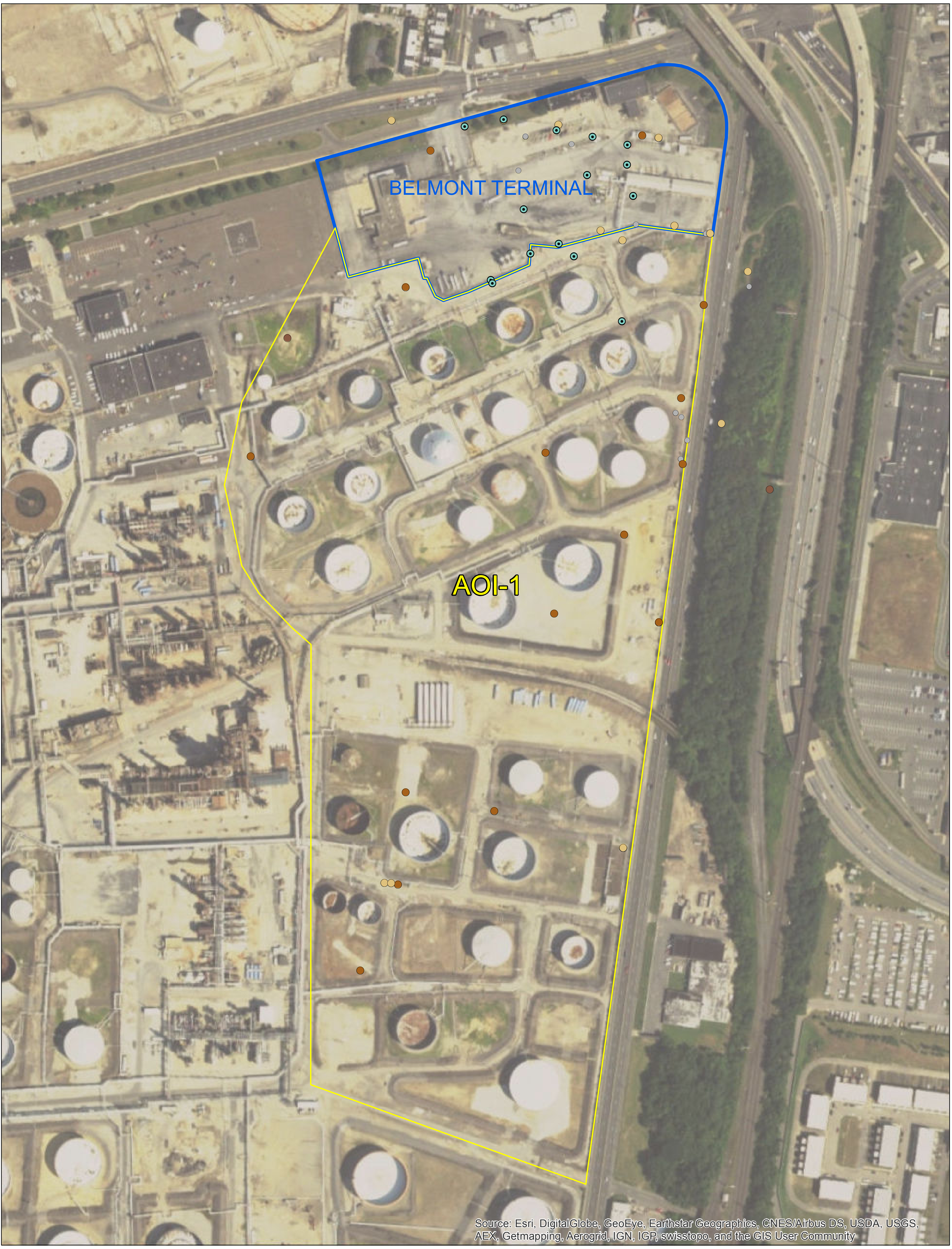
Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

213402434
Prepared by AAH on 8/12/2015
Technical Review by PRB on 8/12/2015
Independent Review by ADK on 3/8/2016

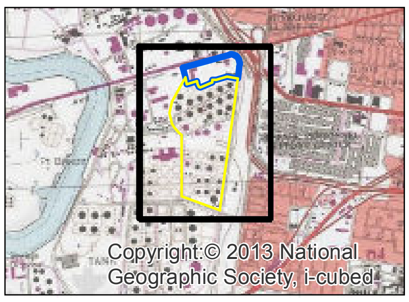
Stantec

EVERGREEN

V:\2134\active\213402434\03_data\hydrogeology\nested_wells\mxds pdfs\LCSM\Figure 8b (Weathering)(2016-02-23)11x17.mxd   Revised: 2016-08-02 By: aklingbeil



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



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Legend

Laboratory Interpreted Degree of LNAPL Sample Weathering

- ◉ Unweathered; Slight
- ● Mild; Moderate
- ● Moderate-High; Heavy; High; Estimated Severe; Extreme; Severe
- ● NA; Undertermined: Unknown
- ▭ AREA OF INTEREST (AOI) 1
- ▭ BELMONT TERMINAL

0 150 300 Feet

1:3,500 (at original document size of 11X17)

N

Figure No.
8B

Title

SUMMARY OF LNAPL SAMPLE WEATHERING DATA – AOI 1 AND BELMONT TERMINAL

Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

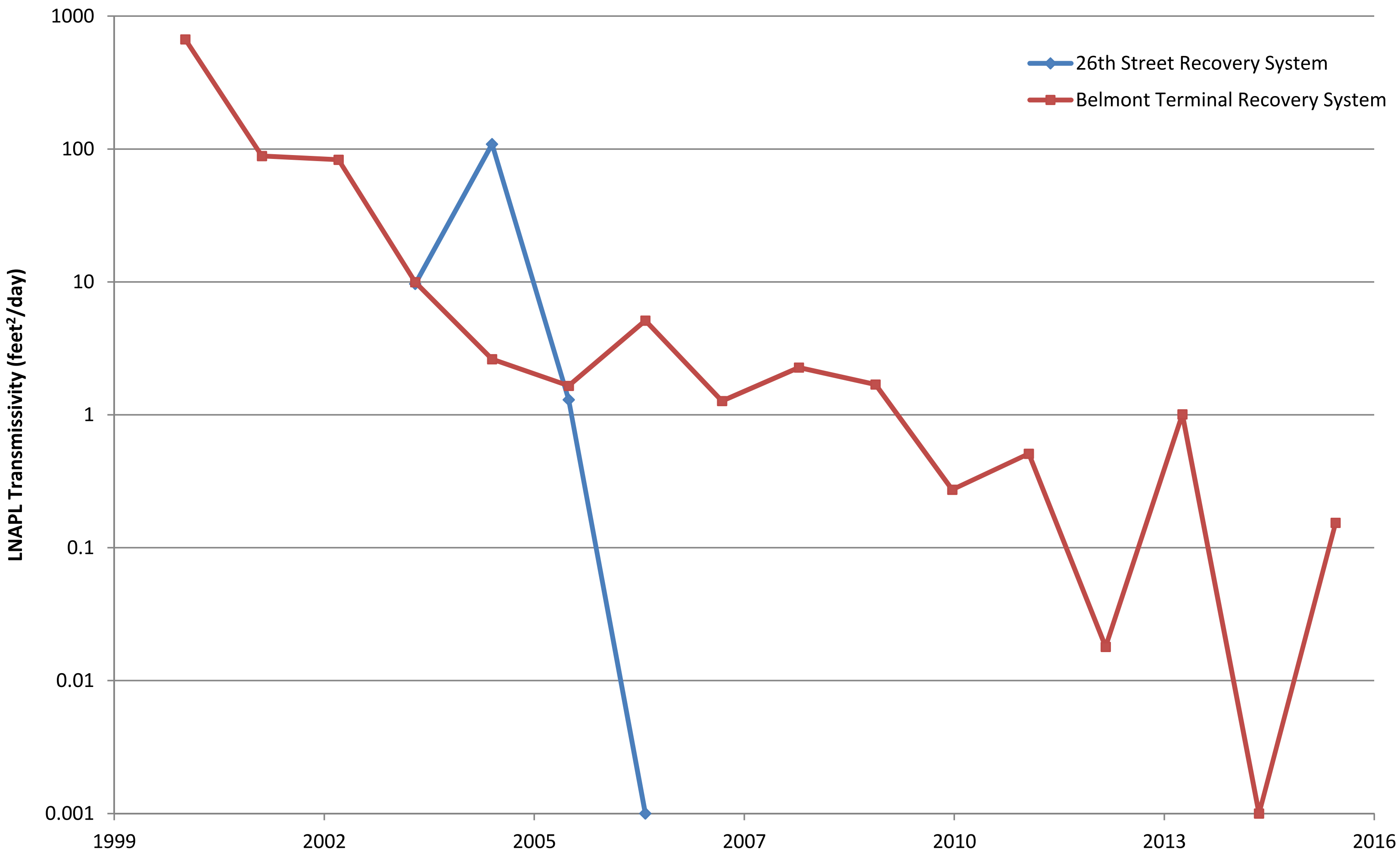
213402434
Prepared by PRB on 2016-02-23
Technical Review by JT on 2016-02-23
Independent Review by ADK on 2016-08-02

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: See Table 3 for additional detail.
3. Degree of LNAPL weathering provided by the analytical laboratory at the time of sample analysis.

Stantec

EVERGREEN



Client/Project

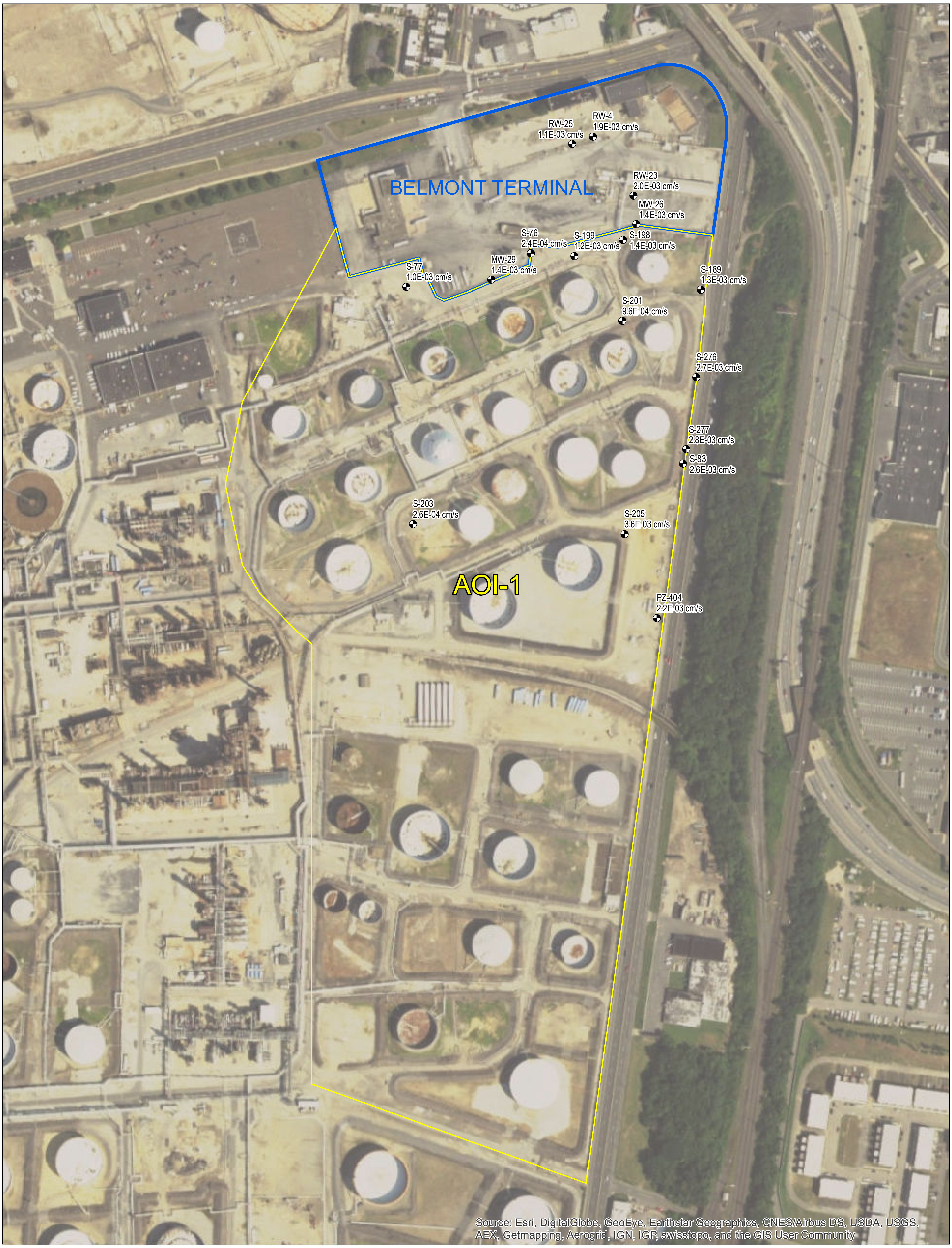
Philadelphia Refinery Complex
LNAPL Site Conceptual Model (LCSM)

Figure/Well No.

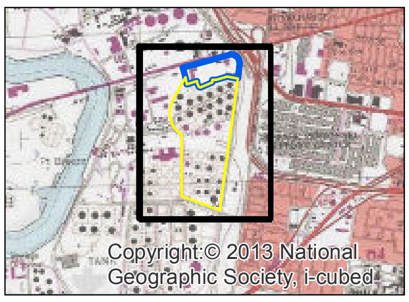
9

Title

LNAPL Transmissivity Vs. Time



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Copyright:© 2013 National Geographic Society, i-cubed

Legend

Monitoring Well

● (contained > 0.5 ft LNAPL in May 2015)

🟨 AREA OF INTEREST (AOI) 1

🟦 BELMONT TERMINAL

0 150 300
Feet
1:3,500 (at original document size of 11X17)

N

Figure No.
10

Title

LNAPL PLUME VELOCITY ESTIMATES

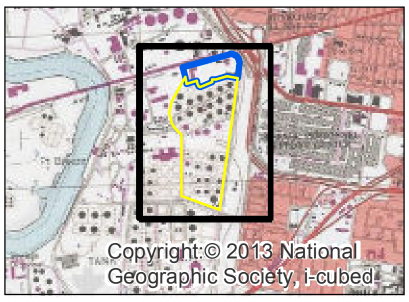
Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

213402434
Prepared by AAH on 2015-12-08
Technical Review by PRB on 2015-12-08
Independent Review by ADK on 2016-08-02

Notes
1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: Stantec
3. LNAPL mobility modeling was completed for 18 wells that had apparent LNAPL thicknesses greater than 0.5 feet in the first half of 2015. Plume velocities were calculated using in the API Interactive LNAPL guide (2004, API).
4. Monitoring well labels denote estimated LNAPL plume velocity in centimeters per second.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Legend

Monitoring Well

●	(contained > 0.5 ft LNAPL in May 2015)
🟨	AREA OF INTEREST (AOI) 1
🟦	BELMONT TERMINAL

0 150 300 Feet

1:3,500 (at original document size of 11X17)

N

Figure No.
11

Title

LDRM ESTIMATED LNAPL TRANSMISSIVITY

Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Project Location
CITY OF PHILADELPHIA,
PENNSYLVANIA

213402434
Prepared by AAH on 2015-12-08
Technical Review by PRB on 2015-12-08
Independent Review by ADK on 2016-08-02

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Sources: See Table 8 for additional details.
3. Monitoring well labels denote LNAPL Transmissivity in square feet per day (ft^2/day) as estimated using hydraulic conductivity values derived from API default values for the soil type present near each well screen interval.
4. The API LDRM was used to estimate LNAPL Transmissivity (Tn) for the 18 wells that had apparent LNAPL thicknesses greater than 0.5 feet in the first half of 2015.

TABLES

Light Non-aqueous Phase Liquid (LNAPL) Site Conceptual Model (LCSM)
Area of Interest 1

PHILADELPHIA REFINERY COMPLEX
PHILADELPHIA, PENNSYLVANIA
PHILADELPHIA REFINERY OPERATIONS,
A SERIES OF EVERGREEN RESOURCES GROUP, LLC
3144 PASSYUNK AVENUE, PHILADELPHIA, PENNSYLVANIA

Table 1

Summary of Aquifer Properties

			Aquifer Parameters				
			T	K	i		
Area	**Well**	**Test Method**	**ft2/d**	**ft/d**	**ft/ft**	**Notes**	**Reference**
26th	RW406	Pumping Test	339.5	27.12		Pumping Well	(Secor, 2003)
26th	RW401	Pumping Test	474	37.86		Observation Well	(Secor, 2003)
26th	PZ401	Pumping Test	290.5	23.205		Observation Well	(Secor, 2003)
26th	PZ402	Pumping Test	229	18.29		Observation Well	(Secor, 2003)
26th	S-125	Pumping Test	392	31.31		Observation Well	(Secor, 2003)
26th	S43	Slug Test		0.78			(Secor, 2003)
26th	S86	Slug Test		0.3			(Secor, 2003)
26th	S116	Slug Test		2.11			(Secor, 2003)
26th	S127	Slug Test		0.29			(Secor, 2003)
26th	RW406	Slug Test		7.22			(Secor, 2003)
26th	S-193	Slug Test		0.12			(Secor, 2004)
26th	S-194	Slug Test		0.009			(Secor, 2004)
26th	S-195	Slug Test		27.1			(Secor, 2004)
Belmont	RW6	Pumping Test	1.61	0.1		Pumping Well	(Mulry and Cresswell, 1998a)
Belmont	OW17	Pumping Test	1.5	0.05		Pumping Well	(Mulry and Cresswell, 1998a)
Belmont	TW9	Pumping Test	4	0.133		Observation Well	(Mulry and Cresswell, 1998a)
Belmont	OW12	Pumping Test	1.49	0.0499		Observation Well	(Mulry and Cresswell, 1998a)
Belmont	OW13	Pumping Test	1.61	0.0539		Observation Well	(Mulry and Cresswell, 1998a)
Belmont	RW15	Pumping Test	1.32	0.044		Observation Well	(Mulry and Cresswell, 1998a)
Belmont					0.03 - 0.04		(Sunoco, 2000)
AOI 1		Geometric Mean of Historic Tests		24	0.0035	Representative of Trenton Gravel	(Sunoco, 2007)

Notes

26th: 26th Street Area

Belmont: Belmont Terminal Area

T: Transmissivity

K: Hydraulic conductivity of water

i: Horizontal hydraulic gradient

ft2/day: square feet per day

ft/day: feet per day

Table 2

Summary of Wells with Submerged Screens

Well ID	Apparent LNAPL Thickness Observed	Hydrostratigraphic Unit
ARCO-1D		lower aquifer
RW-402	Yes	unconfined
RW-404	Yes	unconfined
RW-405	Yes	unconfined
S-211		unconfined
S-213	Yes	unconfined
S-226	Yes	unconfined
S-264D		lower aquifer
S-265*	Yes	unconfined
S-267*		unconfined
S-312		unconfined
S-388D		lower aquifer
S-389D		lower aquifer
S-390D		lower aquifer
S-391D		lower aquifer
S-392D		lower aquifer
S-393D*		lower aquifer
S-394*		lower aquifer
S-395*		unconfined
S-396		unconfined
S-397		unconfined
S-398		middle clay unit aquitard
S-399		lower aquifer
S-400		lower aquifer
S-401		middle clay unit aquitard
S-418		unconfined
S-42I		lower aquifer
S-46		unconfined
S-46D		lower aquifer
S-47I		middle clay unit aquitard
S-52		unconfined
S-82	Yes	unconfined
S-84	Yes	unconfined
S-86	Yes	unconfined
S-87I	Yes	lower aquifer

Notes

* Offsite Well - Belmont Terminal or CSX Property

Yes: Measurable apparent thickness of LNAPL has been observed in this well

Table 3a
Summary of Available LNAPL Sample Data -
AOI 1 and Belmont Terminal

Generalized LNAPL Type[1]	Well ID	LNAPL Sample Date	Analytical Laboratory Data				Analytical Laboratory
			LNAPL Type	Component Proportions (%)	Degree of Weathering	Specific Gravity (gm/ml)	
Light Distillates	RW-1	5/9/2000	Gasoline	NA	Unweathered	0.7616	TGI
	RW-15	5/9/2000	Gasoline	NA	Unweathered	0.7747	TGI
	RW-4	5/9/2000	Gasoline	NA	Unweathered	0.7593	TGI
		4/25/2011	NA	NA	NA	0.7800	TGI
	RW-7	5/9/2000	Gasoline	NA	Unweathered	0.7600	TGI
	OW-18	4/26/2005	Gasoline	90	Moderate-High	0.8241	TGI
			Middle Distillate	10	Moderate		
	OW-2	4/26/2005	Gasoline	90	High	0.8084	TGI
			Middle Distillate	10	High		
	RW-22 (formerly MW-22)	1/8/2001	NA	NA	NA	0.7567	Sunoco
		4/26/2005	Premium Gasoline	95	Slight	QNS	TGI
			Middle Distillate	5	Extreme		
	RW-23 (formerly MW-23)	1/8/2001	NA	NA	NA	0.7571	Sunoco
		4/26/2005	Premium Gasoline	95	Slight	0.7590	TGI
			Middle Distillate	5	High		
	RW-24 (formerly MW-24)	1/8/2001	NA	NA	NA	0.7770	Sunoco
		4/26/2005	Premium Gasoline	95	Slight	0.7667	TGI
			Middle Distillate	5	Extreme		
	S-81	2/27/2004	Gasoline	90	High	0.7948	TGI
			Middle Distillate	10	Extreme		
	RW-110 (formerly S-160)	4/20/2005	Heavy Virgin Naphtha	98	Moderate	0.7436	TGI
			Estimated as Middle Distillate	2	Severe		
	S-161	4/20/2005	Heavy Virgin Naphtha	98	Moderate	QNS	TGI
			Estimated as Middle Distillate	2	Severe		
	S-162	2/27/2004	Heavy Virgin Naphtha	98	Severe	0.7498	TGI
			Estimated as Crude	2	Severe		
	S-50	9/27/2002	Naphtha/Reformed Light Naphtha	100	Mild	NA	ICF
		2/27/2004	Heavy Virgin Naphtha	98	Moderate	0.7508	TGI
			Middle Distillate	2	Severe		
	S-77	4/20/2005	Estimated as Heavy Virgin Naphtha	95	High	0.7677	TGI
			Middle Distillate	5	Severe		
		4/25/2011	NA	NA	NA	0.7600	Lancaster
	S-417	2/11/2016	Gasoline	NA (primary)	Severe	0.8370	Pace
			Diesel	NA (slight)	Severe		
Mixture of Light and Middle Distillates	CSX-MW5	2/27/2002	Gasoline	NA	Heavy	NA	ICF
			Diesel	NA	Heavy		
	MW-26	1/8/2001	NA	NA	NA	0.7835	Sunoco
	MW-27	1/8/2001	NA	NA	NA	0.7831	Sunoco
		4/27/2005	Middle Distillate	55	Slight	0.7979	TGI
			Gasoline	45	Slight		
		4/25/2011	NA	NA	NA	0.8000	Lancaster
	MW-28	1/8/2001	NA	NA	NA	0.7839	Sunoco
		4/27/2005	Gasoline	65	Moderate	0.7918	TGI
			Middle Distillate	35	Slight		
	MW-29	1/8/2001	NA	NA	NA	0.7896	Sunoco
		4/27/2005	Gasoline and Heavy Virgin Naphtha	50	Slight	0.7945	TGI
			Middle Distillate	50	Slight		
		4/25/2011	NA	NA	NA	0.8000	Lancaster
	MW-32	1/8/2001	NA	NA	NA	0.7805	TGI
	MW-34	4/26/2005	Gasoline	75	Moderate	QNS	TGI
			Middle Distillate	25	Moderate		
	MW-41	4/27/2005	Middle Distillate	65	Extreme	0.8154	TGI
			Gasoline	35	Moderate		
	MW-42	4/27/2005	Middle Distillate	50	Severe	QNS	TGI
			Gasoline	45	Moderate		
			Polynuclear Aromatics	5	NA		
	MW-44	4/26/2005	Gasoline	70	Slight	0.7802	TGI
			Middle Distillate	30	Moderate		
	OW-12	4/26/2005	Gasoline	75	Moderate	0.8050	TGI
			Middle Distillate	25	High		
	OW-13	4/27/2005	Gasoline	65	Moderate	QNS	TGI
			Middle Distillate	35	Moderate-High		
	PZ-400	9/27/2002	Gasoline	50	NA	NA	ICF
			Diesel	50	NA		
	RW-25 (formerly MW-25)	1/8/2001	NA	NA	NA	0.7813	Sunoco
	RW-401	9/27/2002	Gasoline	50	NA	NA	ICF
			Diesel	50	NA		
	RW-402	9/27/2002	Diesel	50	NA	NA	ICF
			Gasoline	50	NA		
	RW-406	10/14/2013	NA	NA	NA	0.8044	Sunoco
	S-100	9/27/2002	Gasoline	50	NA	NA	ICF
			Diesel	50	NA		
		3/1/2004	Gasoline	50	Moderate	0.7930	TGI
			Middle Distillate	50	Moderate		
	S-117	2/27/2004	Kerosene (Jet Fuel)	80	Extreme	0.8236	TGI
			Gasoline	20	Extreme		

Table 3a
Summary of Available LNAPL Sample Data - AOI 1 and Belmont Terminal

Generalized LNAPL Type[1]	Well ID	LNAPL Sample Date	Analytical Laboratory Data				Analytical Laboratory
			LNAPL Type	Component Proportions (%)	Degree of Weathering	Specific Gravity (gm/ml)	
Mixture of Light and Middle Distillates	S-181	10/14/2013	NA	NA	NA	0.7945	Sunoco
	S-198	4/20/2005	Gasoline	70	Moderate	QNS	TGI
			Middle Distillate	30	Moderate		
	S-199	4/20/2005	Gasoline	55	Slight	0.7923	TGI
			Middle Distillate	45	Slight		
	S-200	4/20/2005	Gasoline	60	Slight	0.8143	TGI
			Middle Distillate	40	Moderate		
	S-201	4/20/2005	Middle Distillate	60	Slight	0.8030	TGI
			Gasoline	40	Slight		
	S-205	4/20/2005	Gasoline	70	High	QNS	TGI
			Middle Distillate	30	Extreme		
	S-213	4/20/2005	Middle Distillate	60	Extreme	QNS	TGI
			Gasoline	40	Severe		
	S-265	3/9/2010	NA	NA	NA	0.7877	TGI
	S-75	5/9/2000	Distillate	NA	Heavy	0.8000	TGI
			Gasoline	NA	Moderate to Severe		
	S-83	4/20/2005	Gasoline	50	Moderate-High	0.8066	TGI
			Middle Distillate	50	Severe		
	S-89	9/27/2002	Diesel	NA	Heavy	NA	ICF
			Gasoline	NA	Heavy		
		2/27/2004	Middle Distillate	70	Extreme	0.8523	TGI
			Gasoline	25	Extreme		
			Lube Oil	5	Extreme		
	S-98	9/27/2002	Diesel	NA	NA	NA	ICF
			Gasoline	NA	Weathered		
Middle Distillates	S-76	5/9/2000	Distillate	NA	Moderate	0.7916	TGI
			Gasoline	NA	Unweathered		
		3/1/2004	Coker Naphtha	60	Severe	0.7851	TGI
			Middle Distillate	40	High		
	S-82	2/27/2004	Coker Naphtha	50	High	QNS	TGI
			Middle Distillate	50	Extreme		
	MW-33	4/26/2005	Middle Distillate	80	Severe	QNS	TGI
			Unknown Light Ends	20	NA		
	S-208	4/20/2005	Middle Distillate	90	Severe	QNS	TGI
			Gasoline	10	High		
	S-78	2/27/2004	Middle Distillate	98	Extreme	QNS	TGI
			Estimated as Gasoline	2	Extreme		
	S-79	2/27/2004	Middle Distillate	98	Extreme	0.8406	TGI
			Estimated as Gasoline	2	Extreme		
	OW-17	4/26/2005	Unknown Mid Range Material	65	NA	QNS	TGI
			Stoddard Solvent	30	NA		
			Unknown Light Ends	5	NA		
Heavy Distillates	S-126	4/20/2005	Lubricating Oil	88	Severe	QNS	TGI
			Middle Distillate	10	Severe		
			Unknown Light Material	2	NA		

Notes

1. Generalized LNAPL types were assigned by Stantec in an effort to bin laboratory-interpreted product type(s) into broader classes, generally based on boiling point ranges, density and viscosity information where available.

LNAPL = Light Non-Aqueous Phase Liquid
QNS = Quantity Not Sufficient for Density Determination
NA = Not Available/Performed; Otherwise Unknown
gm/ml: grams per milliliter
g/kg: grams per kilogram
TGI: Torkelson Geochemistry, Inc.
Sunoco: Sunoco Refinery Quality Control Laboratory
Lancaster: Lancaster Laboratories (presently Eurofins Lancaster Laboratories, Inc.)
Pace: Pace Analytical Energy Solutions (formerly Zymax Forensics)

Table 3b
Summary of LNAPL Characterization Results
(Density and Viscosity)

Generalized LNAPL Type	Well ID	Dynamic Viscosity of SPL		Density
		(N s/m^2)	(cP)	(g/ml)
Light Distillates	OW-18	6.4E-04	0.64	0.82
	OW-2	6.3E-04	0.63	0.81
	RW-22	6.7E-04	0.67	0.87
	RW-23	5.9E-04	0.59	0.76
	RW-24	5.9E-04	0.59	0.77
	S-81	6.2E-04	0.62	0.79
	S-160	7.1E-04	0.71	0.74
	S-161	7.2E-04	0.72	0.75
	S-162	7.2E-04	0.72	0.75
	S-50	7.2E-04	0.72	0.75
	S-77	7.4E-04	0.74	0.77
Average		**6.7E-04**	**0.67**	**0.78**
Light/Middle Distillates	MW-27	8.4E-04	0.84	0.80
	MW-28	8.3E-04	0.83	0.79
	MW-29	8.3E-04	0.83	0.79
	MW-34	8.2E-04	0.82	0.78
	MW-41	8.6E-04	0.86	0.82
	MW-42	8.3E-04	0.83	0.79
	MW-44	8.2E-04	0.82	0.78
	OW-12	8.5E-04	0.85	0.81
	OW-13	9.1E-04	0.91	0.87
	S-100	8.3E-04	0.83	0.79
	S-198	8.3E-04	0.83	0.79
	S-199	8.3E-04	0.83	0.79
	S-200	8.6E-04	0.86	0.81
	S-201	8.4E-04	0.84	0.80
	S-205	8.5E-04	0.85	0.81
	S-213	8.5E-04	0.85	0.81
	S-83	8.5E-04	0.85	0.81
	S-89	9.0E-04	0.90	0.85
Average		**8.5E-04**	**0.85**	**0.80**
Middle Distillates	S-76	3.5E-03	3.5	0.79
	S-82	3.8E-03	3.8	0.84
	MW-33	3.6E-03	3.6	0.80
	S-208	3.8E-03	3.8	0.84
	S-78	3.8E-03	3.8	0.84
	S-79	3.8E-03	3.8	0.84
	OW-17	3.9E-03	3.9	0.87
Average		**3.7E-03**	**3.72**	**0.83**
Residuum	S-126	5.8E-03	5.8	0.90
Average		**5.8E-03**	**5.8**	**0.90**

Notes:

N s/m^2: Newton Seconds per square meter

cP: Centipois

g/ml: Grams per milliliter

Table 3c

Summary of Tension Parameters for Generalized LNAPL Types

Generalized LNAPL Type	Generalized LNAPL Sub-Type	Air/Water Surface Tension (dynes/cm)	Air/LNAPL Surface Tension (dynes/cm)	LNAPL/Water Surface Tension (dynes/cm)	Source
Light Distillates	Gasoline	62.51	24.21	17.21	Sunoco, 2007 / API Database
Light/Middle Distillates	Gasoline/Middle Distillate	65.7	23.3	14.4	Sunoco, 2007 / PTS Geolab Data, 2005
Middle Distillates	Middle Distillate	57.7	28.6	16.6	Sunoco, 2007 / PTS Geolab Data, 2005
Residuum	Lube Oil	65	31.6	27.1	Sunoco, 2007 / Env. Canada Database

Notes

cm: centimeter

Table 4
LNAPL Transmissivity Estimates
LNAPL Baildown Tests

	Test Summary							LNAPL Transmissivity Estimates (T_n)					
		b_n Static	Q_n	b_n Initial	Test Duration	b_n Final	b_n Recovery	B&R	C&J	CB&P	Average		
Well	Date	ft	gallons	ft	minutes	ft	%	ft^2/day	ft^2/day	ft^2/day	ft^2/day	Notes	Source
71	8/17/1987	3.9		0.95	50	1.6	22%	--	--	--	--		EEI, 1987
74	8/17/1987	2.05		0.3	50	1.3	57%	--	--	--	--	Reportedly recovered to original value within 90 minutes	EEI, 1987
75	8/17/1987	1.4		0	54	0.75	54%	--	--	--	--		EEI, 1987
TW3	11/17/1997	0.31		0.01	270	0.06	17%	--	--	--	<0.1	Insufficient duration	Mulry, 1998
RW6	11/18/1997	0.73		0.02	240	0.49	66%					May be perched	Mulry, 1998
OW12	11/19/1997	0.57		0.09	60	0.16	15%	--	--	--	--	Insufficient duration	Mulry, 1998
S-50	2002	1.03	0.75	0.2	50	0.43	28%	0.9	1.3	--	1.1		Secor, 2003
S-98	2002	0.57	3	0.06	45	0.62	110%	11.5	39.8	25.2	25.5		Secor, 2003
S-100	2002	0.61	2	0.14	209	0.26	26%	196.6	43.0	34.4	91.3	Stable b_n within 12 minutes.	Secor, 2003
CSX-MW-5	2002	0.63	0.13	0.14	41	0.31	35%	1.6	7.1	4.9	4.6		Secor, 2003

Notes

b_n: LNAPL Thickness

Q_n: LNAPL Volume Removed

ft: feet

ft^2/day: Square feet per day

NA: Not available

T_n: LNAPL Transmissivity

--: Unable to estimate T_n

LNAPL Transmissivity Evaluation Methods:

- B&R: Bouwer and Rice (1976)
- C&J: Cooper and Jacob (1946)
- CB&P: Cooper, Bredehoeft and Papadopulos (1967)

Table 5a
LNAPL Transmissivity Estimates
Water Enhanced LNAPL Recovery
System Operation Reports
(Belmont Terminal Recovery Sytem)

Year	Q_w	Q_n	T_w[1]	ρ_n[2]	T_n
	gallons	gallons	ft^2/day	unitless	ft^2/day
1999					
2000	665,571	86,902	6,750	0.76	669.8
2001	3,123,001	53,932	6,750	0.76	88.6
2002	1,982,479	32,109	6,750	0.76	83.1
2003	6,278,545	12,188	6,750	0.76	10.0
2004	10,018,745	5,130	6,750	0.76	2.6
2005	7,385,068	2,381	6,750	0.76	1.7
2006	5,364,308	5,350	6,750	0.76	5.1
2007	3,027,036	750	6,750	0.76	1.3
2008	4,685,153	2,073	6,750	0.76	2.3
2009	8,482,885	2,800	6,750	0.76	1.7
2010	10,024,826	535	6,750	0.76	0.3
2011	7,748,817	769	6,750	0.76	0.5
2012	6,994,896	25	6,750	0.76	0.0
2013	2,432,577	478	6,750	0.76	1.0
2014	205,257	0	6,750	0.76	<0.001
2015	1,374,409	41	6,750	0.76	0.2

Notes

T_w Water Transmissivity

ρ_n LNAPL/Water Density Ratio

Q_n LNAPL Production

Q_w Water Production

T_n LNAPL Transmissivity

ft^2/day: square feet per day

[1]: Estimated T_w based on Greenman et al. (1961) and pumping test results from RW-2.

[2]: Source of ρ_n is average of Site specific values classified as Light End Feed Stock and Middle Distillate Gasoline (Table ##)

Table 5b
LNAPL Transmissivity Estimates
Water Enhanced LNAPL Recovery
System Operation Reports
(26th Street Recovery Sytem)

Year	Q_w	Q_n	T_w[1]	ρ_n[2]	T_n
	gallons	gallons	ft^2/day	unitless	ft^2/day
2003	1,671,090	2,990.25	6,750	0.8	9.66
2004	23,569	475.00	6,750	0.8	108.8
2005	2,314,829	556.25	6,750	0.8	1.30
2006	11,059,830	0.00	6,750	0.8	<0.001
2007	924,034	NA	6,750	0.8	
2008	5,143,833	NA	6,750	0.8	
2009	2,180,648	NA	6,750	0.8	
2010	4,914,472	NA	6,750	0.8	
2011	2,228,821	NA	6,750	0.8	
2012	340,686	NA	6,750	0.8	
2013	6,179,974	NA	6,750	0.8	
2014	4,058,850	NA	6,750	0.8	

Notes

T_w Water Transmissivity

ρ_n LNAPL/Water Density Ratio

Q_n LNAPL Production

Q_w Water Production

T_n LNAPL Transmissivity

ft^2/day: square feet per day

[1]: Estimated T_w based on Greenman et al. (1961) and pumping test results from RW-2.

[2]: Source of ρ_n is average of Site specific values classified as Middle Distillate Gasoline (Table ##)

Table 5c
LNAPL Transmissivity Estimates
Water Enhanced LNAPL Recovery
Historical Pilot Tests

Well	Alternate Well ID	Q_n	Q_w	T_w[1]	ρ_n		T_n	Start Date	End Date	Comments	Reference
		gallons	gallons	ft^2/day	unitless	source	ft^2/day				
S-84	PR-1	1,021	10,800	6,750	0.807	S-83	514.7	10/27/1987	11/2/1987	TOC Sealed to create a vacuum	(EEI, 1987)
RW-1		18,879	505,456	6,750	0.762	RW-1	192.0	9/17/1998	12/31/1998		(Mulry and Cresswell, 1998b)
RW-4		180	8,085	6,750	0.805	OW-12	121.0	9/17/1998	12/31/1998		(Mulry and Cresswell, 1998b)
RW-15		2,590	15,810	6,750	0.775	RW-15	856.7	9/17/1998	12/31/1998		(Mulry and Cresswell, 1998b)
RW-1		2,837	419,440	6,750	0.762	RW-1	34.8	1/1/2000	12/31/2000		(Handex, 2000b)
RW-4		839	11,150	6,750	0.805	OW-12	409.0	1/1/2000	3/31/2000	LNAPL may be underestimated because totalizer stopped working and not sure if GW volume is for whole year	(Handex, 2000b)
RW-6		0.2	681,190	6,750	0.808	OW-2	<0.001	1/1/2000	12/31/2000		(Handex, 2000b)
RW-7		454	420,450	6,750	0.760	RW-7	5.5	1/1/2000	12/31/2000		(Handex, 2000b)
RW-22	MW-22	417	4,337	6,750	0.757	RW-22	491.0	4/18/2001	5/4/2001	Qn is limited to LNAPL recovered through LNAPL pump	(Handex, 2001b)
RW-24	MW-24	55	6,062	6,750	0.767	RW-24	47.1	5/4/2001	5/14/2001	Daily recovery rates after NAPL was drawn down below pump intake	(Handex, 2001b)
RW-405		8	440	6,750	0.852	S-89	98.0		<1/9/2003	Flow rates are maximum and LNAPL recovery may have been limited	(Secor, 2003)
RW-406		116	9,042	6,750	0.793	S-100	68.7		<1/9/2003	Flow rates are maximum and LNAPL recovery may have been limited	(Secor, 2003)

Notes

T_w Water Transmissivity

ρ_n LNAPL/Water Density Ratio

Q_n LNAPL Production

Q_w Water Production

T_n LNAPL Transmissivity

ft^2/day: square feet per day

[1]: Estimated T_w based on Greenman et al. (1961) and pumping test results from RW-2.

Table 6
Summary of LNAPL Pore Entry Pressure Calculations

Well	Generalize LNAPL Type	σ_{nw}	σ_{an}	σ_{aw}	ρ_r	ρ_r Source	h_d	h_d Reference	b_n[crit]		b_n[2015]
		dynes/cm	dynes/cm	dynes/cm			m		m	ft	ft
RW-4	Light Distillates	17.21	24.21	62.51	0.78	Average[1]	0.069	Literature Estimate for Sand	0.12	0.40	3.98
RW-23	Light Distillates	17.21	24.21	62.51	0.76	PTS	0.069	Literature Estimate for Sand	0.11	0.37	3.51
MW-29	Light/Middle Distillates	14.4	23.3	65.7	0.79	PTS	0.069	Literature Estimate for Sand	0.10	0.34	2.18
S-198	Light/Middle Distillates	14.4	23.3	65.7	0.79	PTS	0.069	Literature Estimate for Sand	0.10	0.34	1.89
S-205	Light/Middle Distillates	14.4	23.3	65.7	0.81	PTS	0.069	Literature Estimate for Sand	0.11	0.36	1.45
S-100	Light/Middle Distillates	14.4	23.3	65.7	0.79	PTS	0.069	Literature Estimate for Sand	0.10	0.34	1.29
MW-26	Light Distillates	17.21	24.21	62.51	0.78	Average[1]	0.069	Literature Estimate for Sand	0.12	0.40	1.28
S-203	Middle Distillates	16.6	28.6	57.7	0.83	Average[1]	0.069	Literature Estimate for Sand	0.16	0.52	1.26
S-199	Light/Middle Distillates	14.4	23.3	65.7	0.79	PTS	0.069	Literature Estimate for Sand	0.10	0.34	1.12
S-189	Light Distillates	17.21	24.21	62.51	0.78	Average[1]	0.069	Literature Estimate for Sand	0.12	0.40	1.08
S-76	Middle Distillates	16.6	28.6	58	0.79	PTS	0.069	Literature Estimate for Sand	0.14	0.45	1.03
S-277	Light/Middle Distillates	14.4	23.3	65.7	0.80	Average[1]	0.069	Literature Estimate for Sand	0.11	0.35	0.84
S-77	Light Distillates	17.2	24.2	62.5	0.77	TGI	0.069	Literature Estimate for Sand	0.12	0.38	0.81
S-276	Light/Middle Distillates	14.4	23.3	65.7	0.80	Average[1]	0.069	Literature Estimate for Sand	0.11	0.35	0.78
S-201	Light/Middle Distillates	14.4	23.3	65.7	0.80	TGI	0.069	Literature Estimate for Sand	0.11	0.35	0.77
RW-25	Light Distillates	17.21	24.21	62.51	0.78	TGI	0.069	Literature Estimate for Sand	0.12	0.40	0.76
S-83	Light/Middle Distillates	14.4	23.3	65.7	0.81	TGI	0.069	Literature Estimate for Sand	0.11	0.36	0.72
PZ-404	Light/Middle Distillates	14.4	23.3	65.7	0.80	Average[1]	0.069	Literature Estimate for Sand	0.11	0.35	0.57

Notes:

$$b_n[crit] = \left(\frac{\sigma nw}{(1-\rho r)\sigma aw} + \frac{\sigma an}{\rho r\ \sigma aw}\right)\frac{hd}{\sigma aw}$$

b_n[crit] = minimum LNAPL thickness in monitoring well for LNAPL to penetrate the formation (LNAPL apparent thickness; m);

σ_{nw} = LNAPL/water interfacial tension (dynes/cm)

σ_{an} = Air/LNAPL interfacial tension (dynes/cm)

σ_{aw} = Air/water interfacial tension (dynes/cm)

ρ_r = relative LNAPL density (density of LNAPL/density of water)

h_d = displacement pressure head also known as bubbling pressure head (meters (m))

cm: centimeter

m: meter

ft: feet

Tension parameters are based on API database value for generalized product type (Sunoco, 2007)

Relative LNAPL density values are based on site specific samples collected assuming groundwater density of 1000kg/m^3

PTS: PTS Labroratory

TGI: Torkelson Geochemistry, Inc.

1: Source listed is average of Site specific values for generalized product type

Table 7
Summary of LNAPL Plume Velocity Estimates

		Soil Properties[1]							Groundwater Conditions[2]	Source Area Parameters[3]	LNAPL Properties[7]				Results[4]
Well	Soil Type Surrounding Well Screen	API Soil Type	van Genuchten Alpha	van Genuchten n	Saturated Hydraulic Conductivity	Residual Saturation of Water	Residual Saturation of LNAPL	Total Porosity	Groundwater Hydraulic Gradient	Initial Thickness of LNAPL	Density	Oil/Water Interfacial Tension	Oil/Air Interfacial Tension	Viscosity	Plume Velocity
			(1/ft)		(ft/day)					ft	gm/cm^3	dynes/cm	dynes/cm	cp	cm/sec
RW-4	Silty Sand	Silty Sand	0.5517	2.02	450	0.36	0.23	0.41	0.0035	3.98	0.78	17.21	24.21	0.67	1.8E-03
RW-23	Silty Sand	Silty Sand	0.5517	2.02	450	0.36	0.23	0.41	0.0035	3.51	0.76	17.21	24.21	0.59	1.9E-03
MW-29	Medium grained Sand	Medium Sand	0.4602	2.04	450	0.29	0.15	0.38	0.0035	2.18	0.79	14.4	23.3	0.83	1.0E-03
S-198	Coarse sand and gravel	Coarse Sand[8]	1.1795	1.62	450	0.27	0.15	0.33	0.0035	1.89	0.79	14.4	23.3	0.83	1.9E-03
S-205	Coarse sand	Coarse Sand	1.1795	1.62	450	0.27	0.15	0.33	0.01	1.45	0.81	14.4	23.3	0.85	5.5E-03
S-100	SW[5]	Coarse Sand	1.1795	1.62	450	0.27	0.15	0.33	0.01	1.29	0.79	14.4	23.3	0.83	5.1E-03
MW-26	Silt	Silty Sand	0.5517	2.02	450	0.36	0.23	0.41	0.0035	1.28	0.78	17.2	24.2	0.67	9.8E-04
S-203*	Sandy gravel	Coarse Sand[8]	1.1795	1.62	450	0.27	0.15	0.33	0.0035	1.26	0.83	16.6	28.6	3.72	4.2E-04
S-199	Sandy coarse gravel	Coarse Sand[8]	1.1795	1.62	450	0.27	0.15	0.33	0.0035	1.12	0.79	14.4	23.3	0.83	1.7E-03
S-189	Gravelly Sand	Coarse Sand[8]	1.1795	1.62	450	0.27	0.15	0.33	0.0035	1.08	0.78	17.21	24.21	0.67	2.1E-03
S-76	Silty clay with little fine sand	Fine Sand	0.6644	2.61	450	0.32	0.2	0.43	0.0035	1.03	0.79	16.6	28.6	3.52	1.0E-04
S-277	Sand with fine to coarse grave	Coarse Sand[8]	1.1795	1.62	450	0.27	0.15	0.33	0.01	0.84	0.80	14.4	23.3	0.85	4.6E-03
S-77	Fine sand trace gravel	Coarse Sand[8]	1.1795	1.62	450	0.27	0.15	0.33	0.0035	0.81	0.77	17.2	24.2	0.74	1.7E-03
S-276	Sand with fine gravel	Coarse Sand[8]	1.1795	1.62	450	0.27	0.15	0.33	0.01	0.78	0.80	14.4	23.3	0.85	4.5E-03
S-201	Coarse sandy gravel	Coarse Sand[8]	1.1795	1.62	450	0.27	0.15	0.33	0.0035	0.77	0.80	14.4	23.3	0.84	1.6E-03
RW-25	Medium to coarse sand	Coarse Sand	1.1795	1.62	450	0.27	0.15	0.33	0.0035	0.76	0.78	17.21	24.21	0.67	1.9E-03
S-83	coarse sand with gravel and tr	Coarse Sand[8]	1.1795	1.62	450	0.27	0.15	0.33	0.01	0.72	0.81	14.4	23.3	0.85	4.5E-03
PZ-404	oorly sorted sands and gravels	Coarse Sand[8]	1.1795	1.62	450	0.27	0.15	0.33	0.01	0.57	0.80	14.4	23.3	0.85	4.1E-03

Notes

ft: feet

1/ft: per foot

gm/cm^3: grams per cubic centimeter

dynes/cm: dynes per centimeter

cP: Centipoise

cm/sec: centimeters per second

* No LNAPL Characterization samples collected from this well. LNAPL density, viscosity, and tension parameter are based on results from nearest well that was sampled (S-79)

1: Soil Properties except for hydraulic conductivity are API default values for the soil type specified. Hydraulic conductivity value is estimated from pumping test results from RW-2 (IST, 1998).

2: Based on 2007 SCR (Sunoco, 2007)

3: Maximum observed LNAPL apparent thickness in first half of 2015

4: API Interactive LNAPL Guide Mobility Calculation Tool

5: Boring log not available for well S-100. 2007 SCR listed soil type as SW (Sunoco, 2007).

6: Boring log not available for well PZ-404. Referenced log for RW-405.

7: LNAPL properties based on Site specific values for viscosity and density and literature values for tension parameters

8: During LDRM modelling, use of default API soil parameter values for gravel resulted in simulated T_n values that were higher than the maximum observed at the site. Values for coarse sand were found to more closely match estimated T_n values for the Site.

Table 8

Summary of LDRM Input and Results

Well	Thickness, Elevations, Vertical Gradient			Fluid Characteristics					Soil Characteristics										Results: API LDRM					
	Max b_n[1]	Water table depth[2]	Water Vertical Gradient[3]	LNAPL density[4]	LNAPL Viscosity[4]	Air/Water surface tension[4]	Air/LNAPL Surface Tension[4]	LNAPL/Water Surface Tension[4]	Soil Type Near Capillary Fringe Zone	API Soil Type	Porosity[5]	Hydraulic Conductivity (K)		van Genuchten "N"[5]	Van Genuchten "a"[5]	Irreducible water saturation[5]	Residual LNAPL Saturation[5]	Residual LNAPL f-factor[5]	LNAPL Thickness	Total LNAPL	Mobile LNAPL	Recoverable LNAPL	LNAPL Transmissivity (T_n)	
												Regional K (pumping test)[6]	Local K (soil type)[7]										Based on regional K (Pumping Test)[6]	Based on Local K (soil type)[7]
	ft	ft		gm/cc	cp	dyne/cm	dyne/cm	dyne/cm				ft/day	ft/day		ft^{-1}				ft	ft	ft	ft	ft2/day	ft2/day
RW-4	3.98	26.73	0	0.780	0.670	62.51	24.21	17.21	Silty Sand	Silty Sand	0.41	450	0.96	2.02	0.552	0.36	Variable	0.3	3.98	0.5	0.5	0.35	505.61	1.08
RW-23	3.51	28.13	0	0.759	0.587	62.51	24.21	17.21	Silty Sand	Silty Sand	0.41	450	0.96	2.02	0.552	0.36	Variable	0.3	3.51	0.46	0.46	0.32	487.77	1.04
MW-29	2.18	26.51	0	0.795	0.834	65.7	23.3	14.4	Medium grained Sand	Medium Sand	0.38	450	23.95	2.04	0.460	0.29	Variable	0.3	2.18	0.18	0.18	0.12	101.36	5.4
S-198	1.89	26.52	0	0.792	0.832	65.7	23.3	14.4	Coarse sand and gravel	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	1.89	0.2	0.2	0.14	238.5	20.17
S-205	1.45	18.74	0	0.807	0.847	65.7	23.3	14.4	Coarse sand	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	1.45	0.12	0.12	0.08	133.93	11.34
S-100	1.29	24.26	0	0.793	0.833	65.7	23.3	14.4	SW	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	1.29	0.11	0.11	0.07	114.95	9.72
MW-26	1.28	23.63	0	0.780	0.670	62.51	24.21	17.21	Silt	Silty Sand	0.41	450	0.96	2.02	0.552	0.36	Variable	0.3	1.28	0.05	0.05	0.03	24.11	0.05
S-203*	1.26	28.63	0	0.830	3.720	57.7	28.6	16.6	Sandy gravel	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	1.26	0.06	0.06	0.04	14.37	1.22
S-199	1.12	25.93	0	0.792	0.832	65.7	23.3	14.4	Sandy coarse gravel	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	1.12	0.08	0.08	0.06	86.52	7.32
S-189	1.08	26.1	0	0.780	0.670	62.51	24.21	17.21	Gravelly Sand	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	1.08	0.07	0.07	0.05	79.21	6.7
S-76	1.03	27.68	0	0.785	3.520	57.7	28.6	16.6	Silty clay with little fine sand	Fine Sand	0.43	450	3.28	2.61	0.664	0.32	Variable	0.3	1.03	0.05	0.05	0.03	2.03	0.01
S-277	0.84	21.25	0	0.800	0.850	65.7	23.3	14.4	Sand with fine to coarse gravel	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	0.84	0.05	0.05	0.03	43.01	3.64
S-77	0.81	12.66	0	0.768	0.735	62.51	24.21	17.21	Fine sand trace gravel	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	0.81	0.04	0.04	0.03	39.84	3.37
S-276	0.78	22.02	0	0.800	0.850	65.7	23.3	14.4	Sand with fine gravel	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	0.78	0.02	0.02	0.01	3.81	0.32
S-201	0.77	23.5	0	0.803	0.843	65.7	23.3	14.4	Coarse sandy gravel	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	0.77	0.04	0.04	0.03	34.69	2.93
RW-25	0.76	25.52	0	0.781	0.670	62.51	24.21	17.21	Medium to coarse sand	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	0.76	0.03	0.03	0.02	34.59	2.93
S-83	0.72	19.33	0	0.807	0.847	65.7	23.3	14.4	Fine to coarse sand with gravel and trace silt	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	0.72	0.03	0.03	0.02	28.46	2.42
PZ-404	0.57	26.18	0	0.800	0.850	65.7	23.3	14.4	Poorly sorted sands and gravels	Coarse Sand	0.33	450	38.06	1.62	1.180	0.27	Variable	0.3	0.57	0.02	0.02	0.01	16.85	1.42

Notes

b_n: LNAPL thickness

ft: feet

gm/cc: grams per cubic centimeter

cp: centipoise

dyne/cm: dyne per centimeter

* No LNAPL Characterization samples collected from this well. LNAPL density, viscosity, and tension parameter are based on results from nearest well that was sampled (S-79)

1. Max b_n was based on the maximum value observed in 2015
2. Water table depth corresponds to the uncorrected depth to water reading collected on the same date as the max b_n value.
3. The LDRM model is relatively insensitive to this parameter.
4. Sunoco, 2007

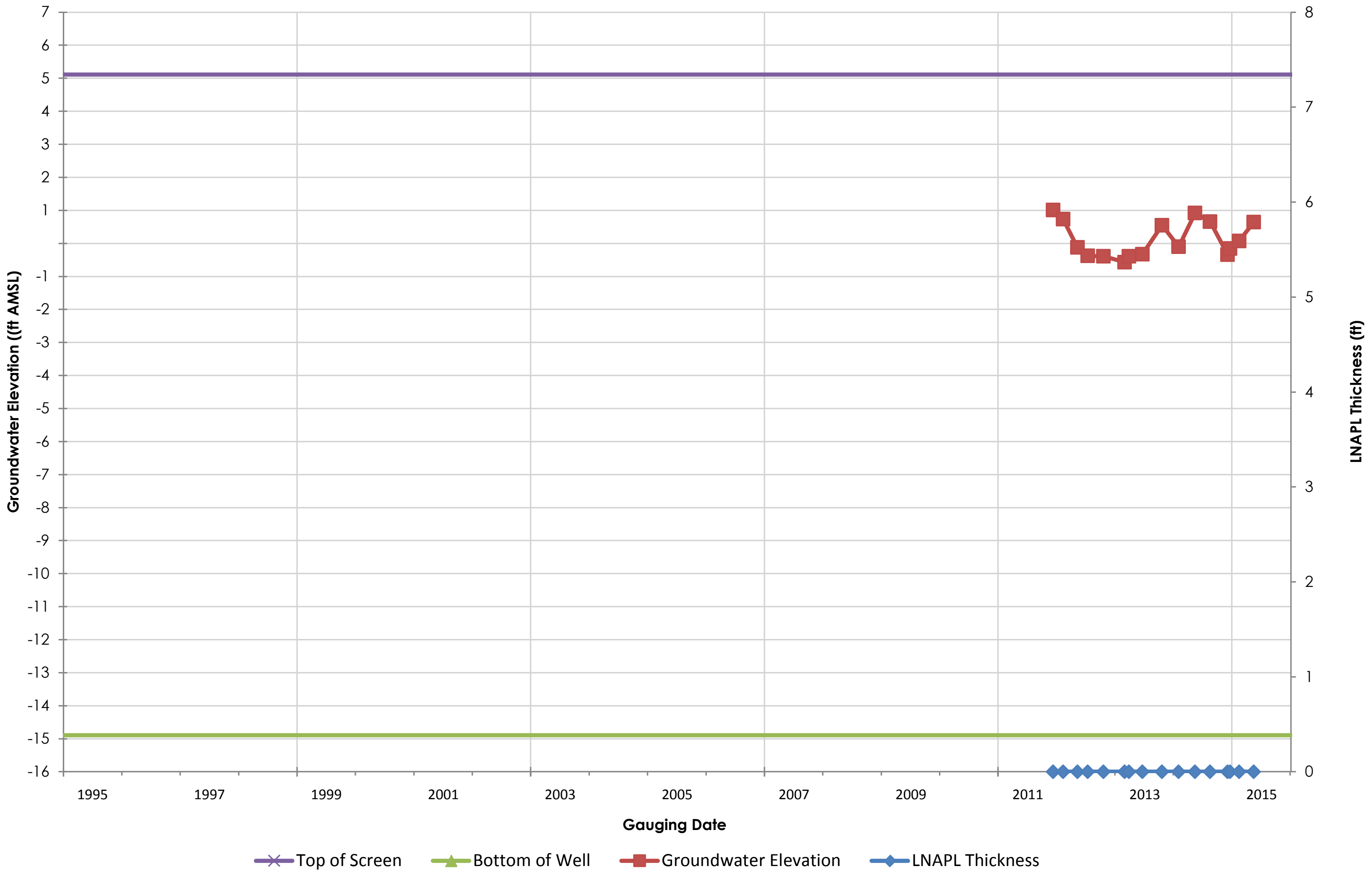
5: API Interactive LNAPL Guide Mobility Calculation Tool

6: Hydraulic conductivity value estimated from an aquifer test that utilized recovery well RW-2 as a pumping well (IST, 1998).

7: Hydraulic conductivity values estimated from API default values for the soil type near each well's capillary fringe zone.

APPENDIX I
APPARENT LNAPL THICKNESS AND GROUNDWATER ELEVATION HYDROGRAPHS

Light Non-aqueous Phase Liquid (LNAPL) Site Conceptual Model (LCSM)
Area of Interest 1
PHILADELPHIA REFINERY COMPLEX
PHILADELPHIA, PENNSYLVANIA
PHILADELPHIA REFINERY OPERATIONS,
A SERIES OF EVERGREEN RESOURCES GROUP, LLC
3144 PASSYUNK AVENUE, PHILADELPHIA, PENNSYLVANIA



Client/Project

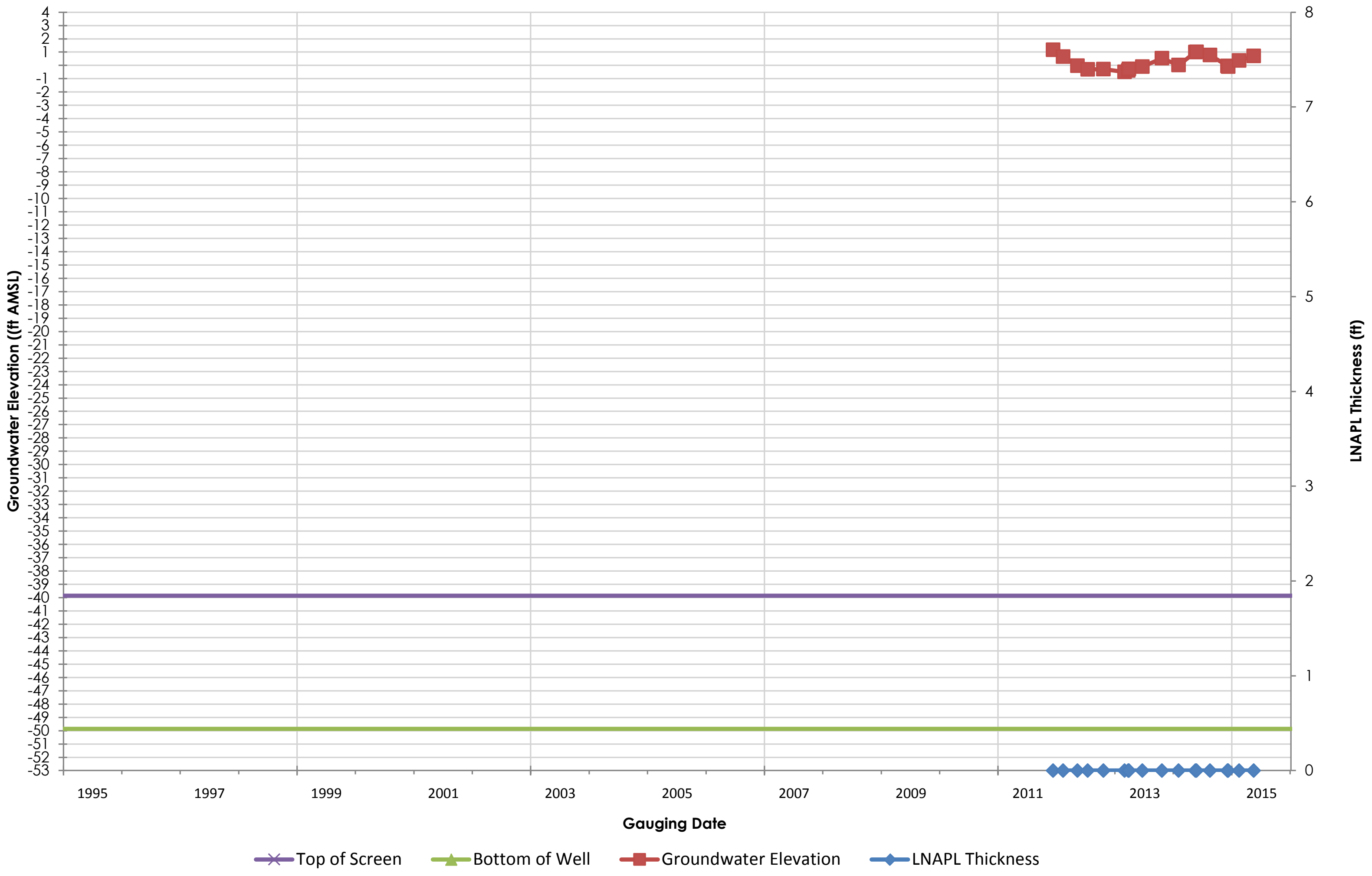
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

ARCO-1

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

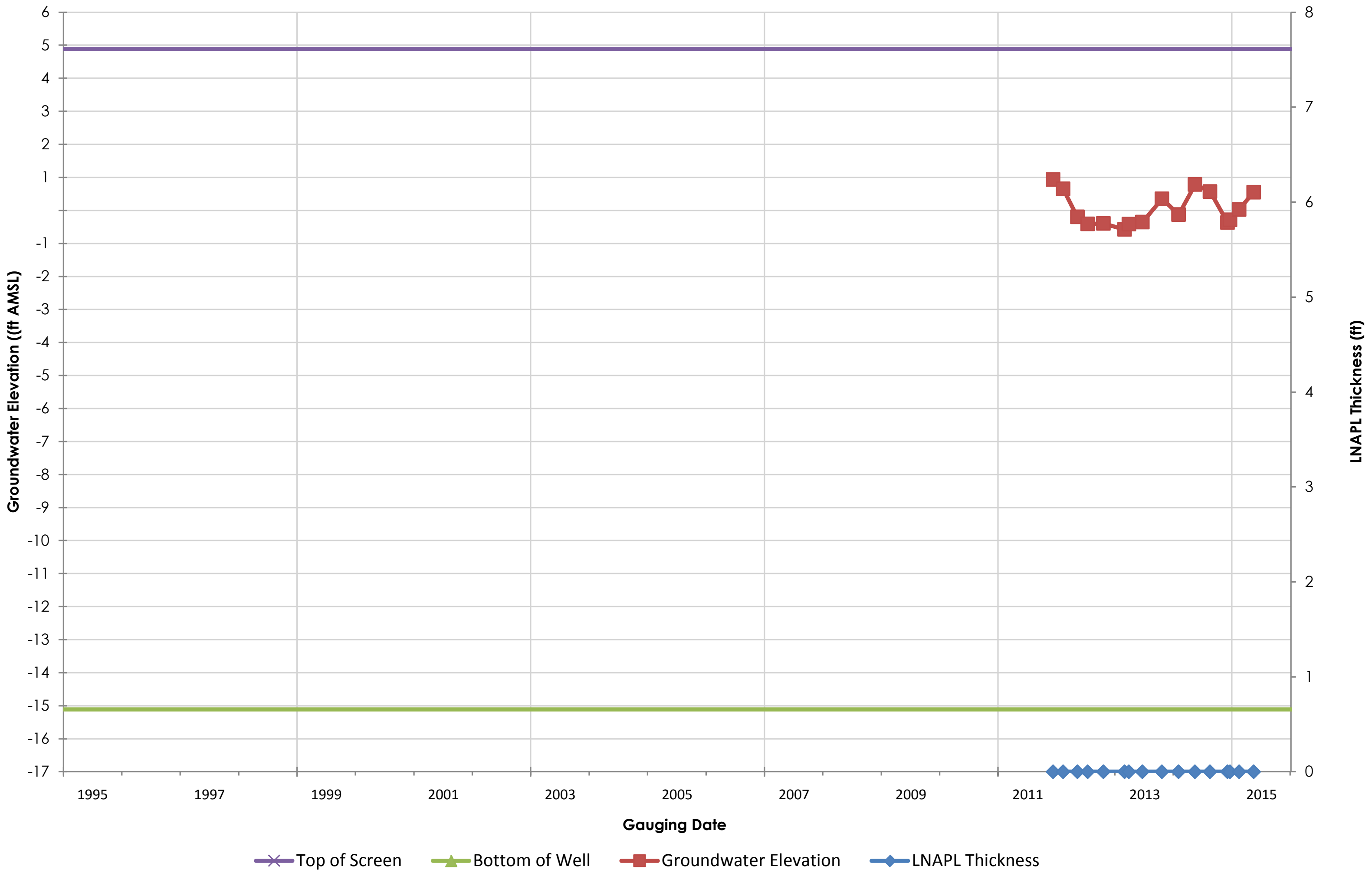
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

ARCO-1D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

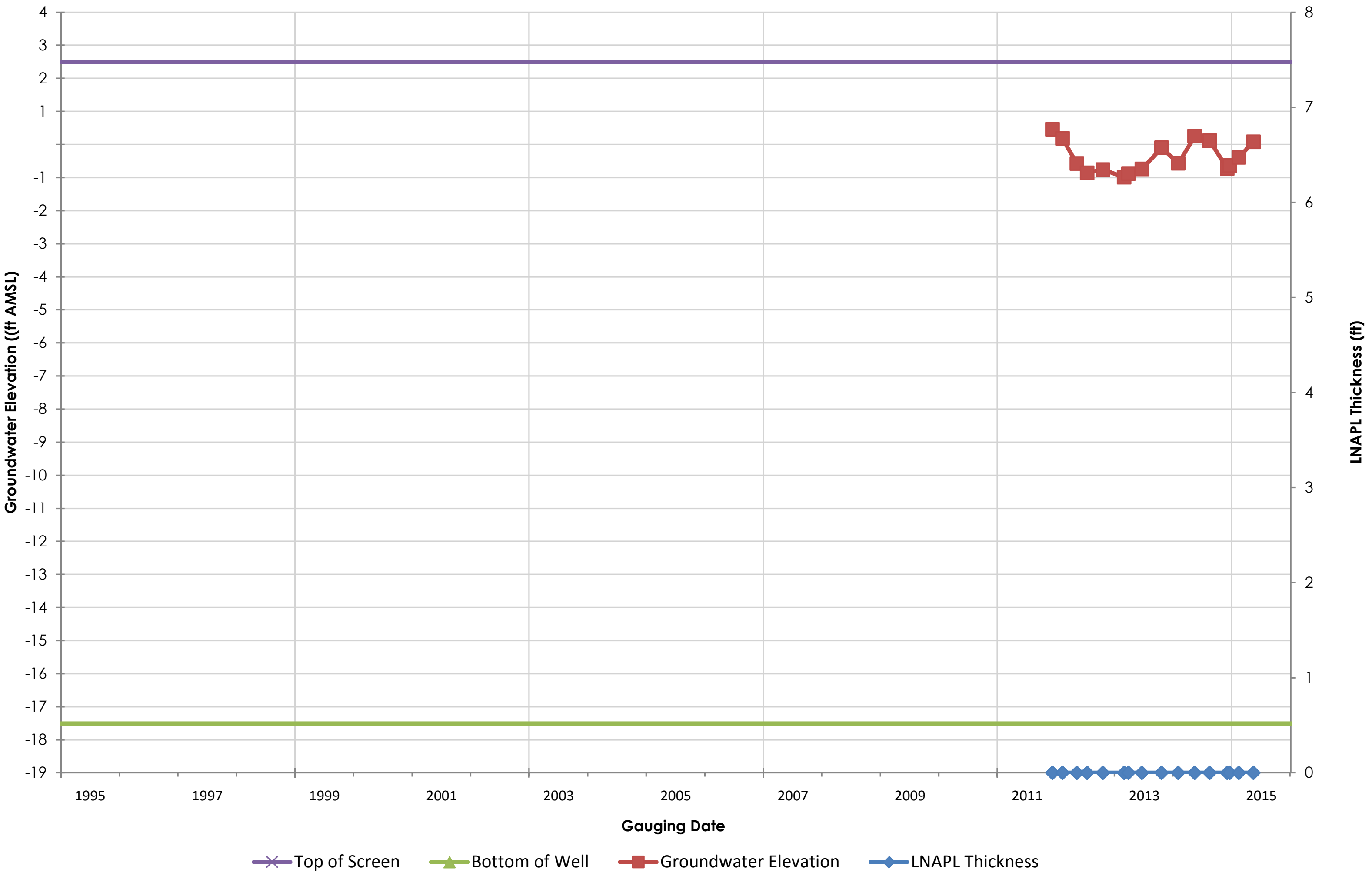
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

ARCO-2

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

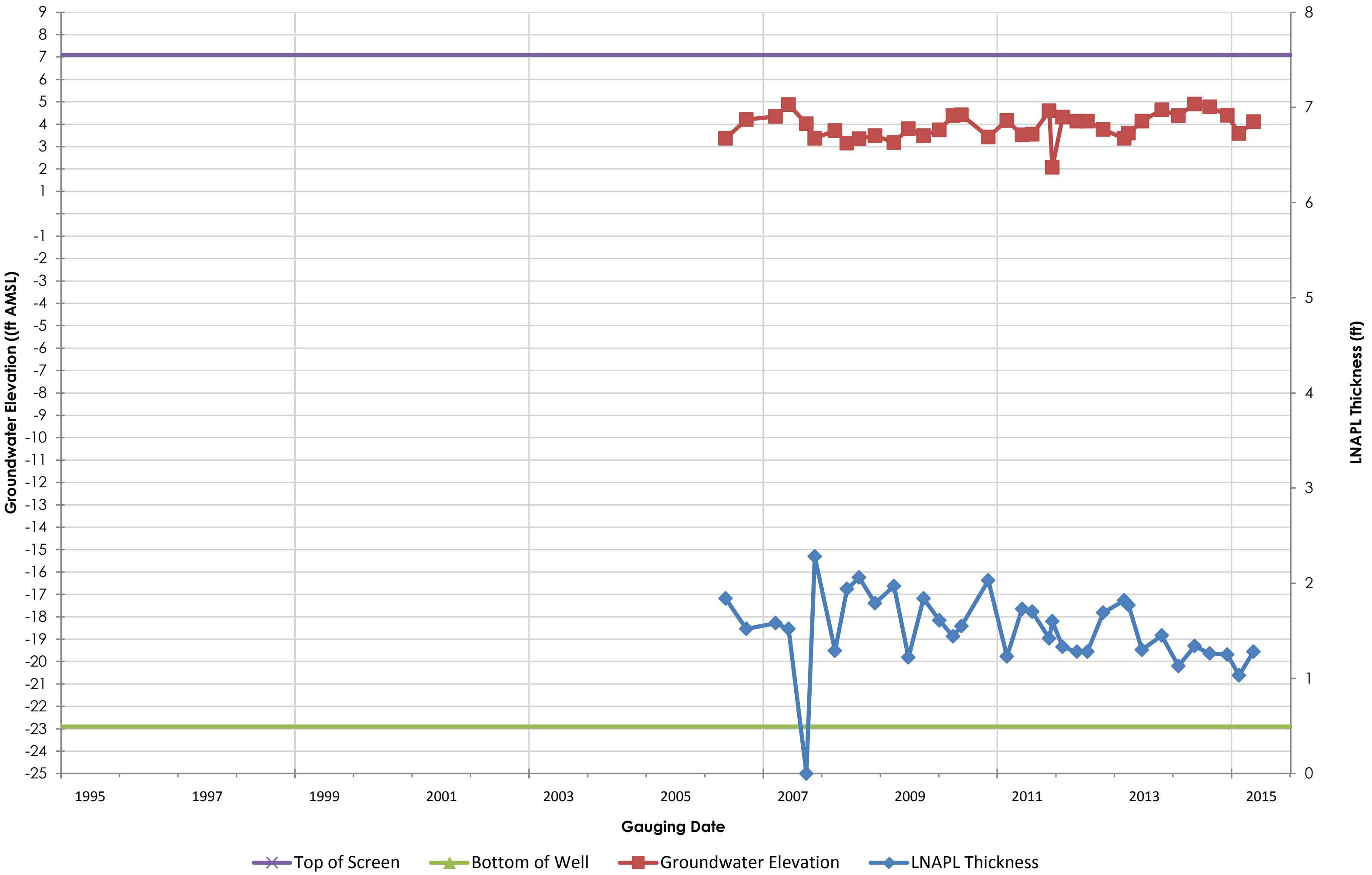
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

ARCO-3

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

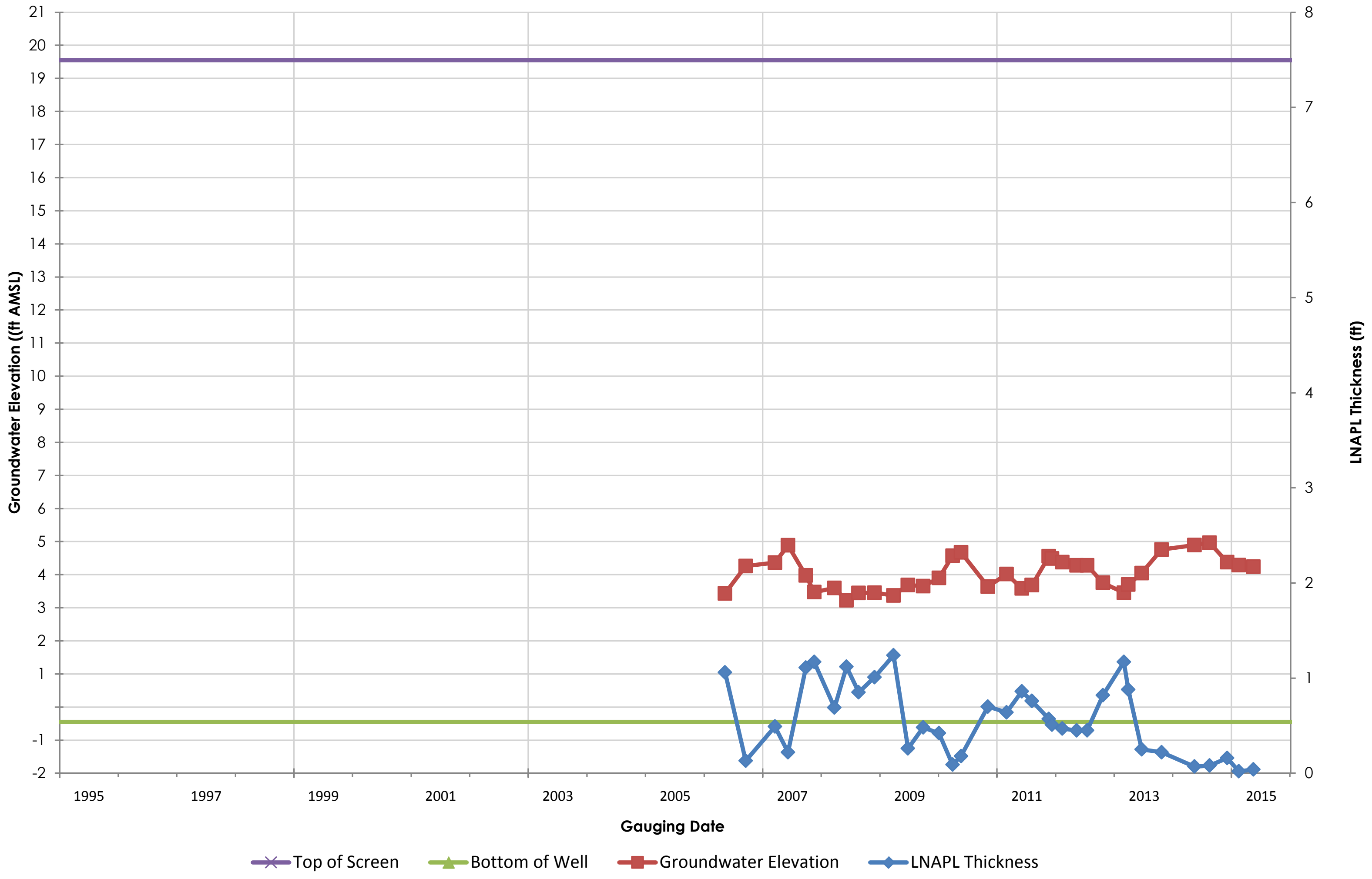
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-26

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

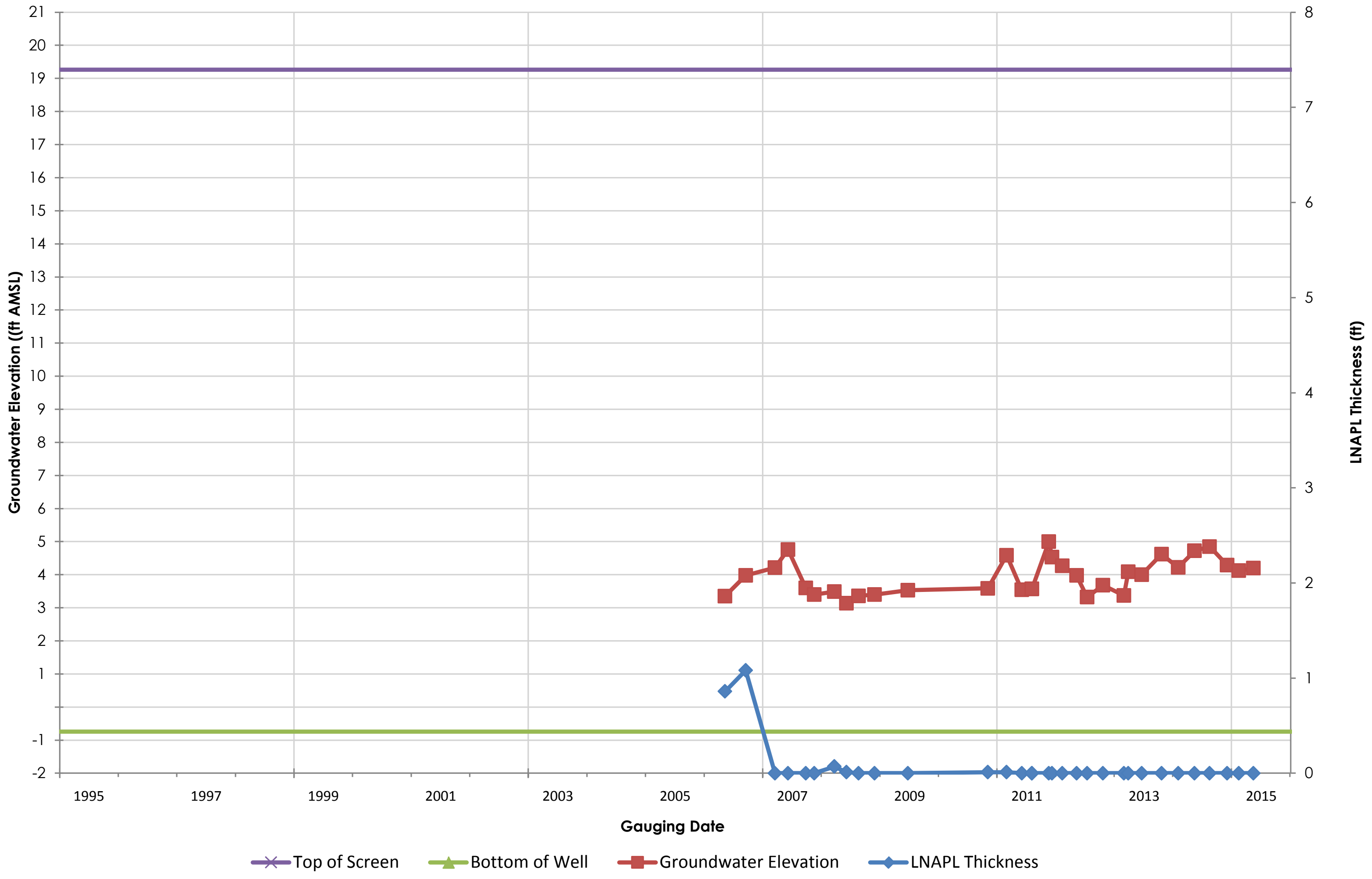
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-27

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

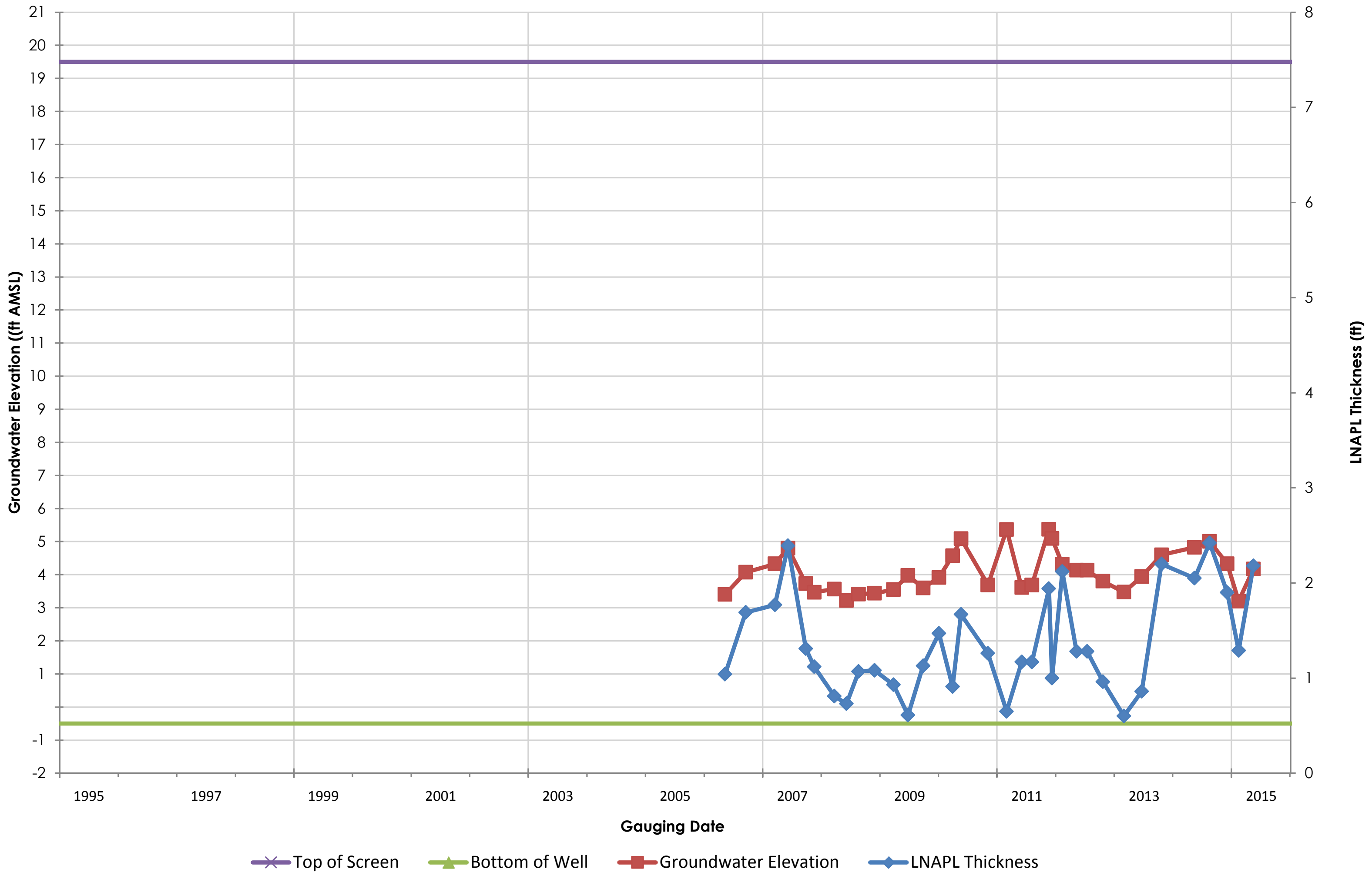
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-28

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

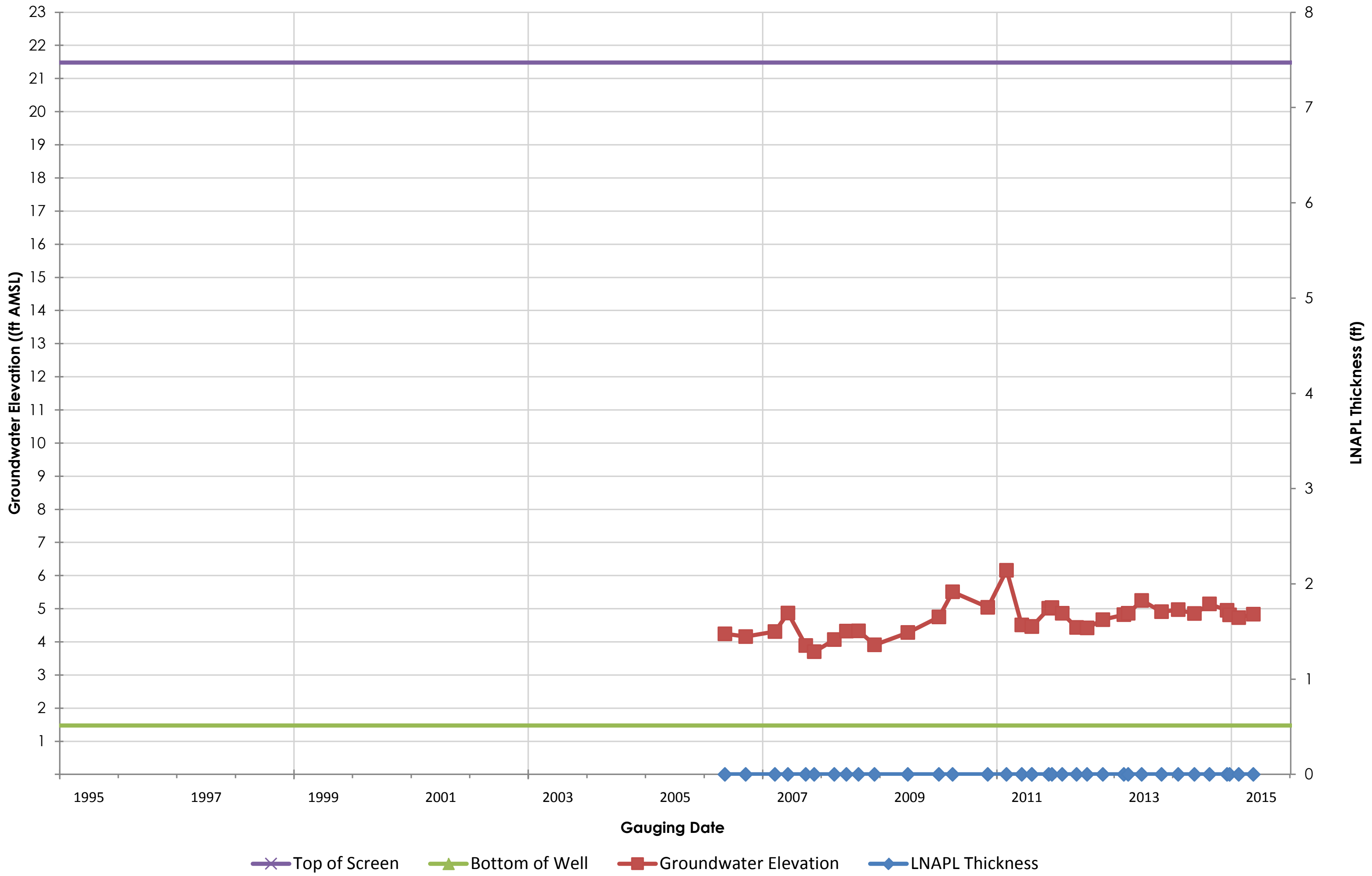
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-29

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

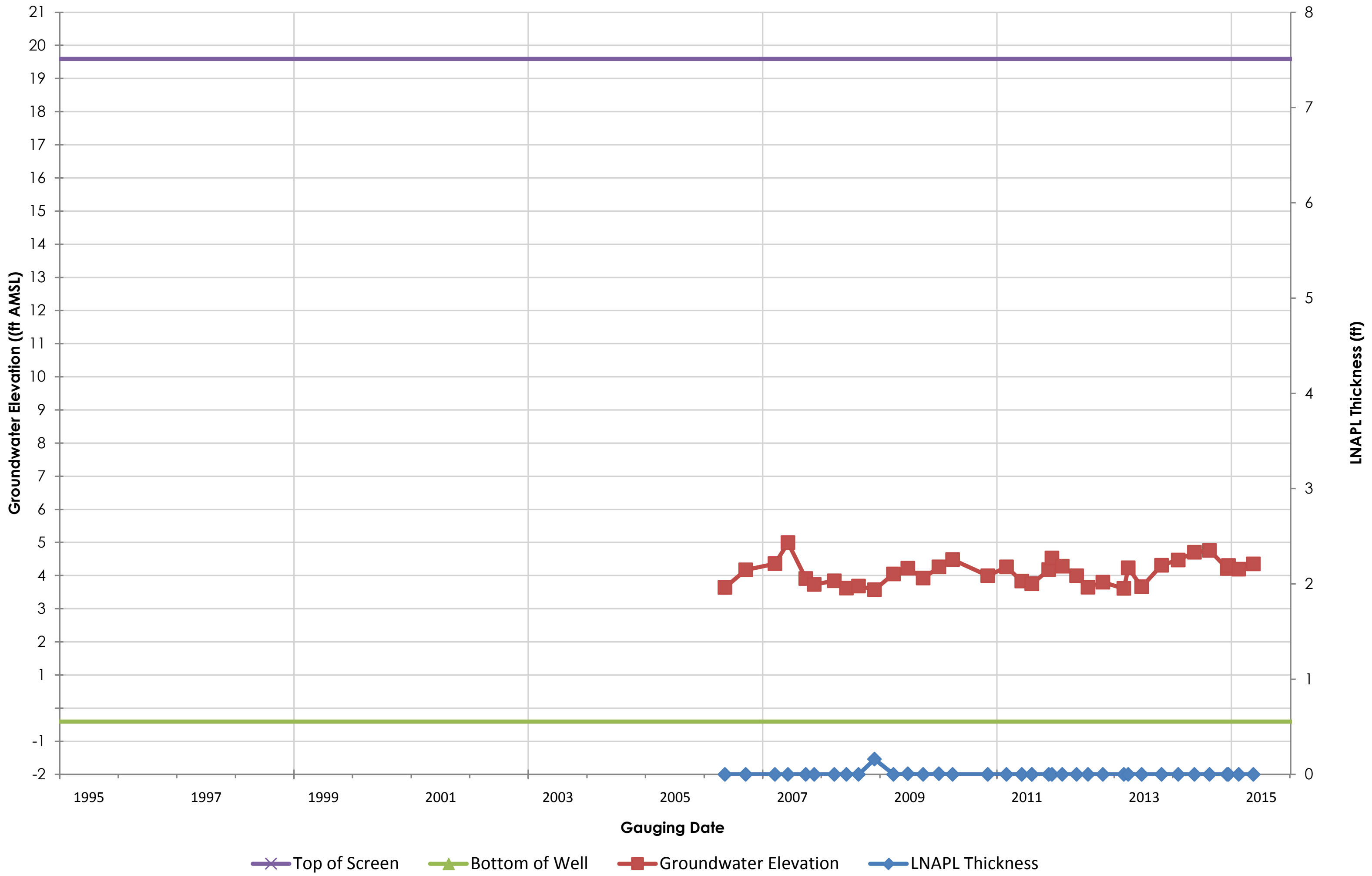
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-31

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

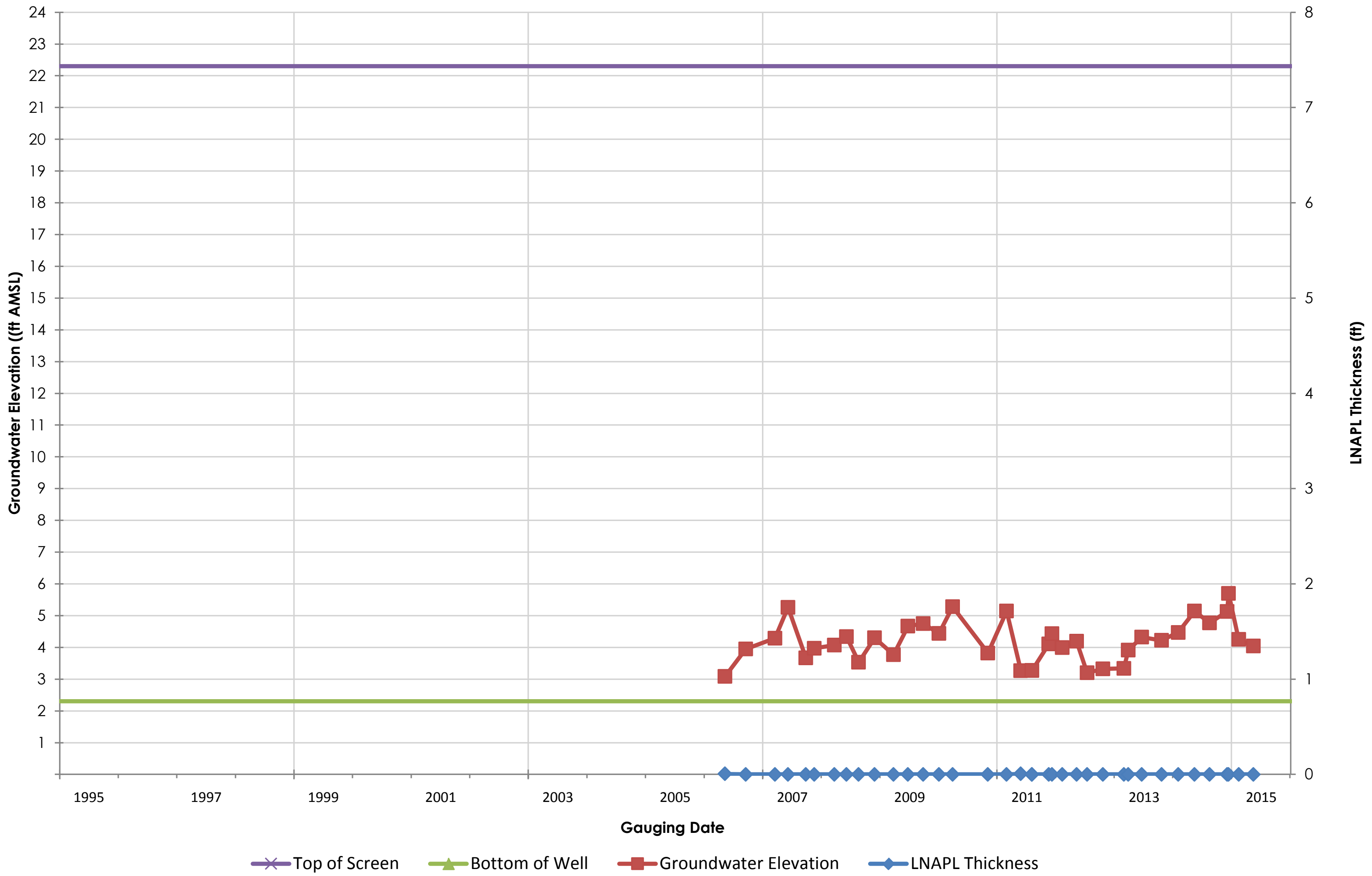
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-32

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

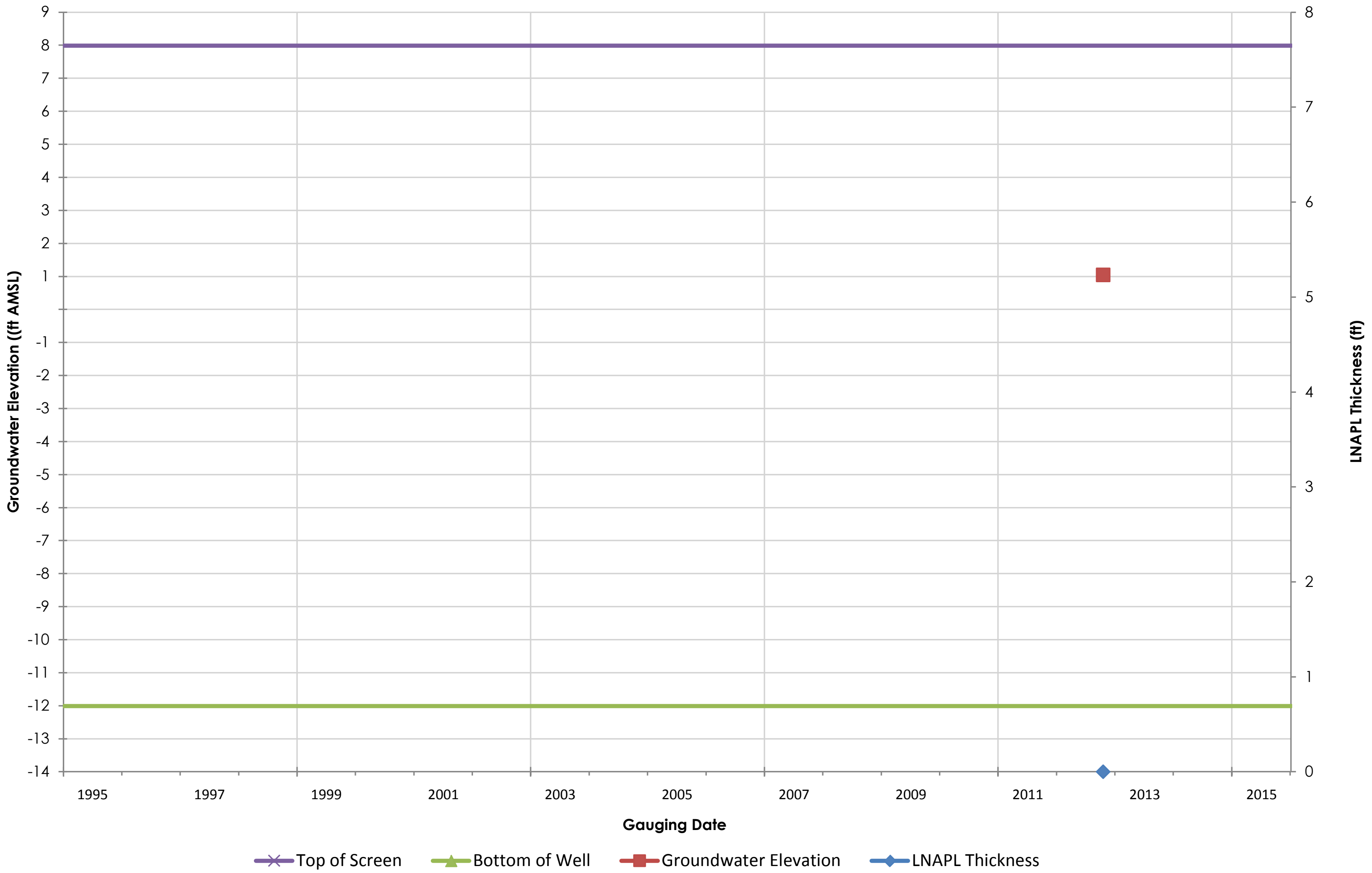
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-33

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

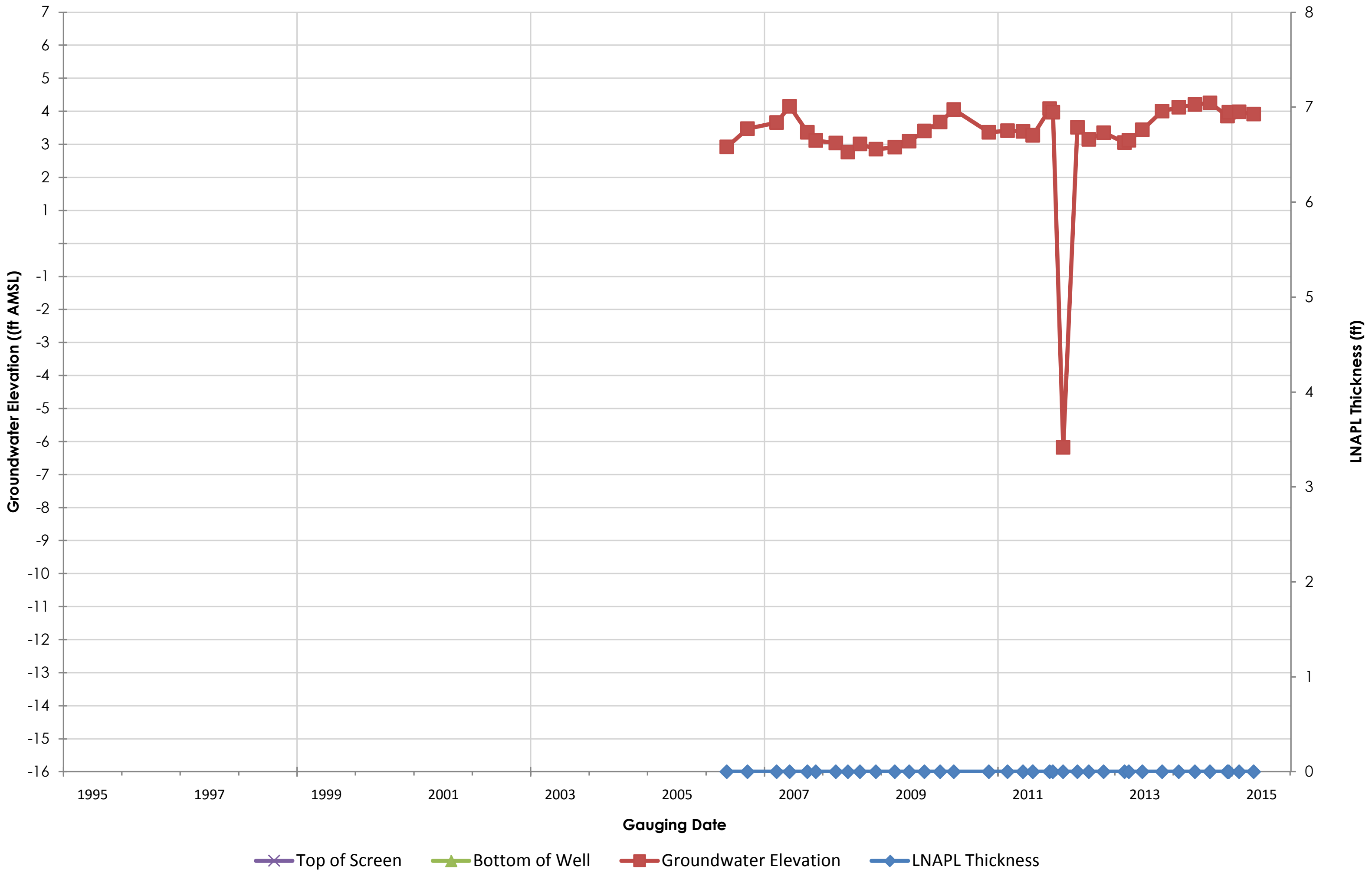
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-34

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

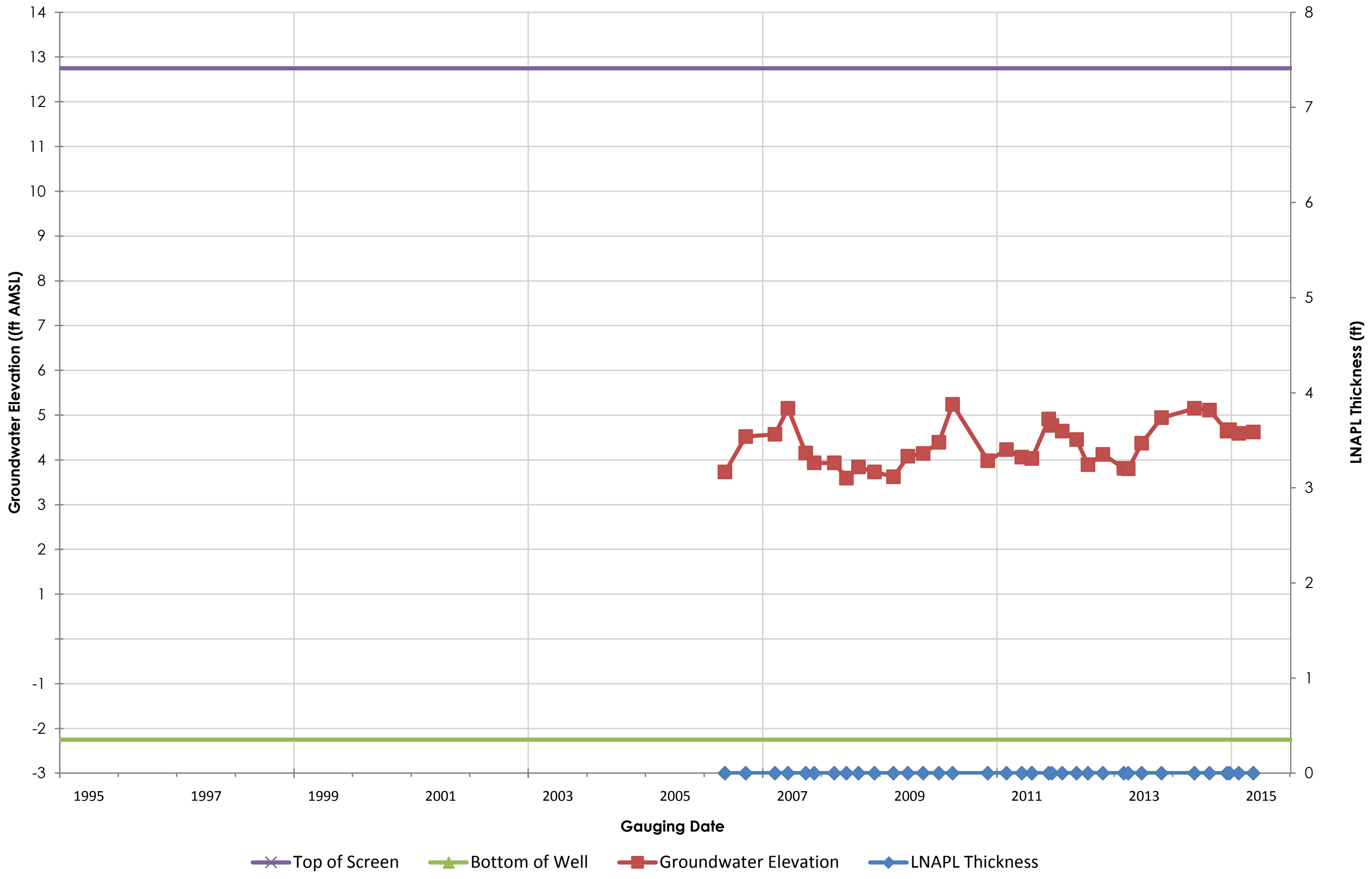
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-35

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

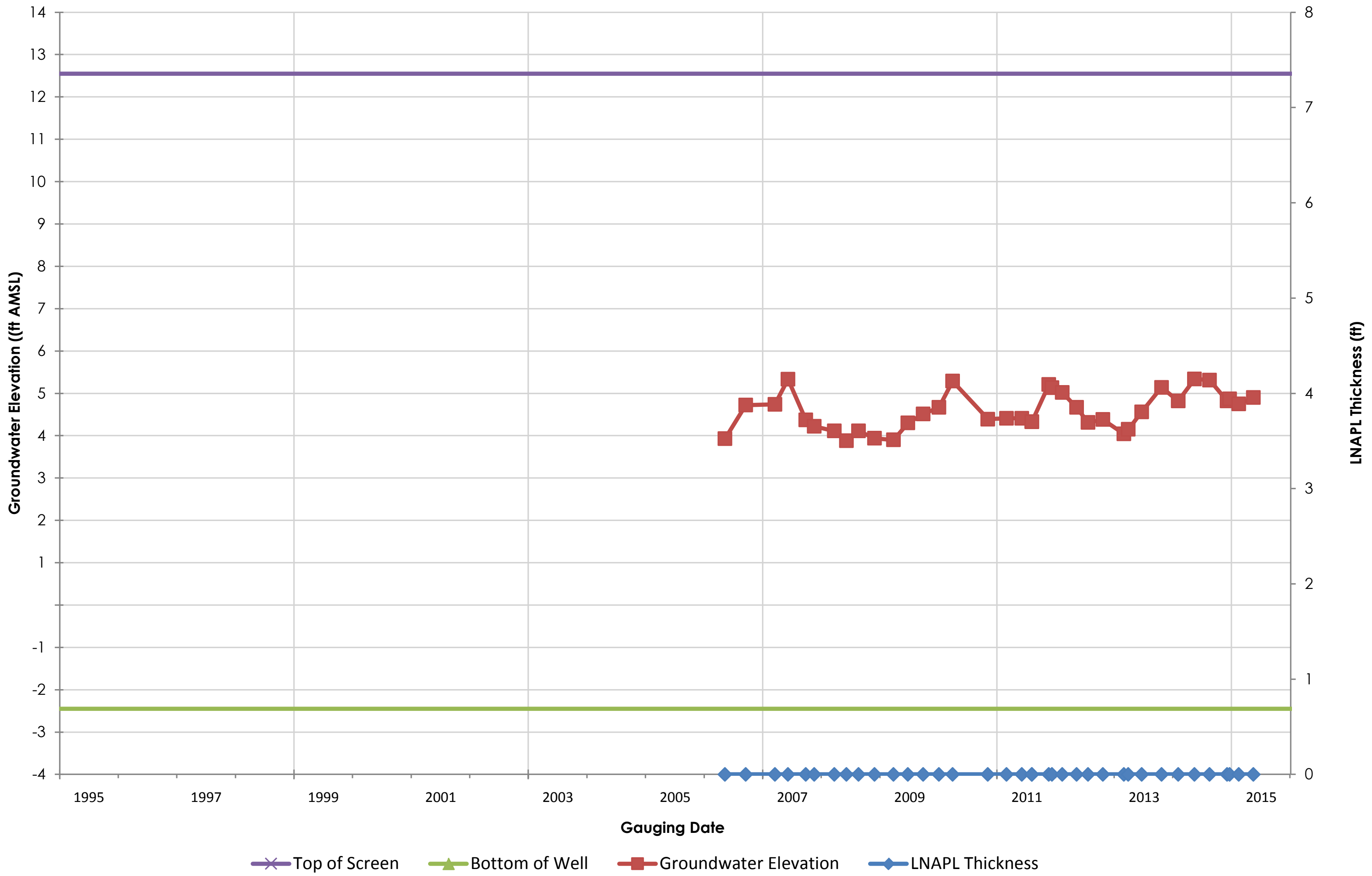
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-36

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

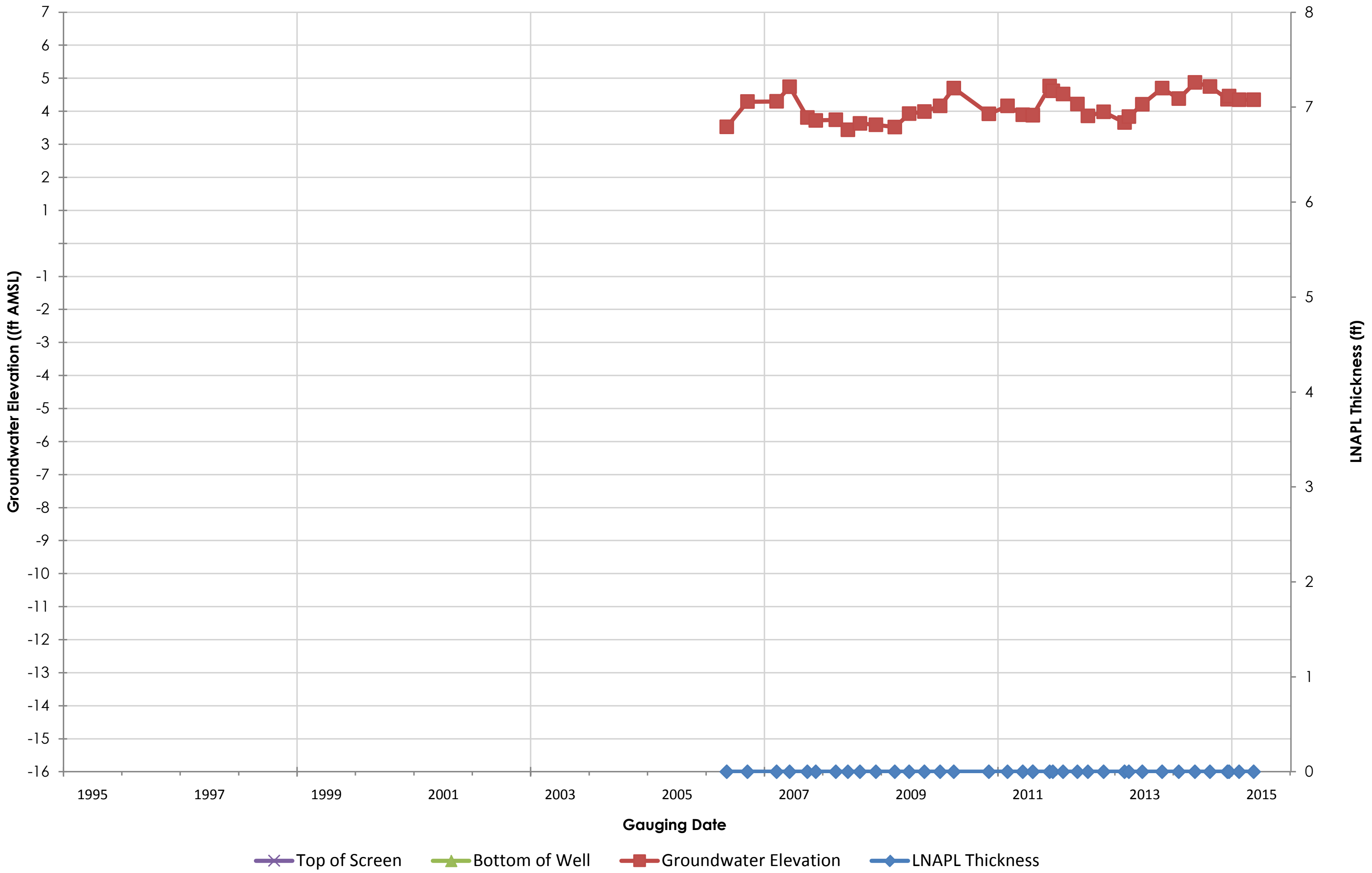
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-37

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

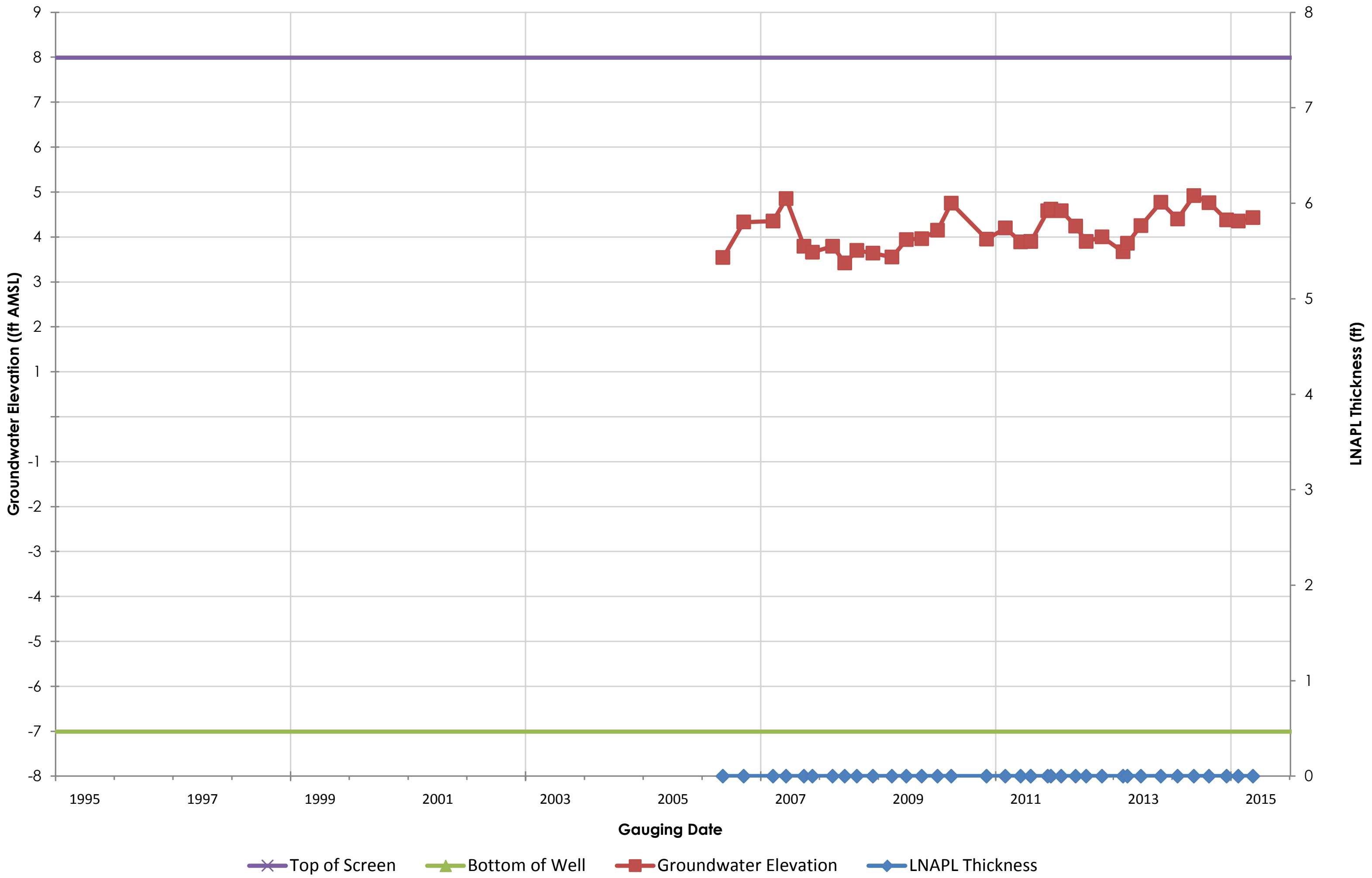
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-38

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

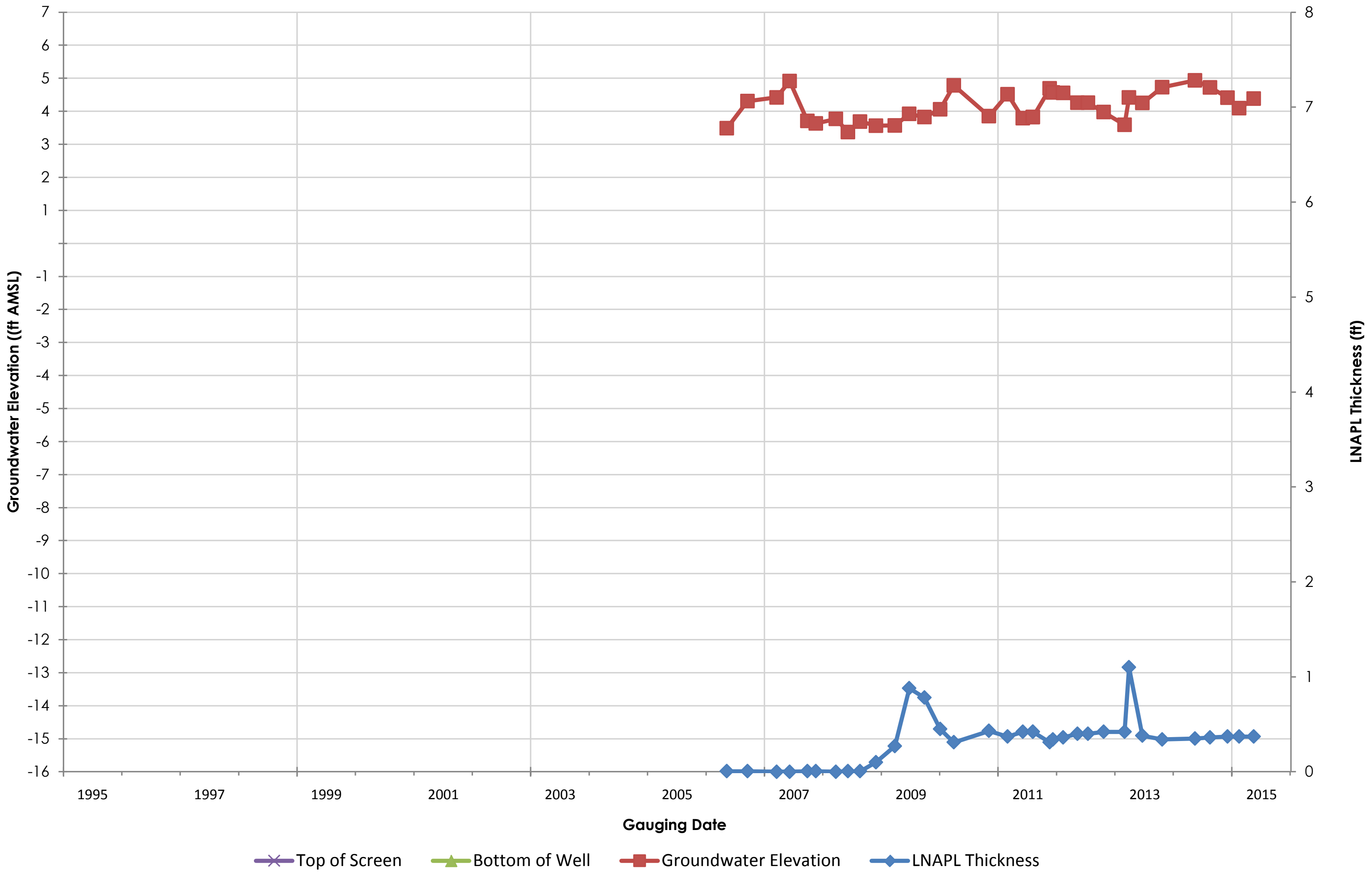
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-39

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

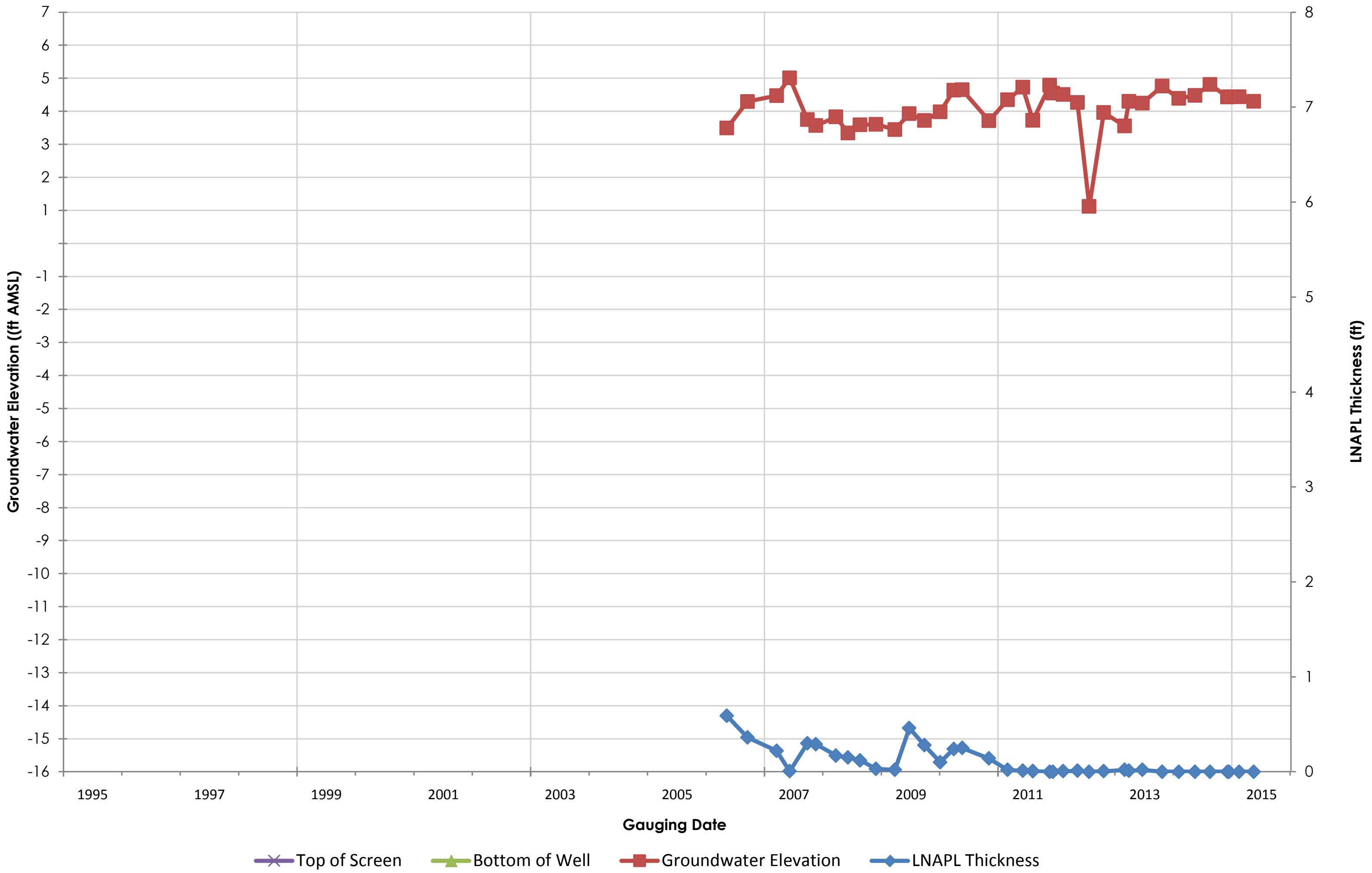
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-40

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

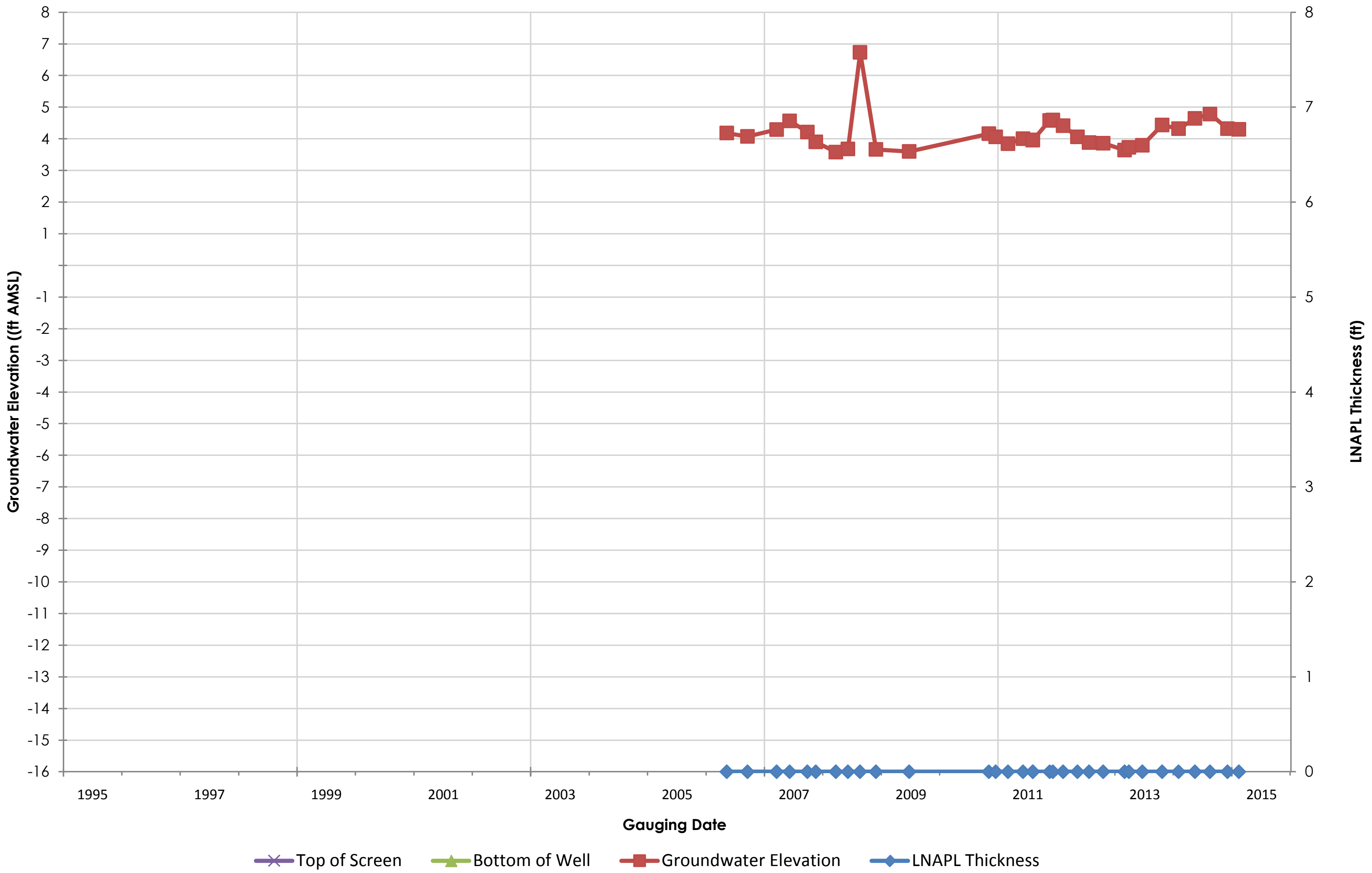
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-41

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

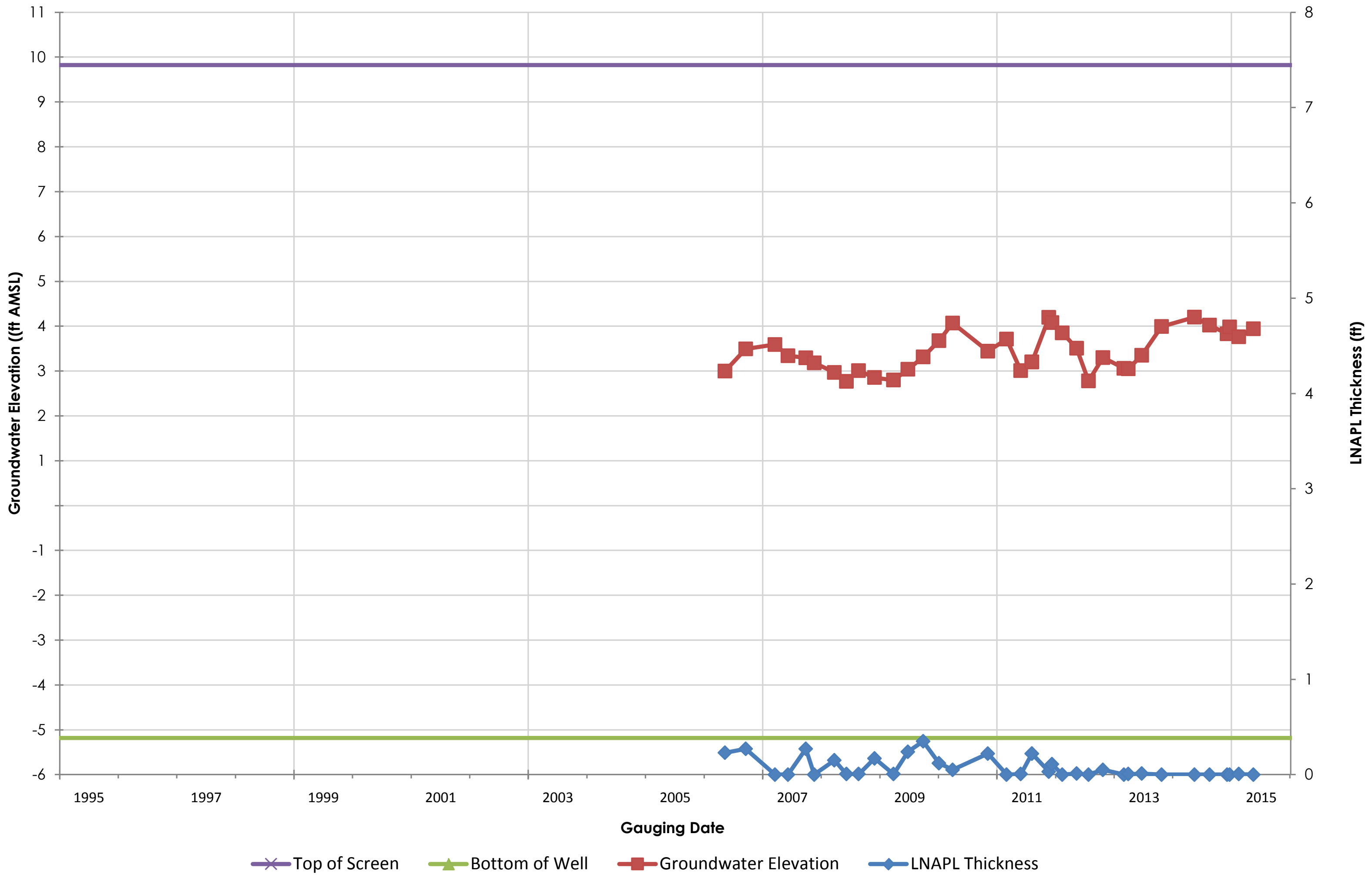
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-43

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

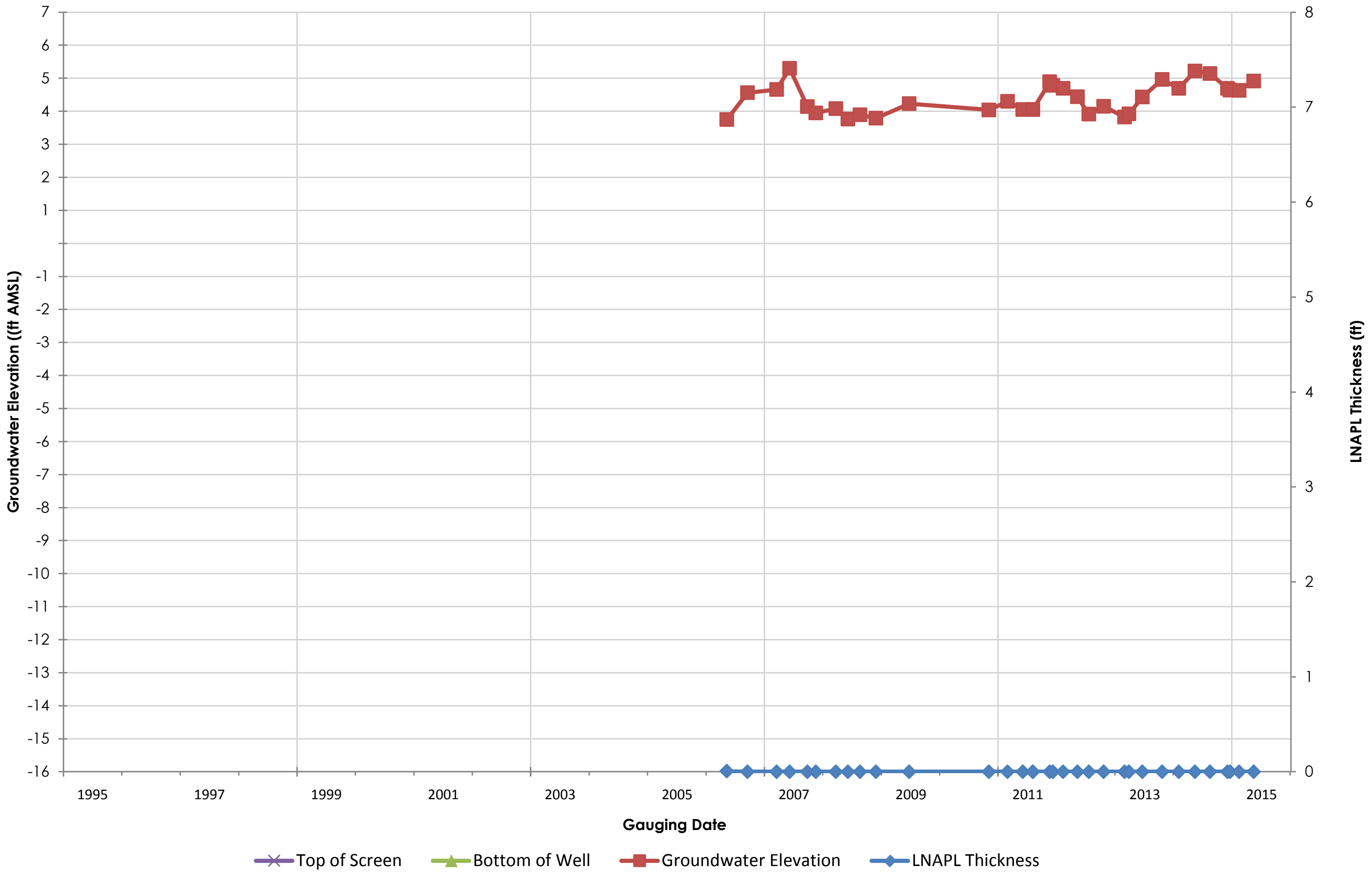
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

MW-44

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

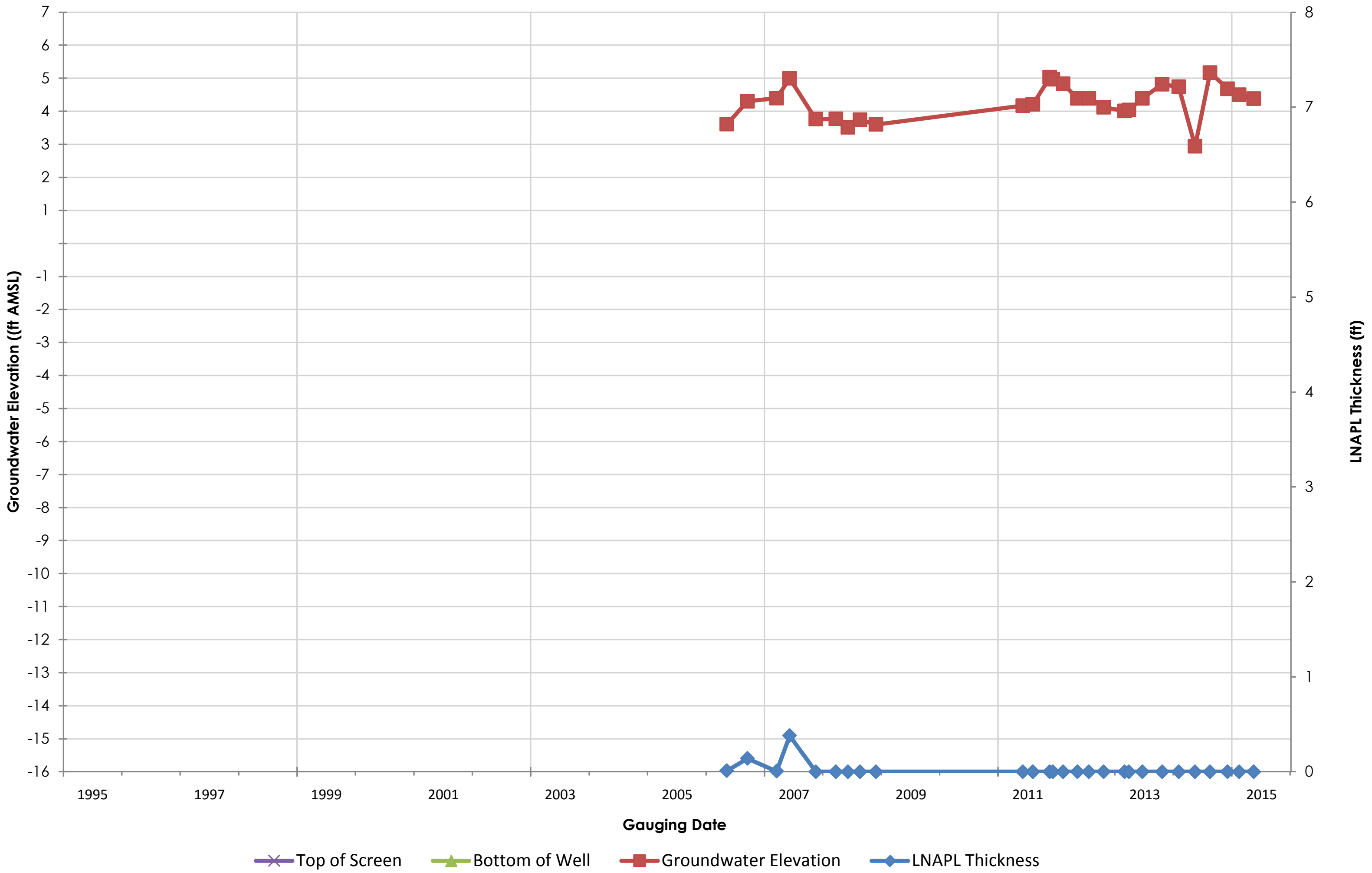
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

OW-2

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

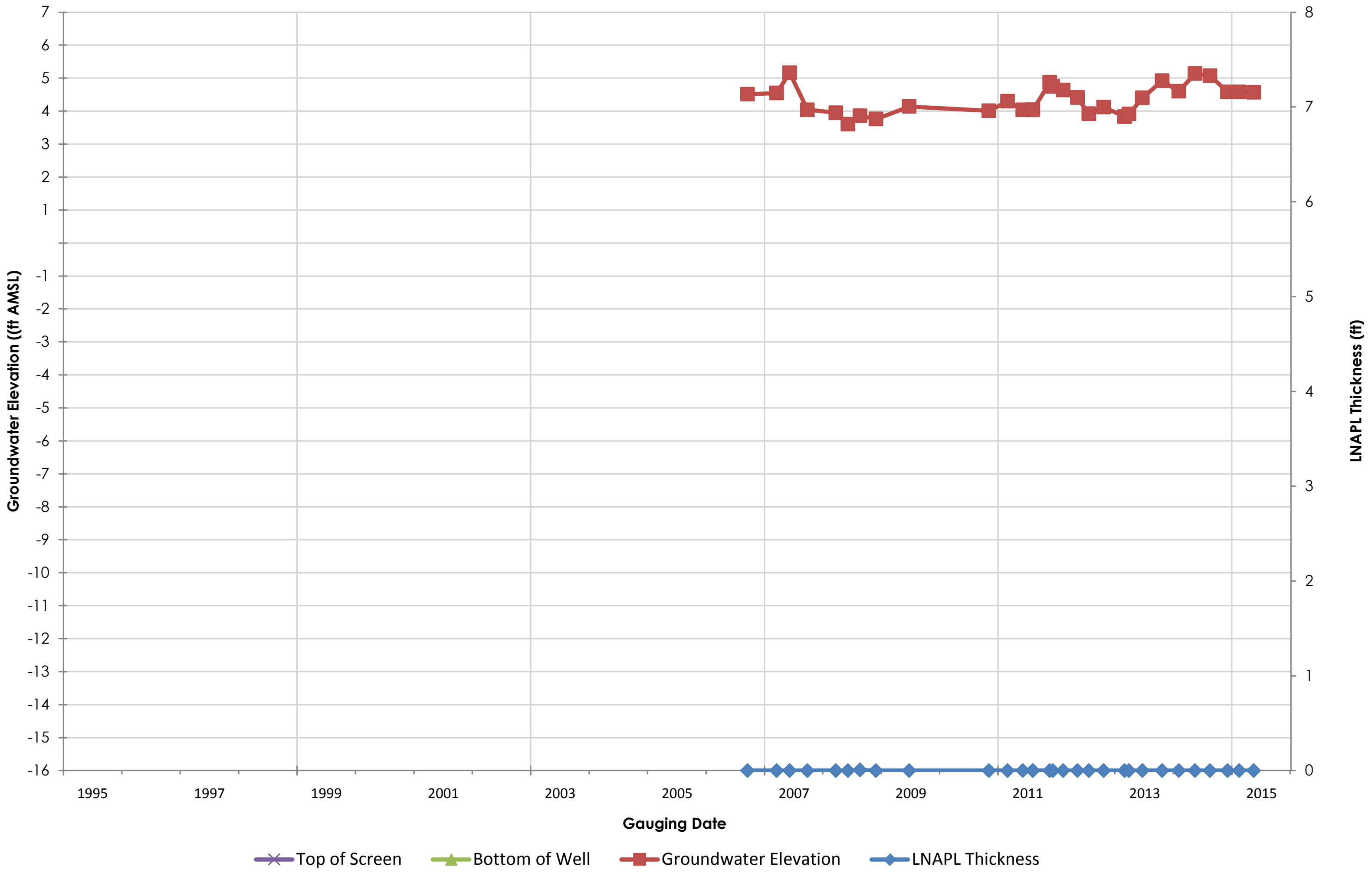
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

OW-12

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

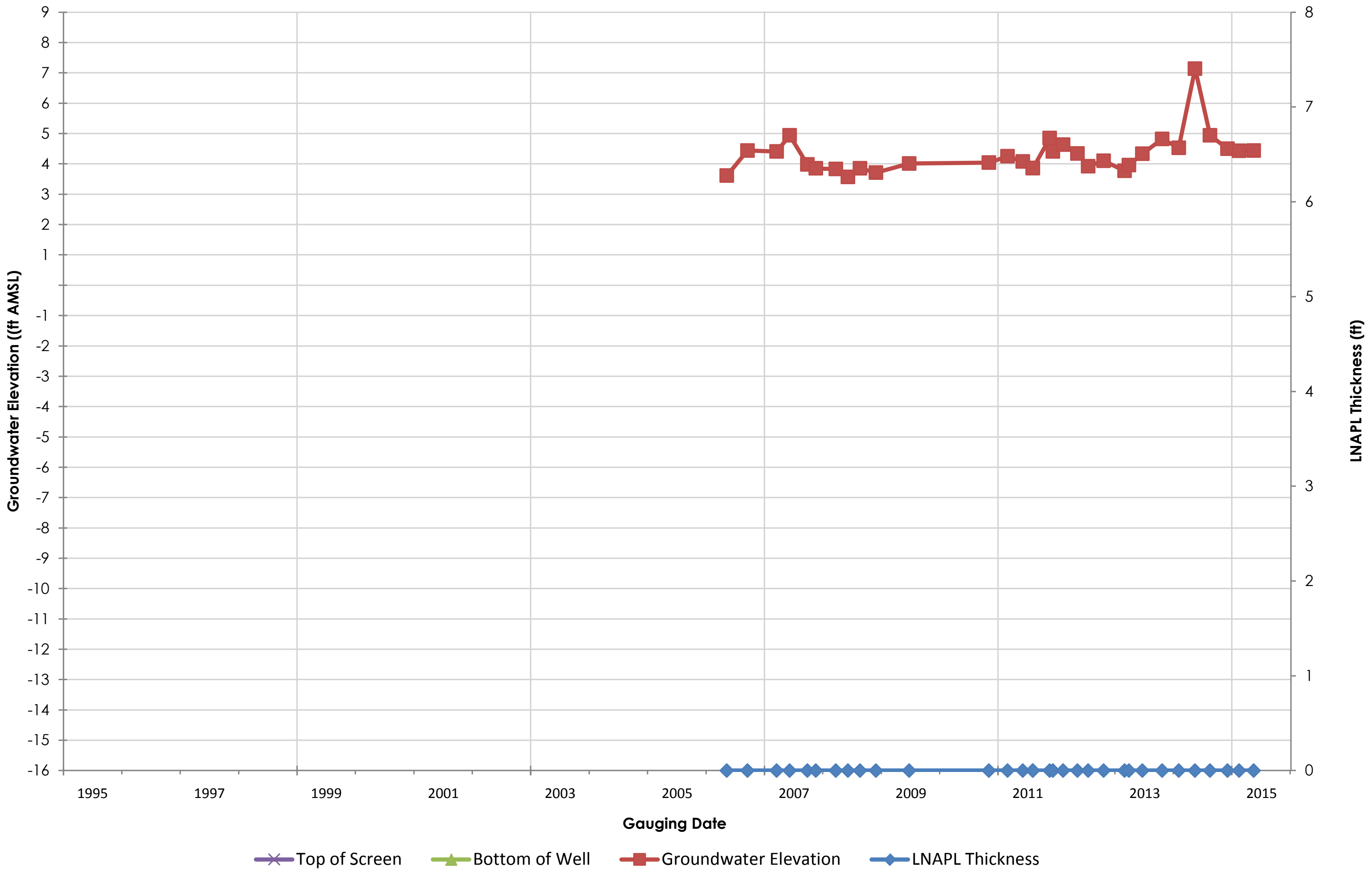
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

OW-13

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

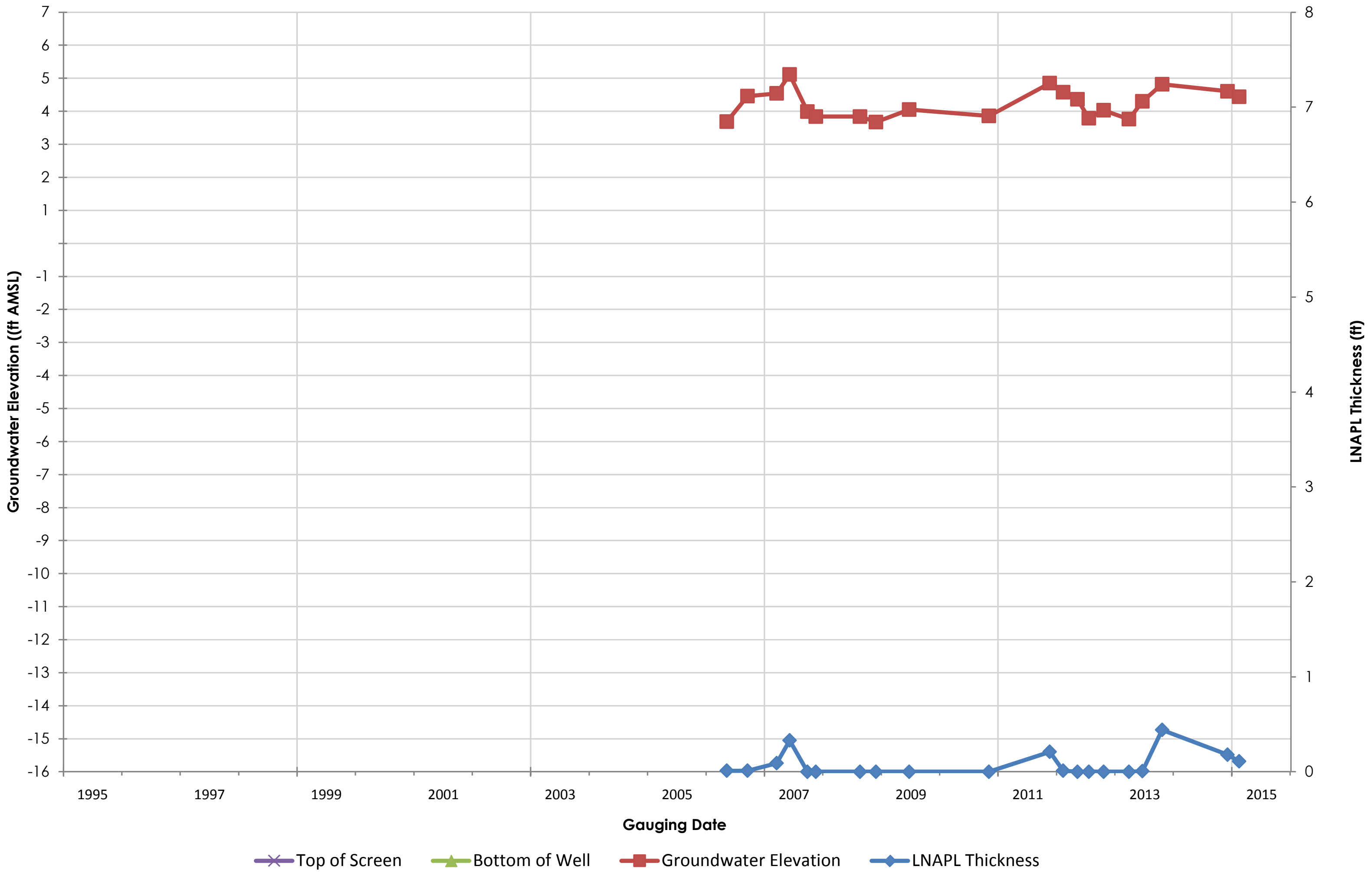
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

OW-14

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

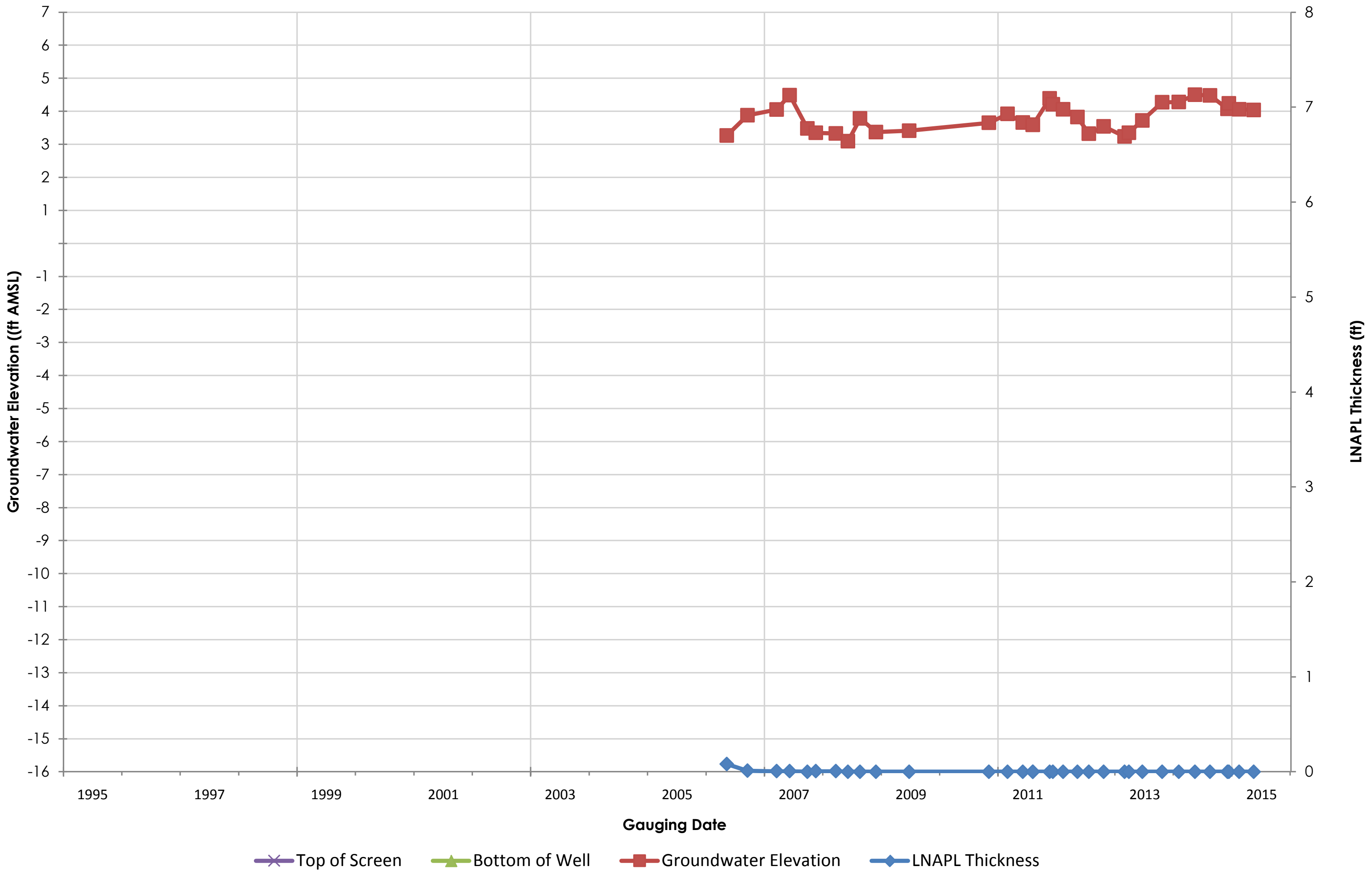
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

OW-16

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

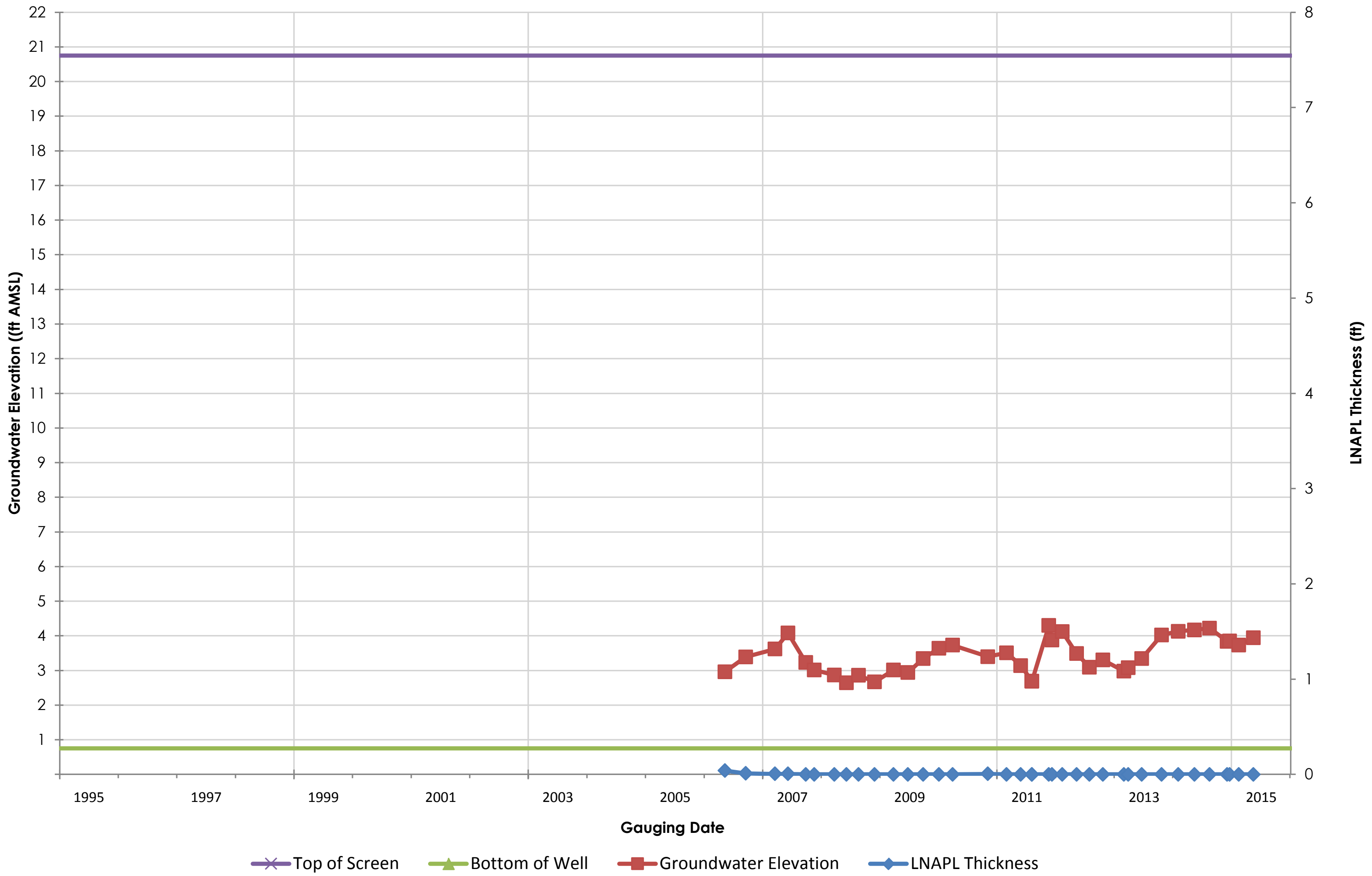
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

OW-17

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

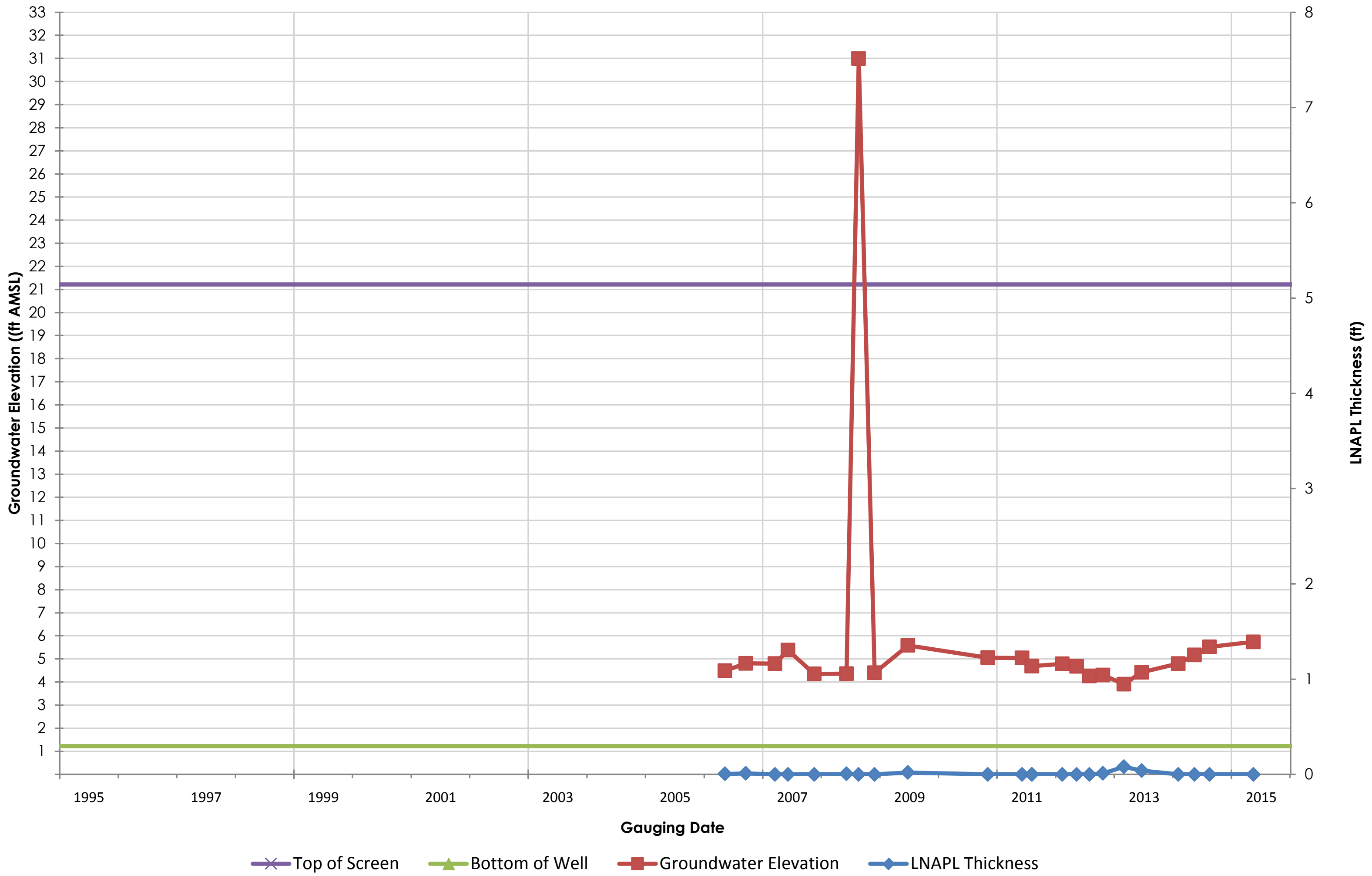
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

OW-18

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

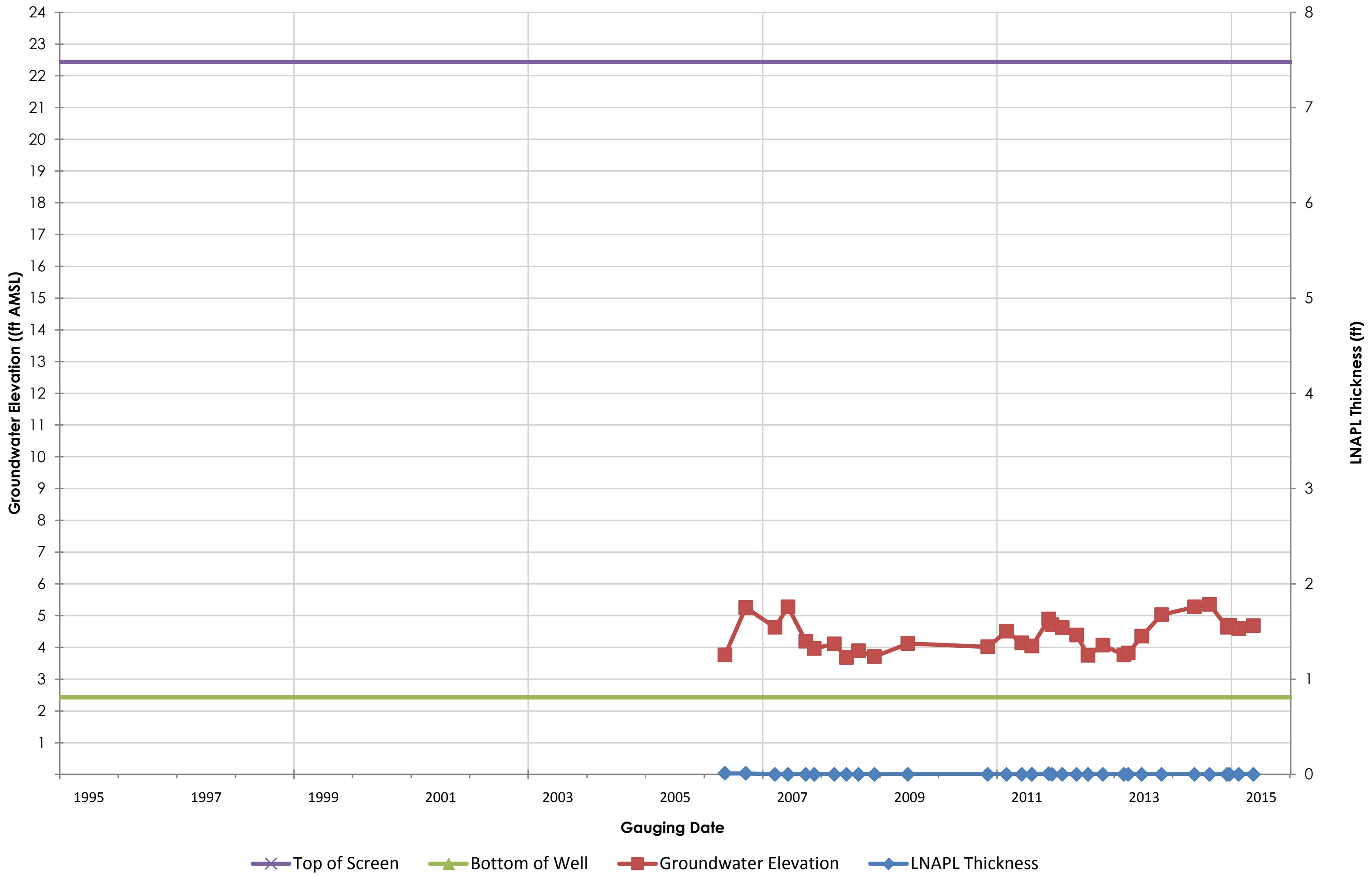
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

OW-19

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

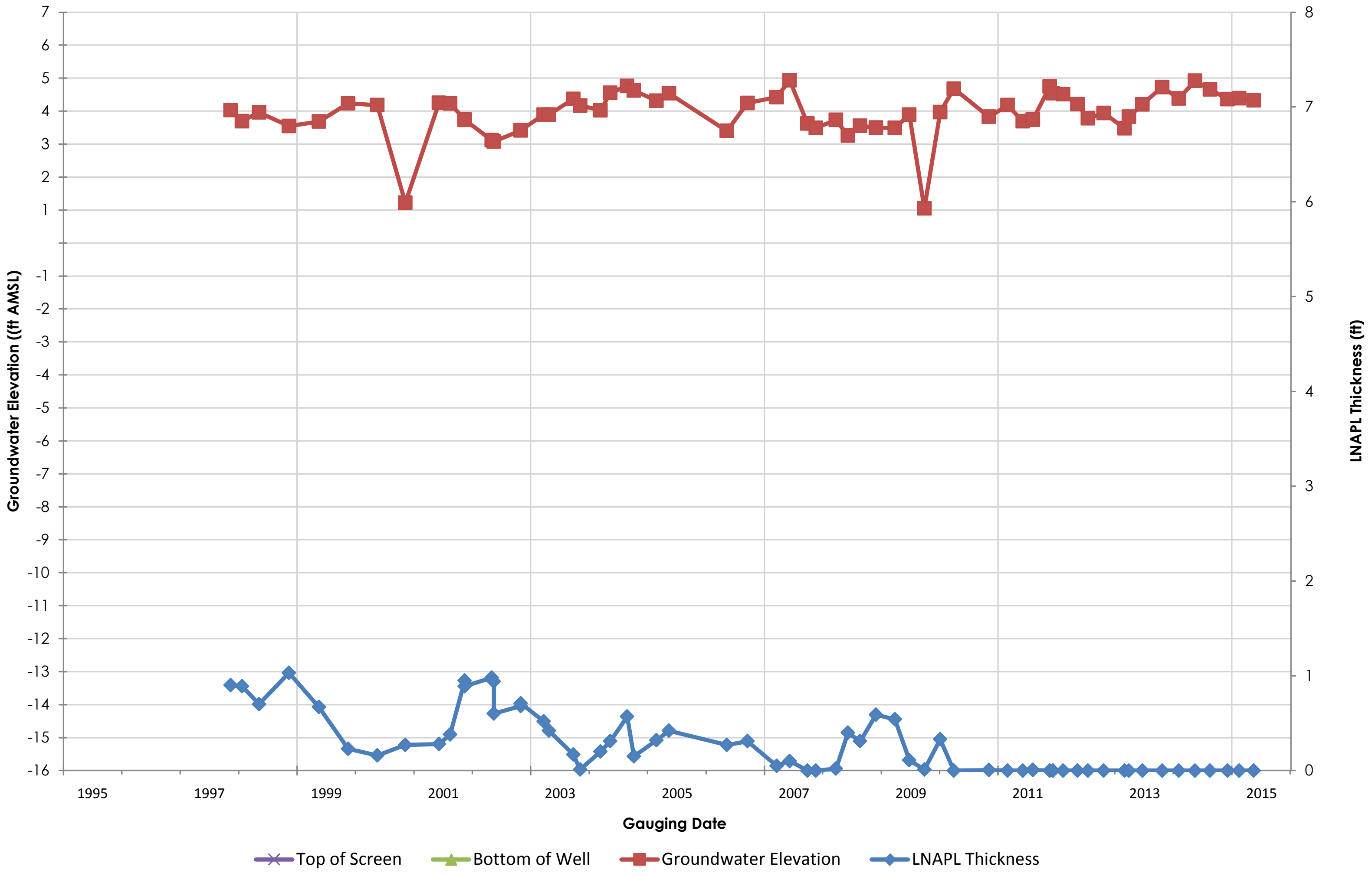
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

OW-20

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

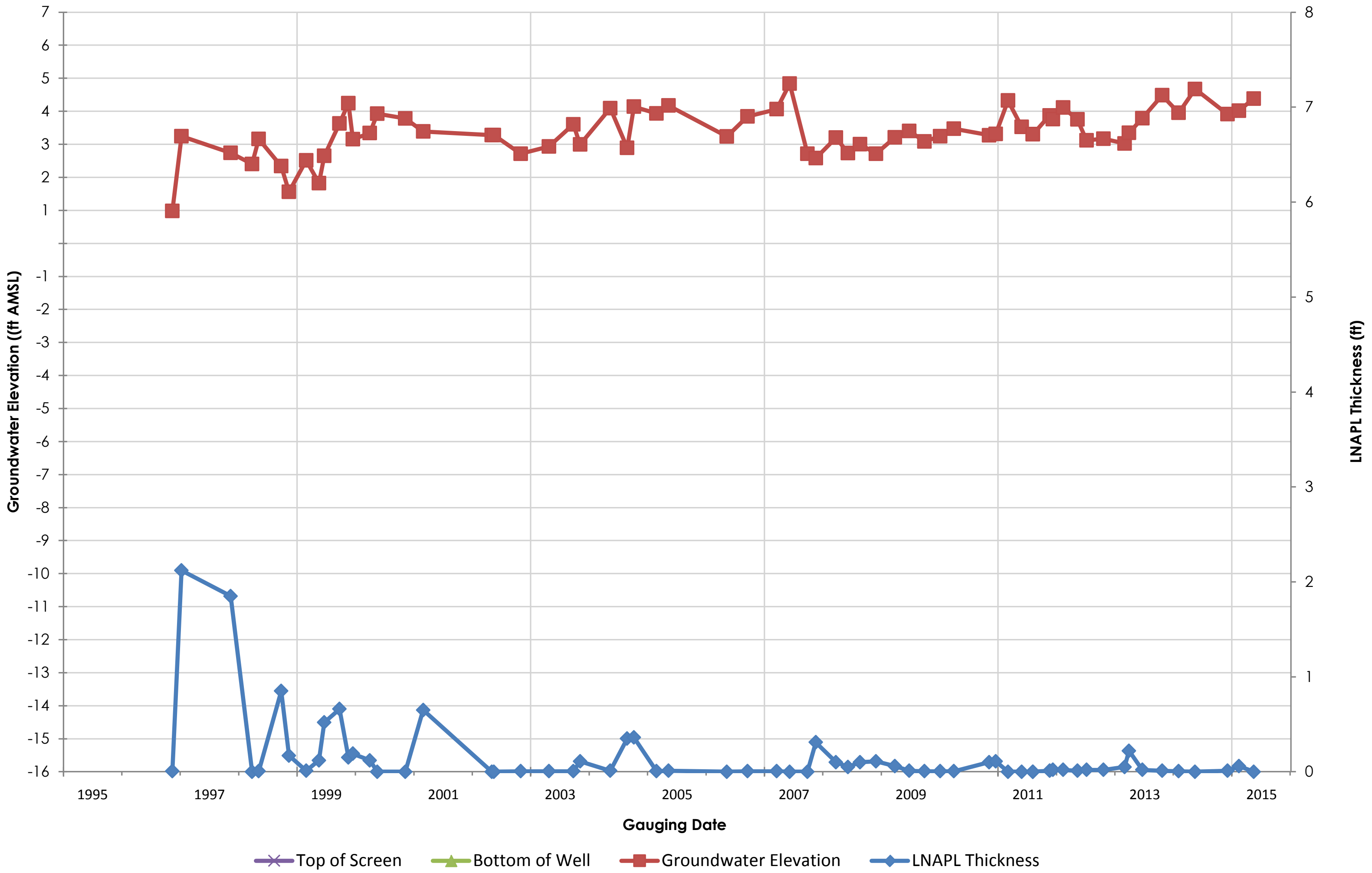
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

PZ-400

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

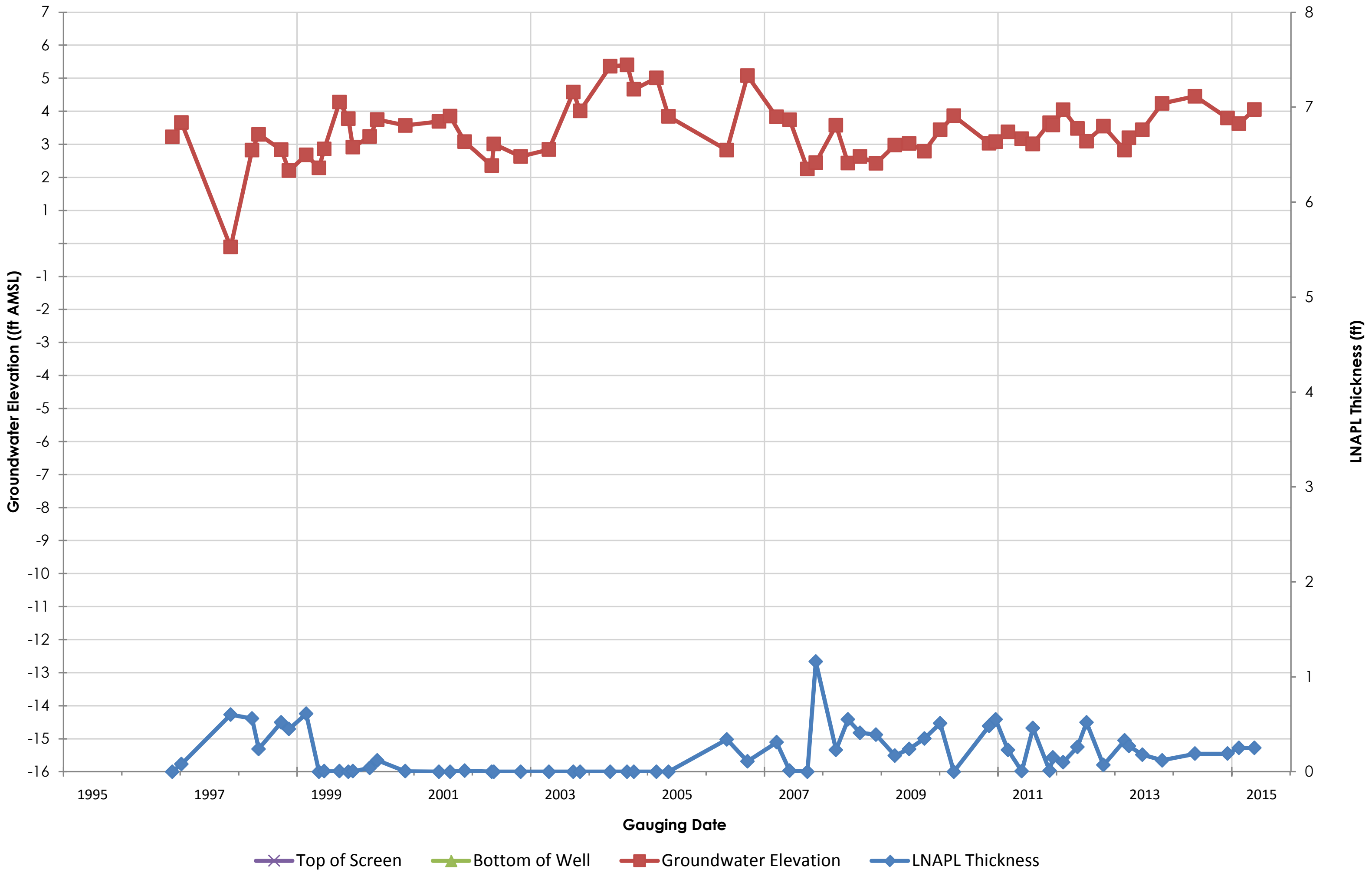
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

PZ-401

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

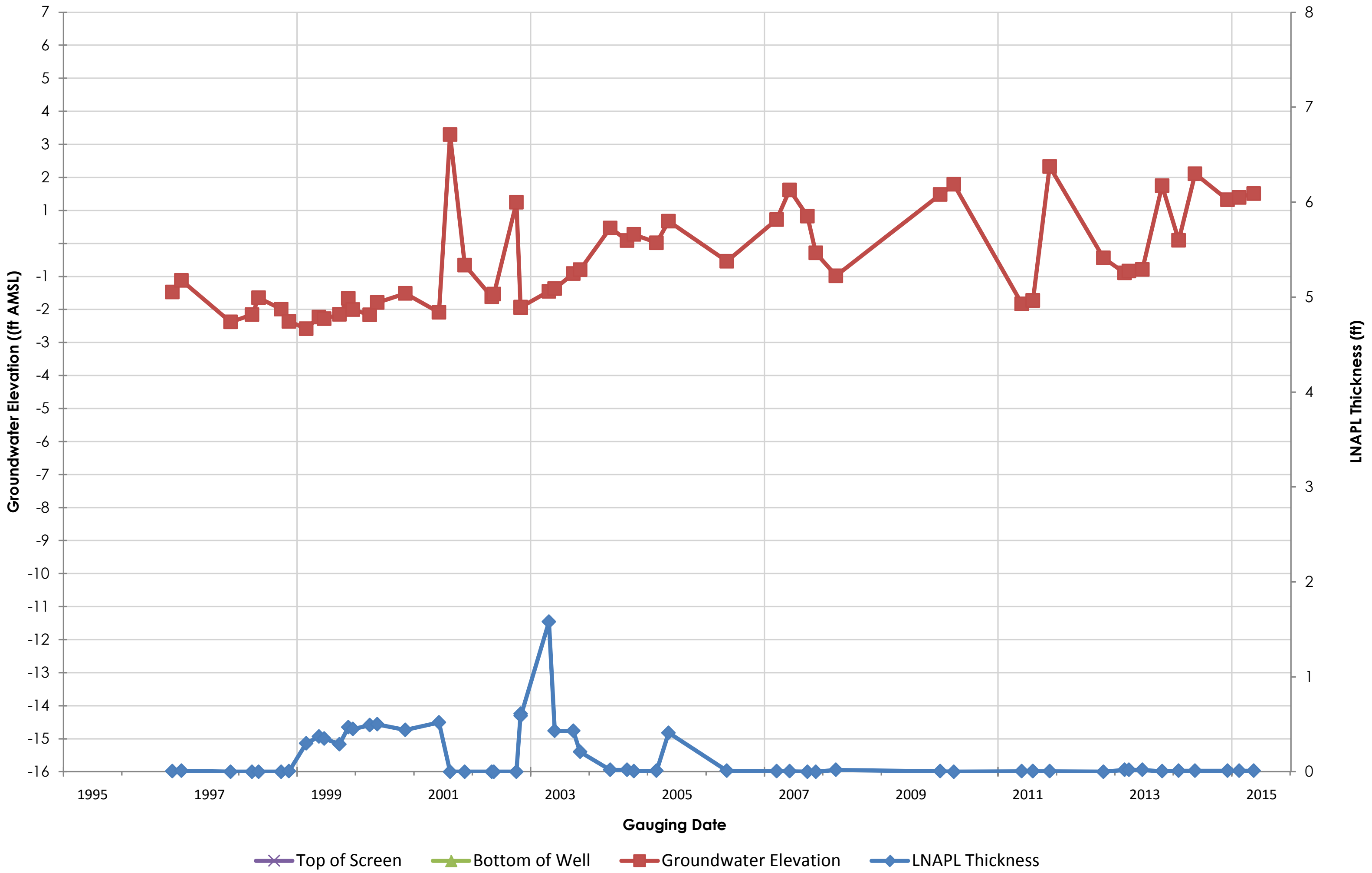
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

PZ-402

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

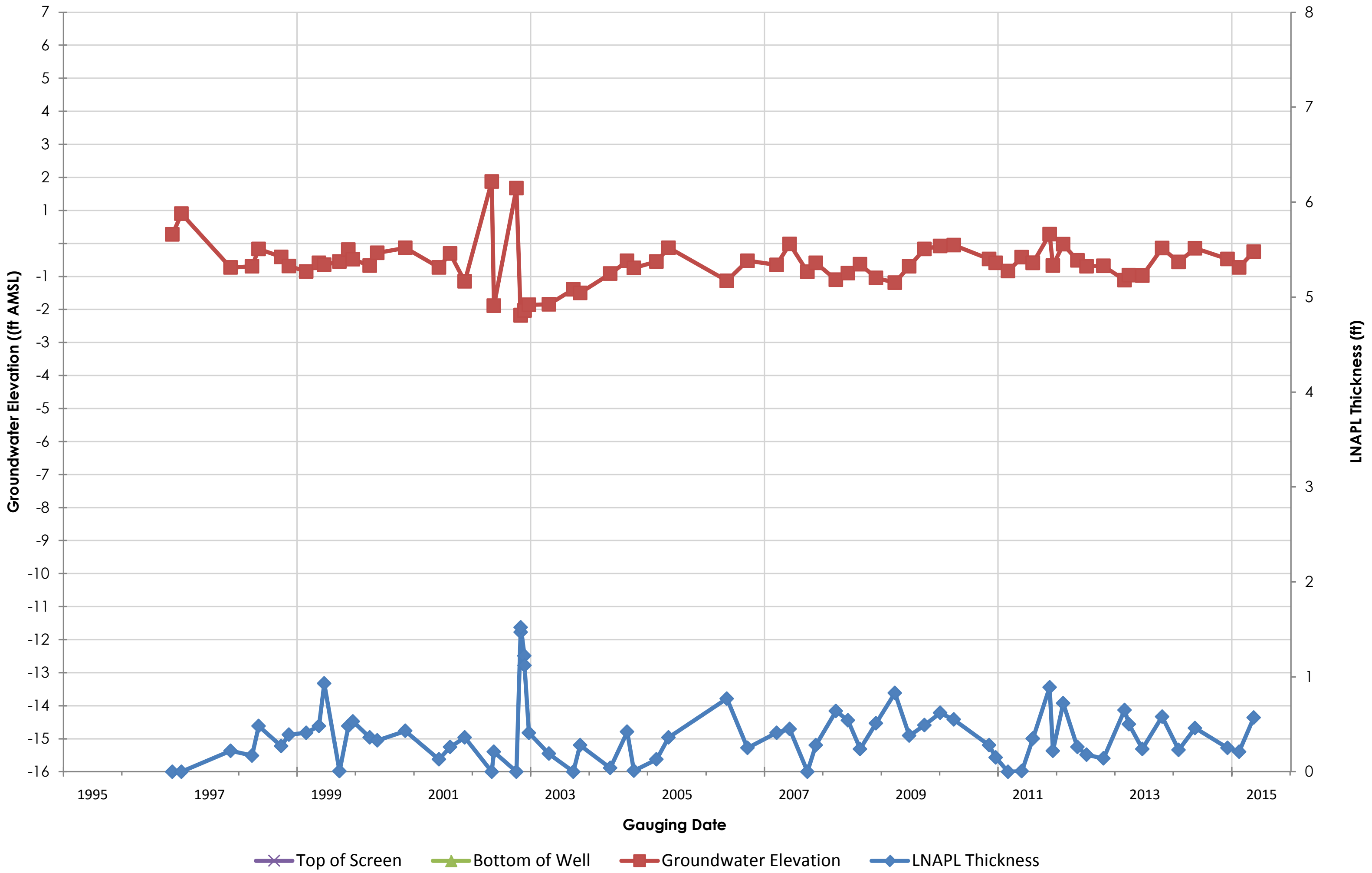
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

PZ-403

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

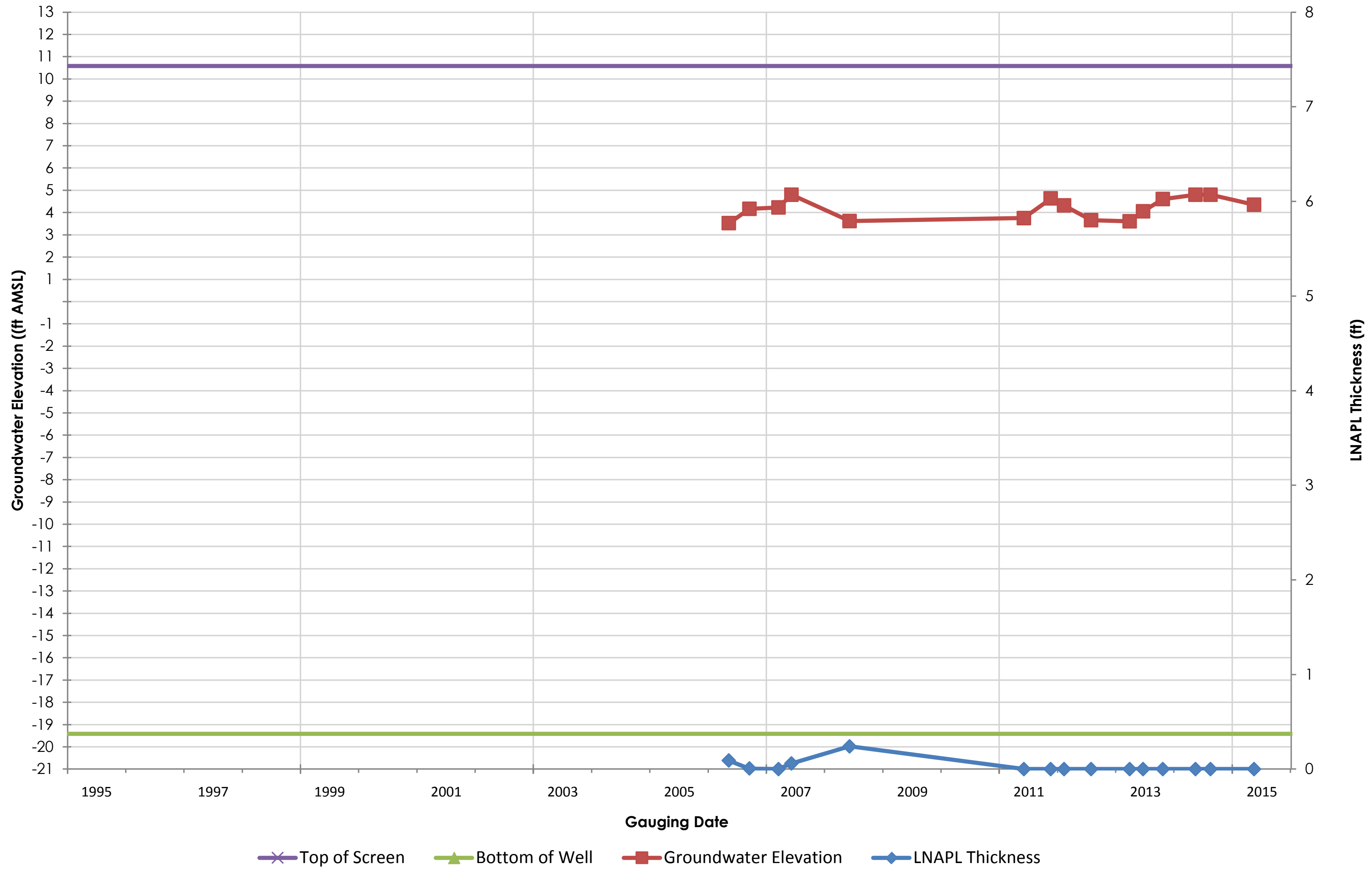
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

PZ-404

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

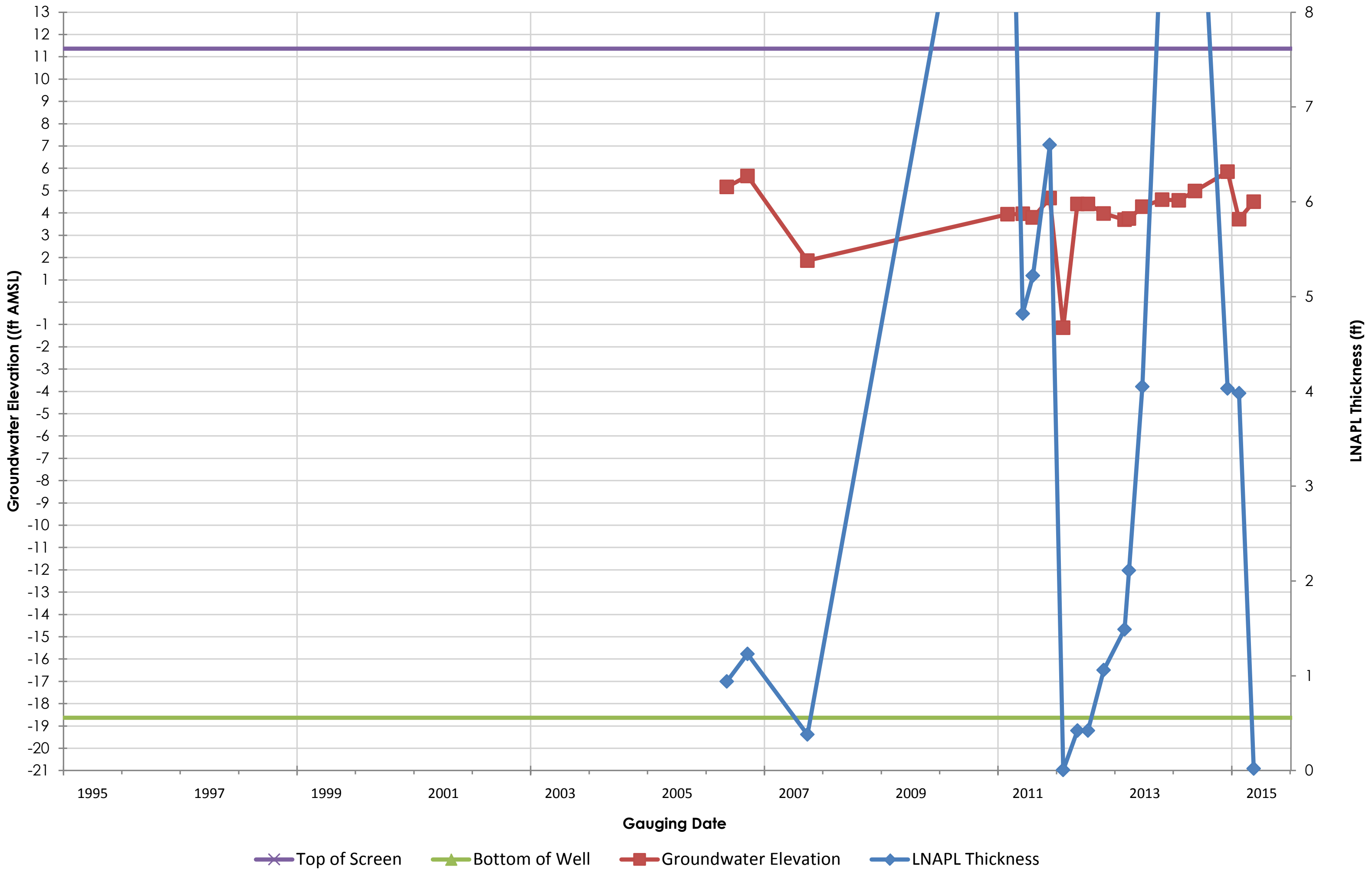
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-1

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

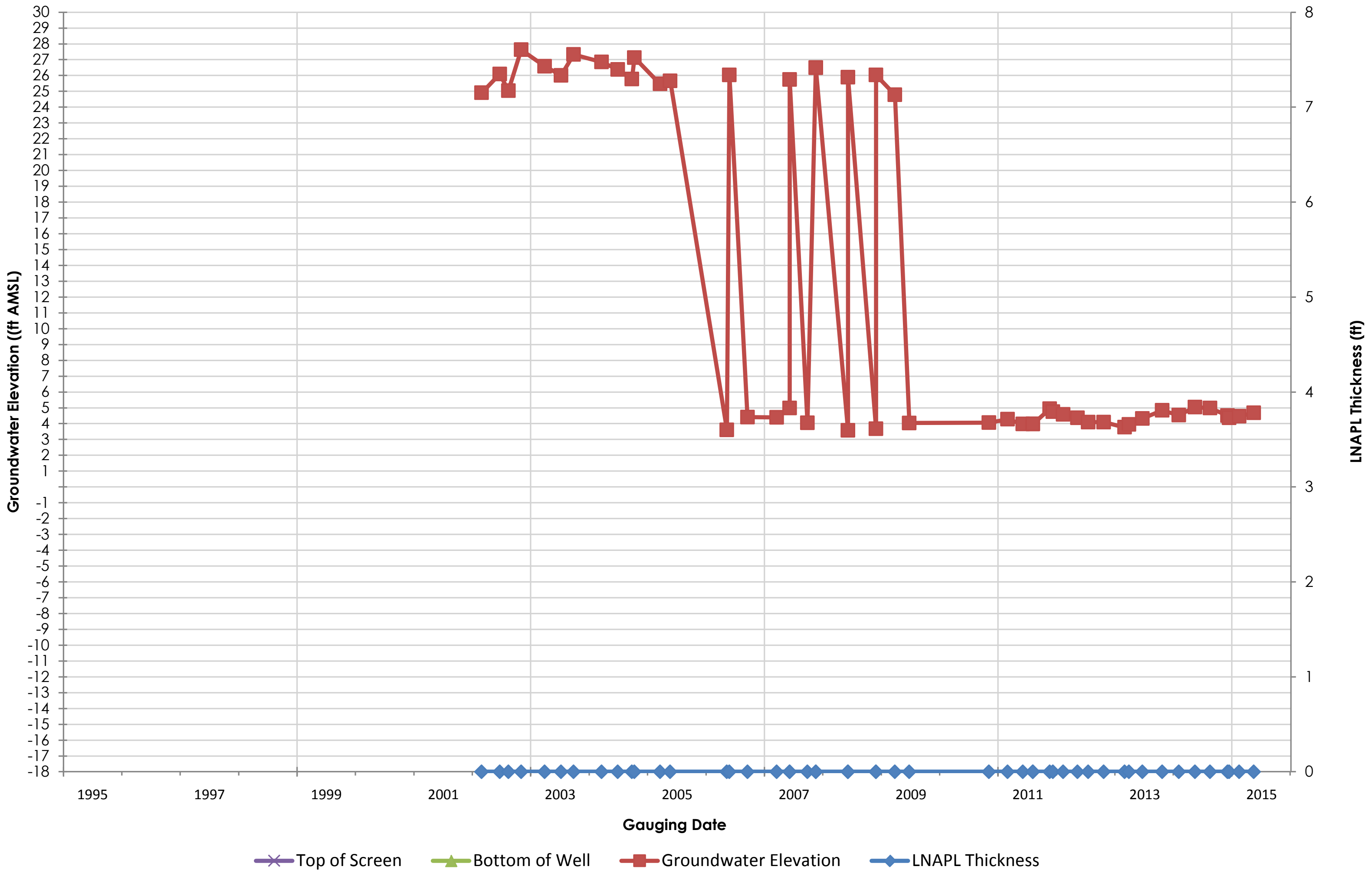
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-4

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

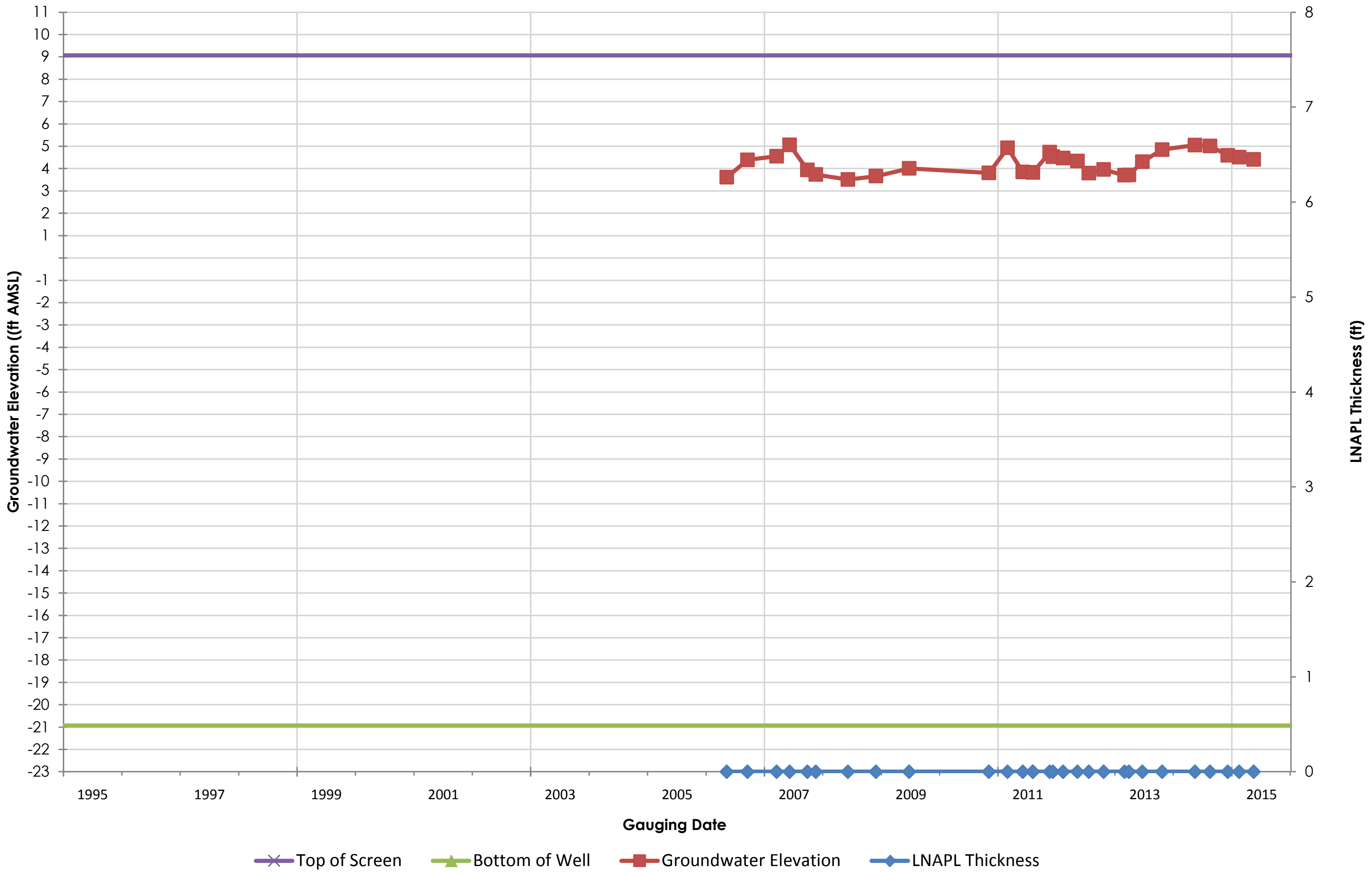
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-6

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

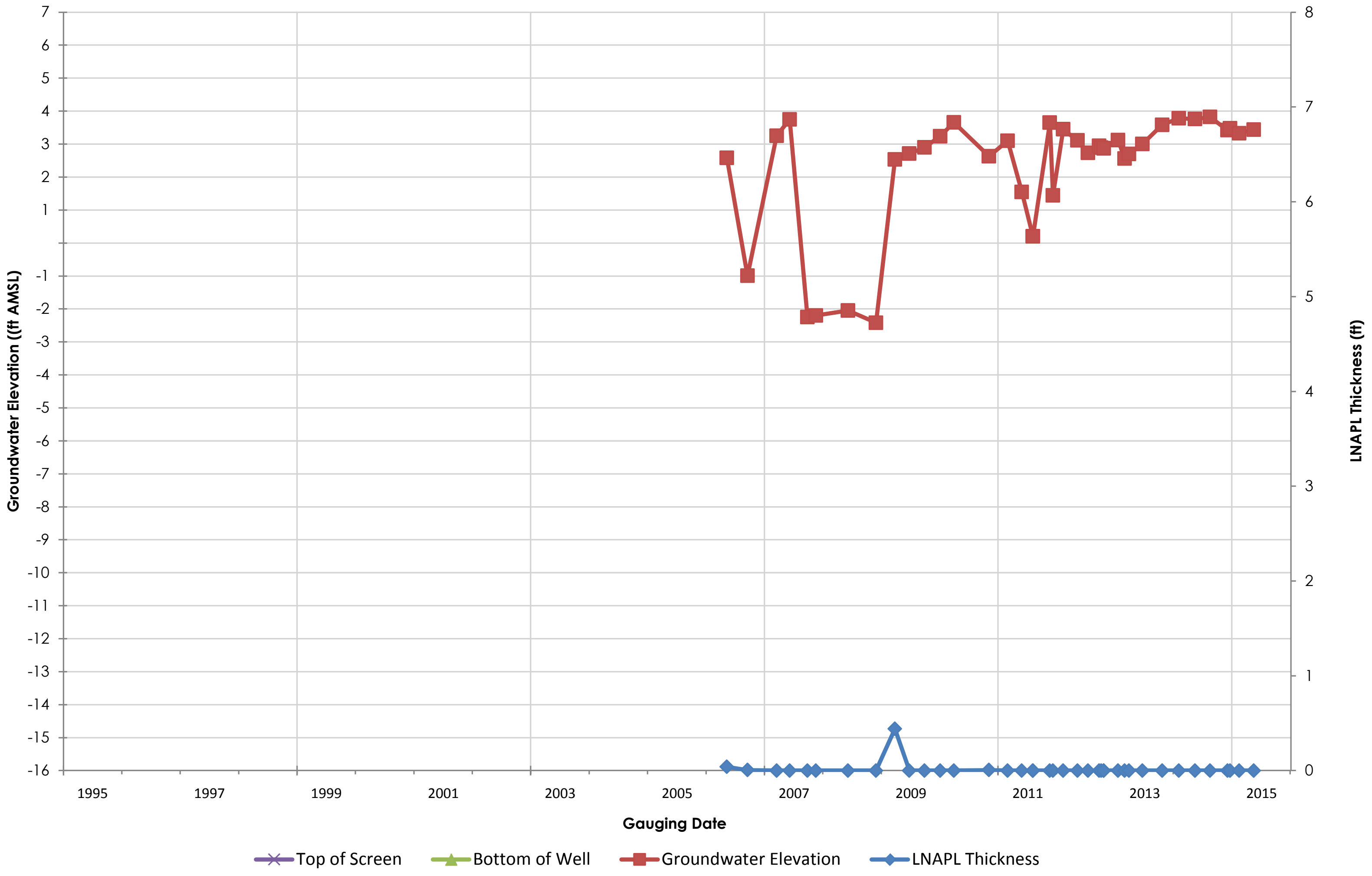
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-7

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

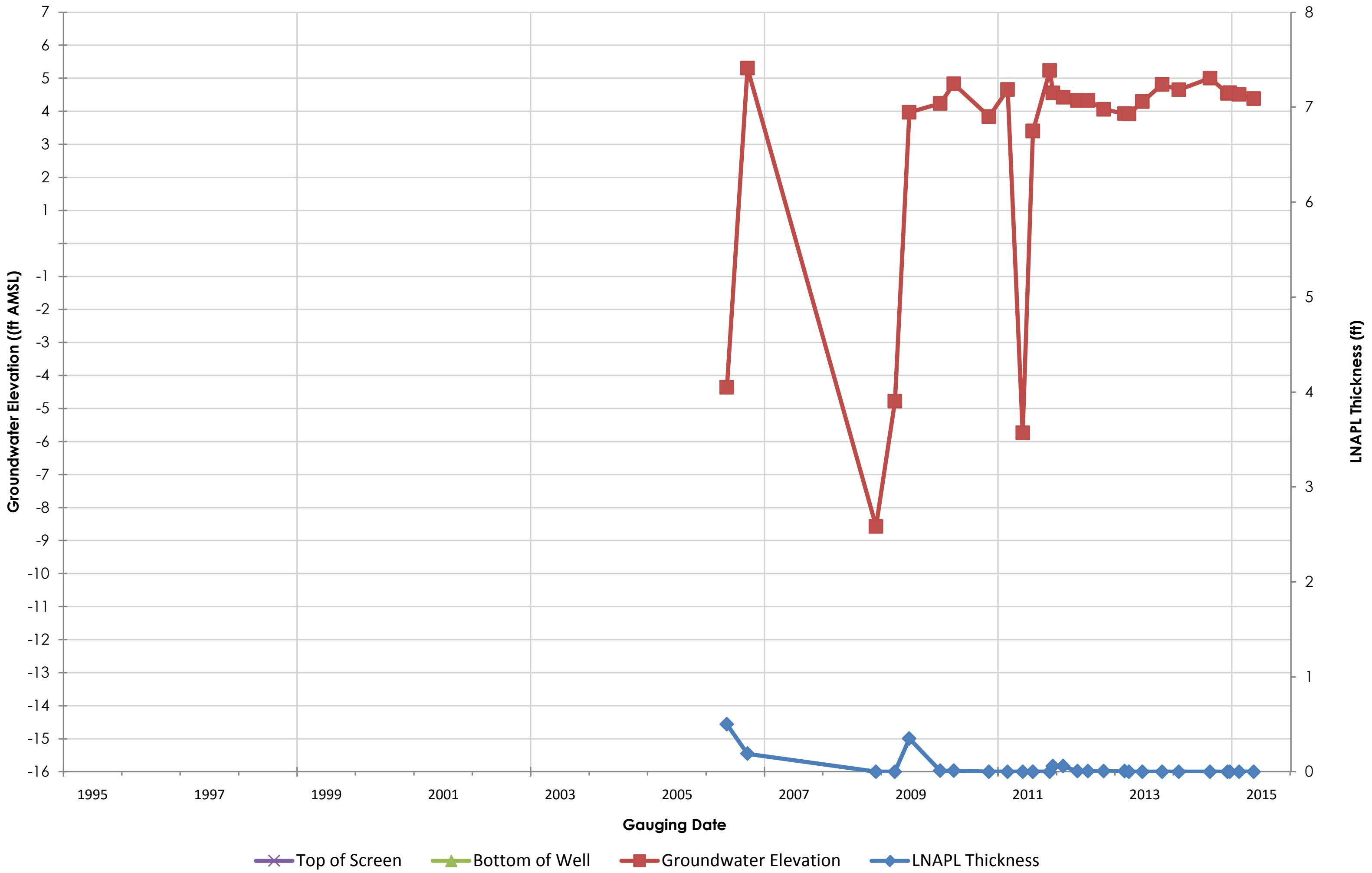
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-15

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

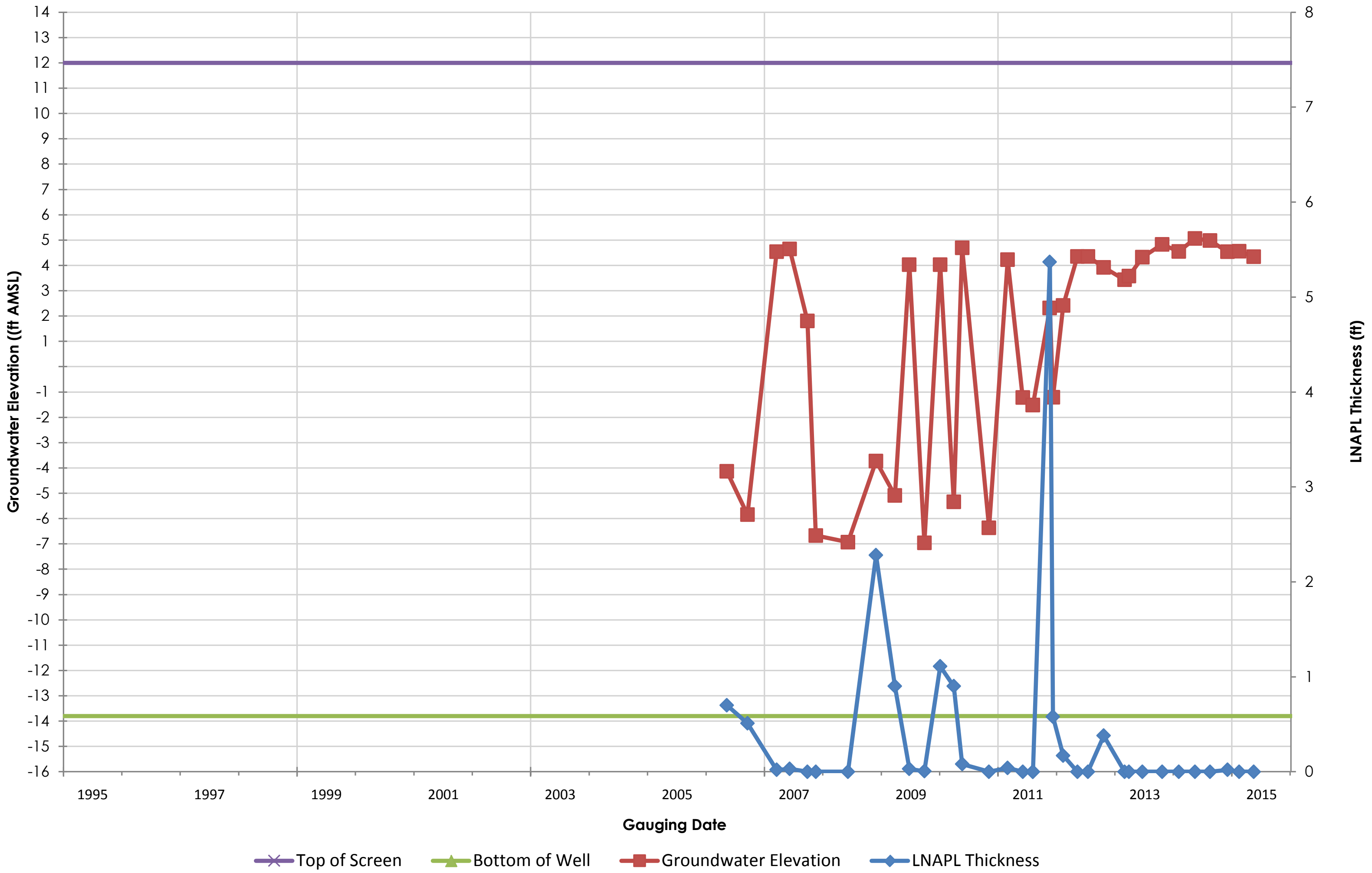
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-21

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

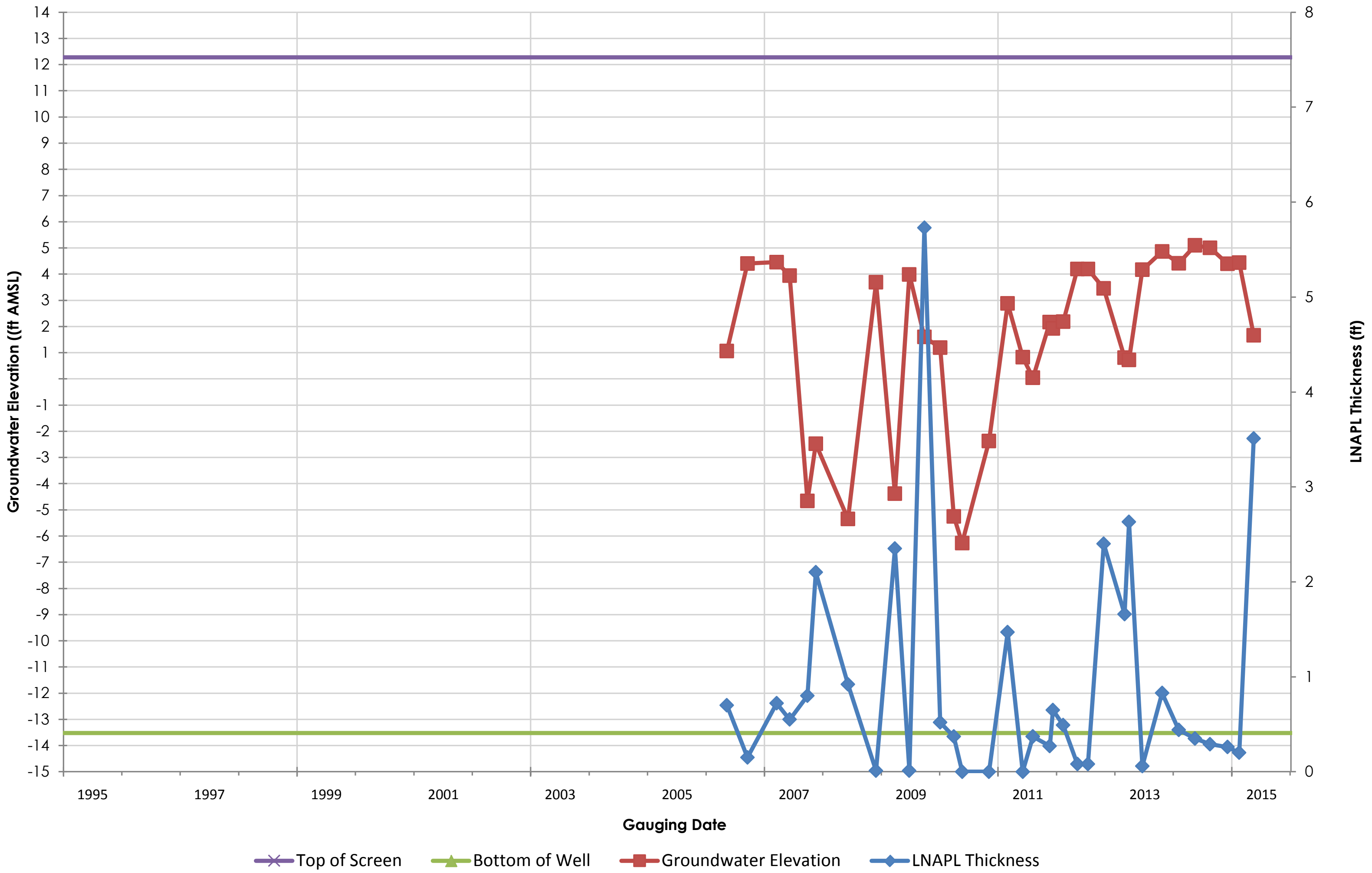
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-22

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

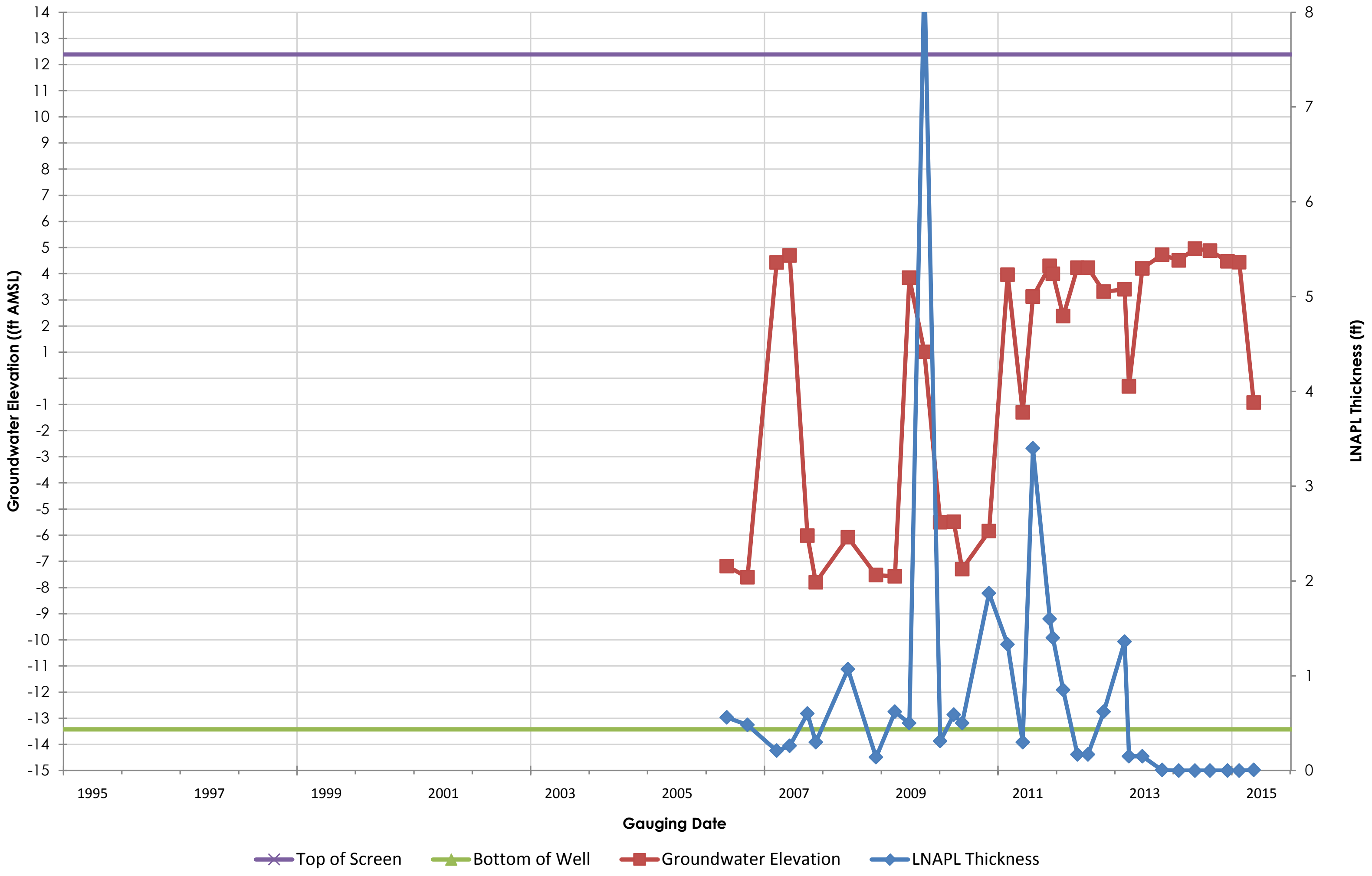
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-23

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

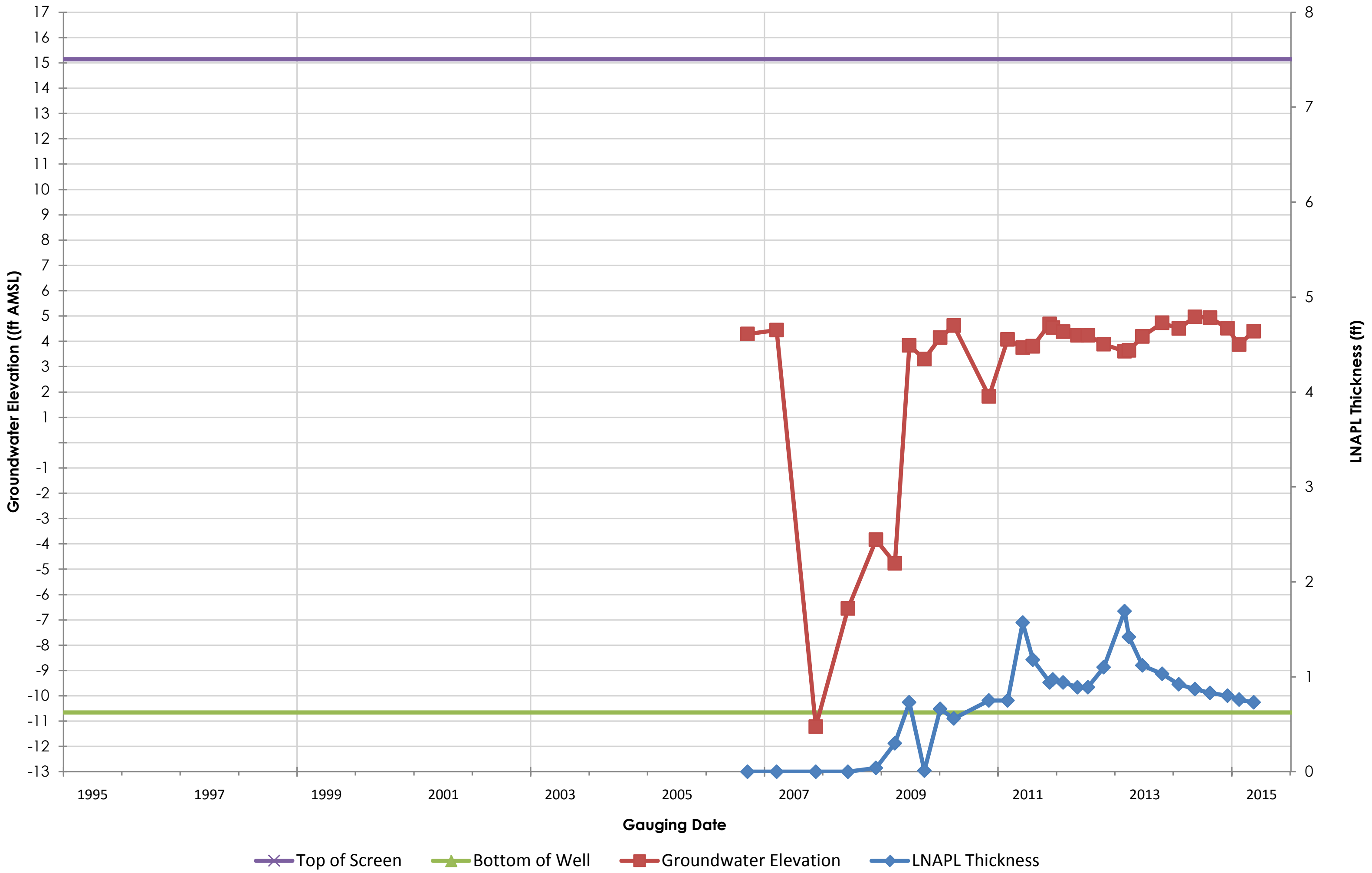
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-24

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

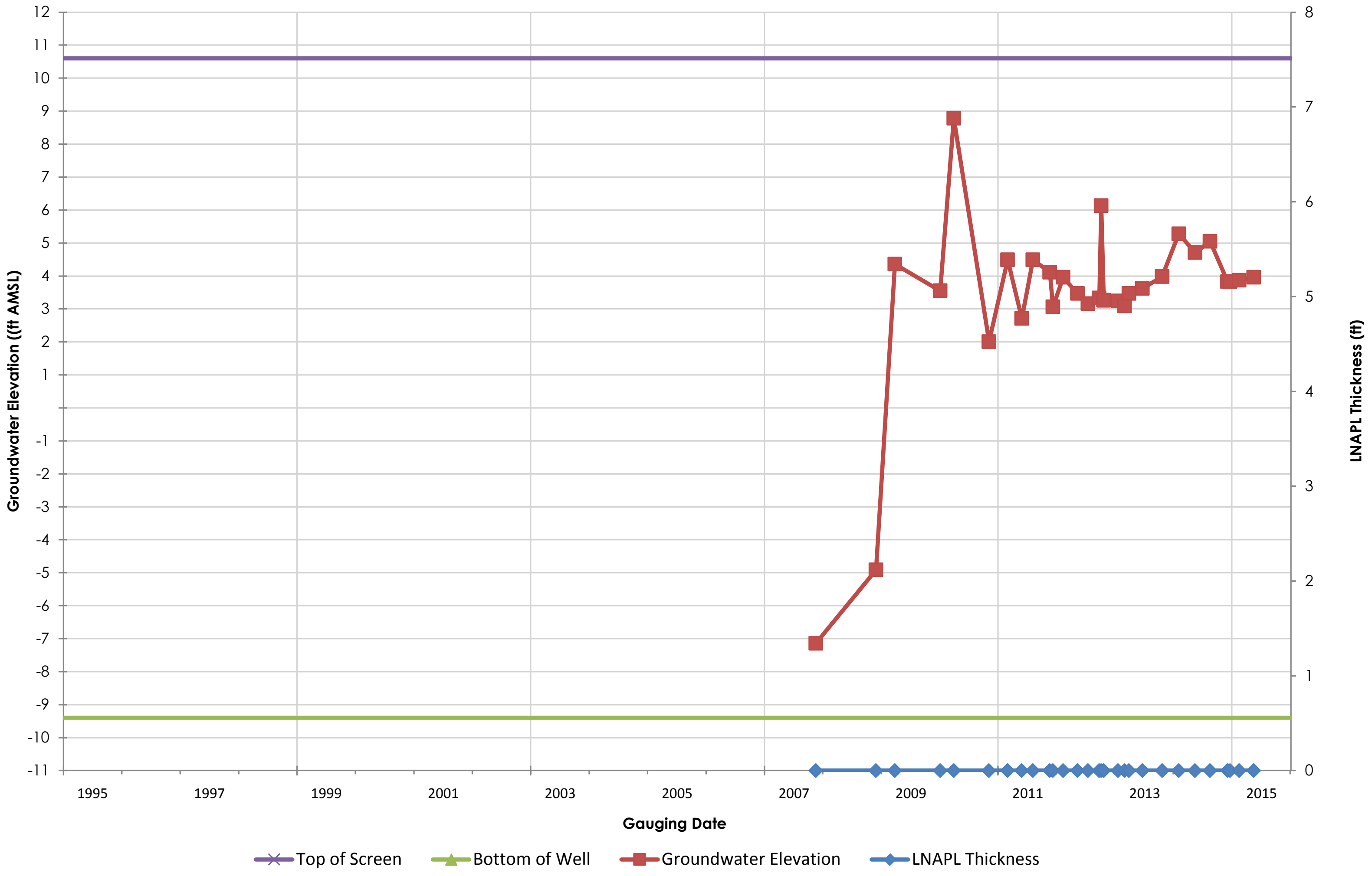
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-25

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

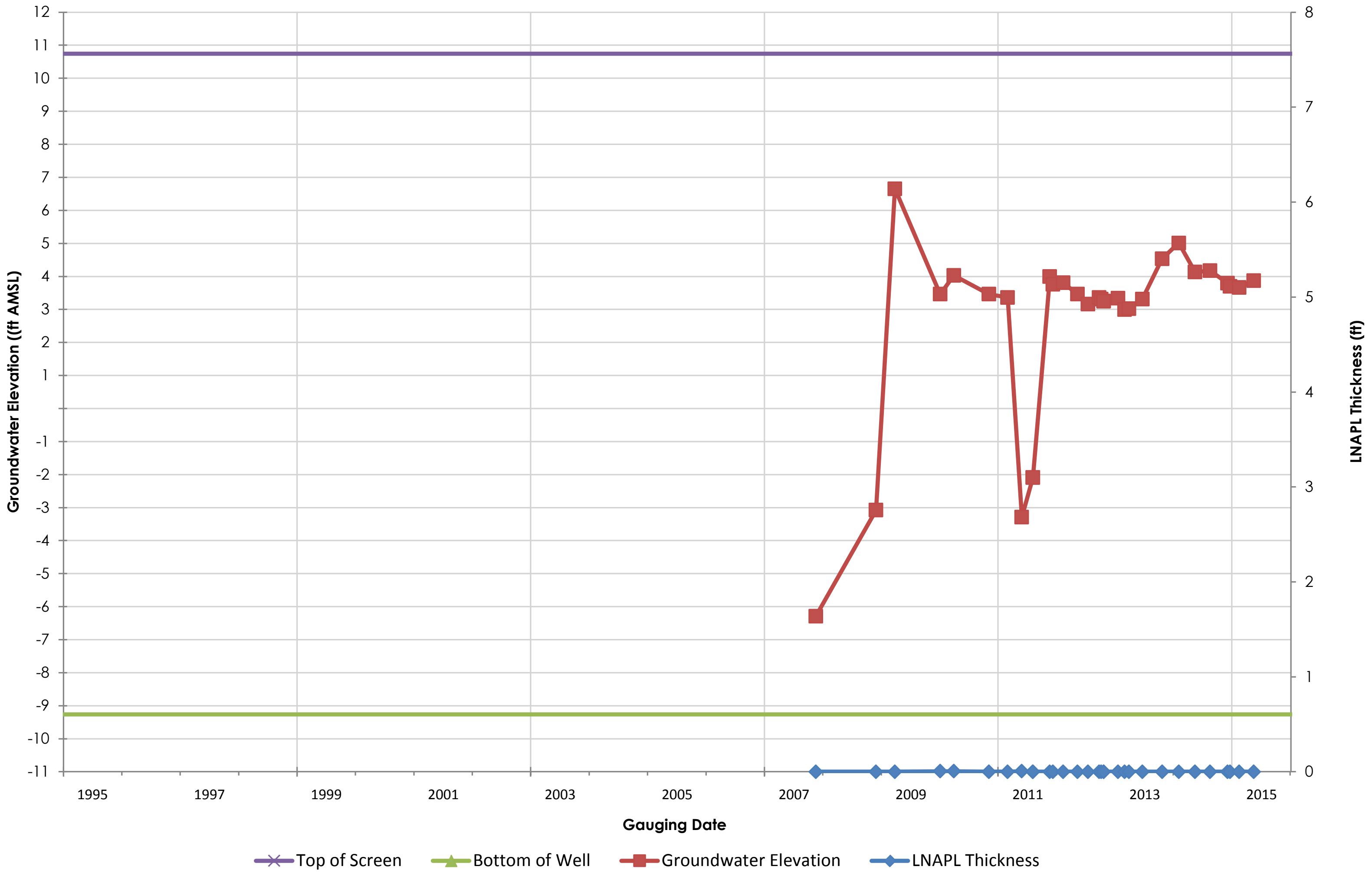
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-26

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

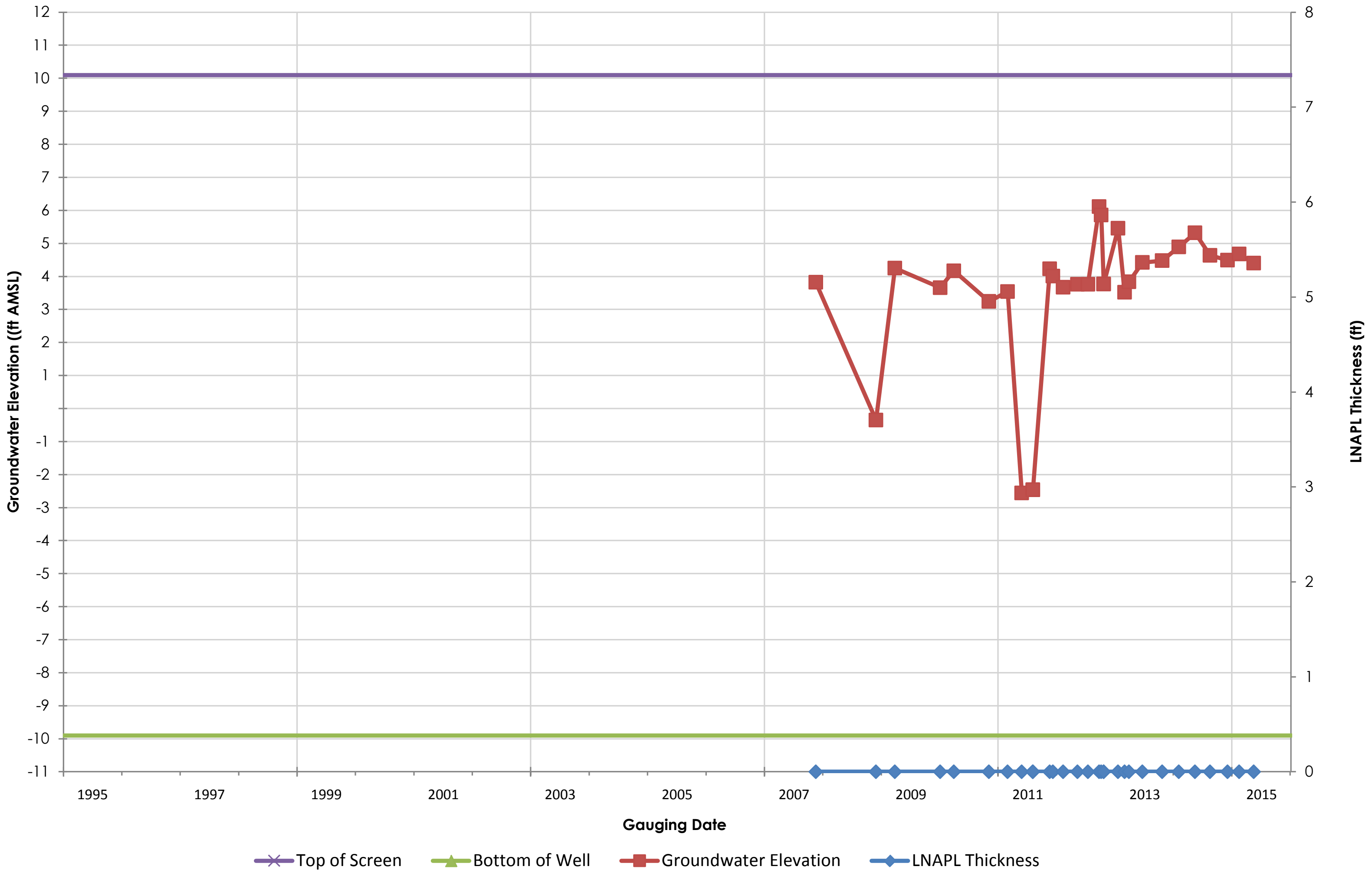
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-27

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

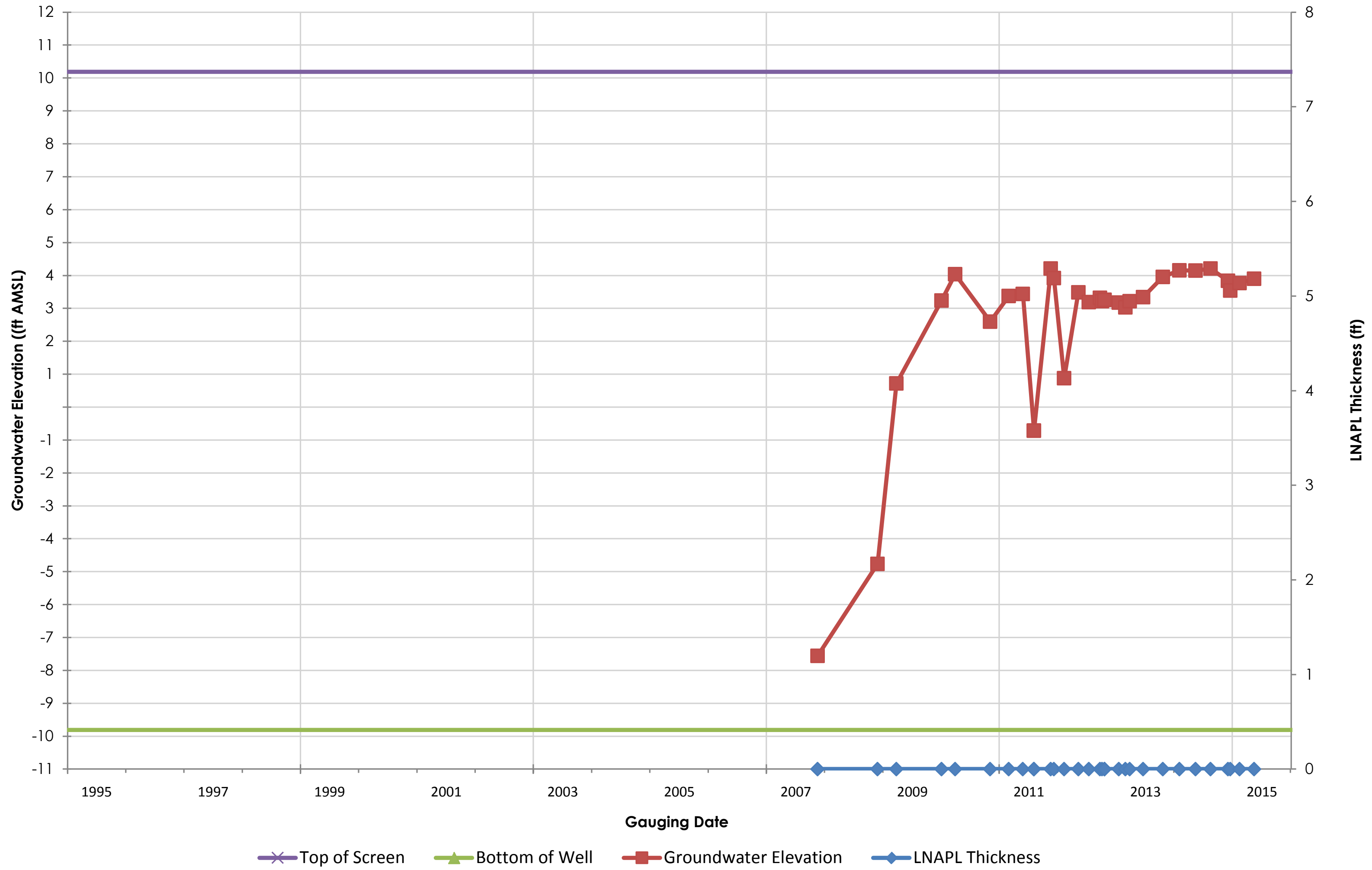
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-28

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Stantec

Client/Project

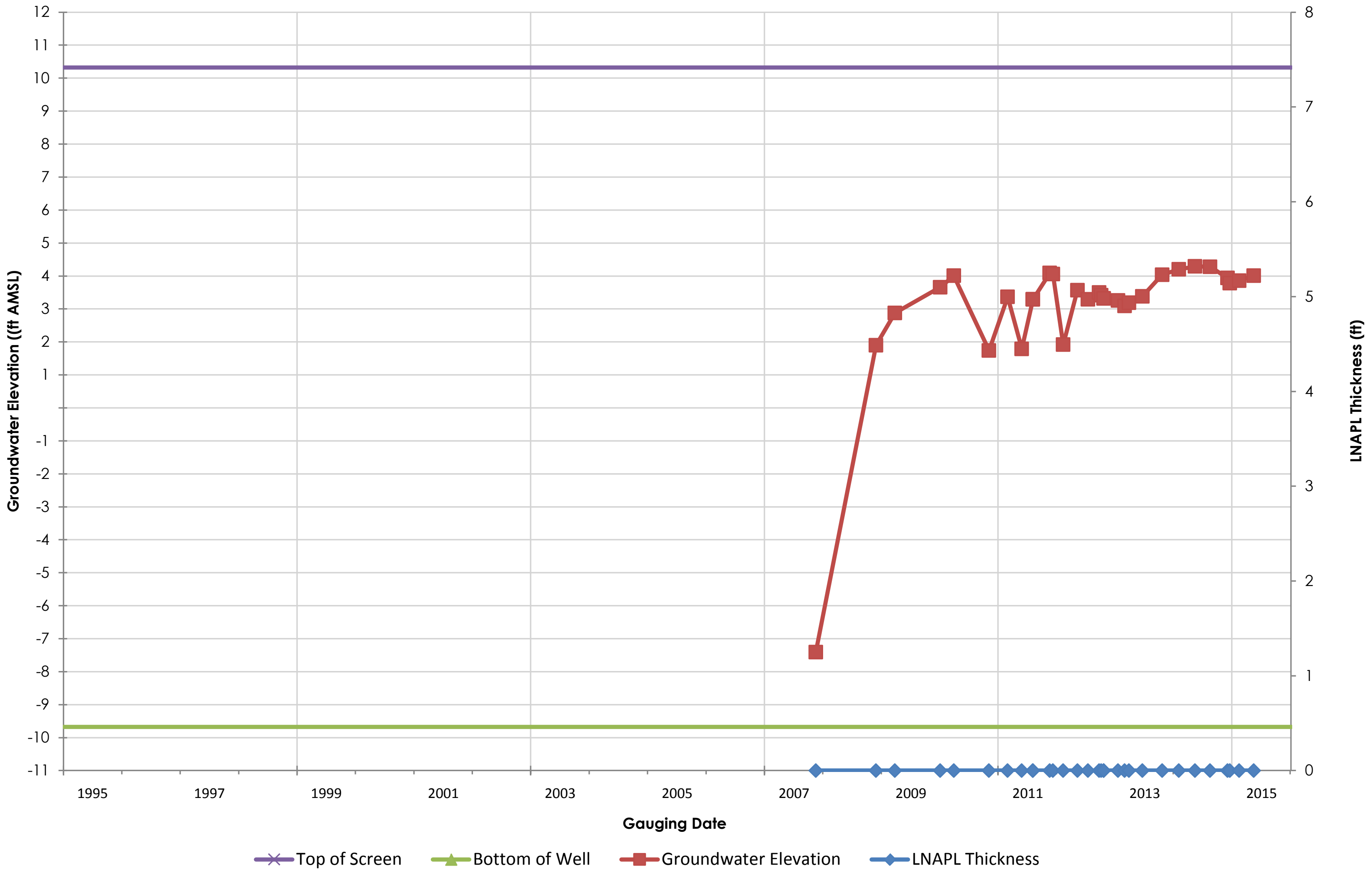
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-29

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

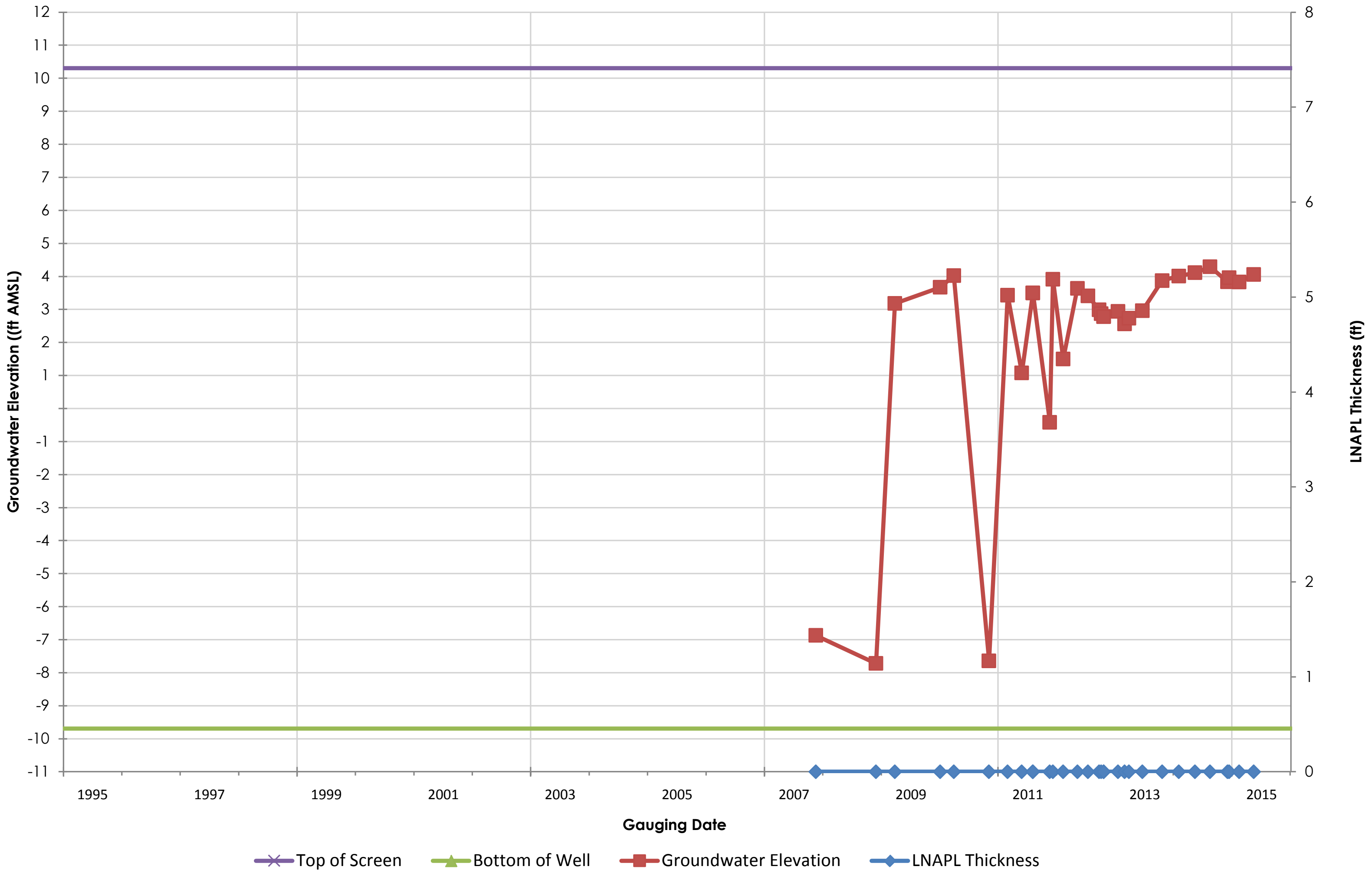
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-30

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

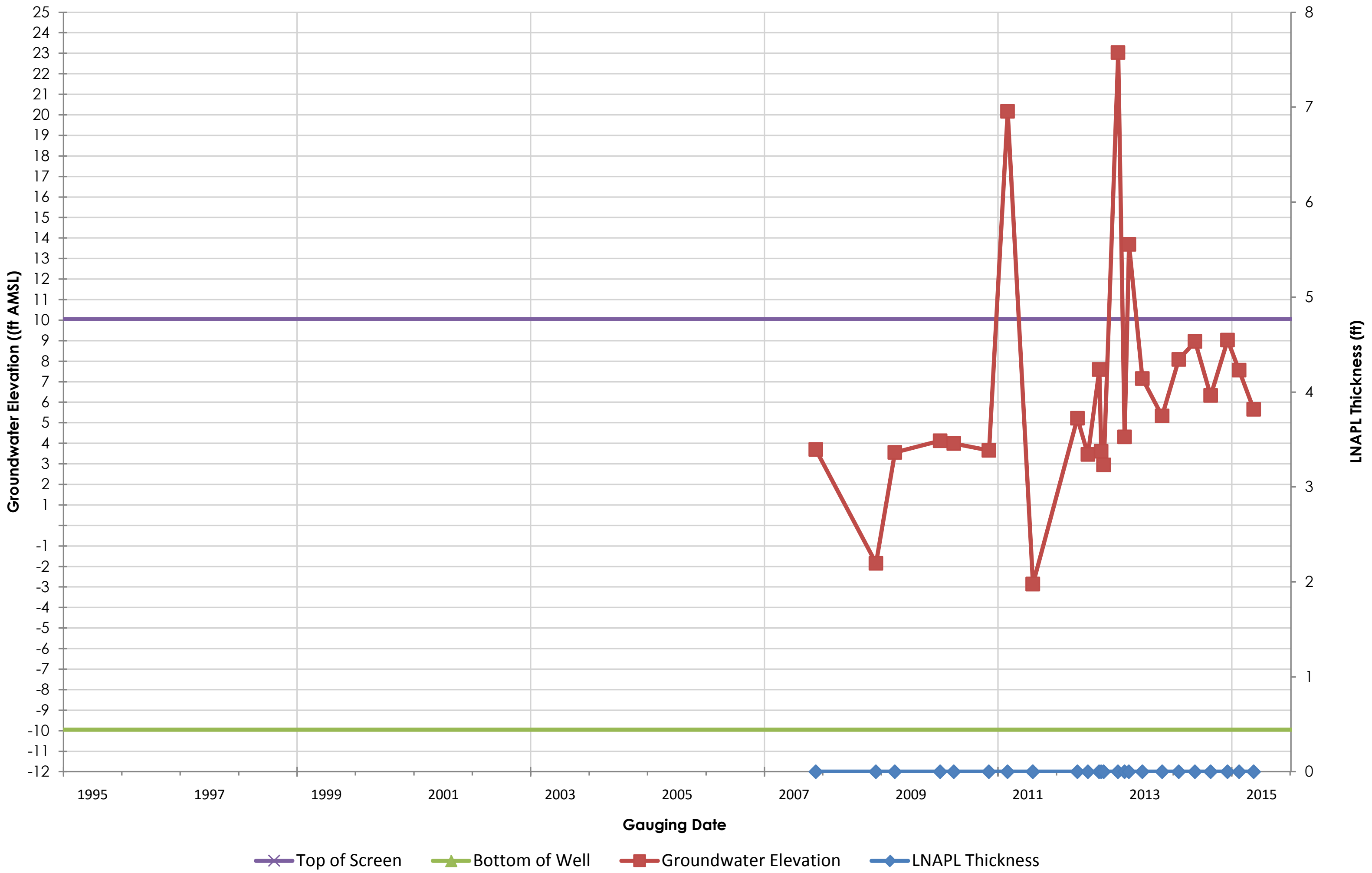
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-31

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

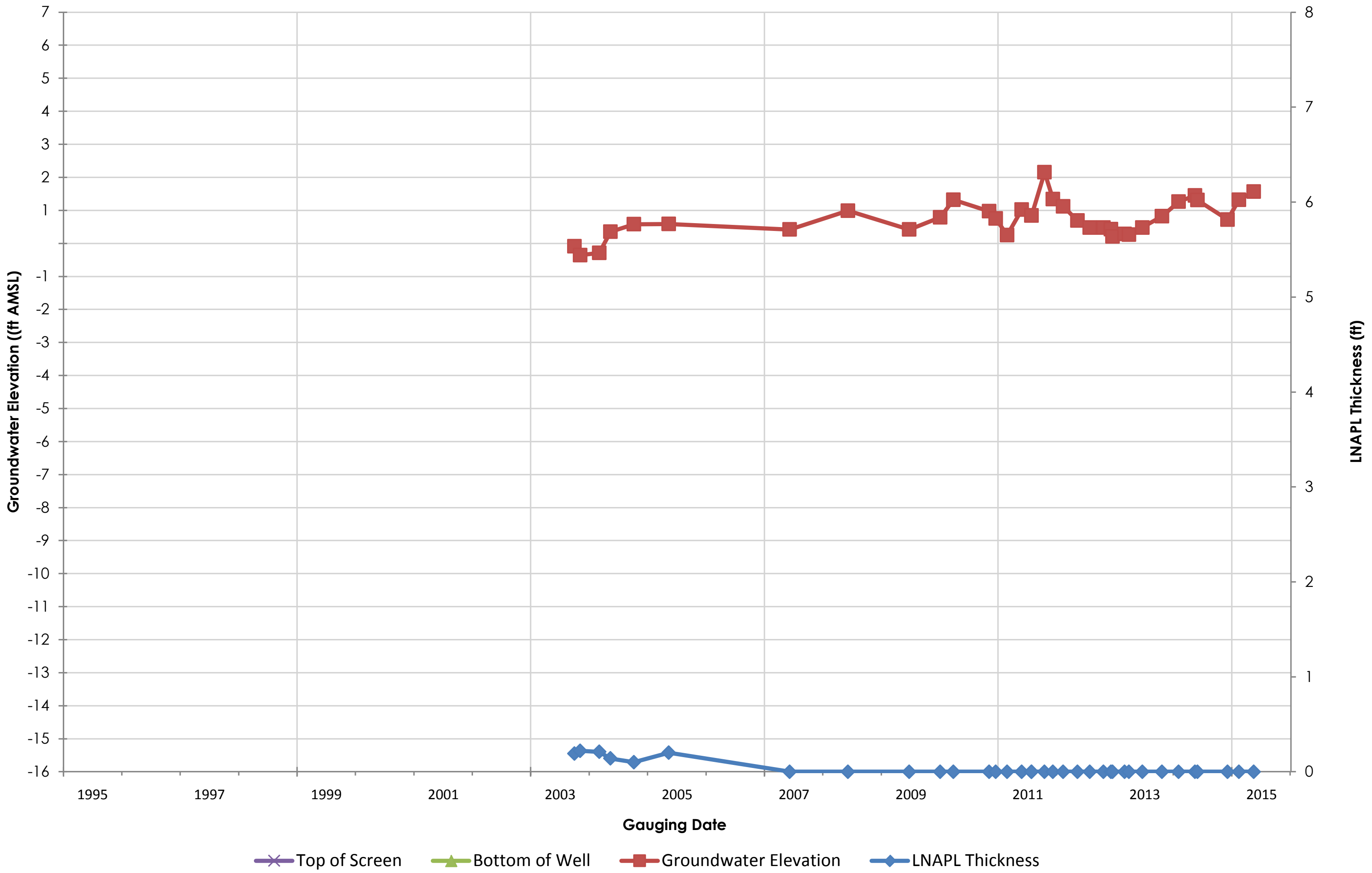
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-32

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

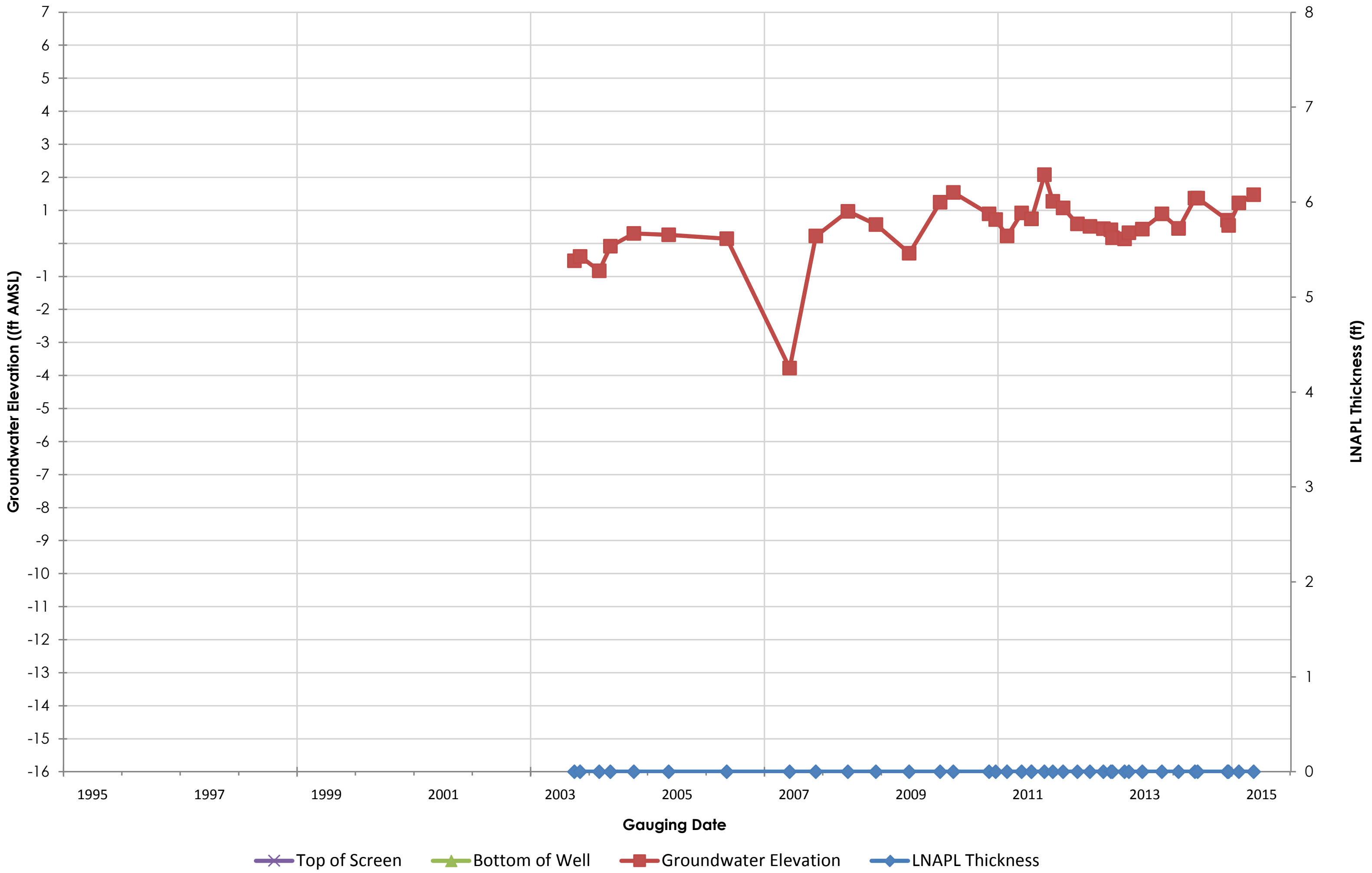
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-110

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

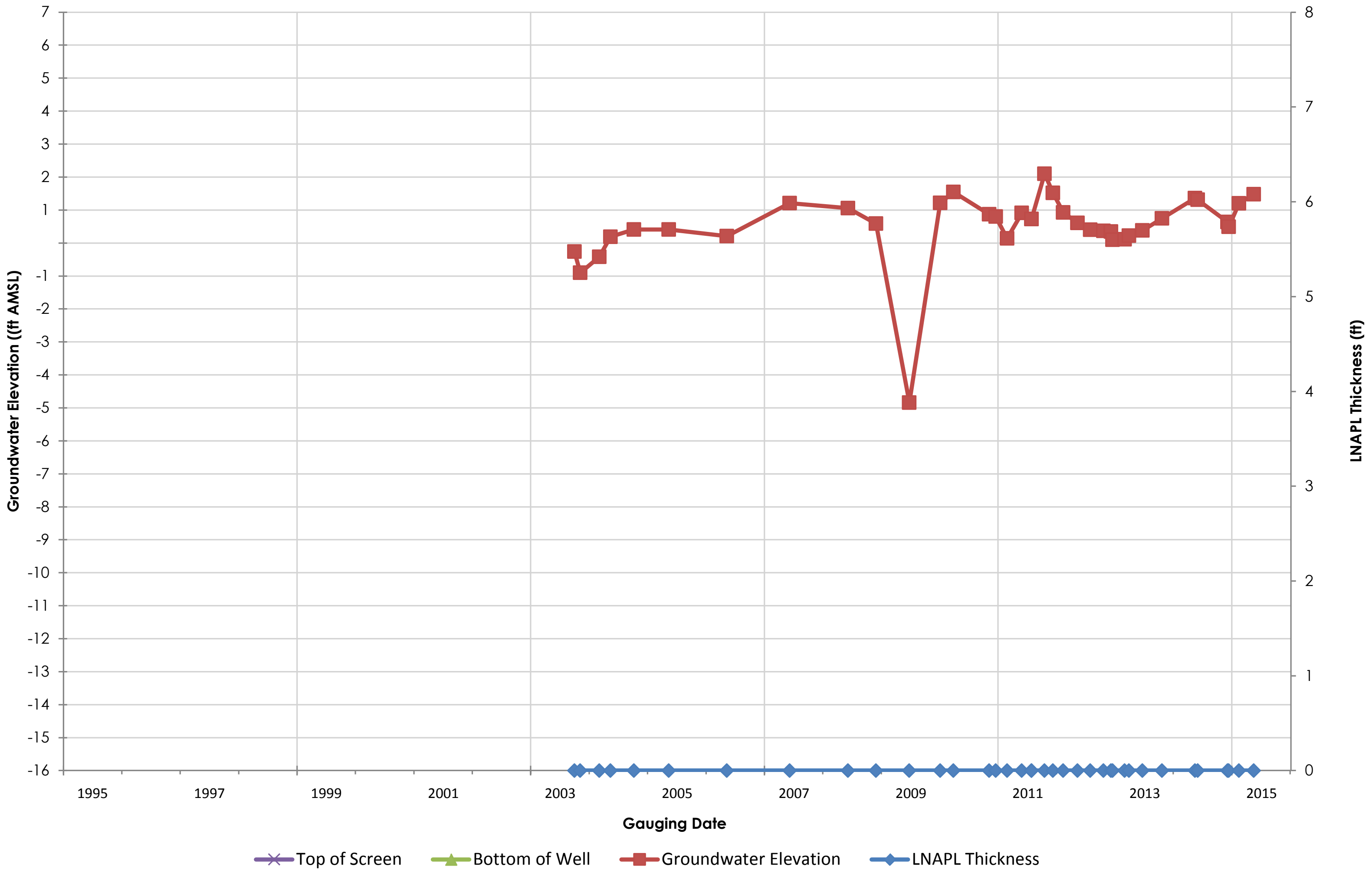
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-111

Title

**Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval**



Client/Project

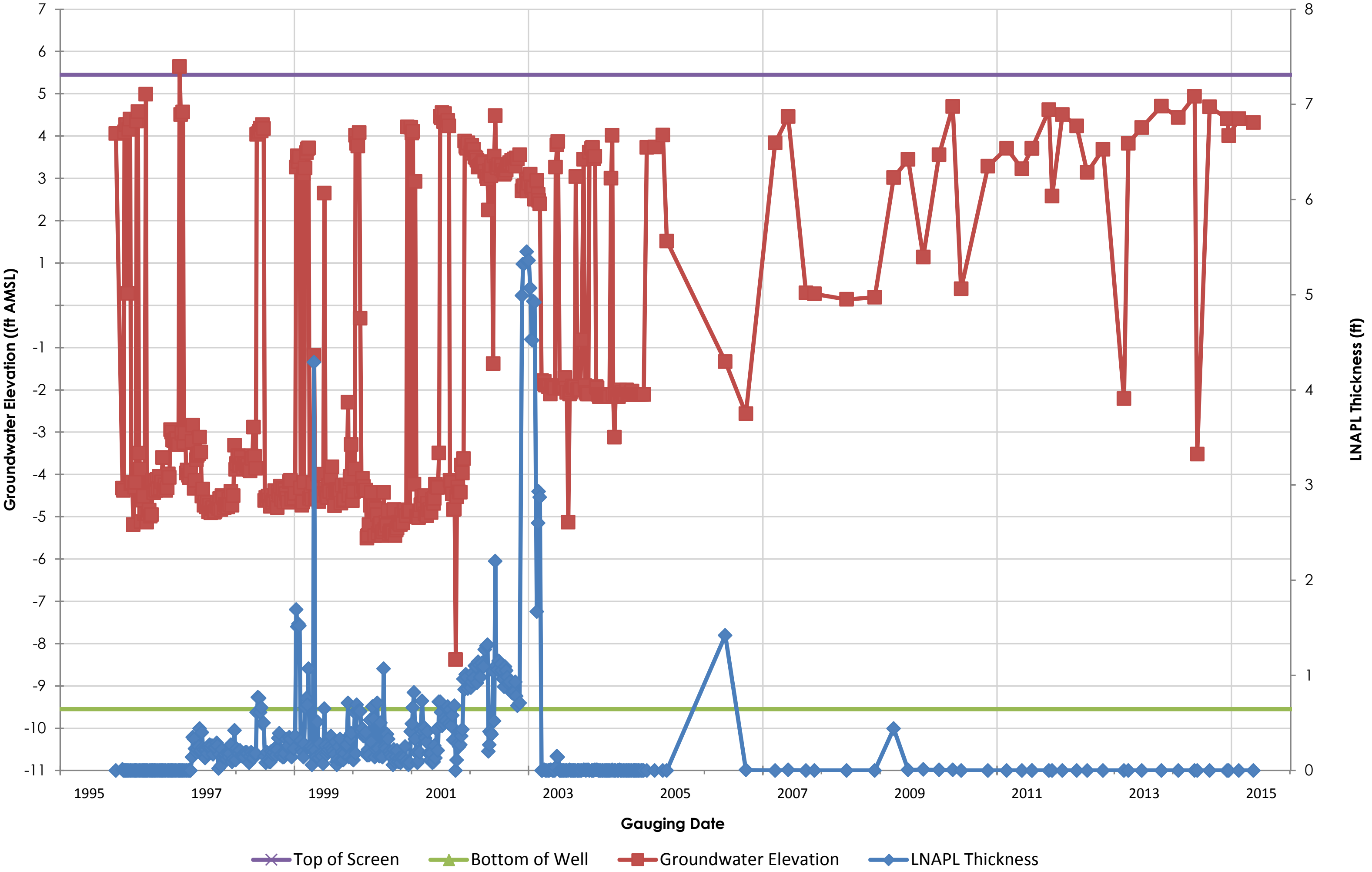
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-112

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

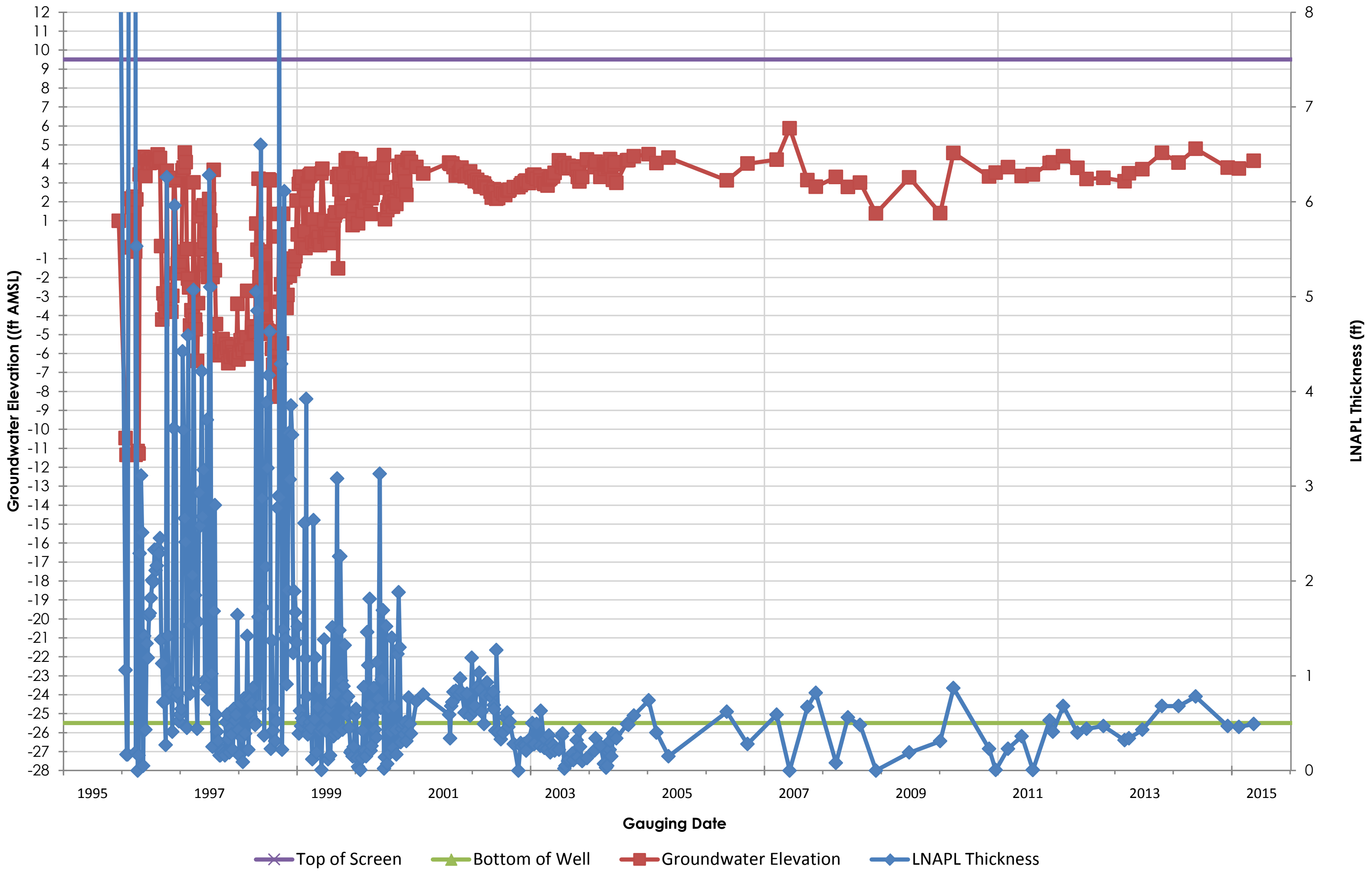
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-400

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

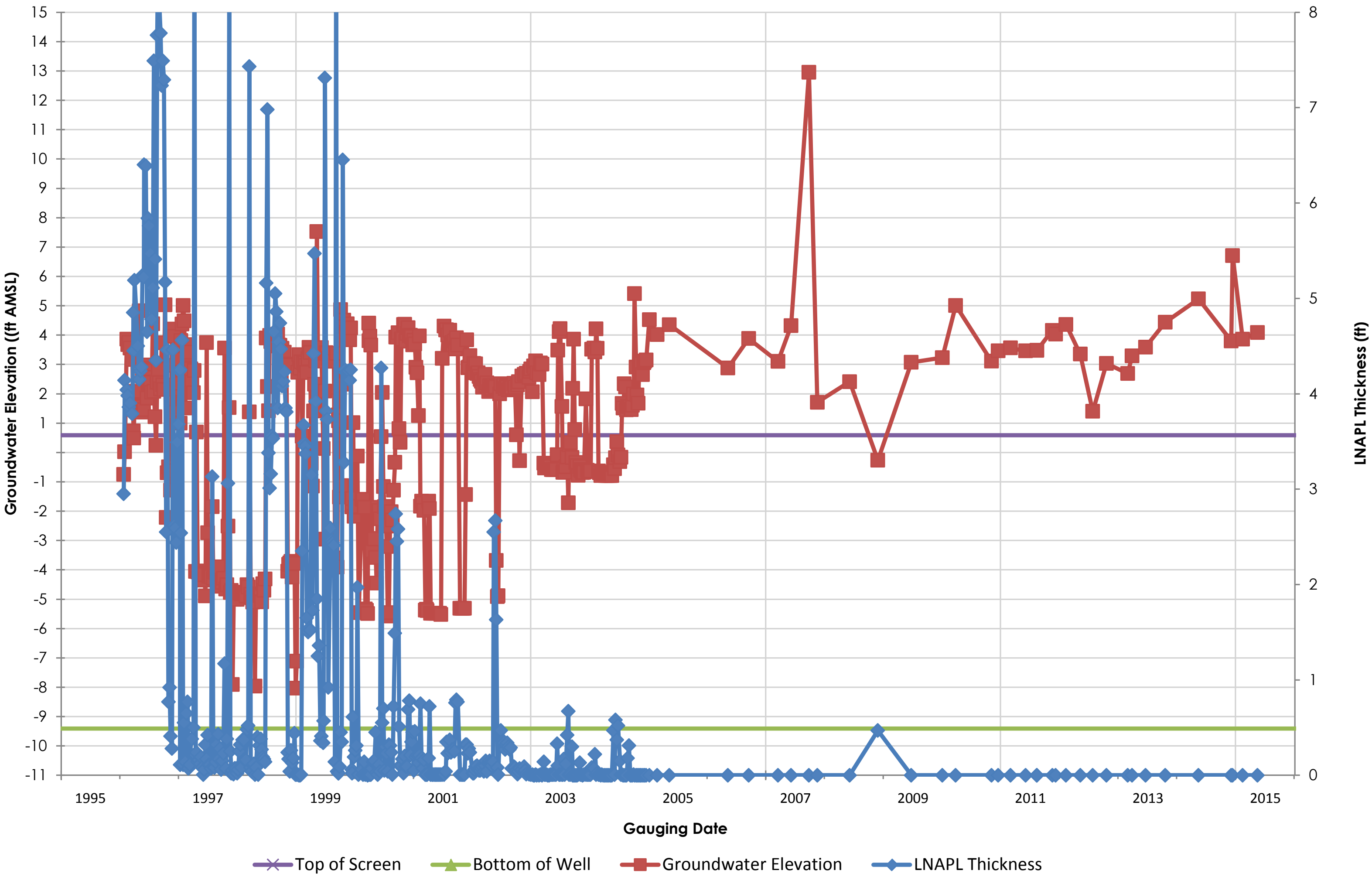
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-401

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

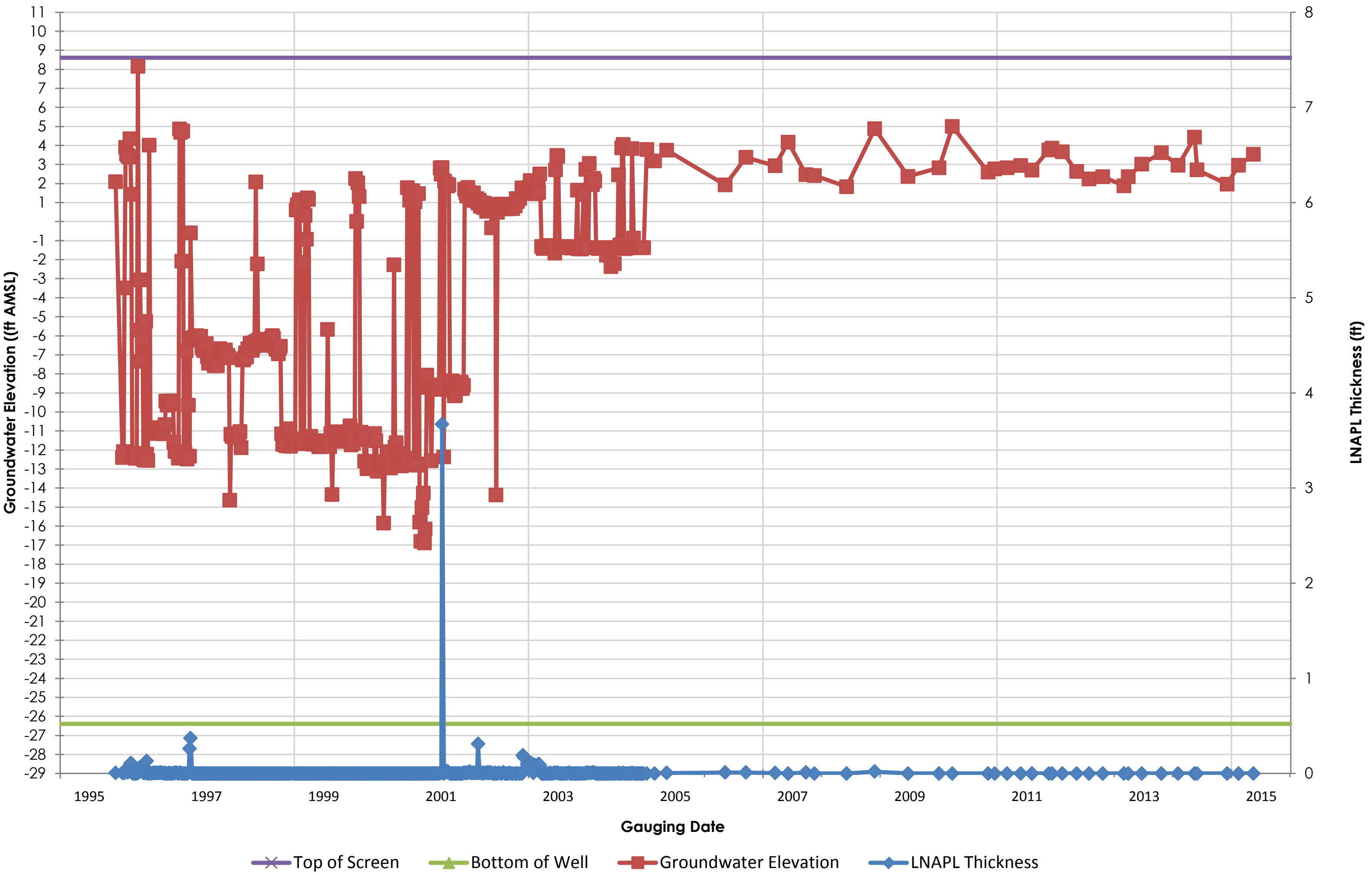
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-402

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

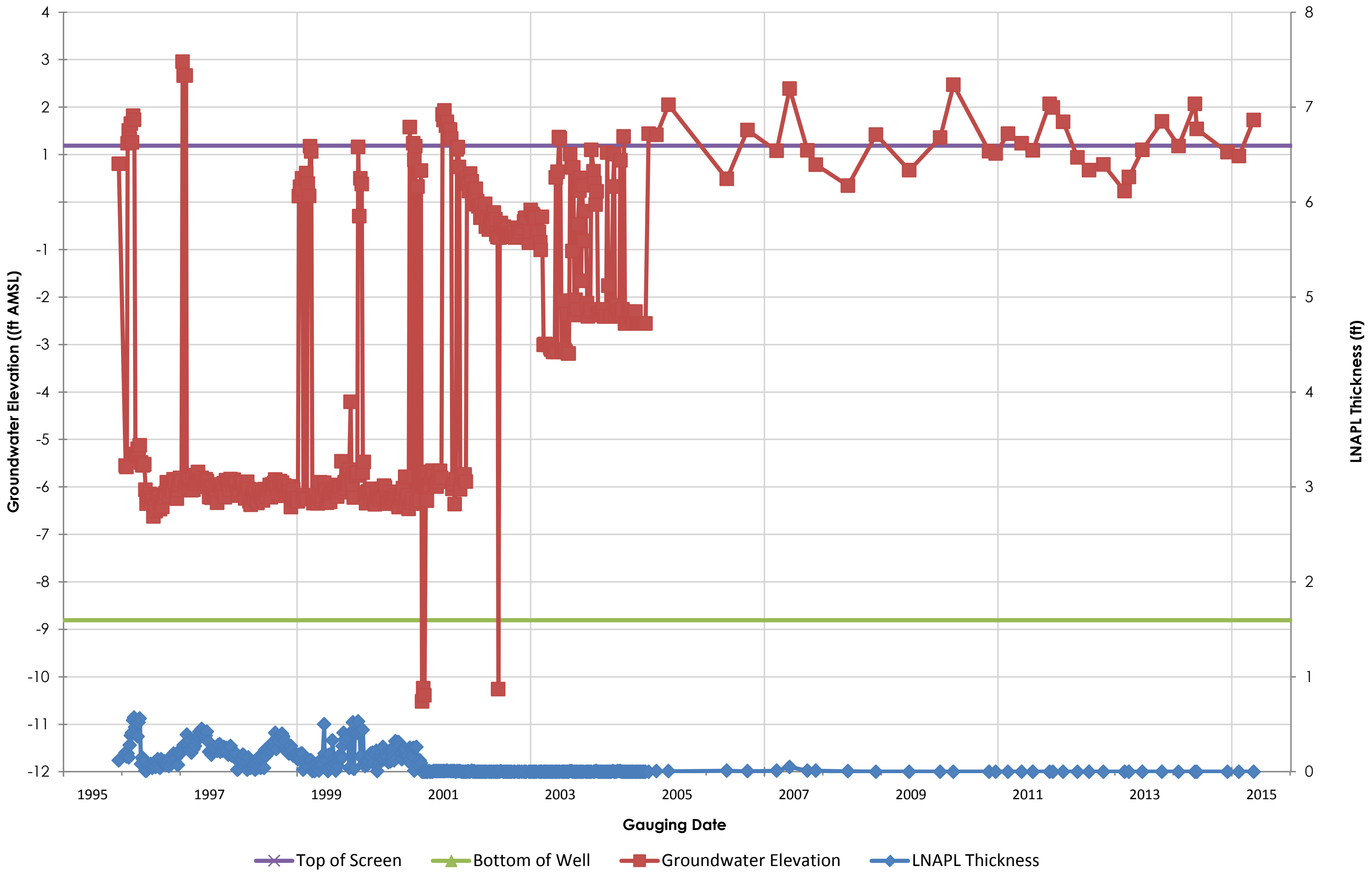
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-403

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

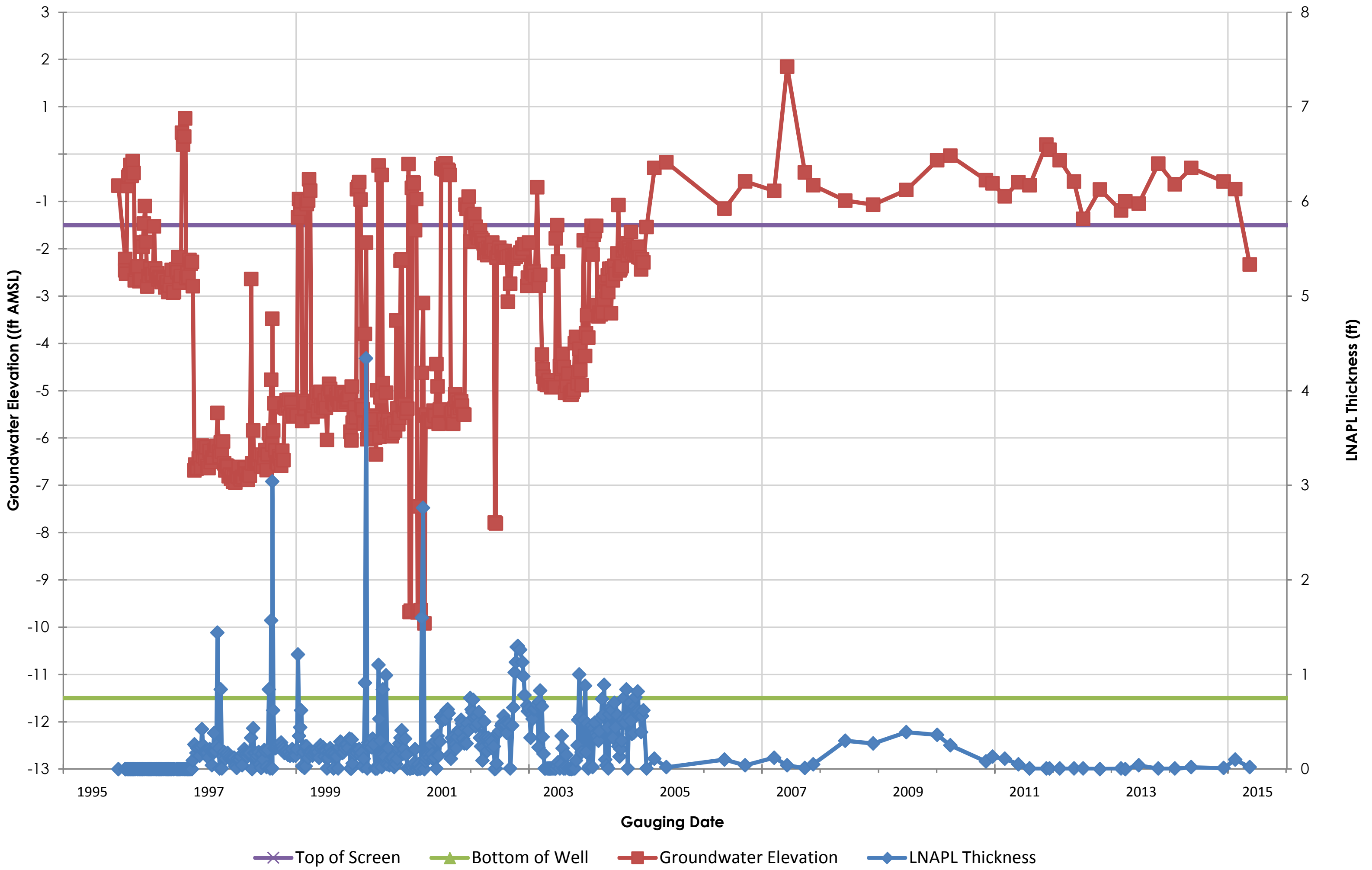
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-404

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

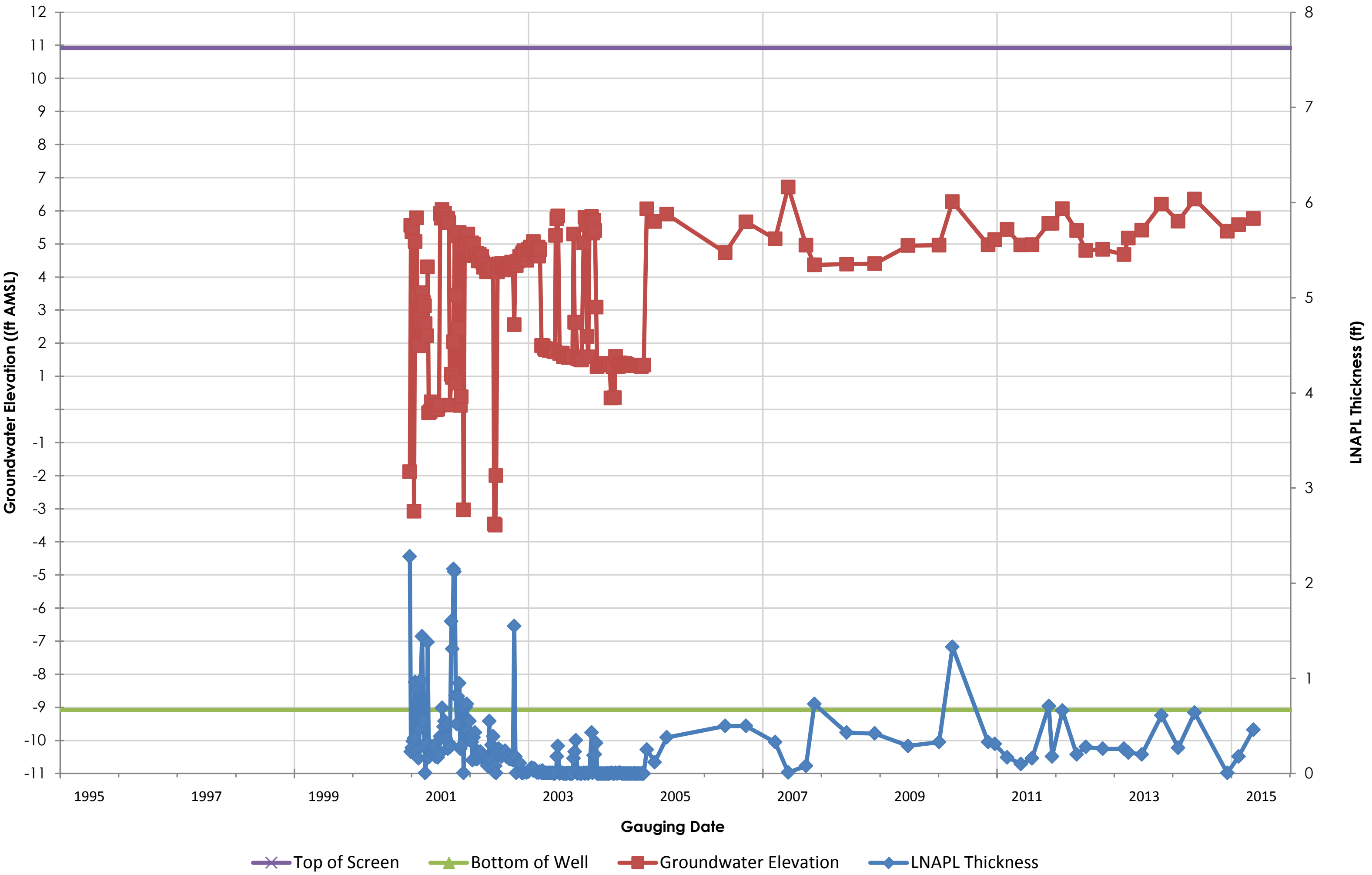
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-405

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

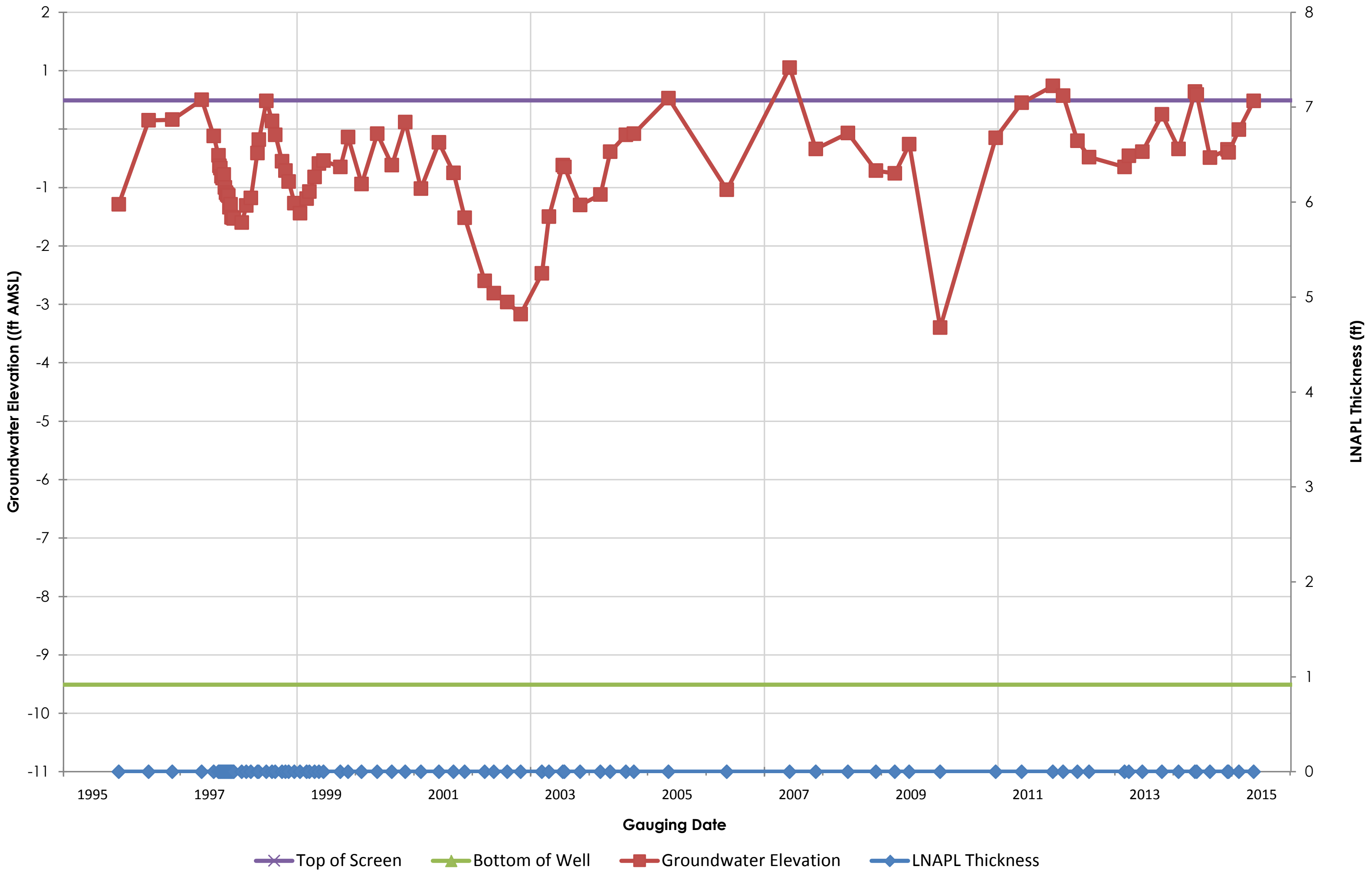
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

RW-406

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

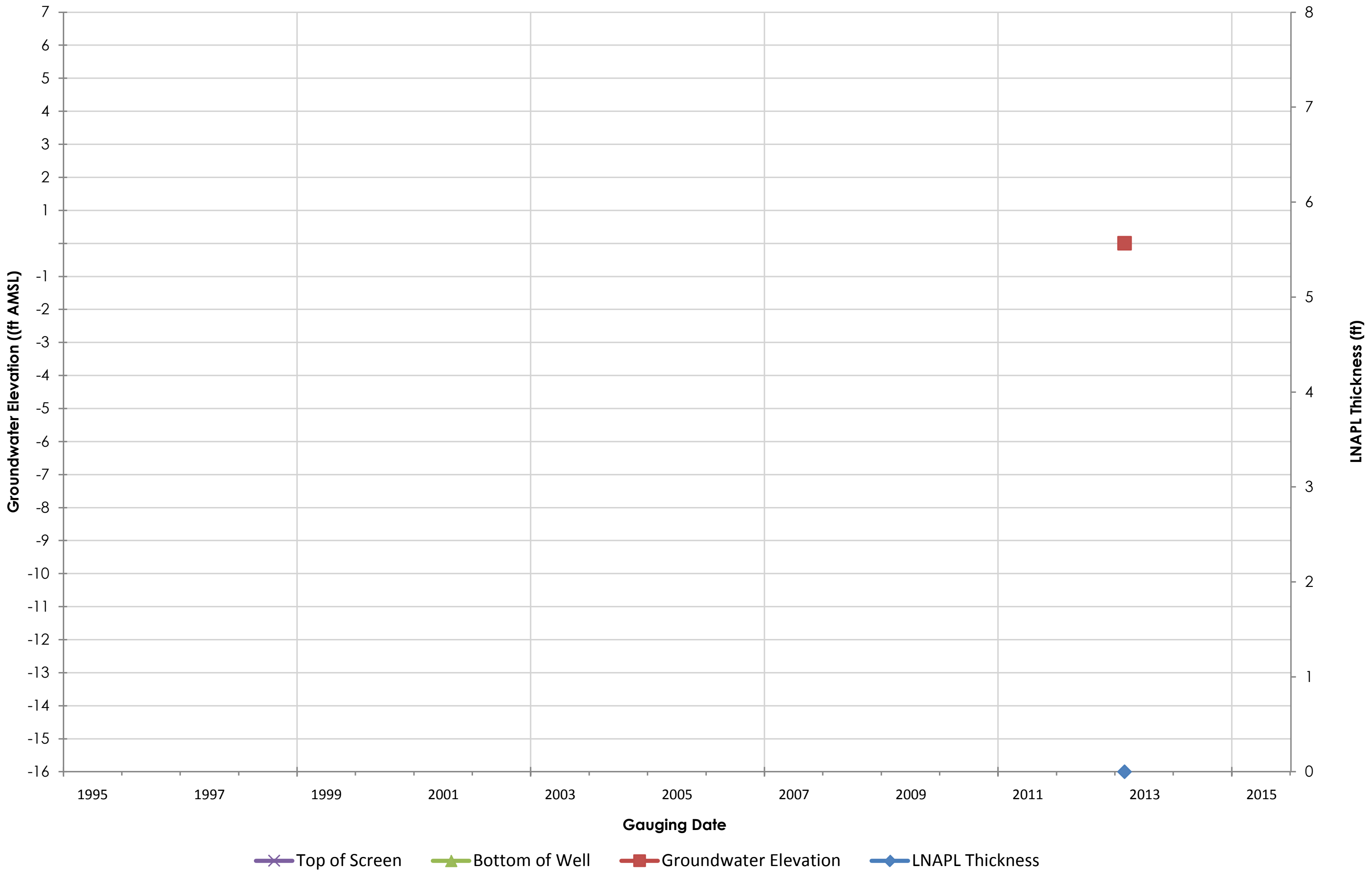
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-41

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

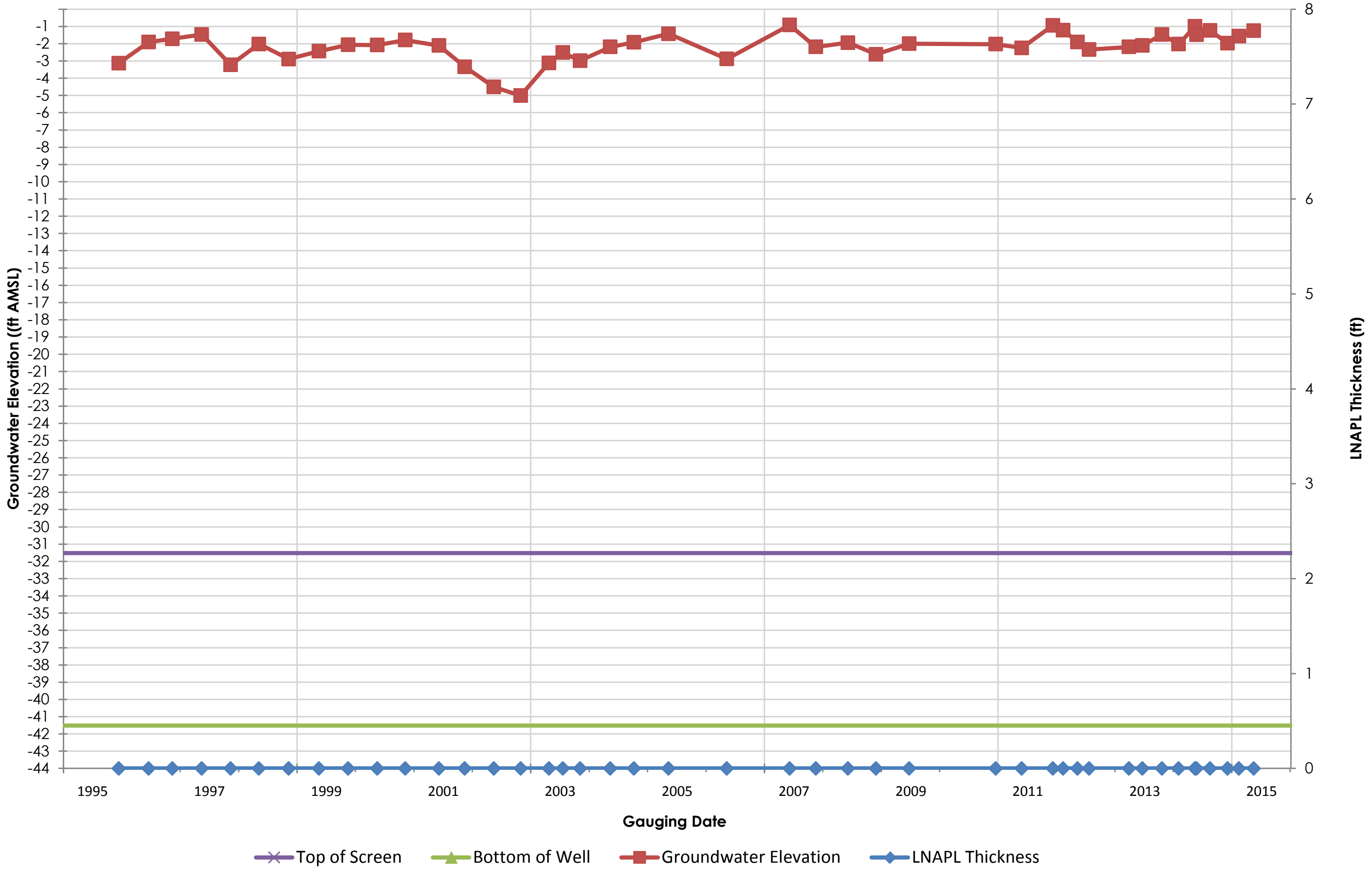
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-42

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

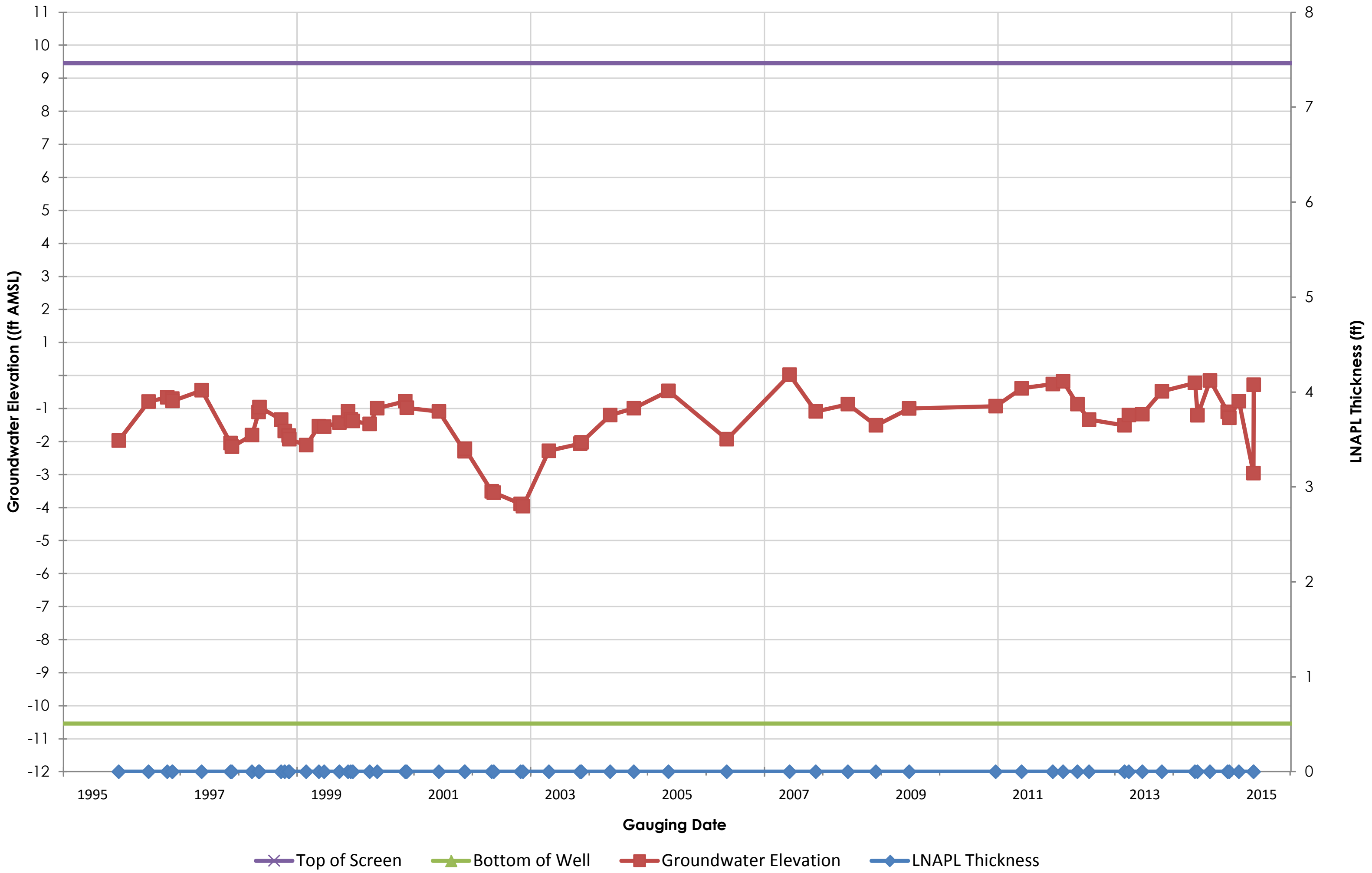
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-42I

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

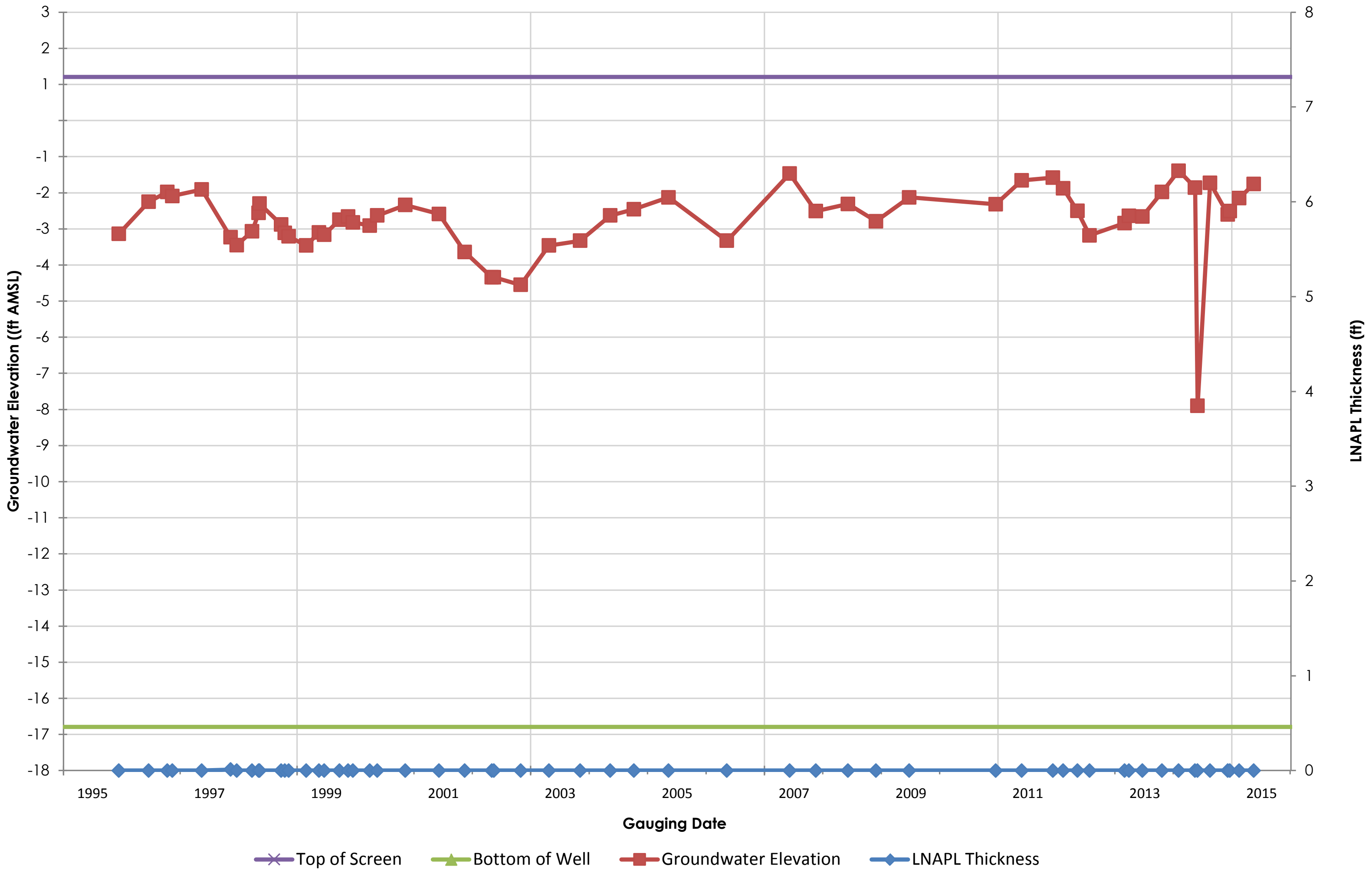
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-43

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

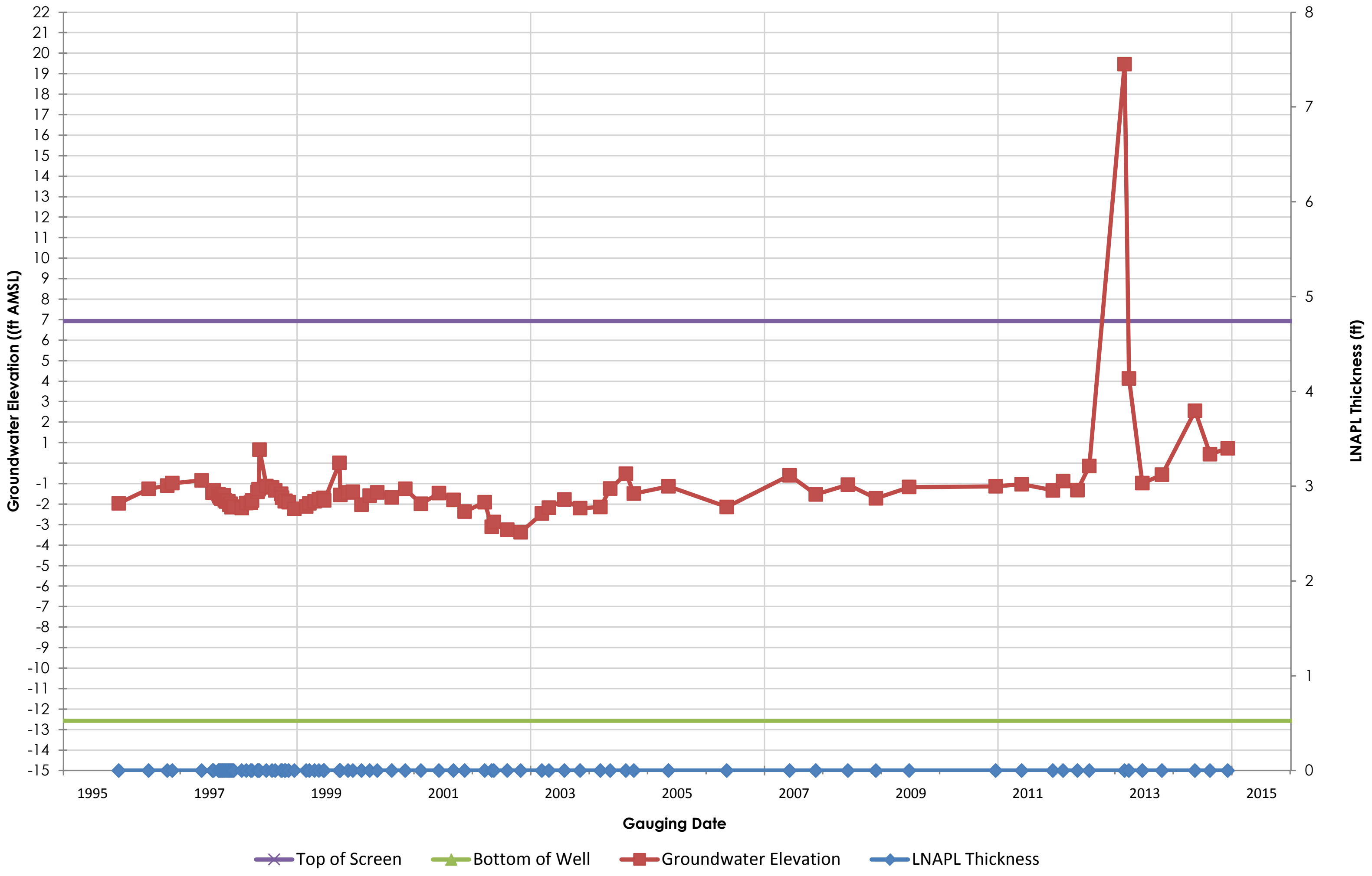
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-44

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

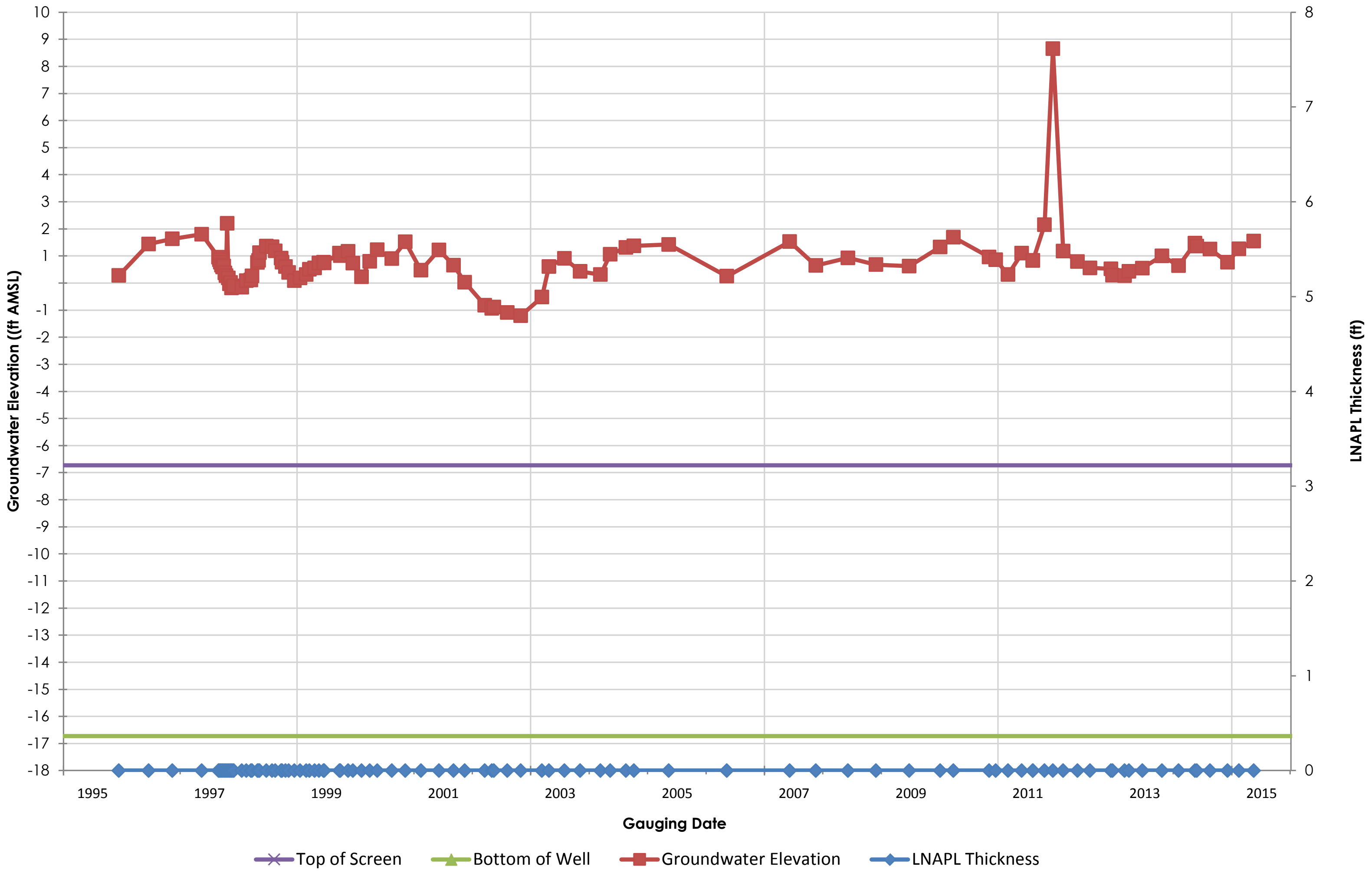
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-45

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

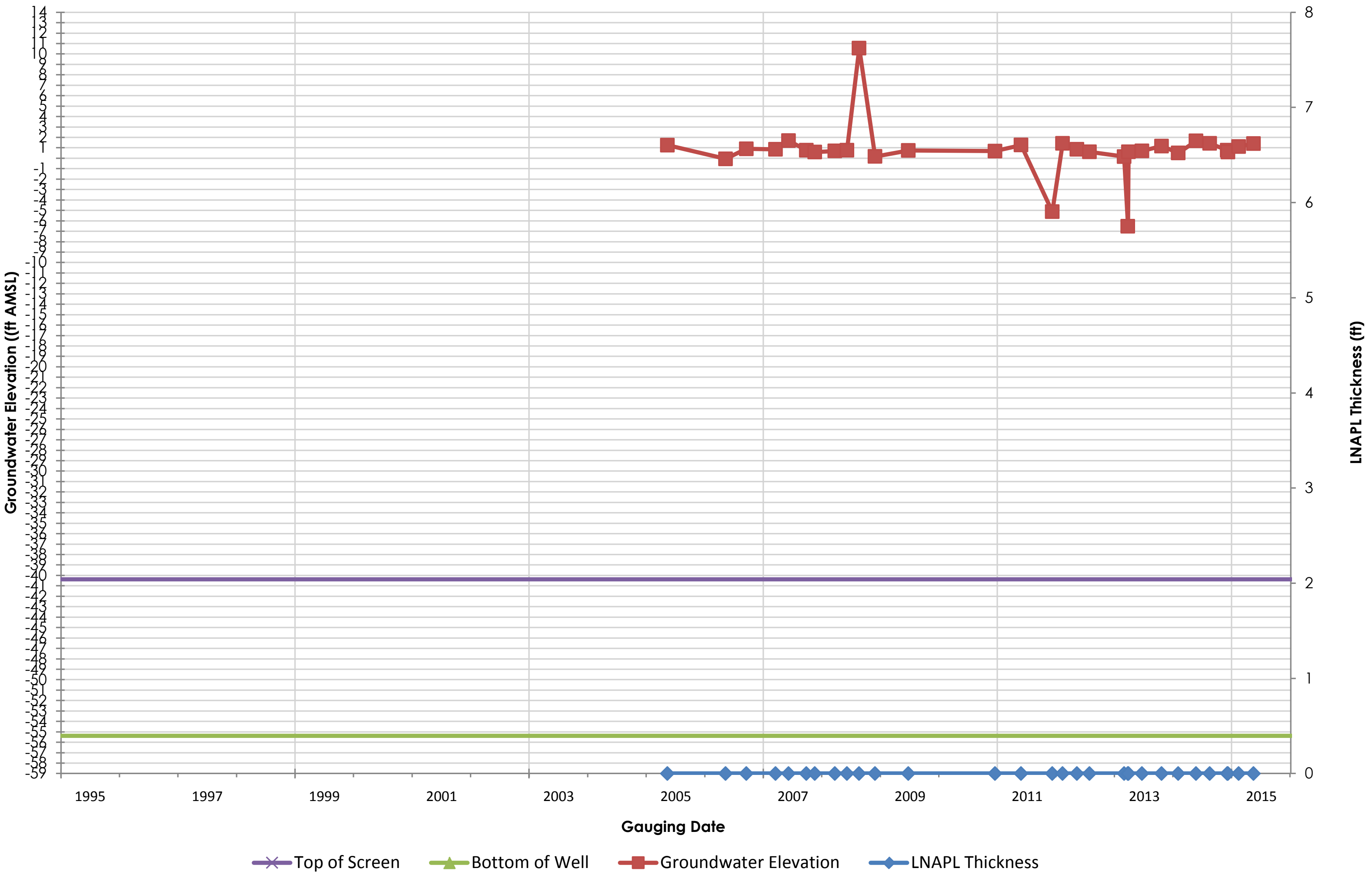
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-46

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

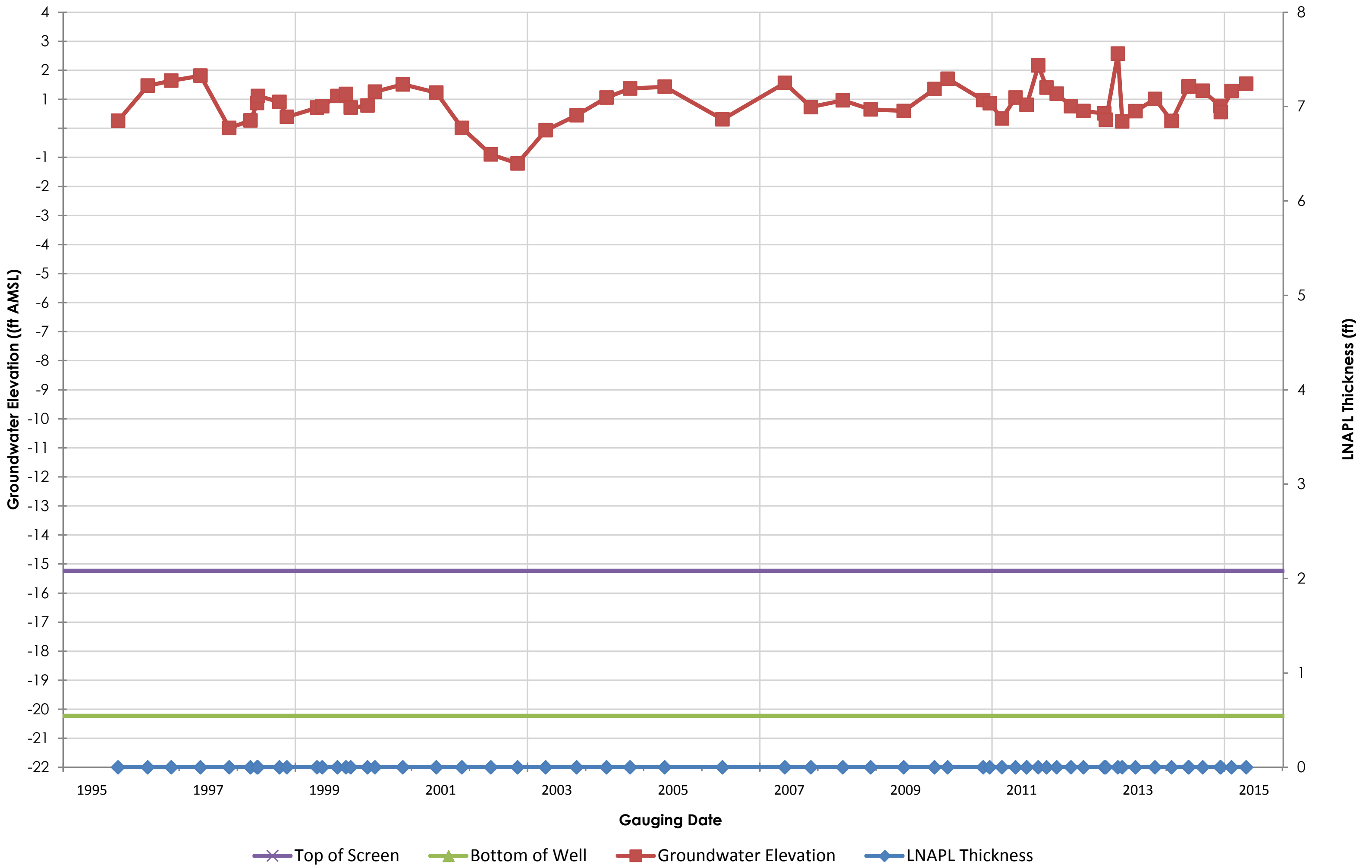
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-46D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

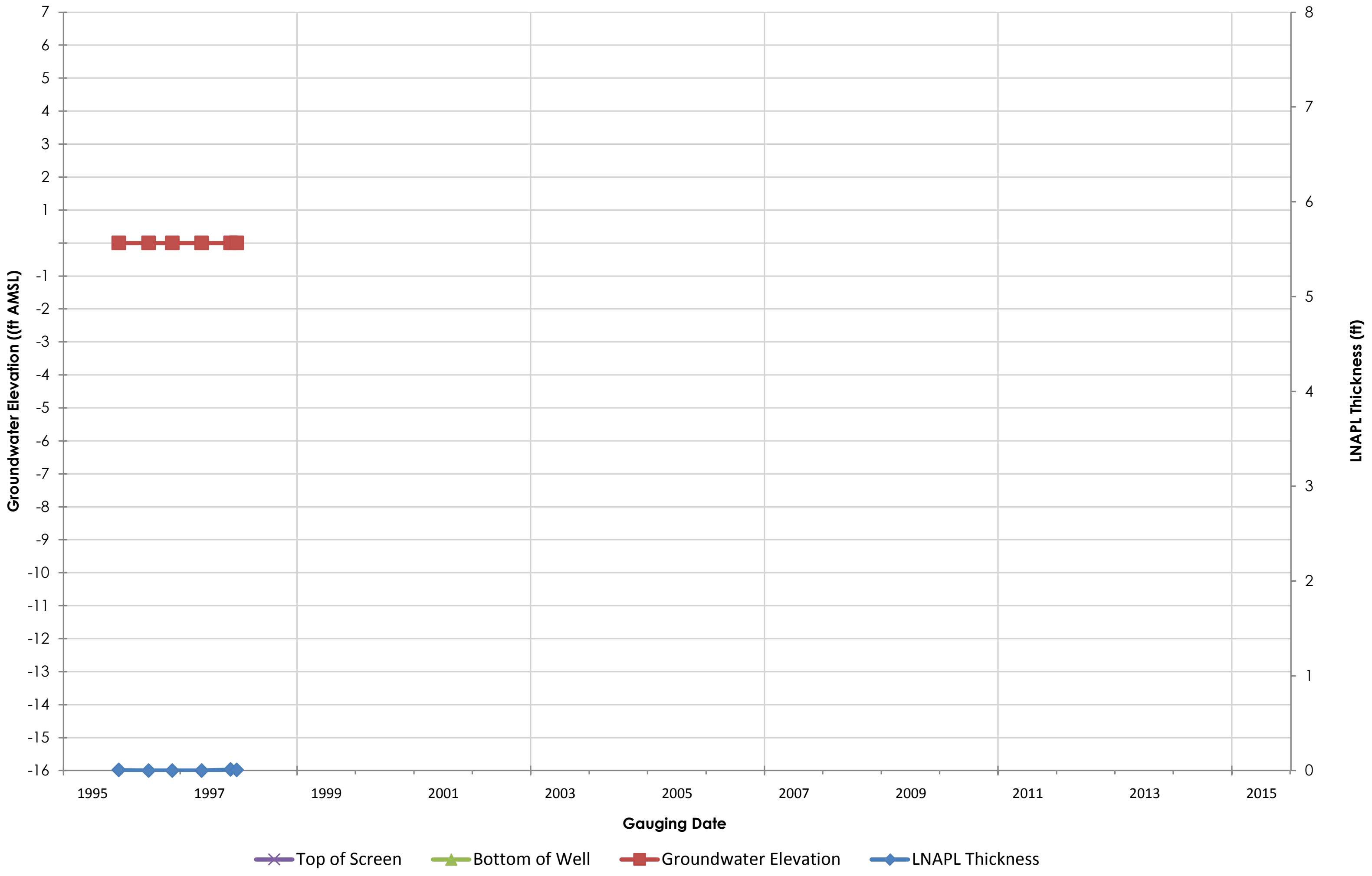
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-47I

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

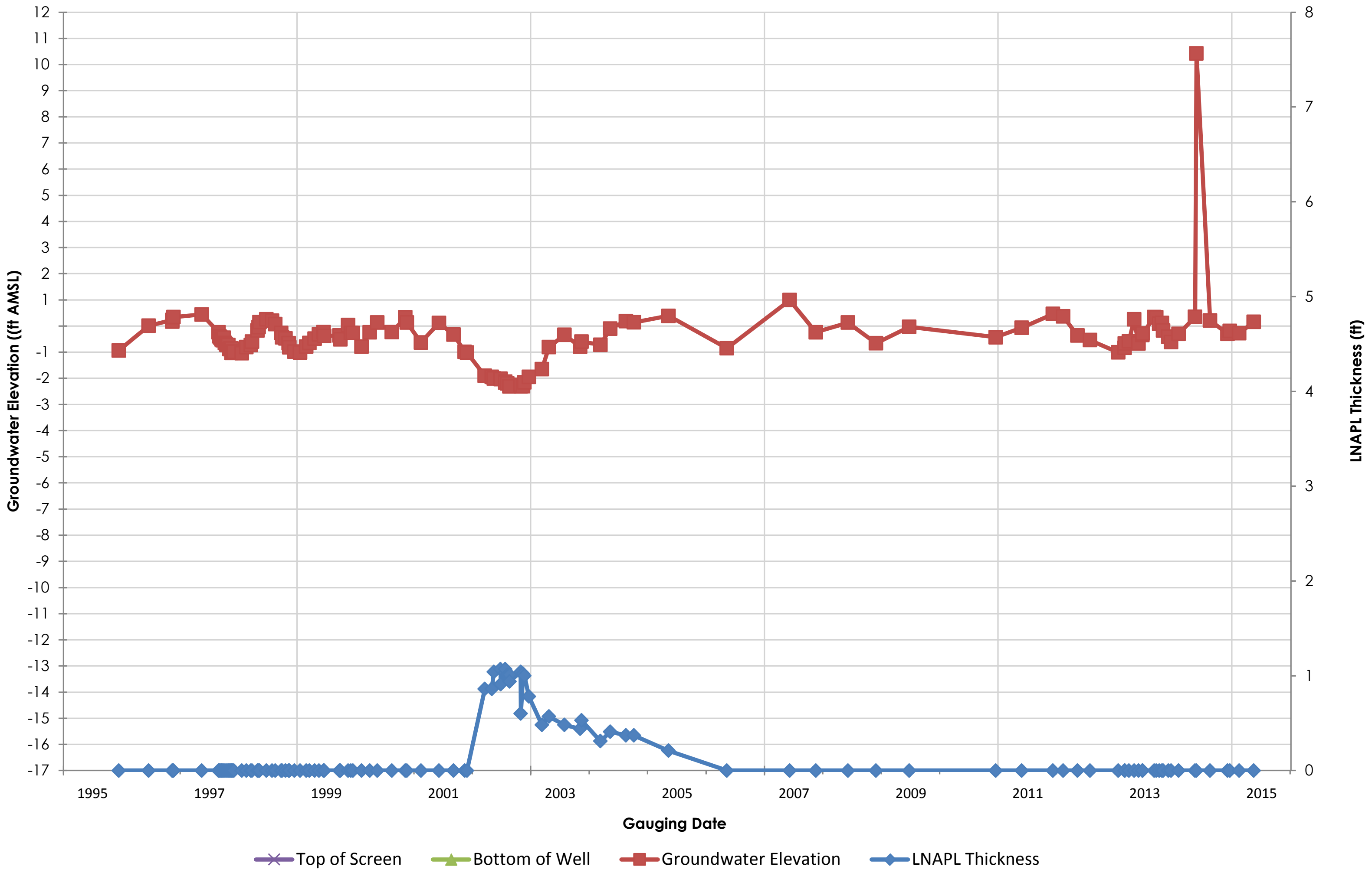
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-49

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

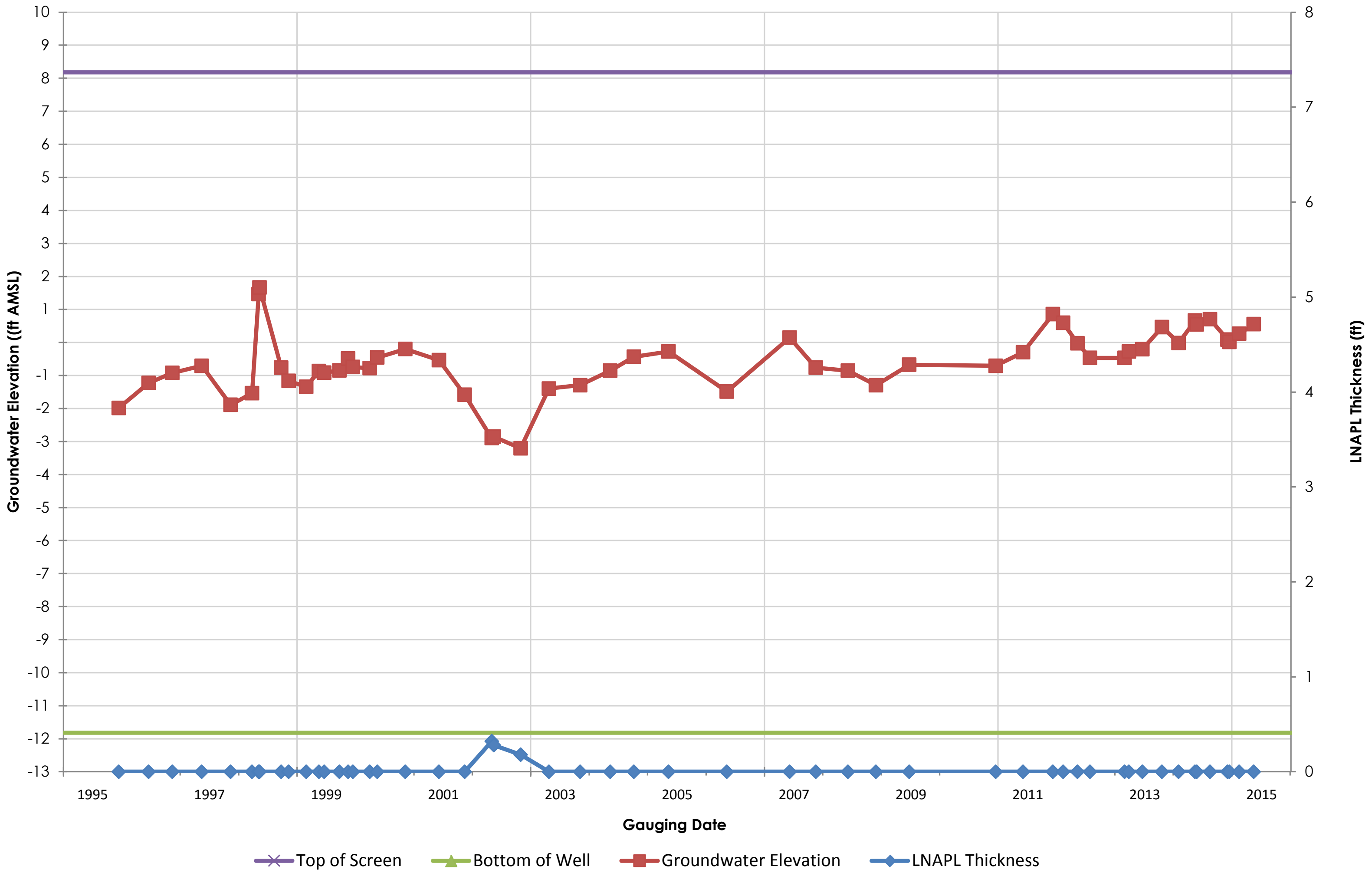
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-50

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

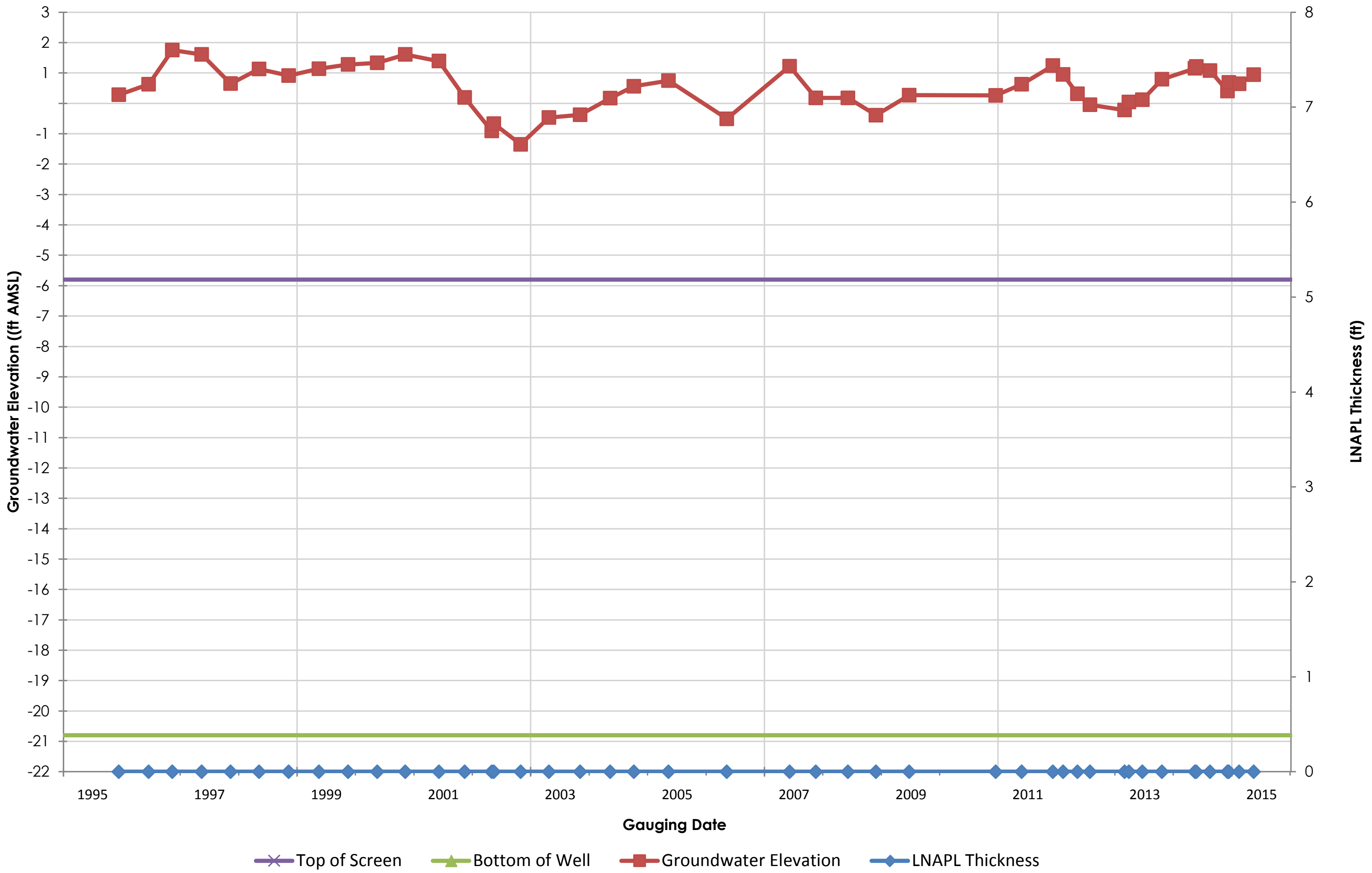
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-51

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

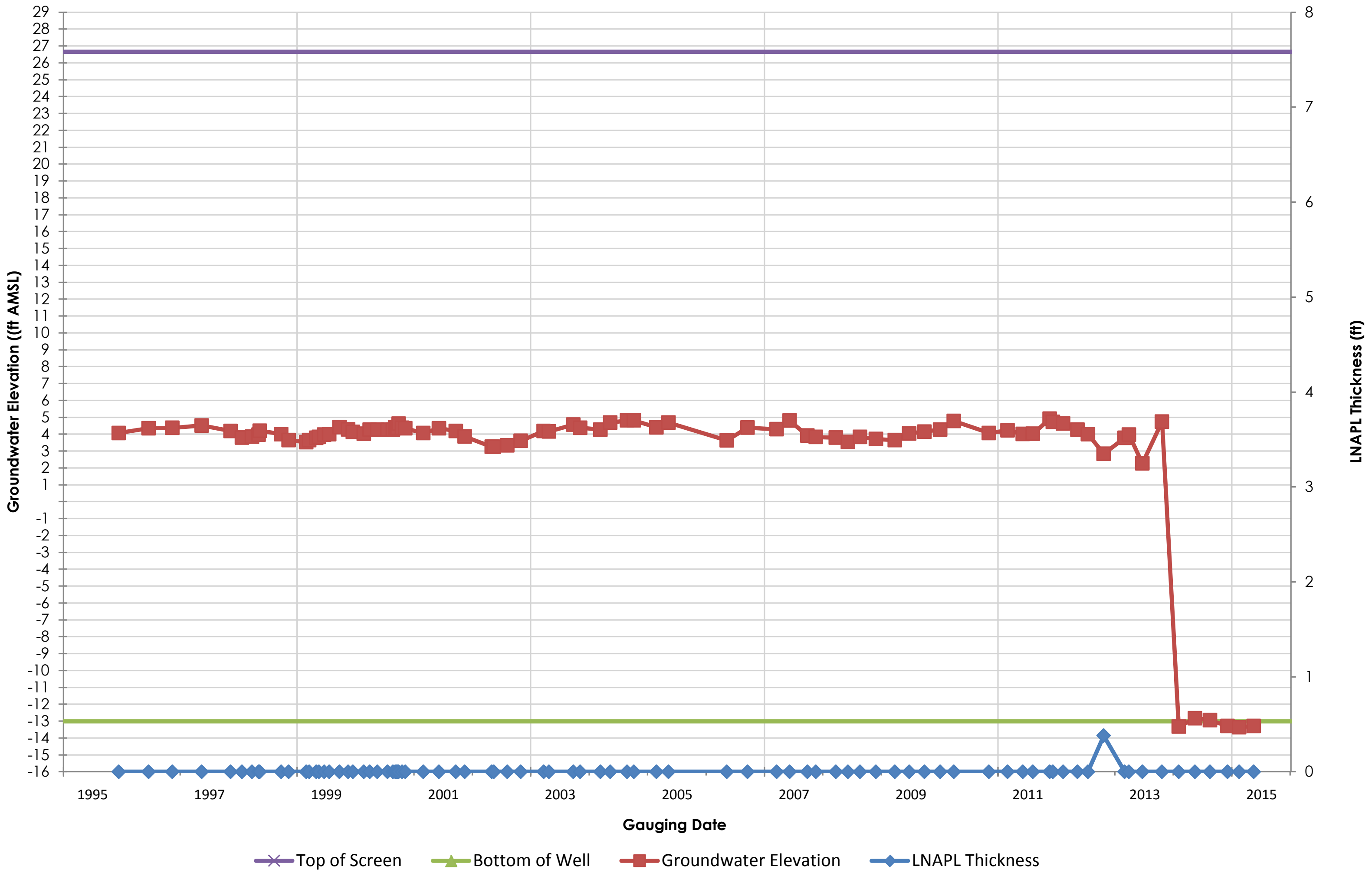
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-52

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

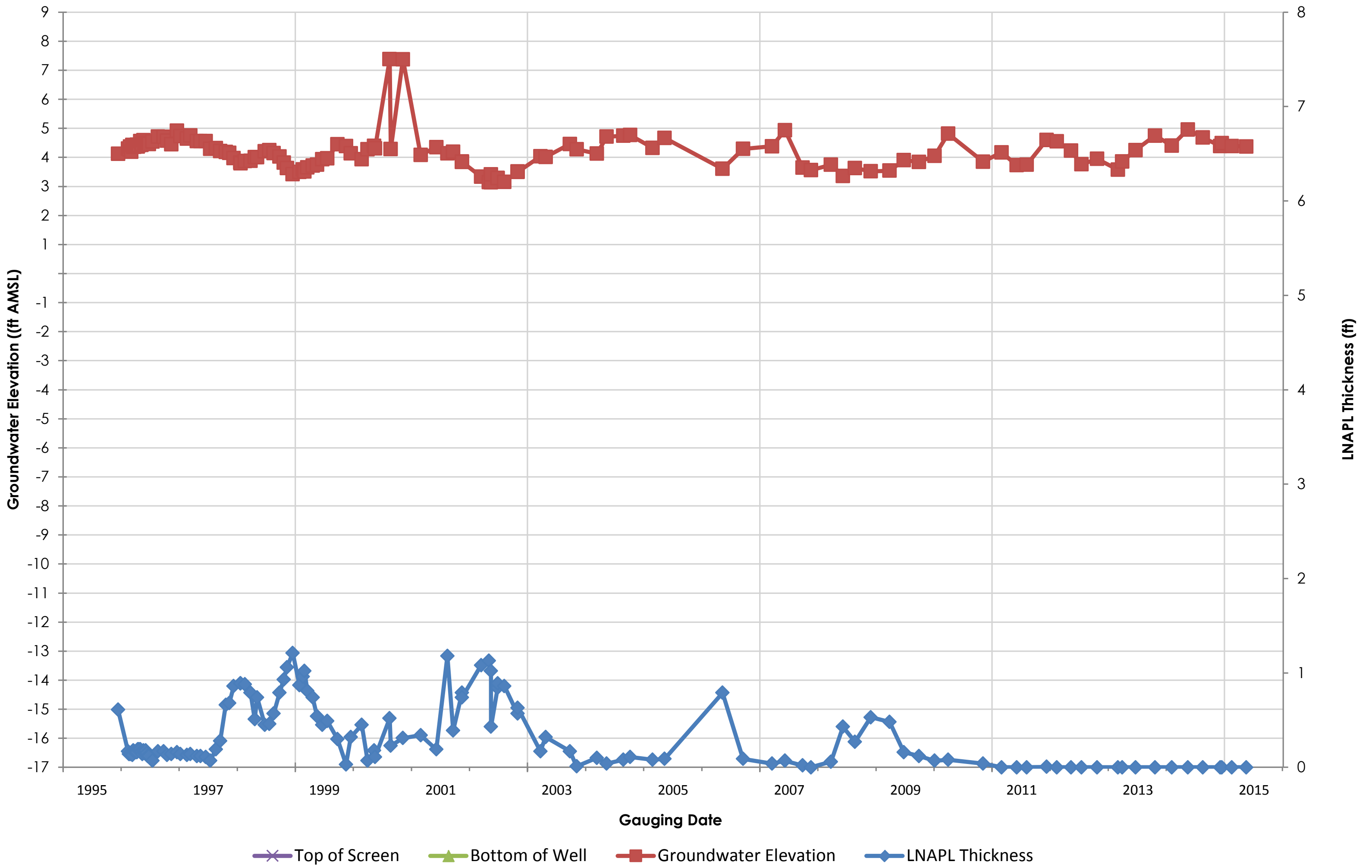
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-74

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

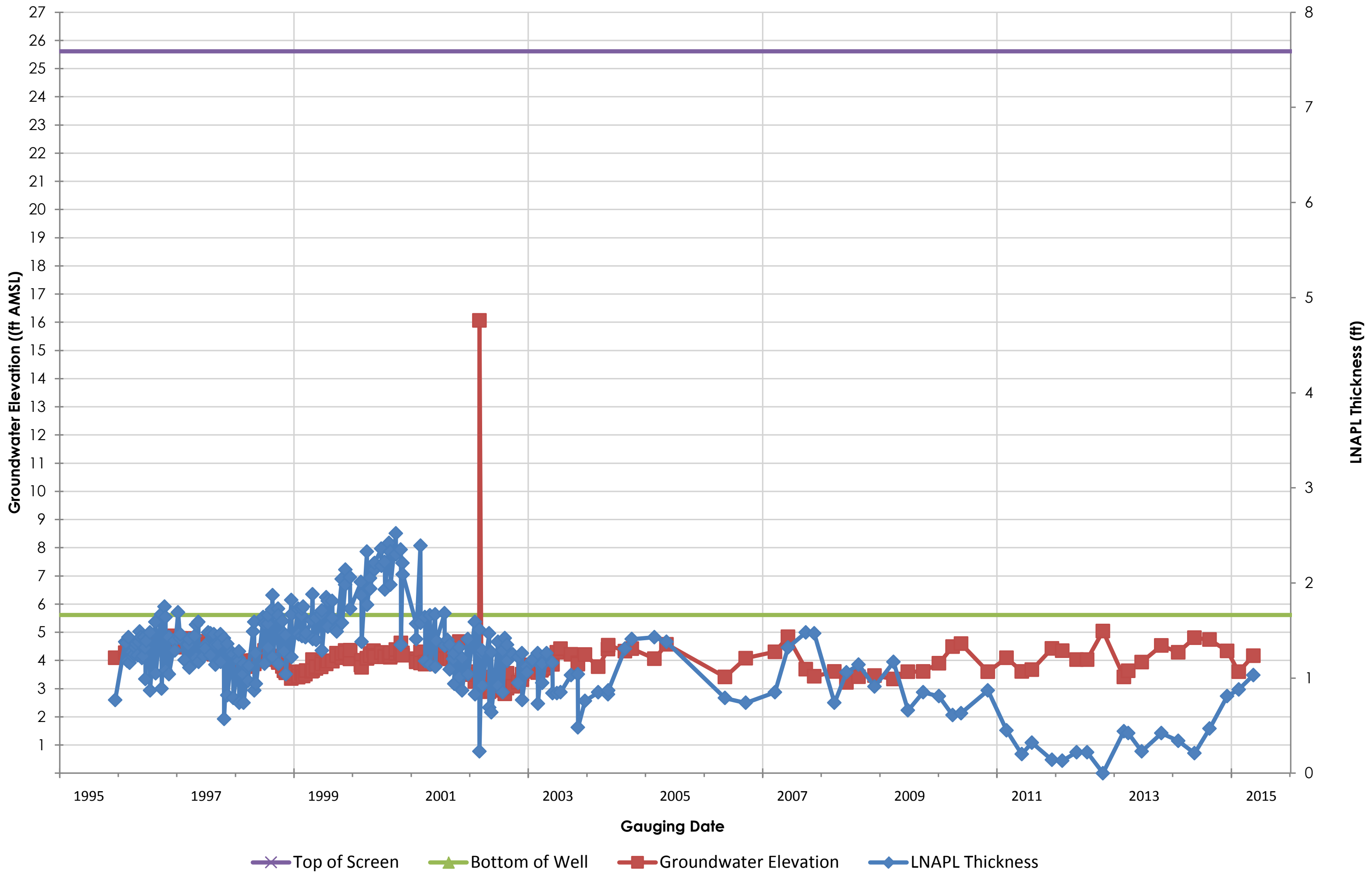
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-75

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

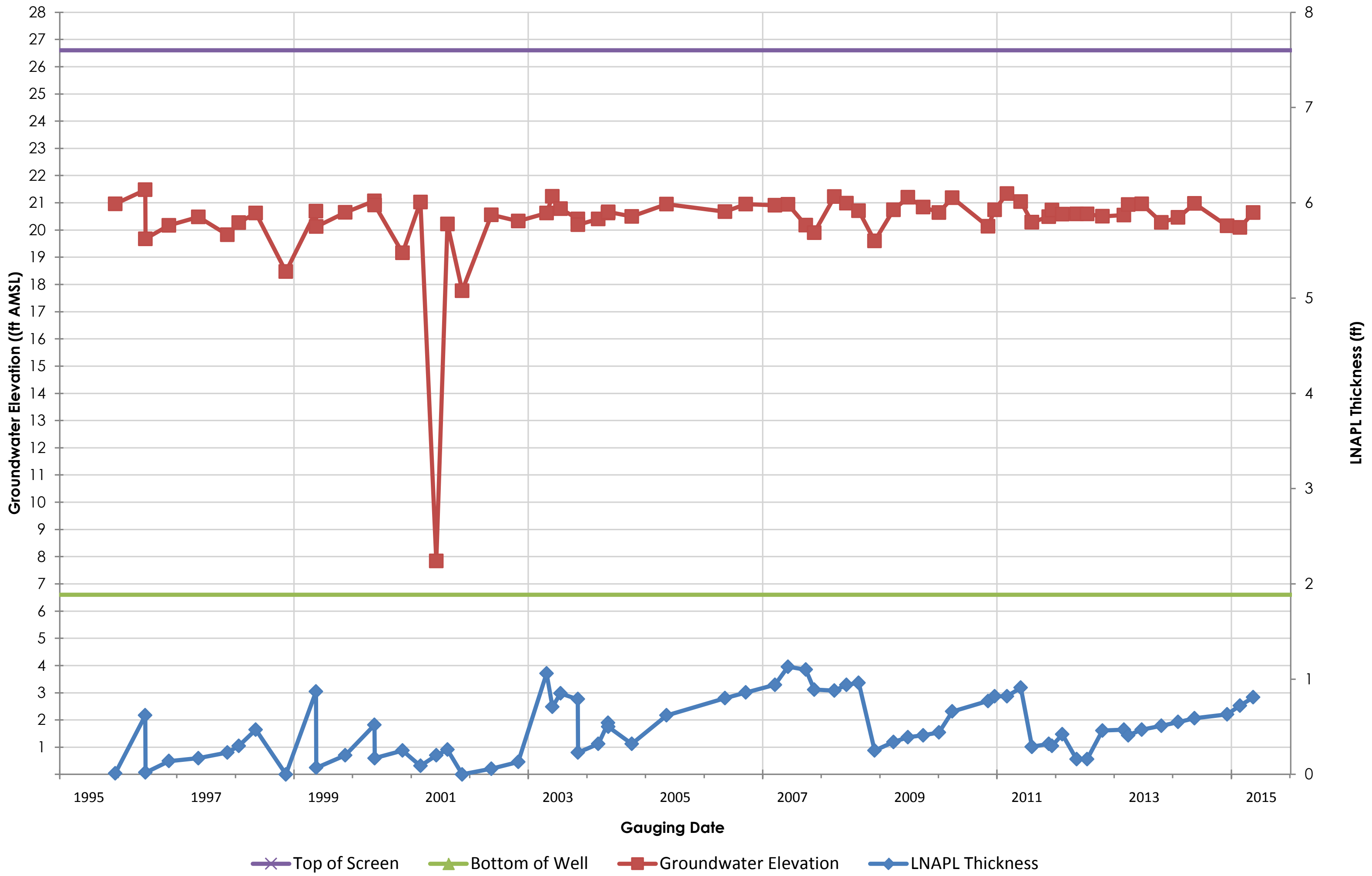
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-76

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

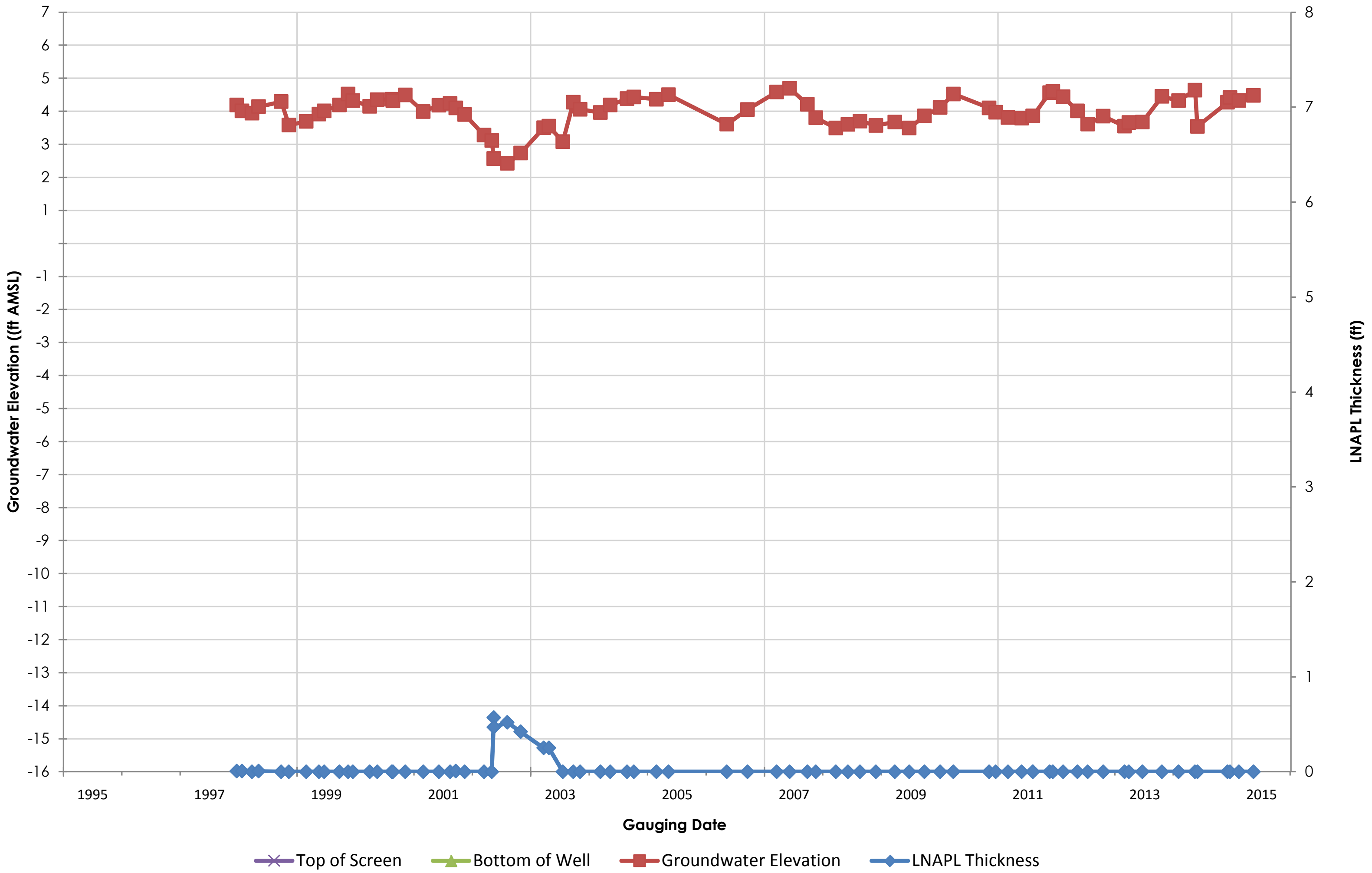
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-77

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

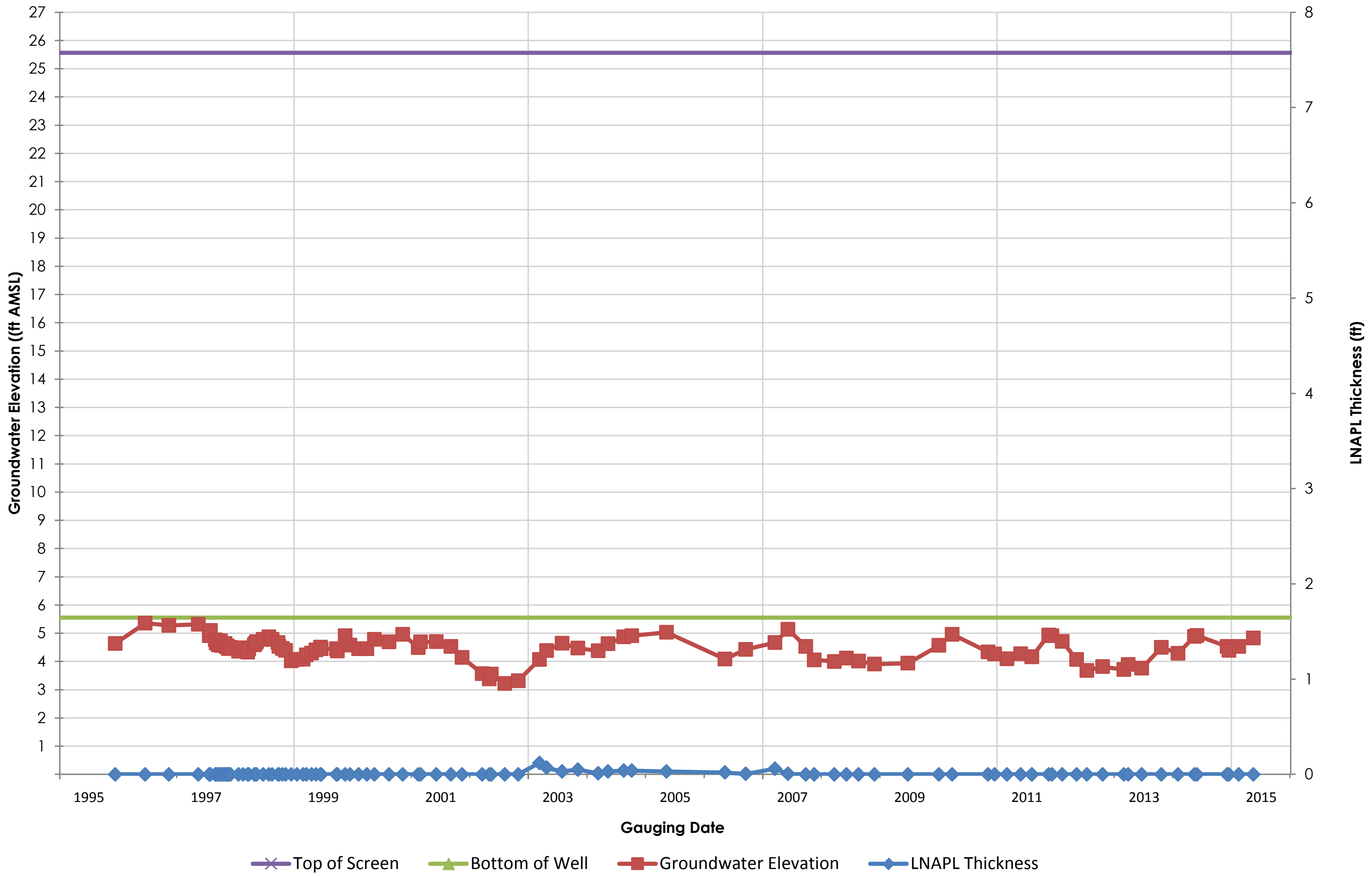
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-77P

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

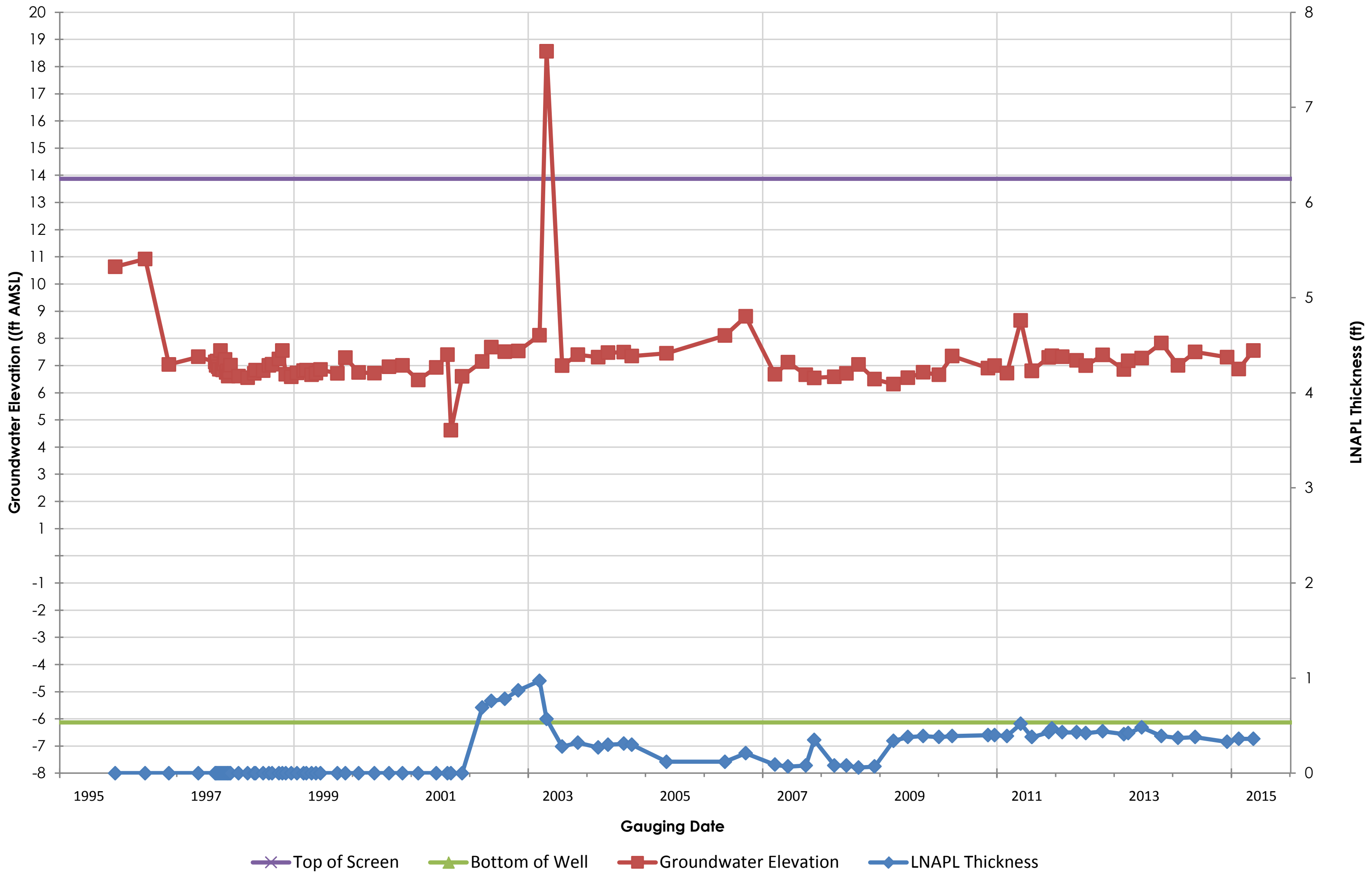
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-78

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

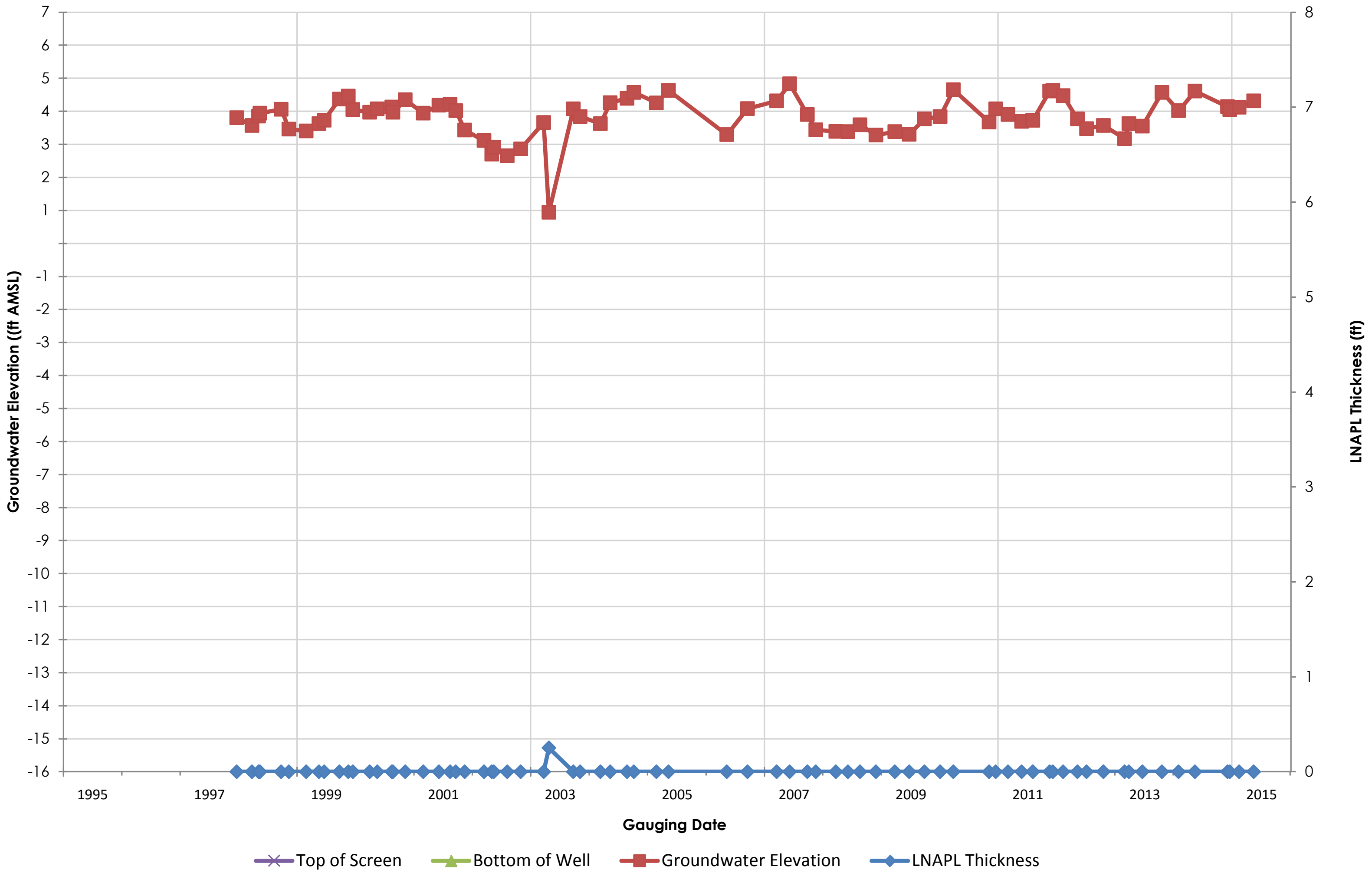
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-79

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

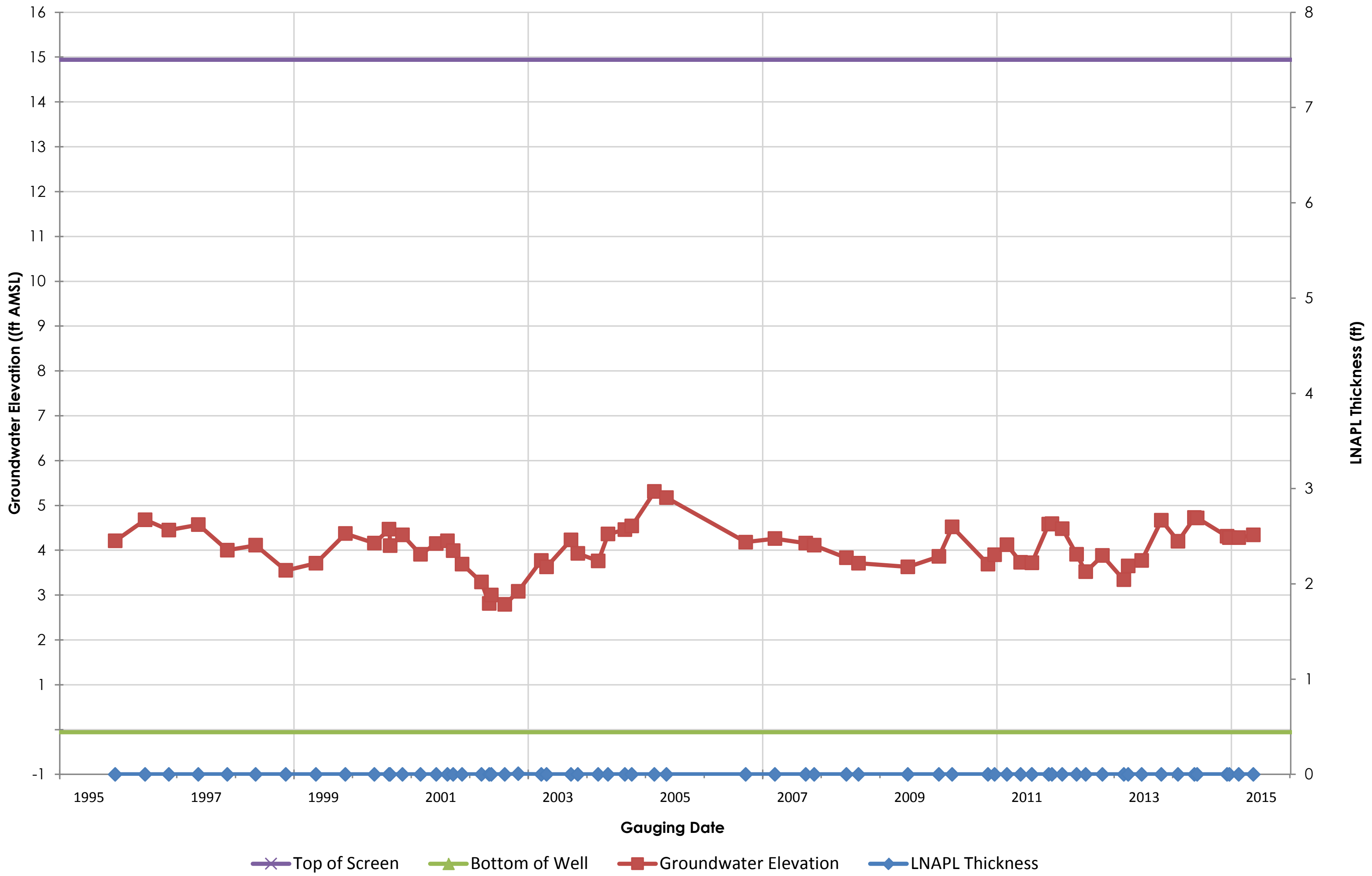
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-79P

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

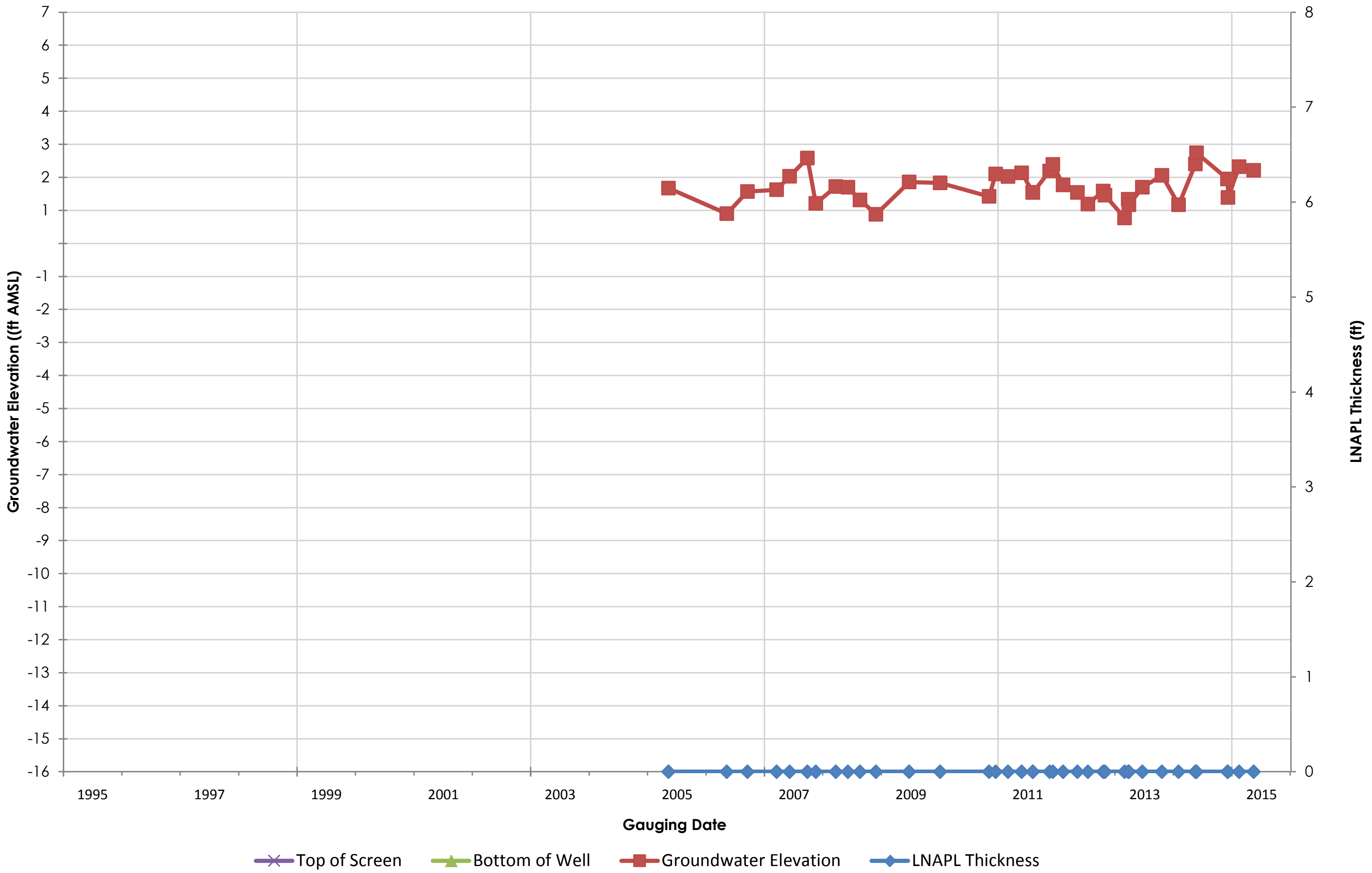
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-80

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

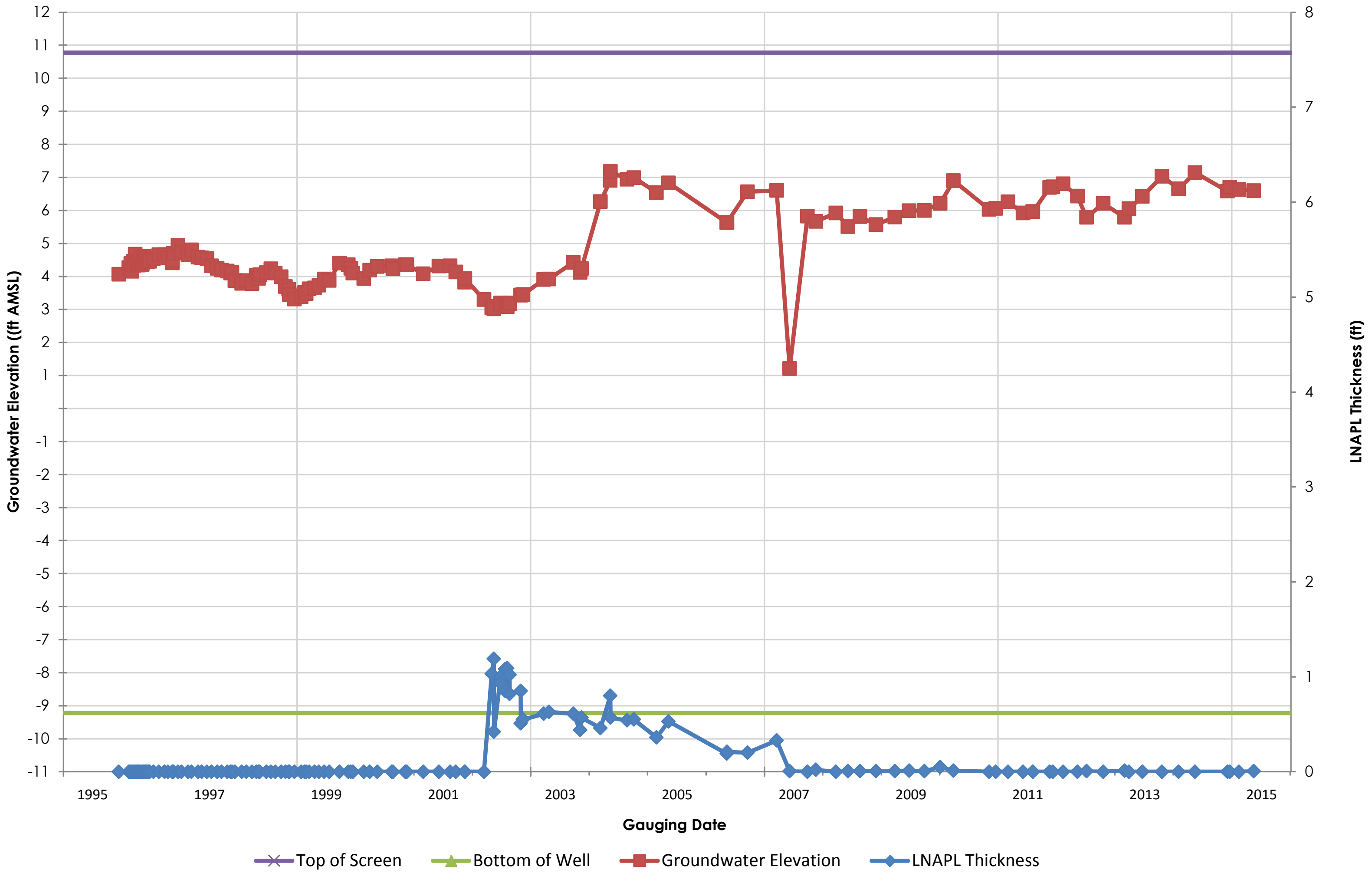
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-80D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

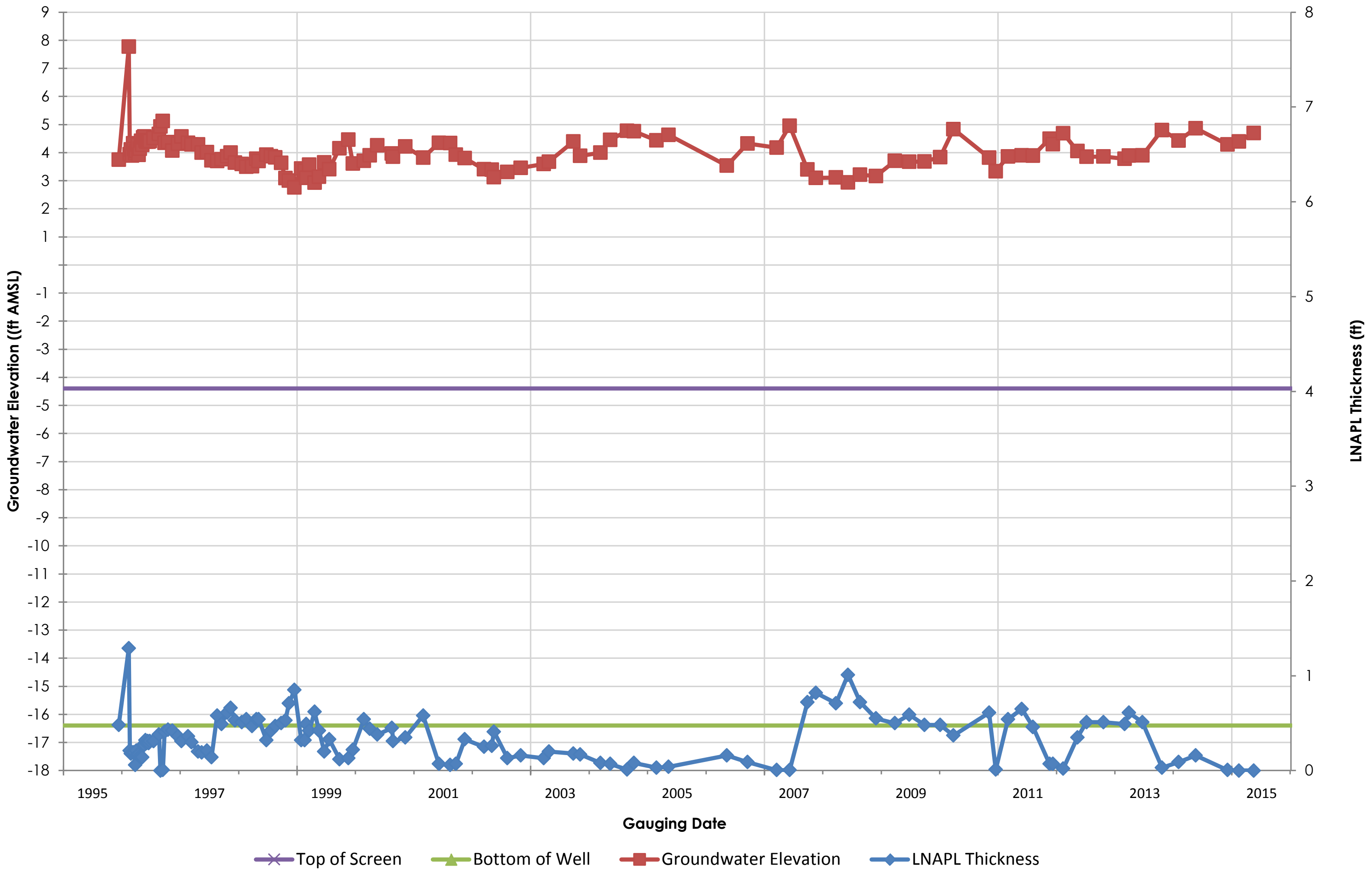
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-81

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

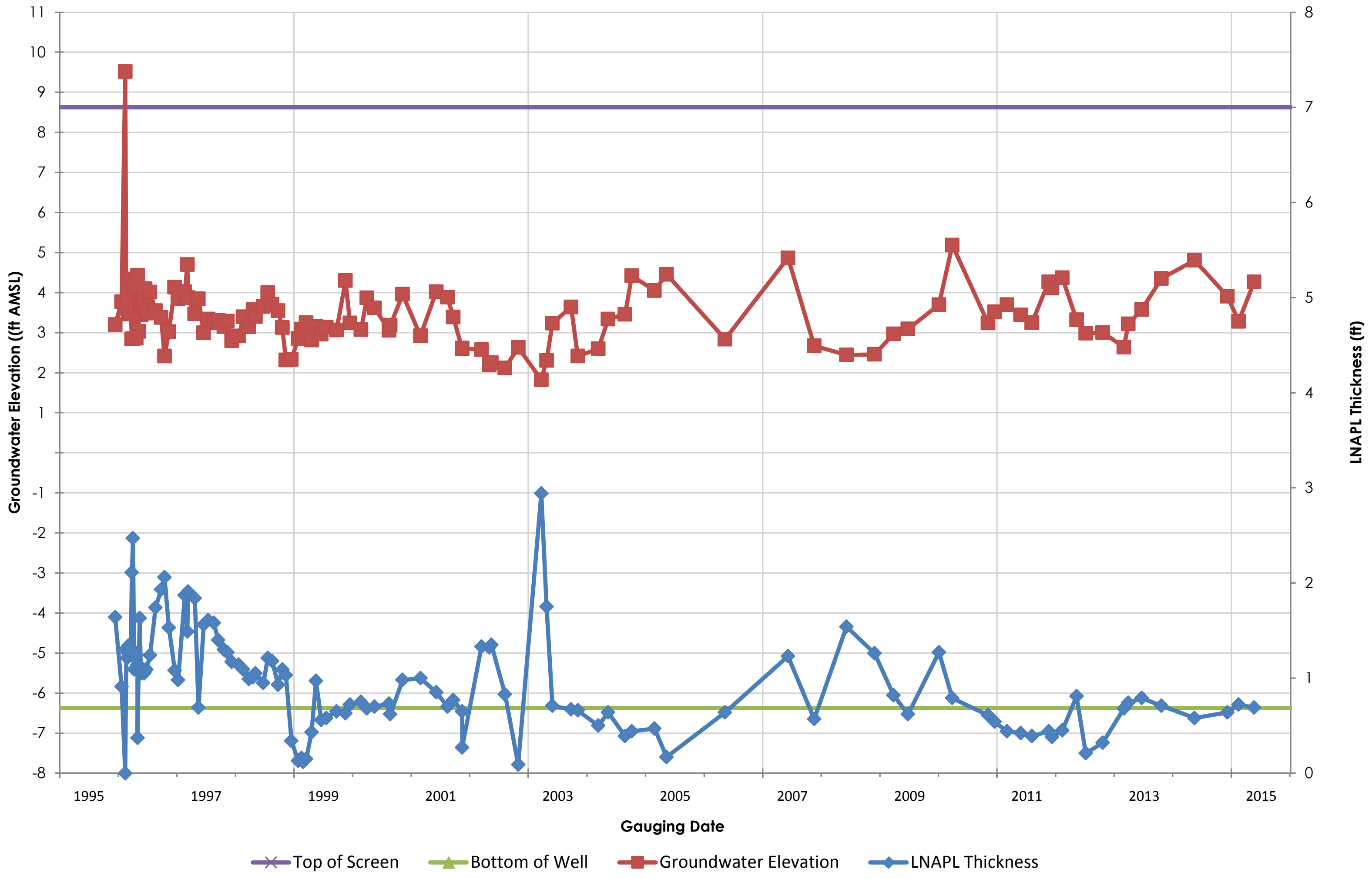
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-82

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

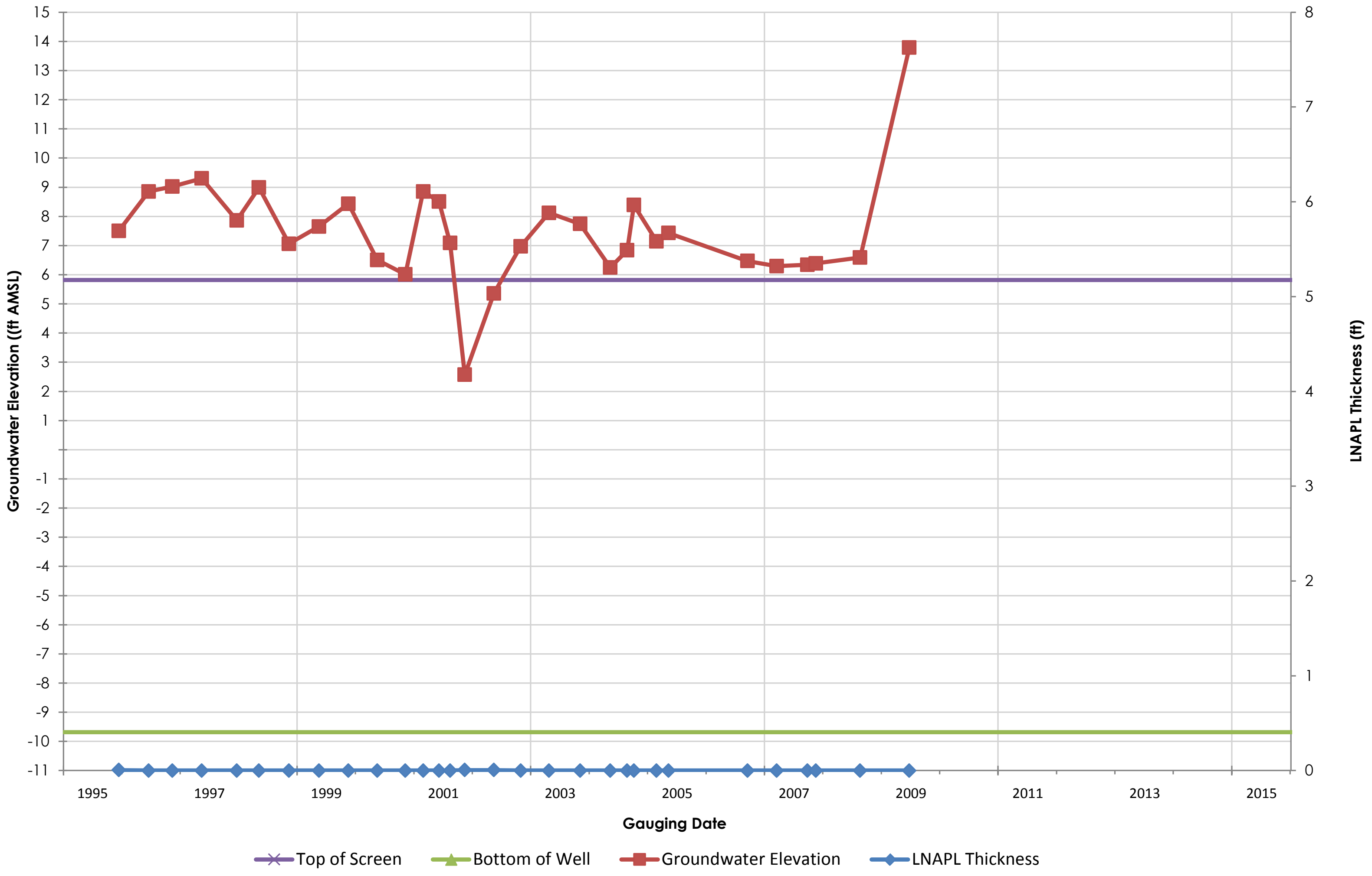
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-83

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

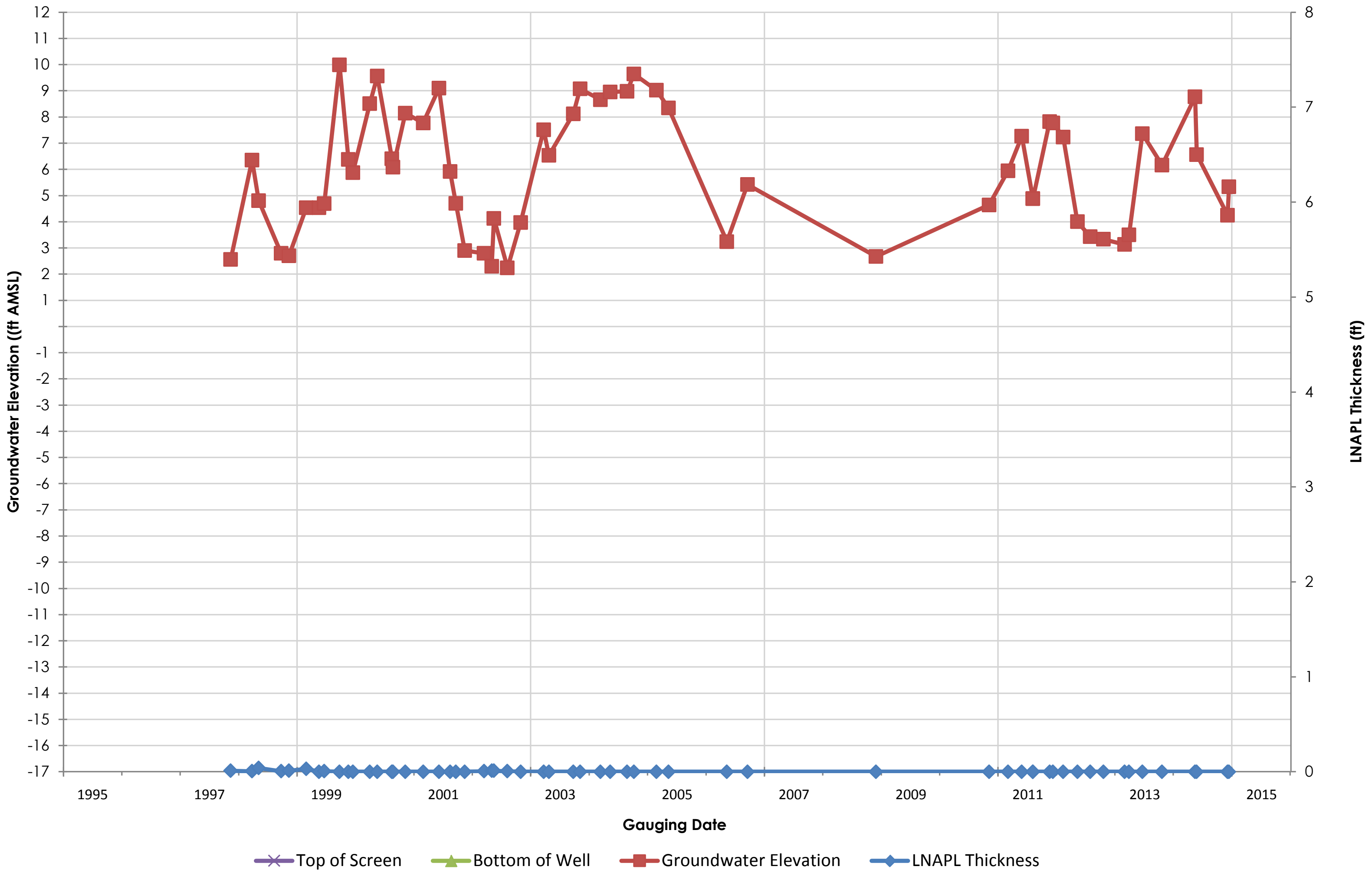
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-84

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

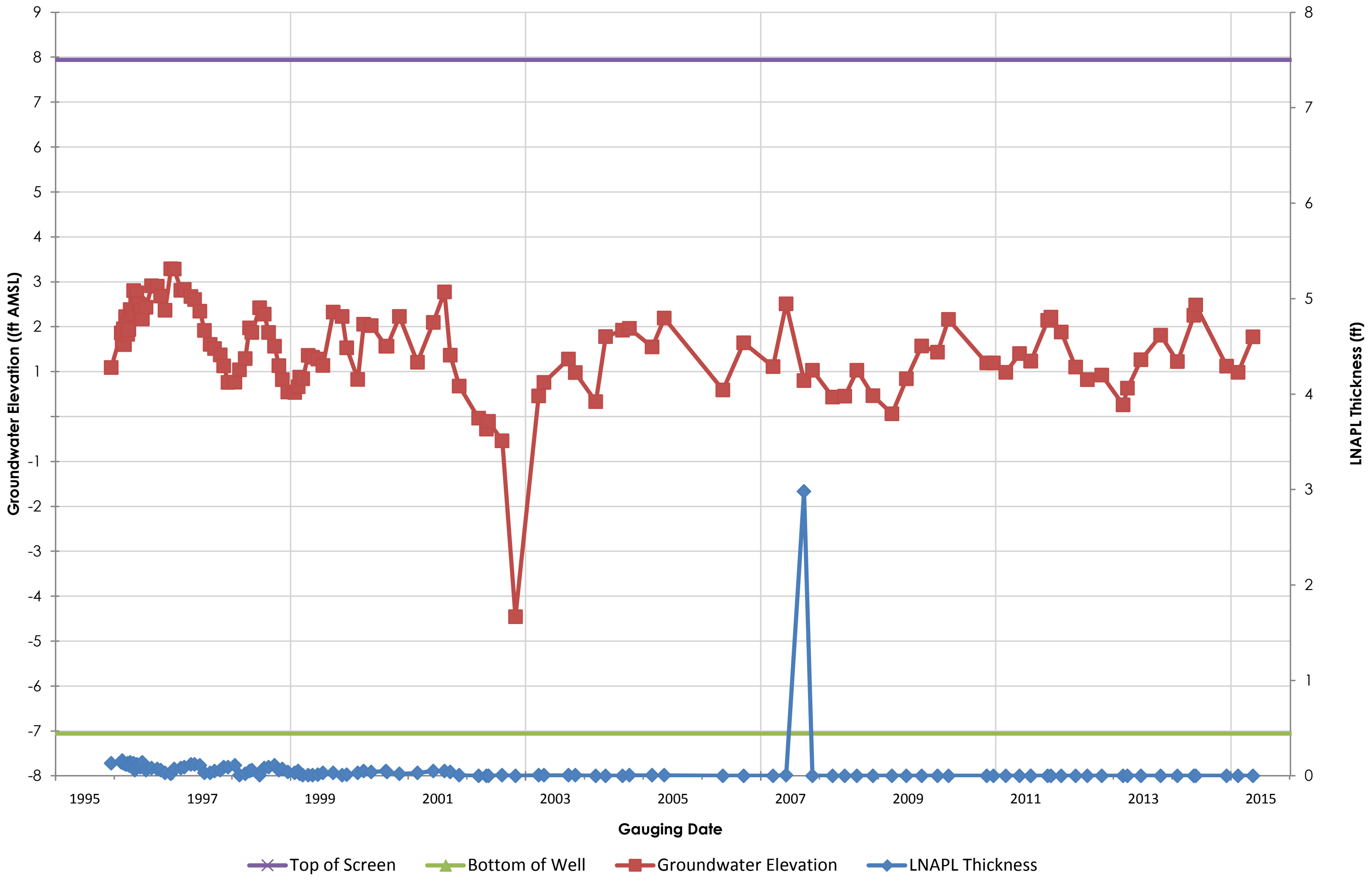
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-84P

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

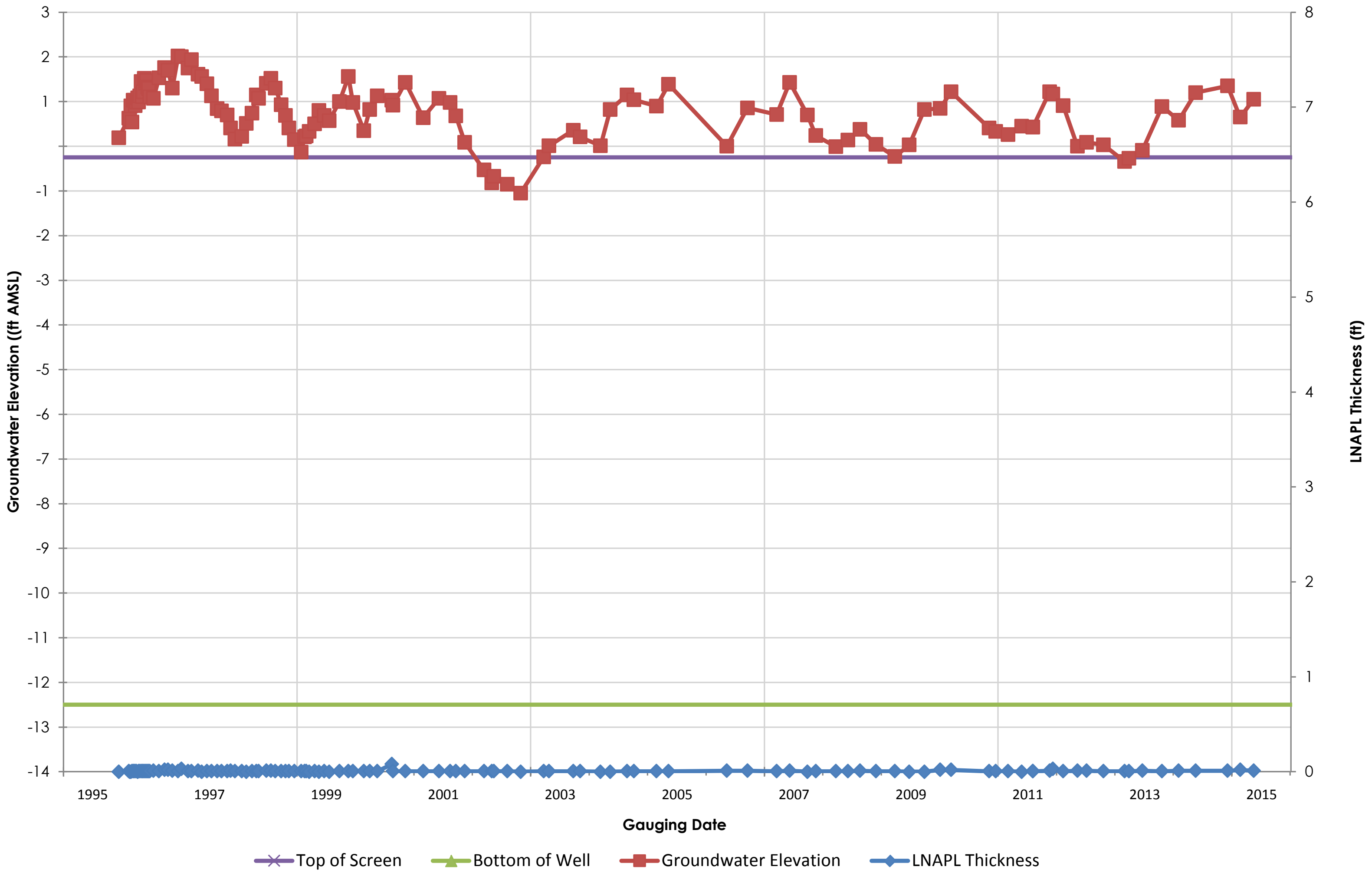
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-85

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

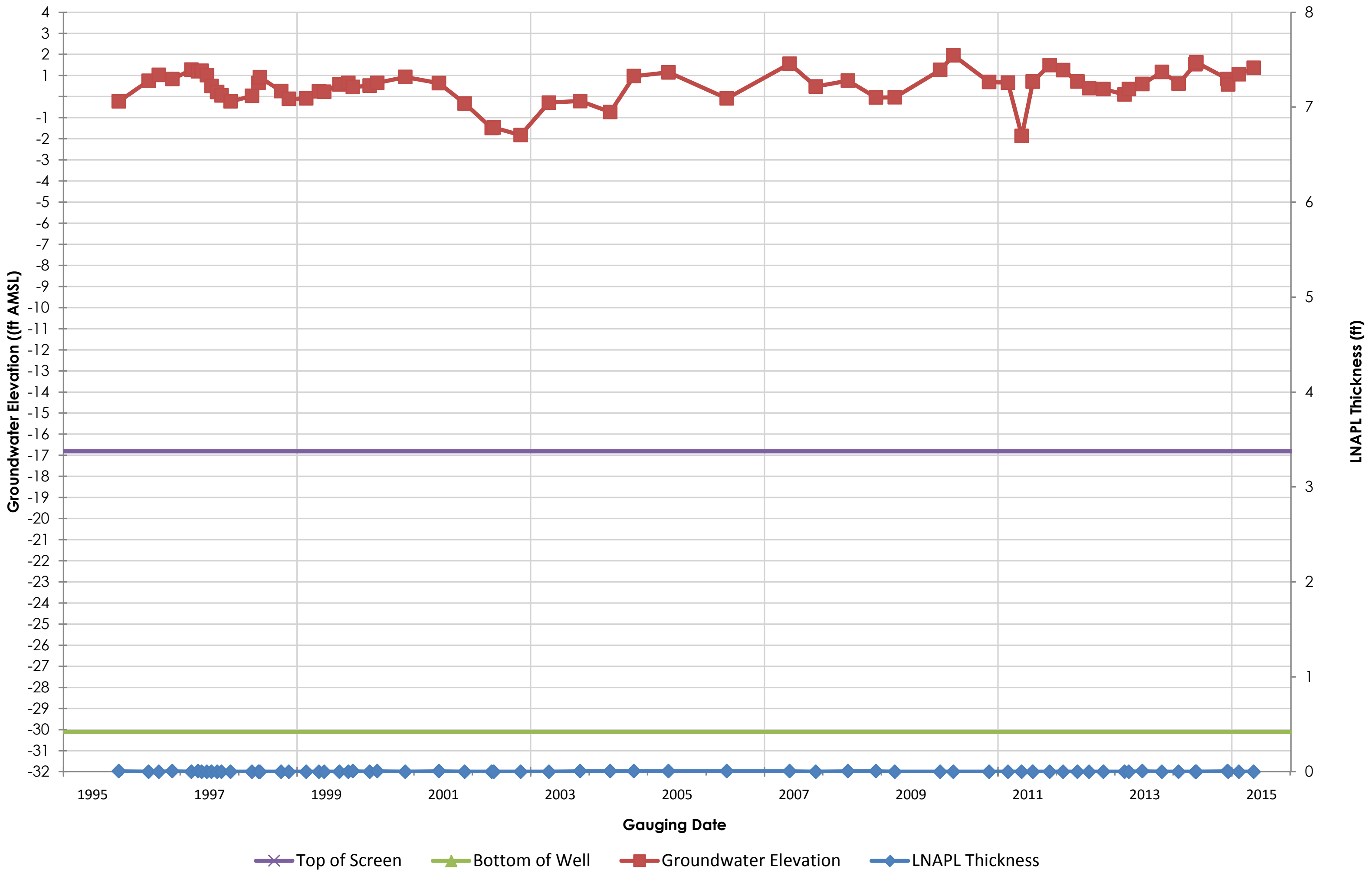
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-86

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

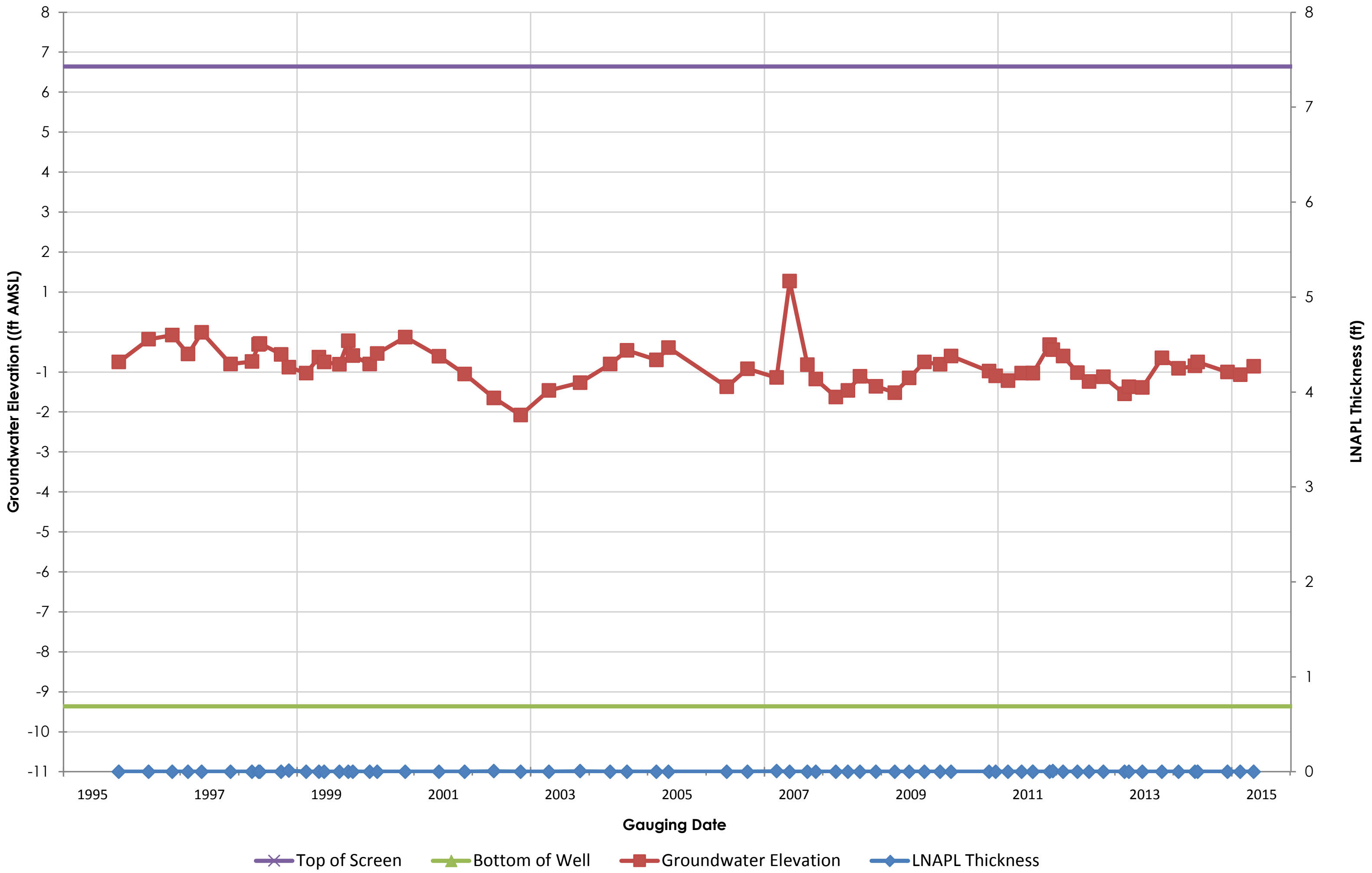
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-87I

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

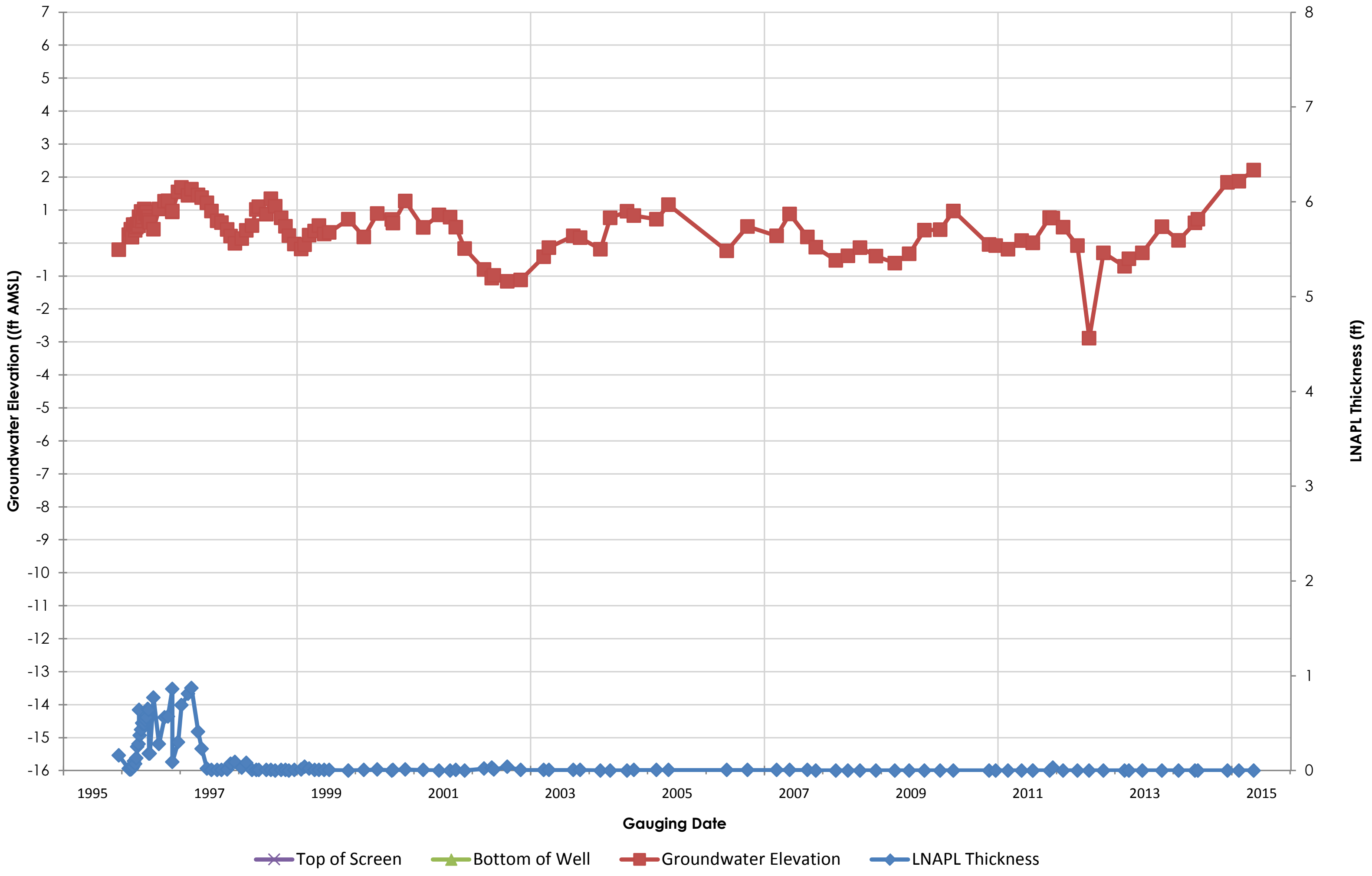
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-88

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

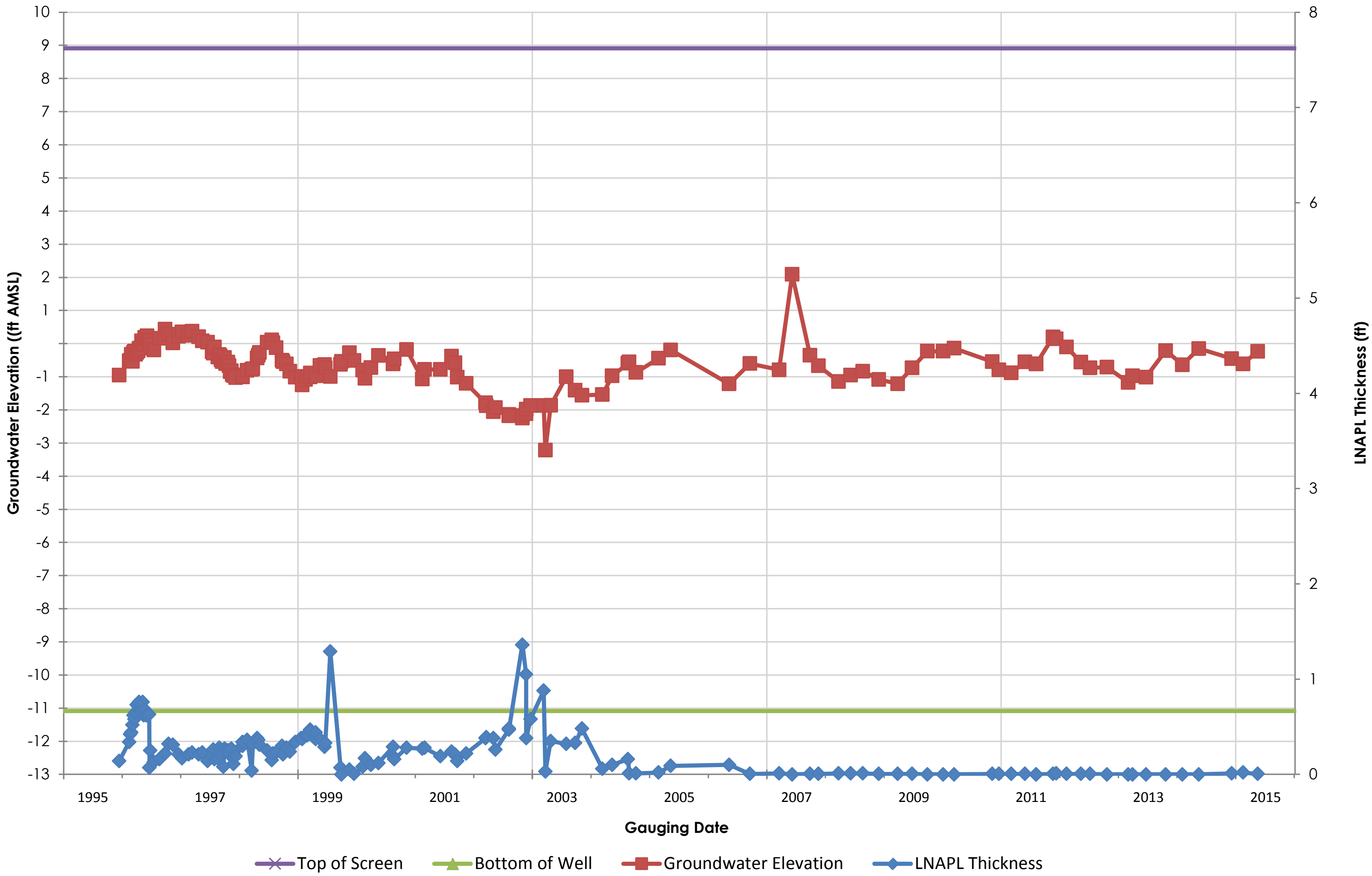
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-88A

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

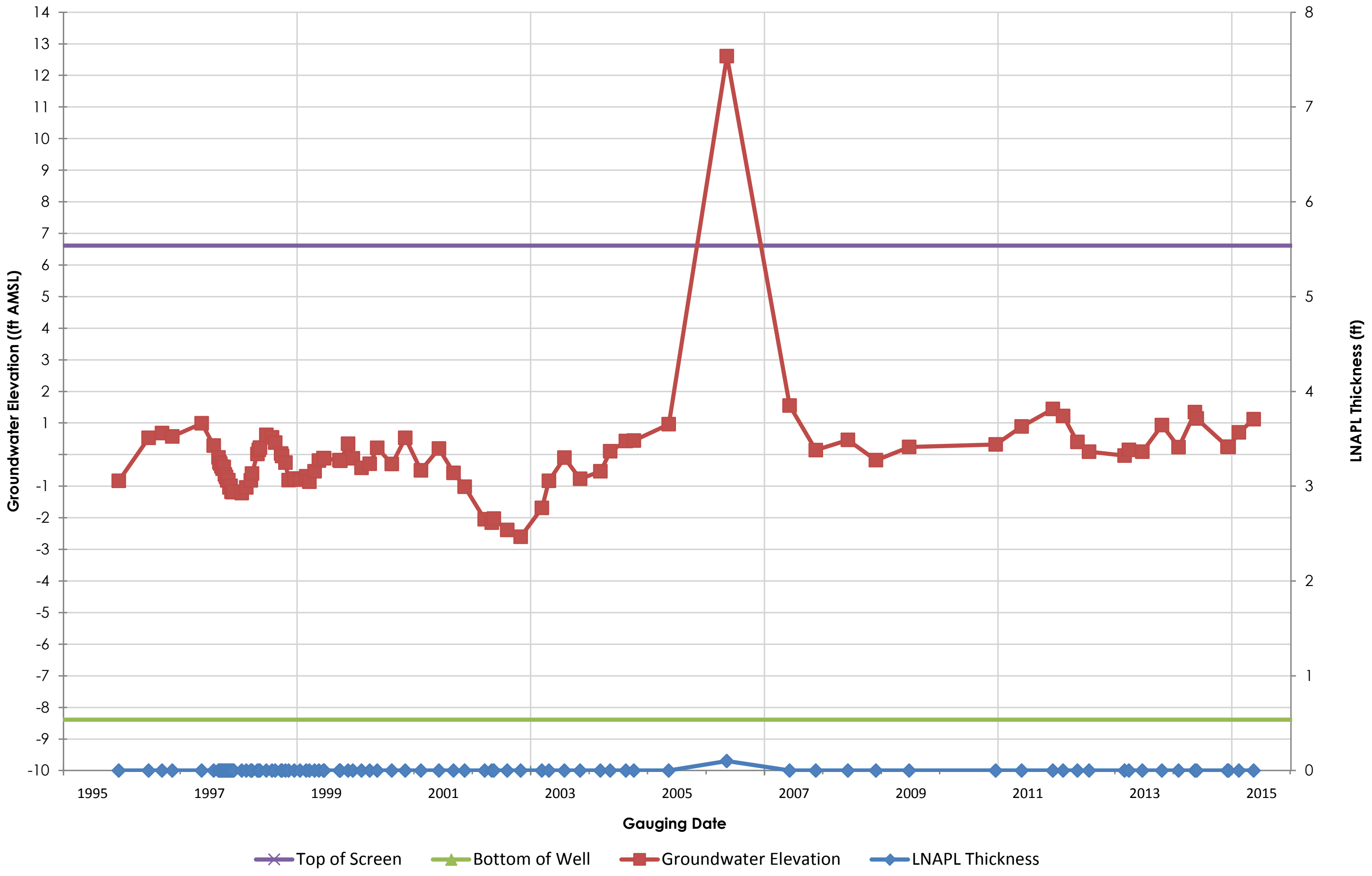
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-89

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

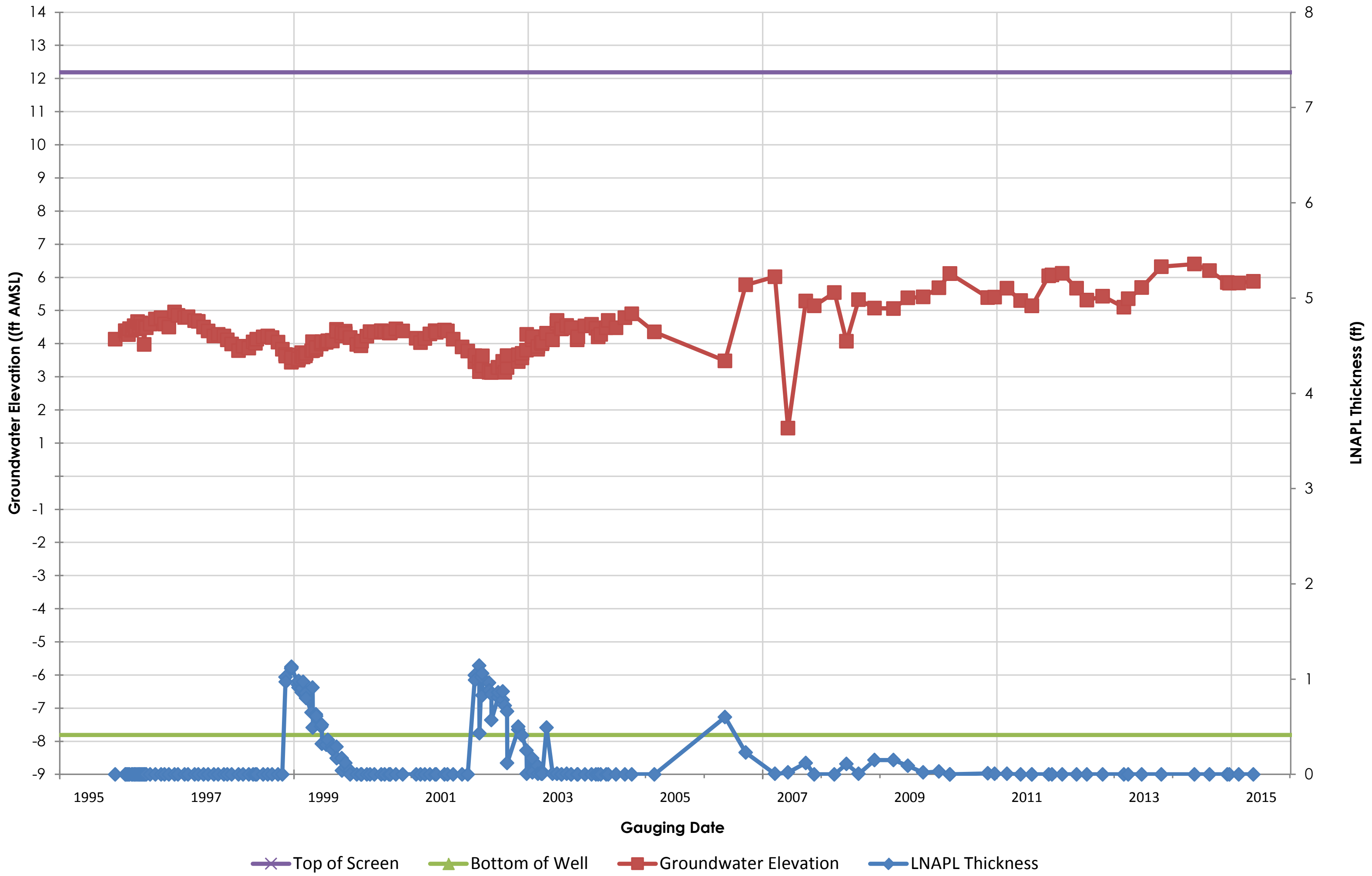
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-95

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Stantec

Client/Project

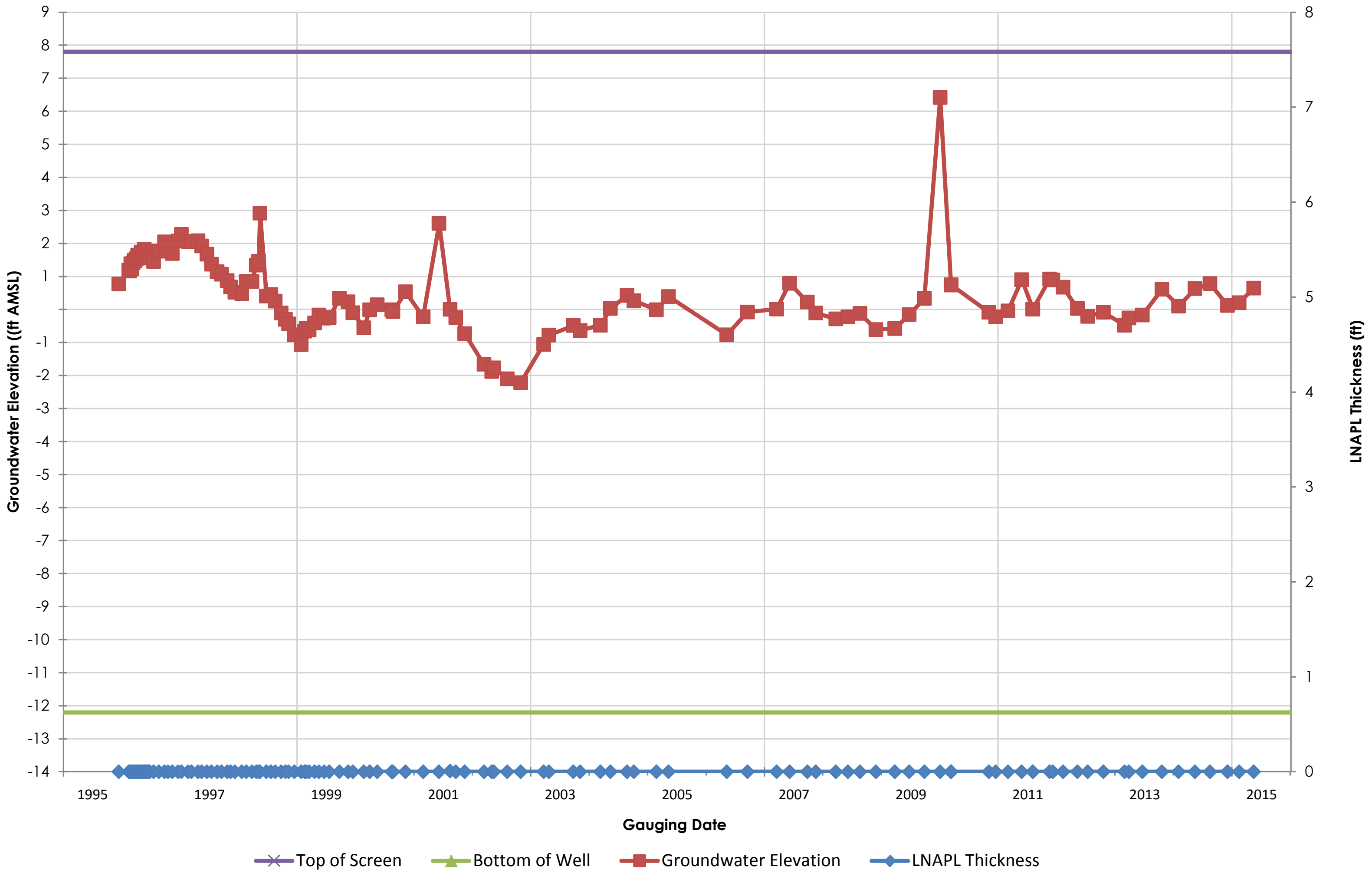
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-98

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

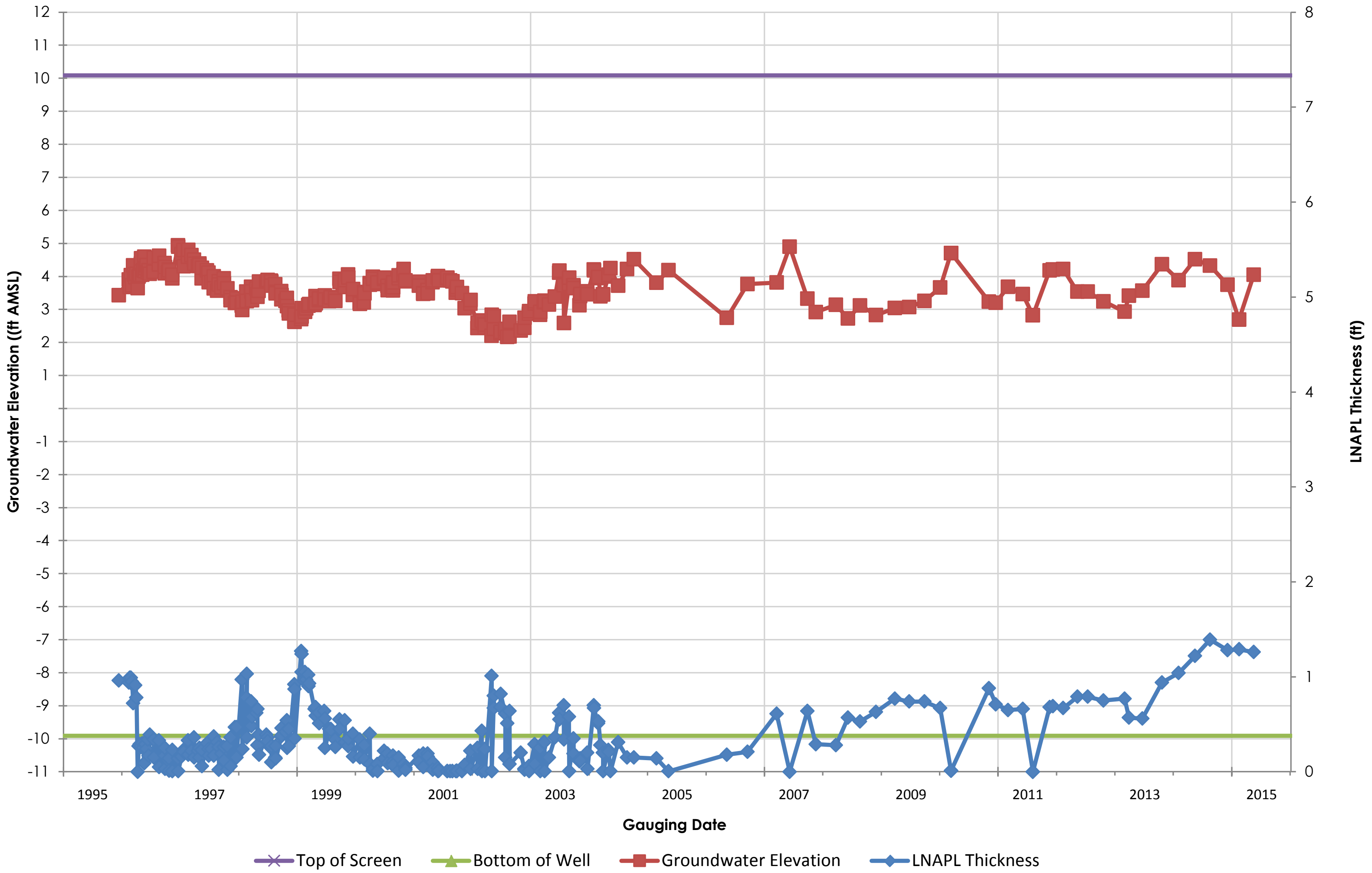
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-99

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

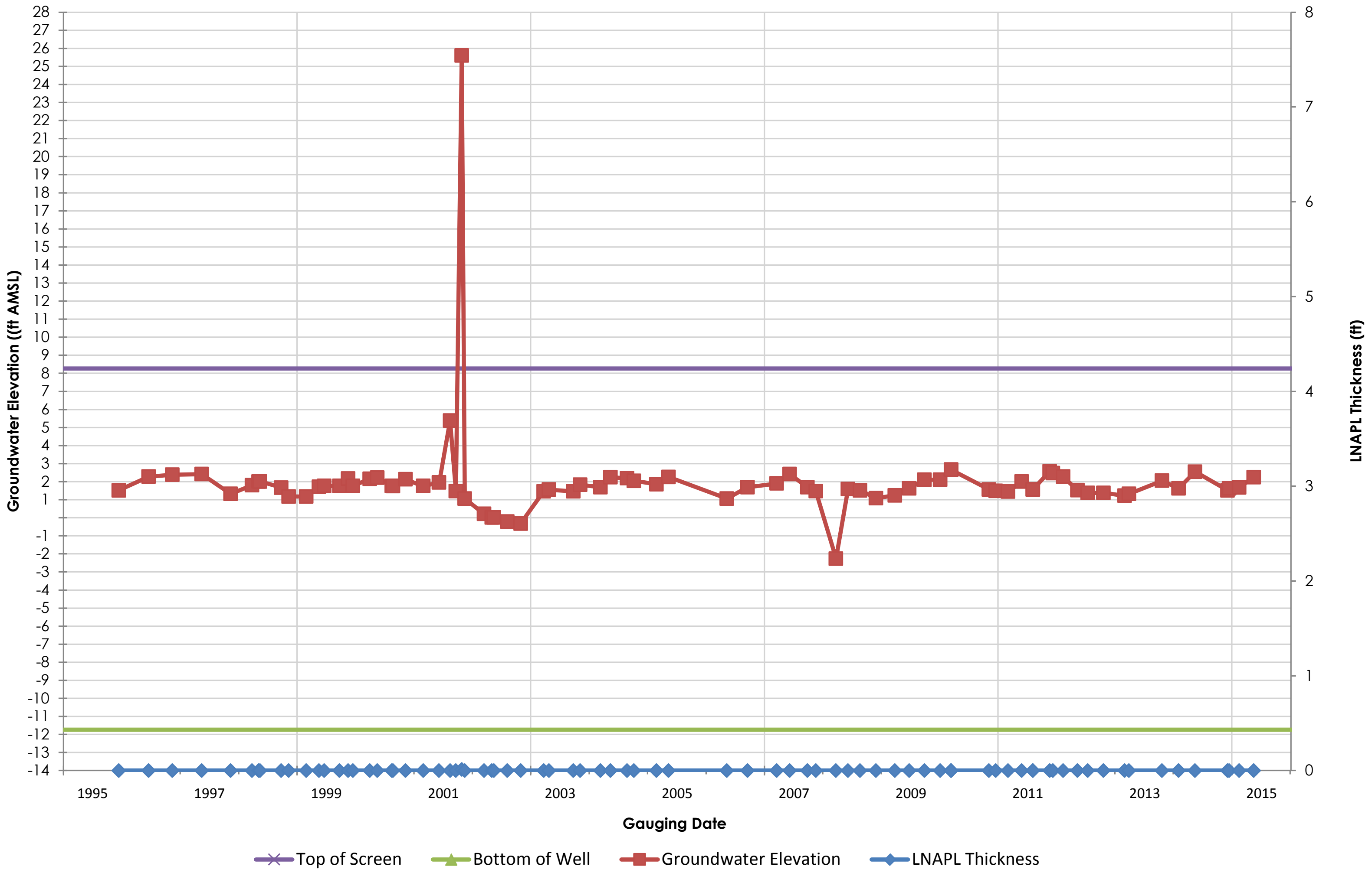
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-100

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

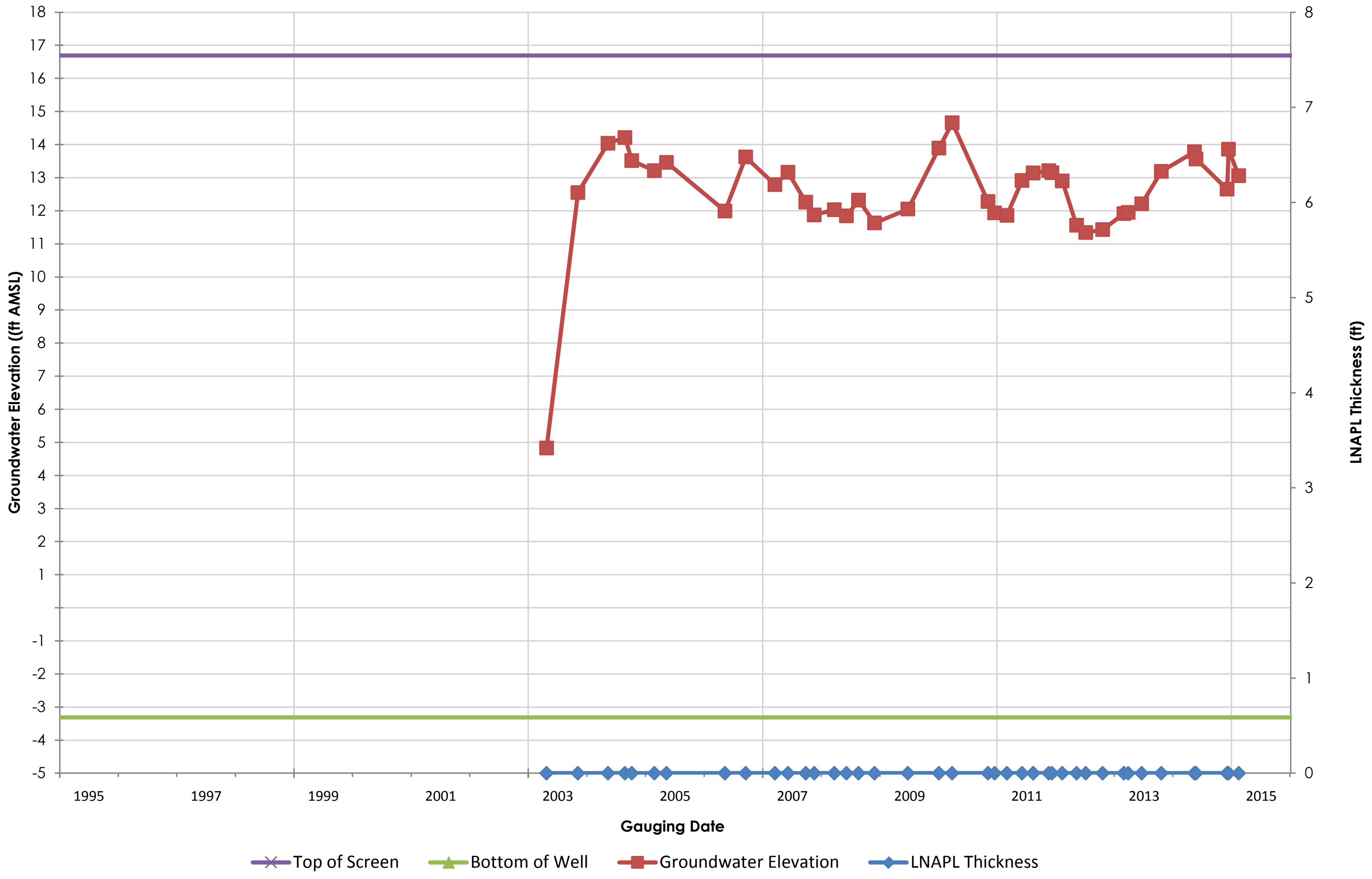
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-101

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

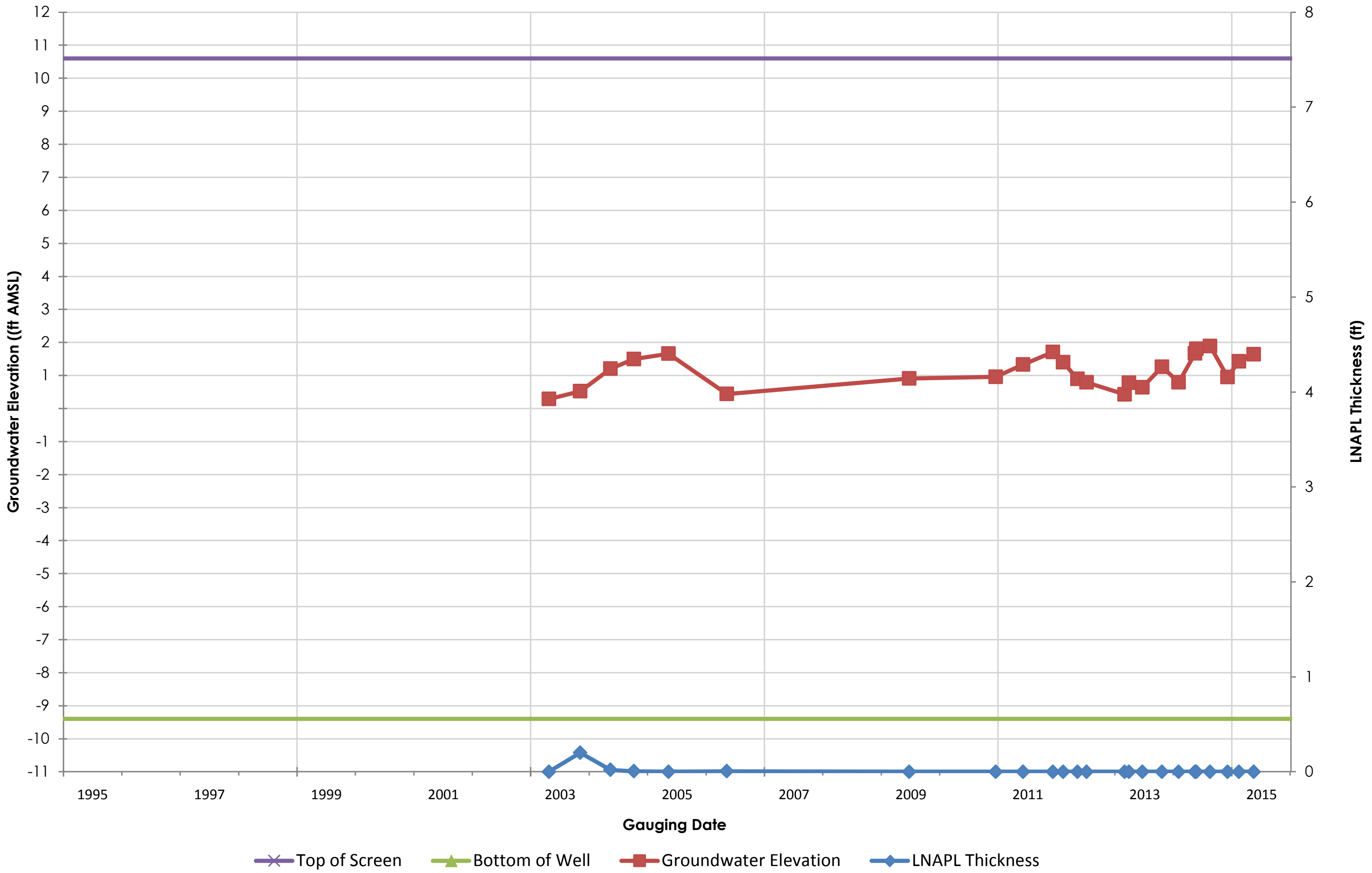
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-116

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

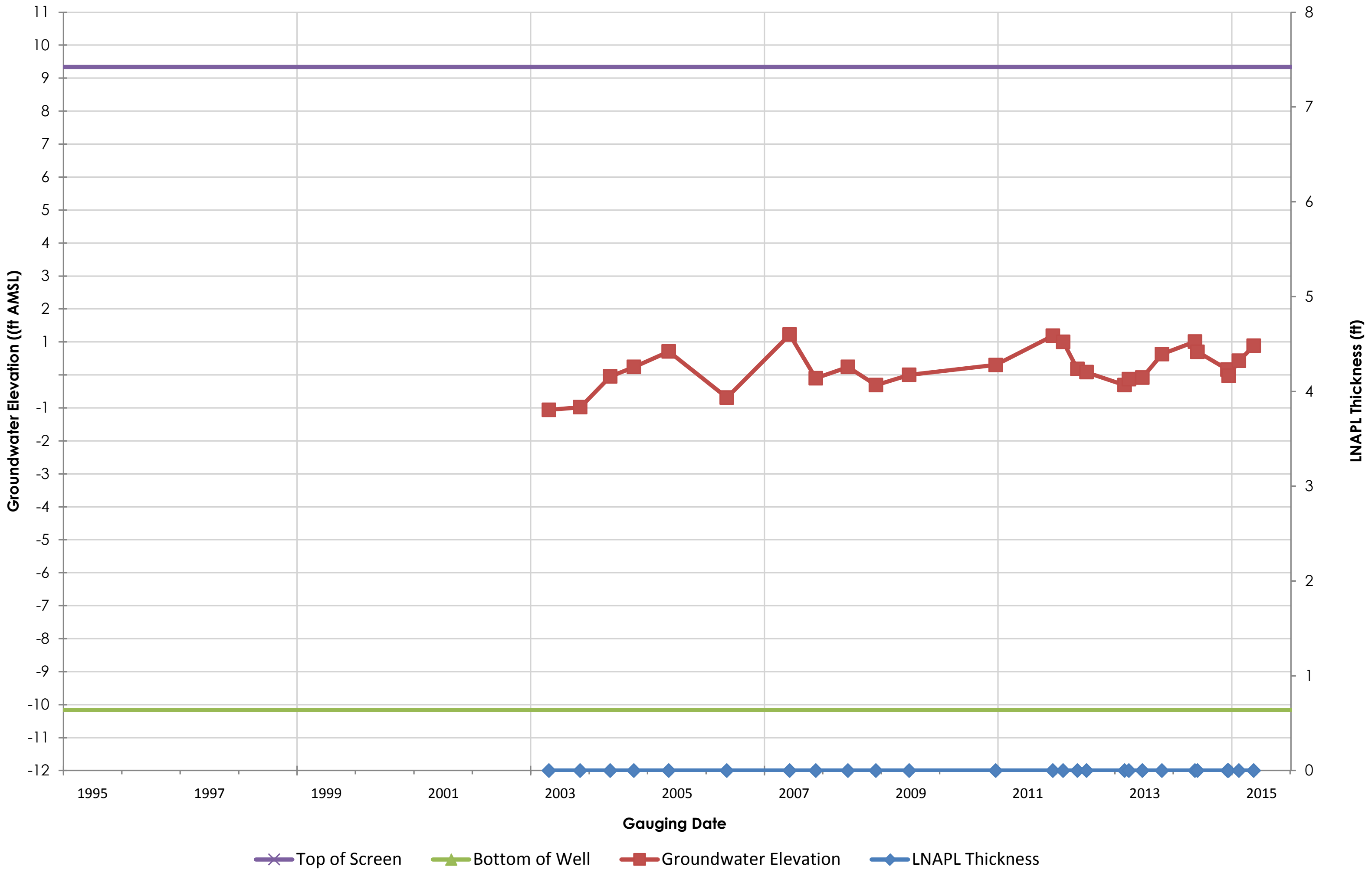
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-117

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

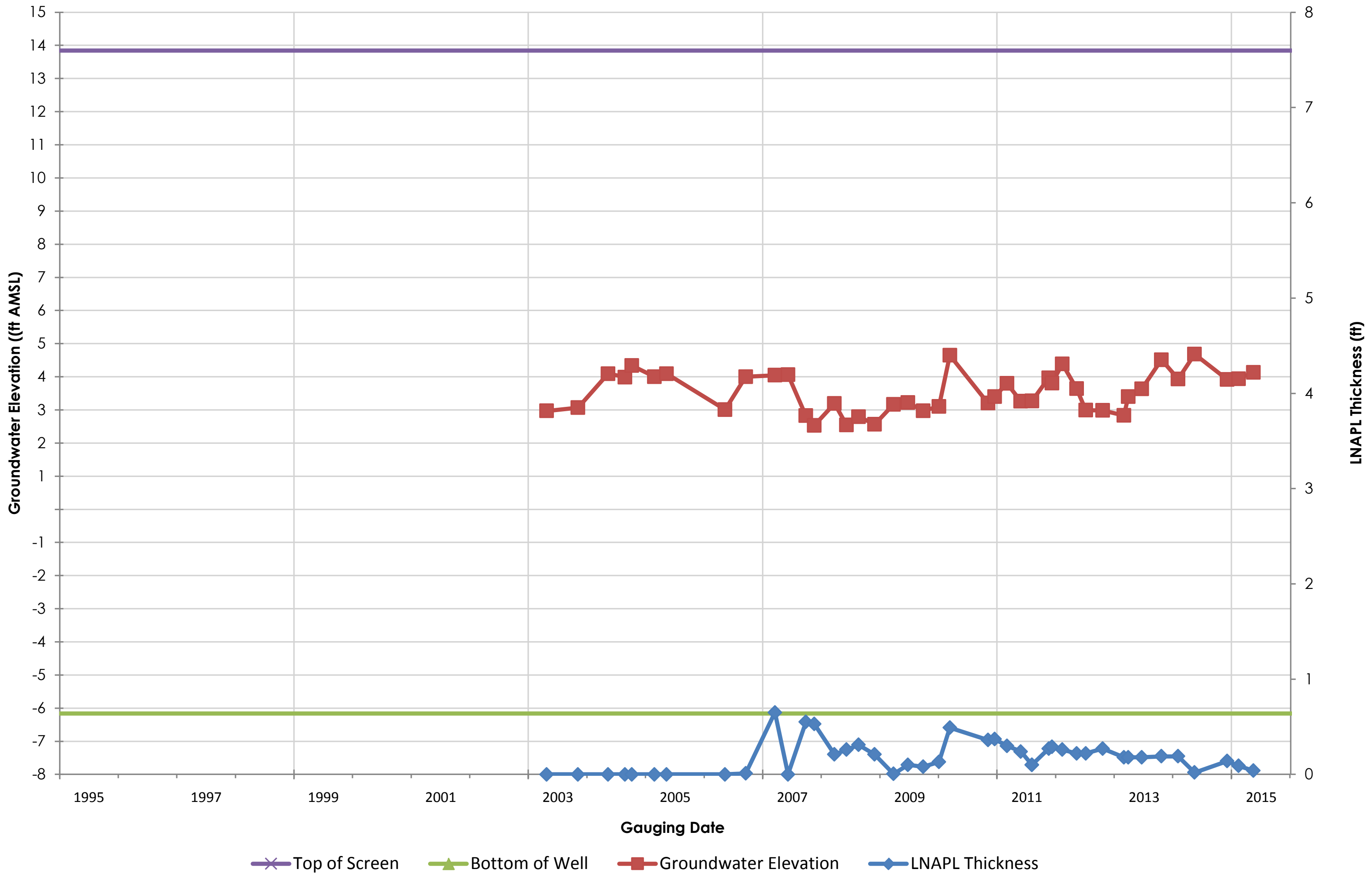
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-118

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

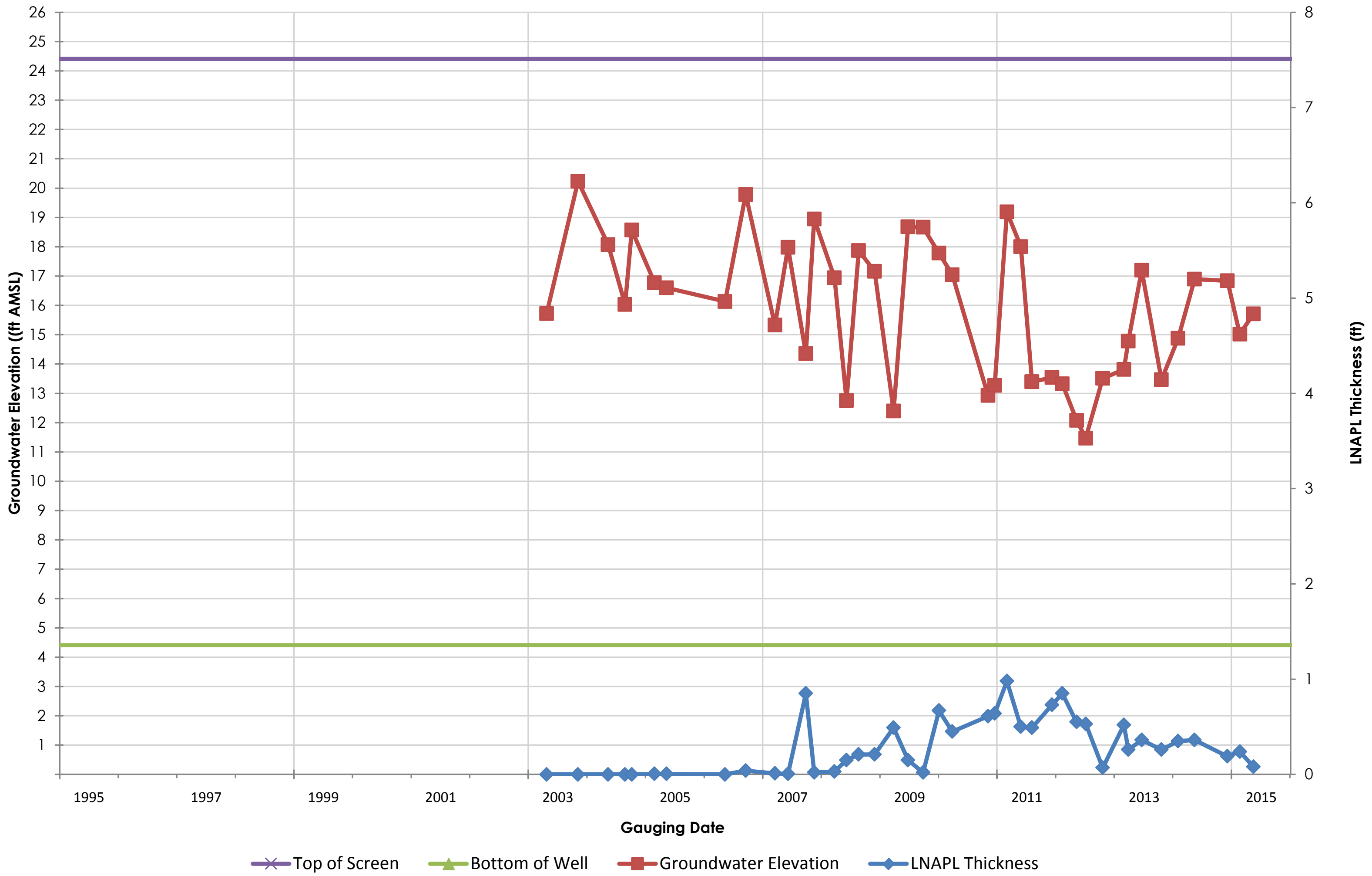
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-125

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

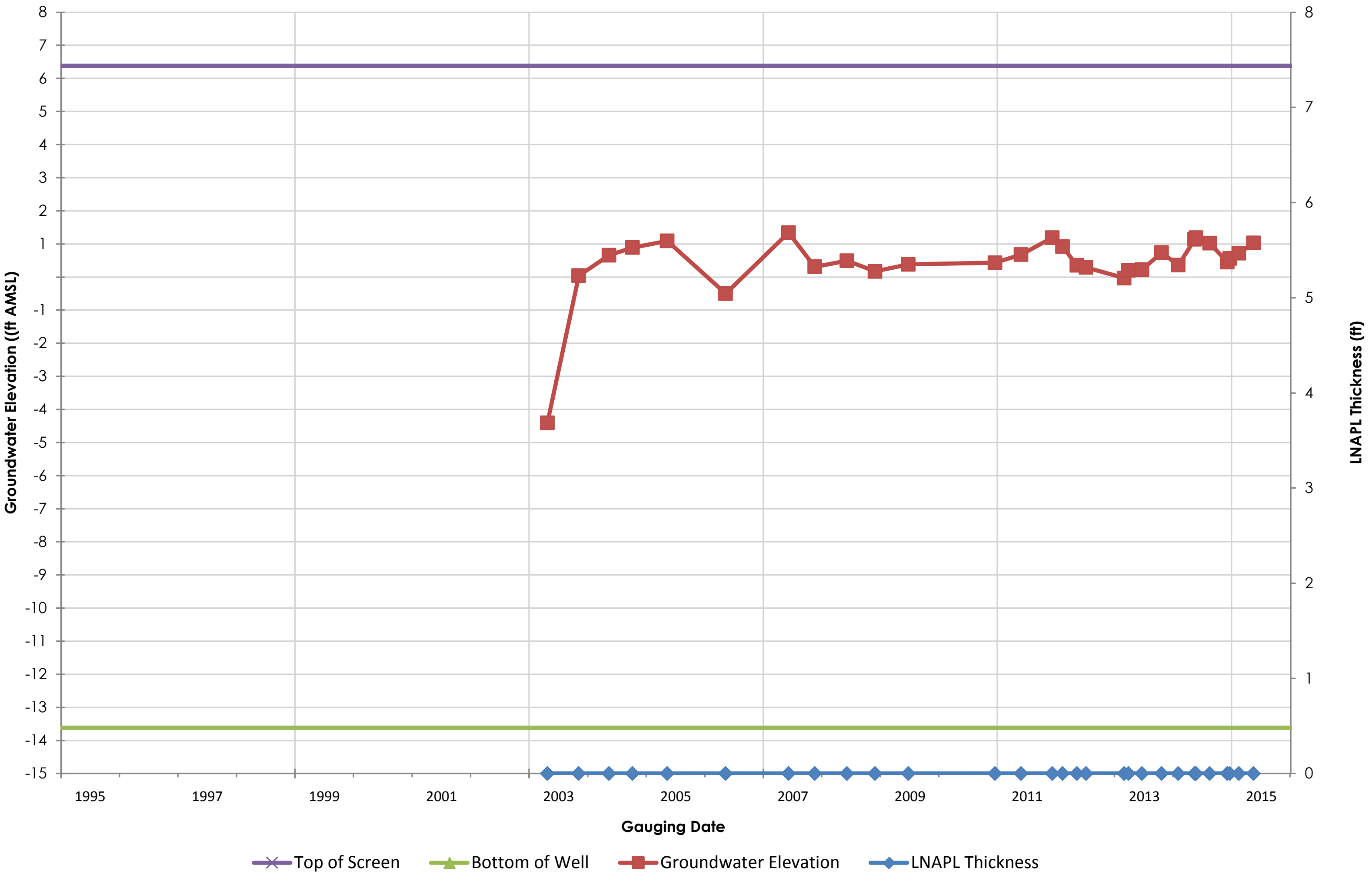
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-126

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

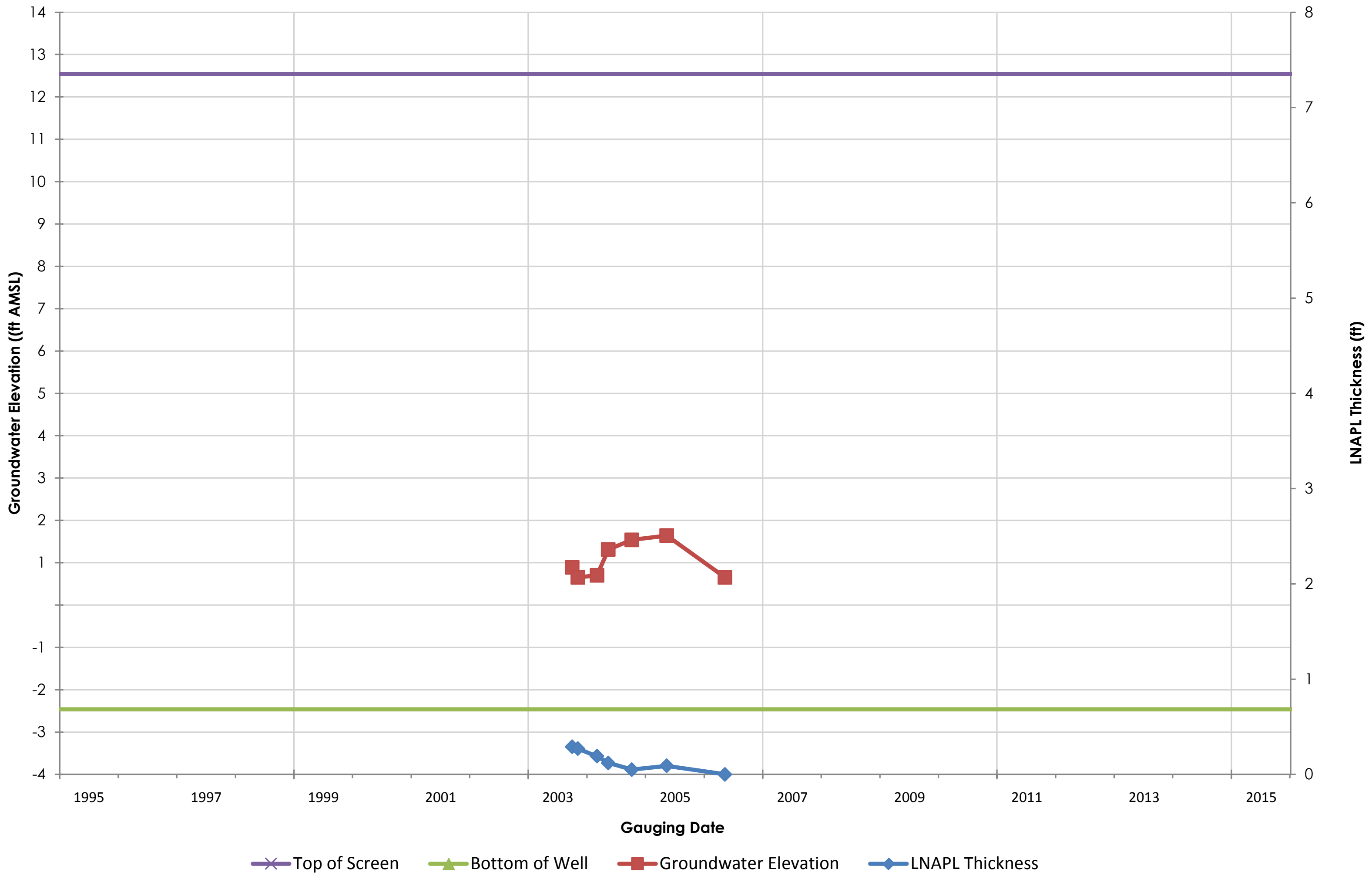
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-127

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Stantec

Client/Project

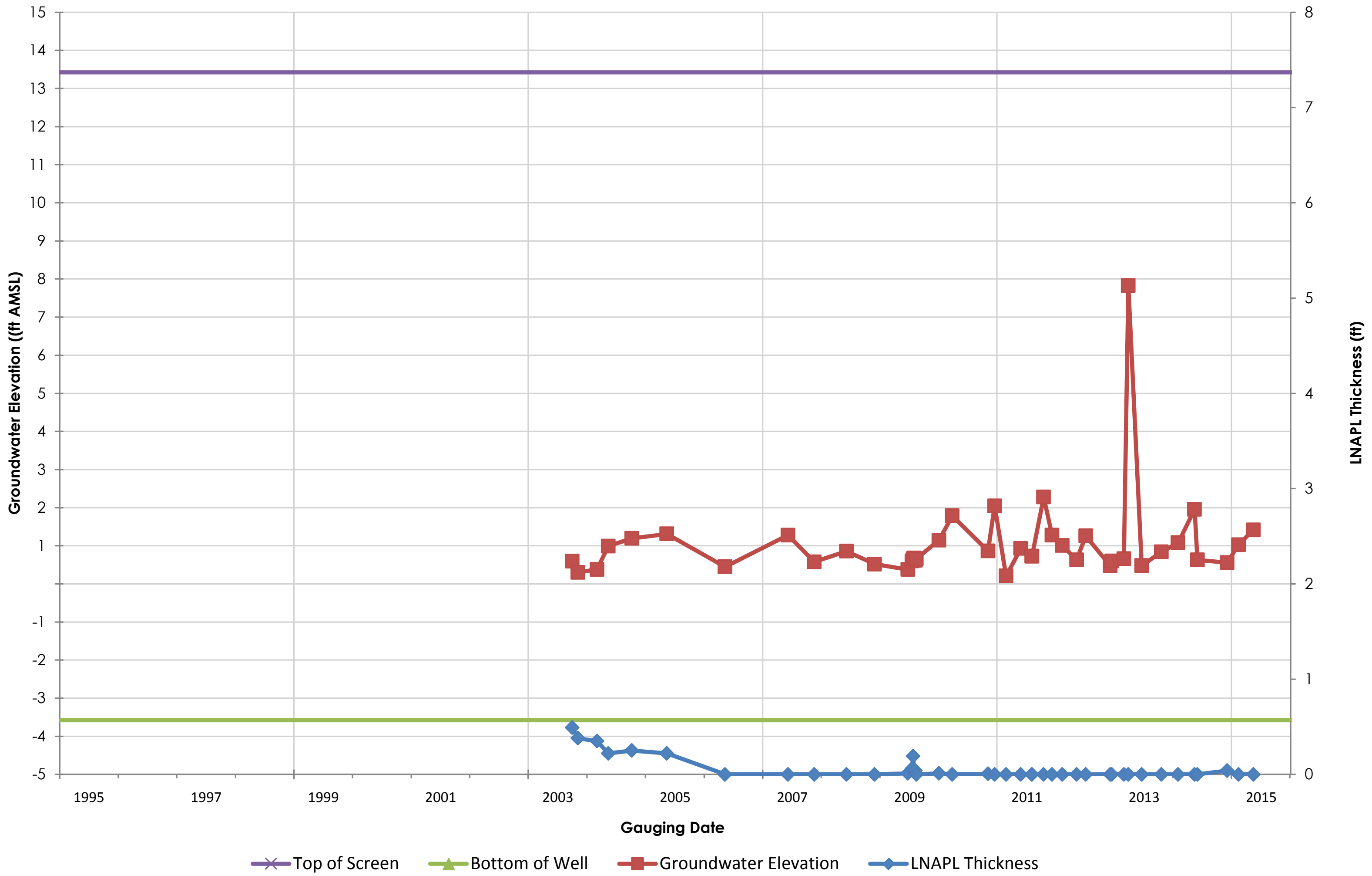
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-161

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

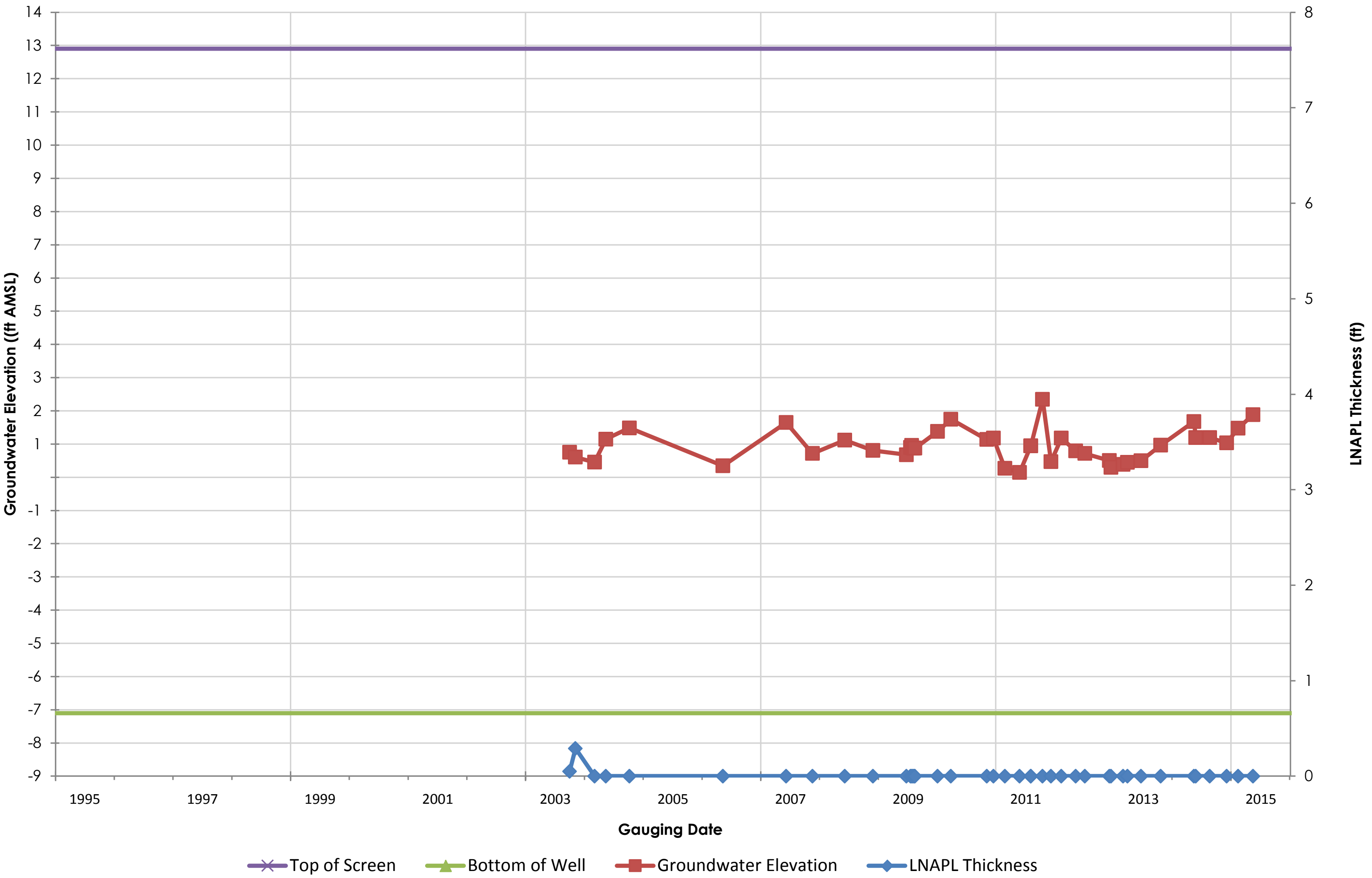
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-162

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

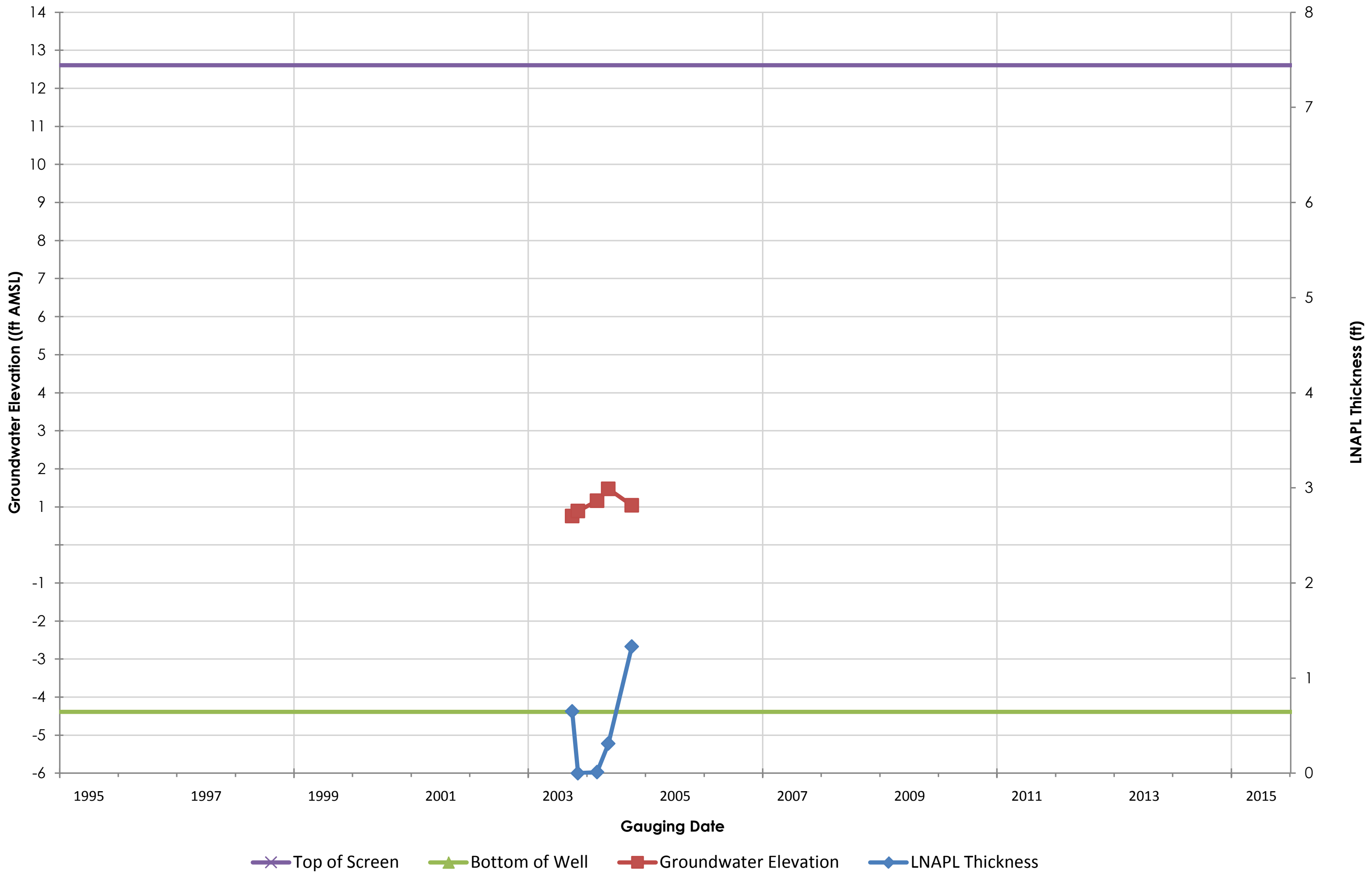
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-164

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

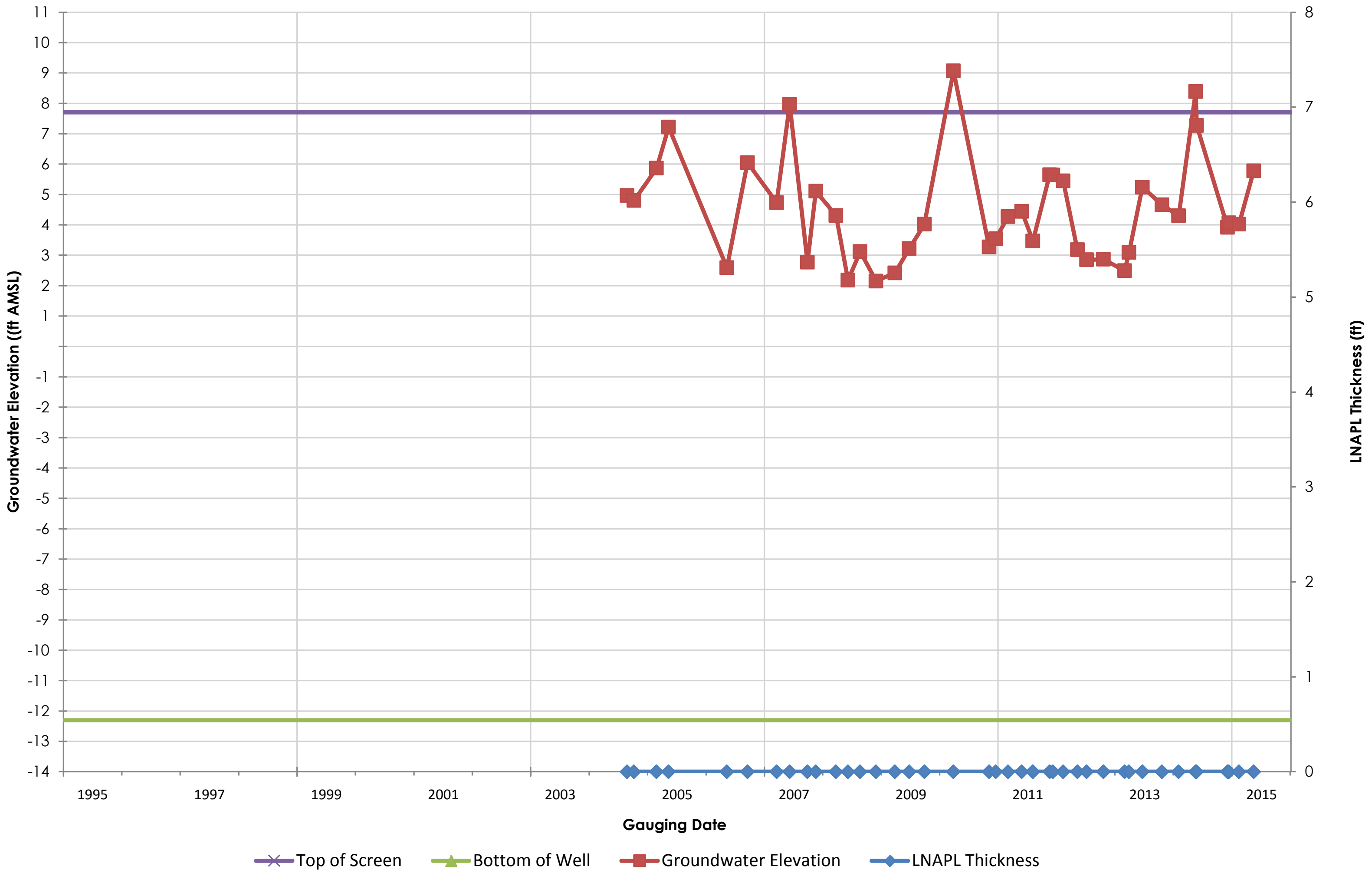
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-171

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

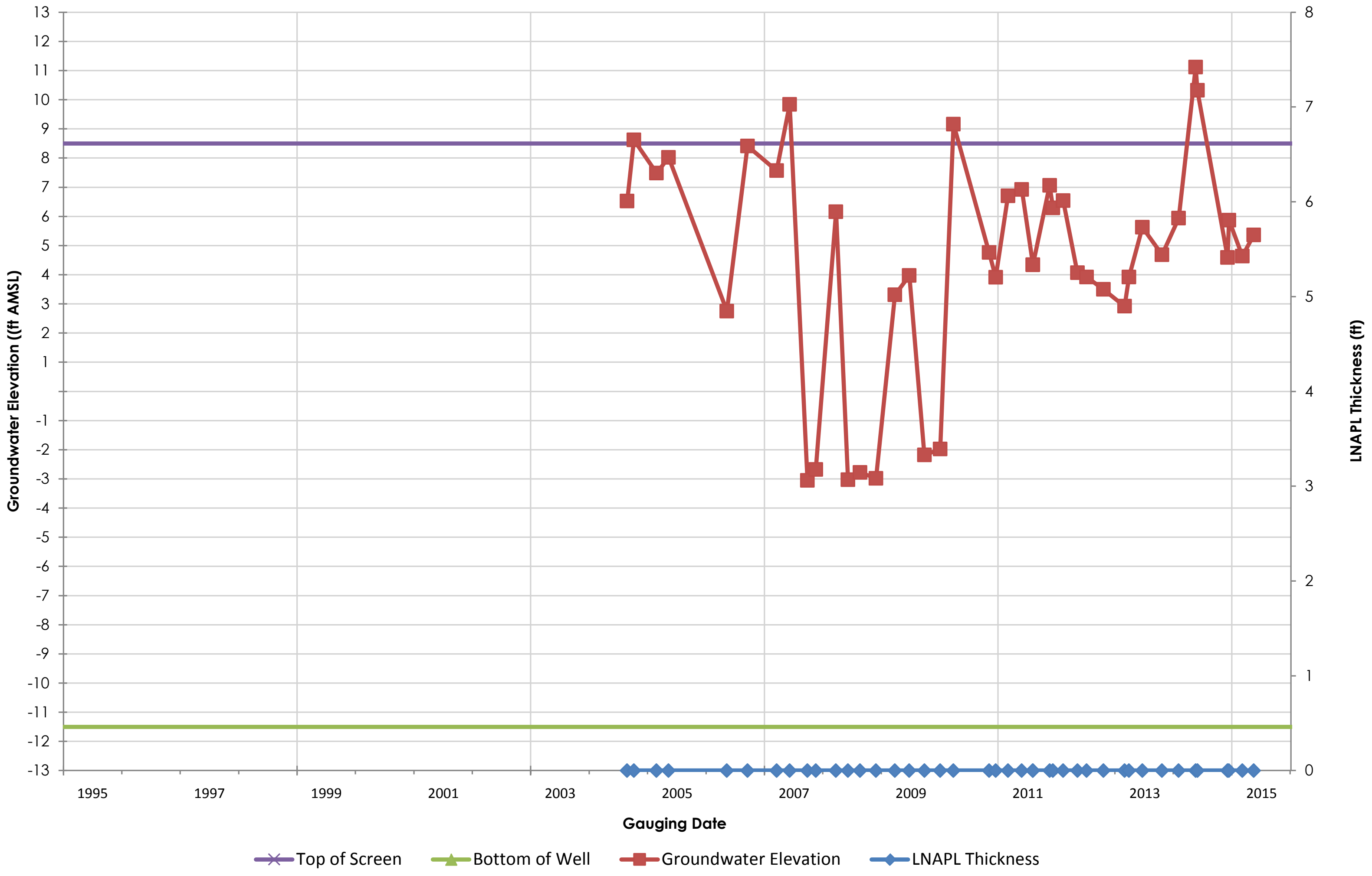
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-179

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

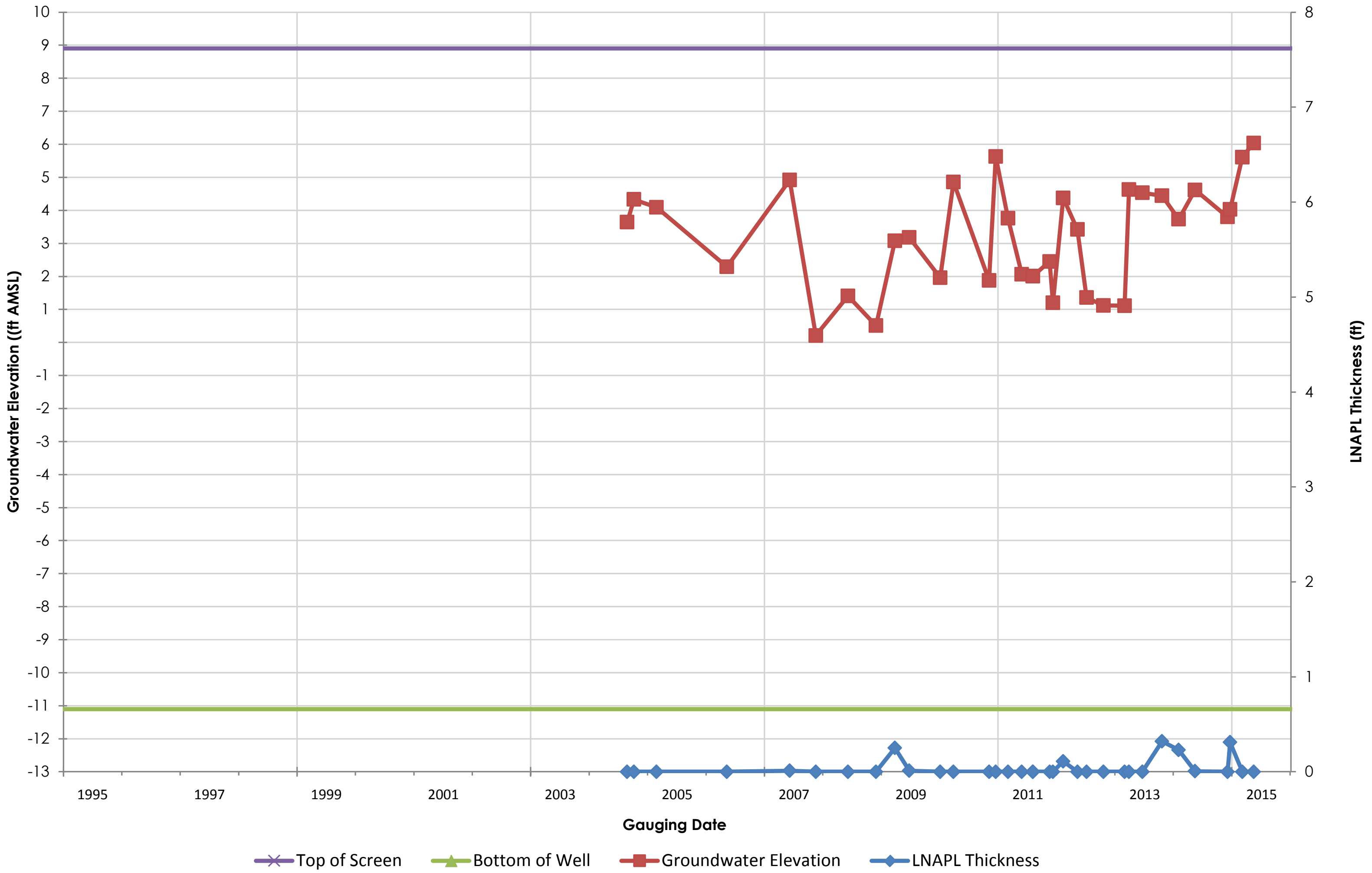
Stantec

Figure/Well No.

S-180

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

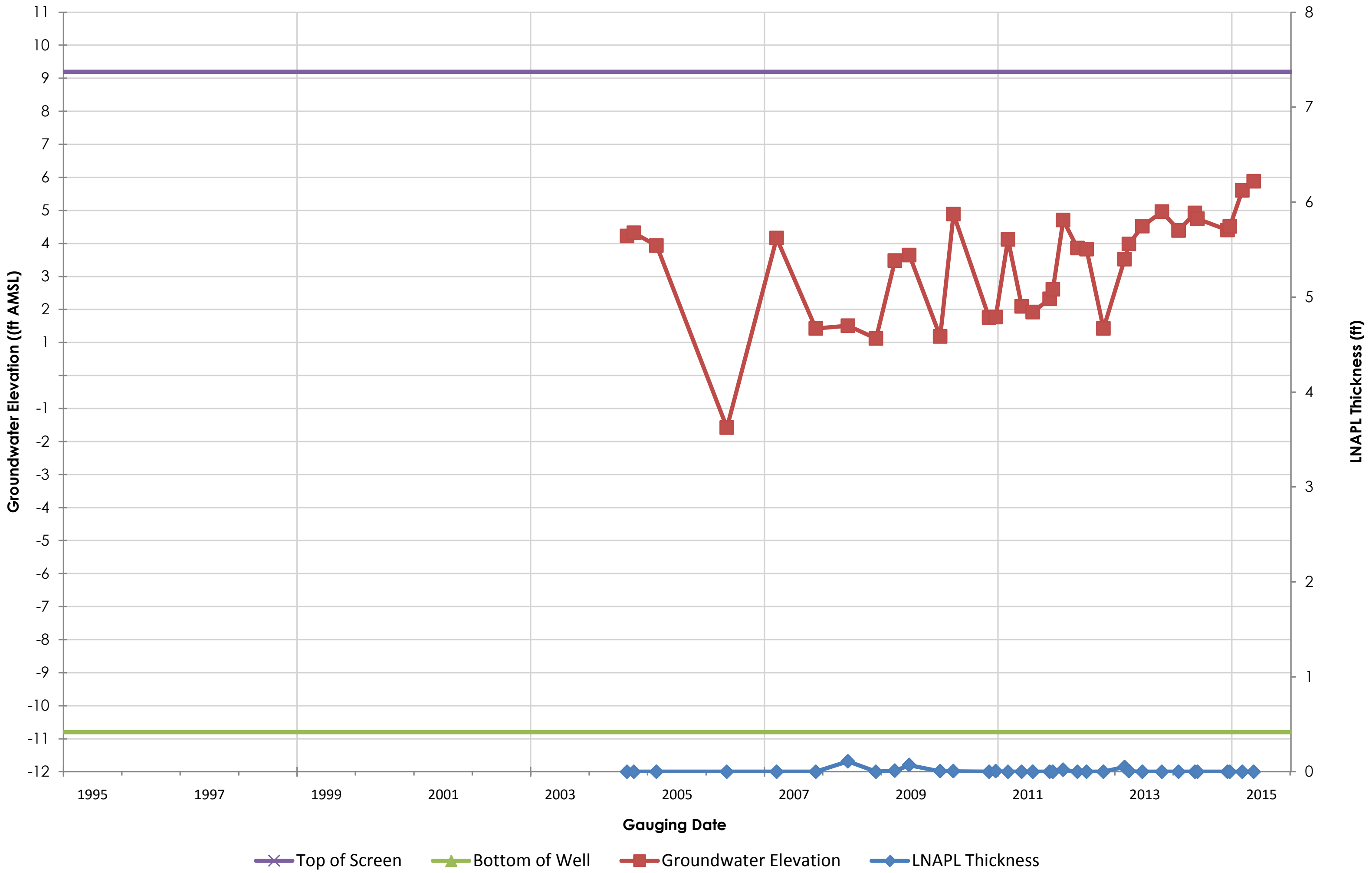
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-181

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

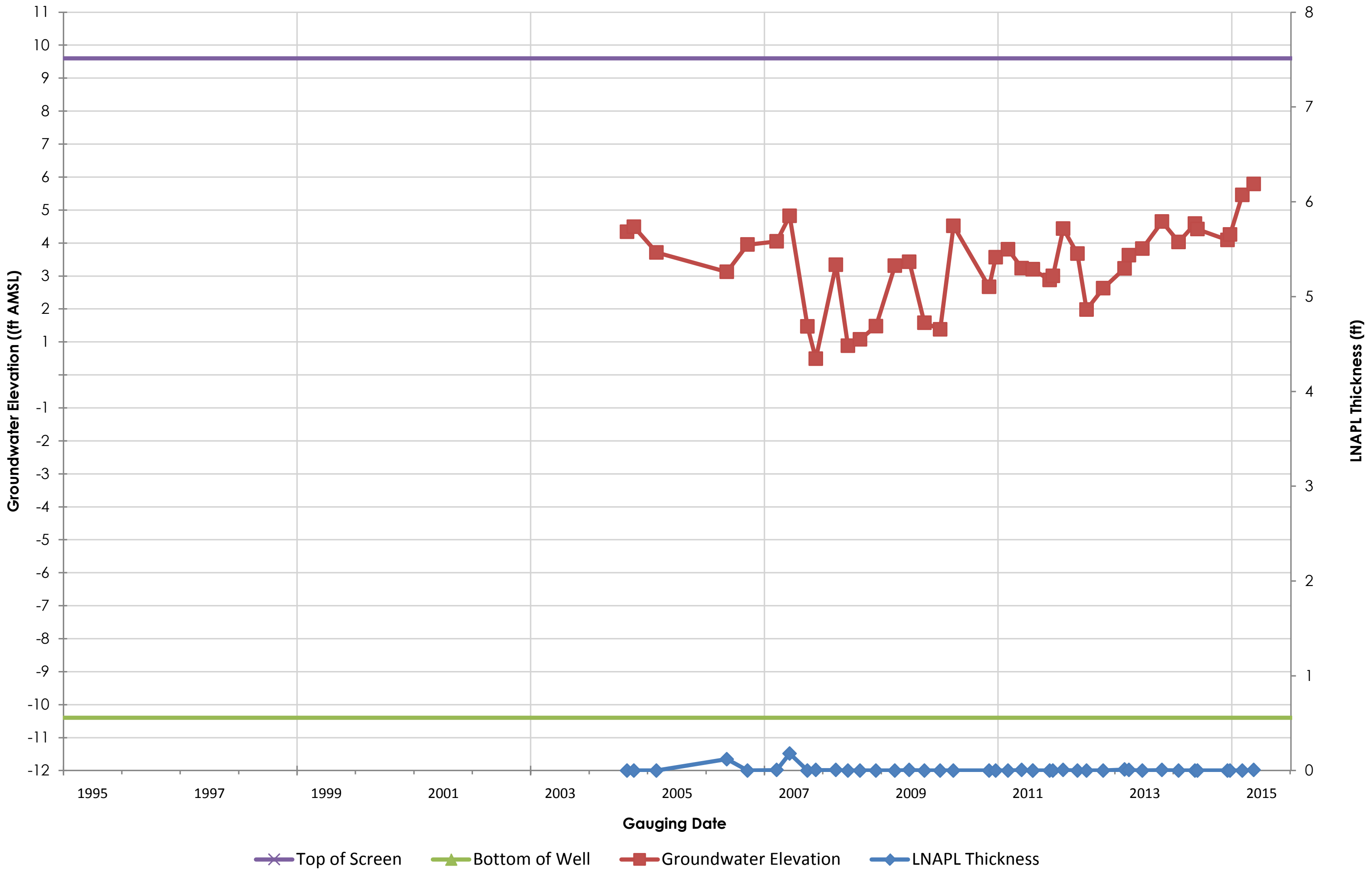
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-182

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

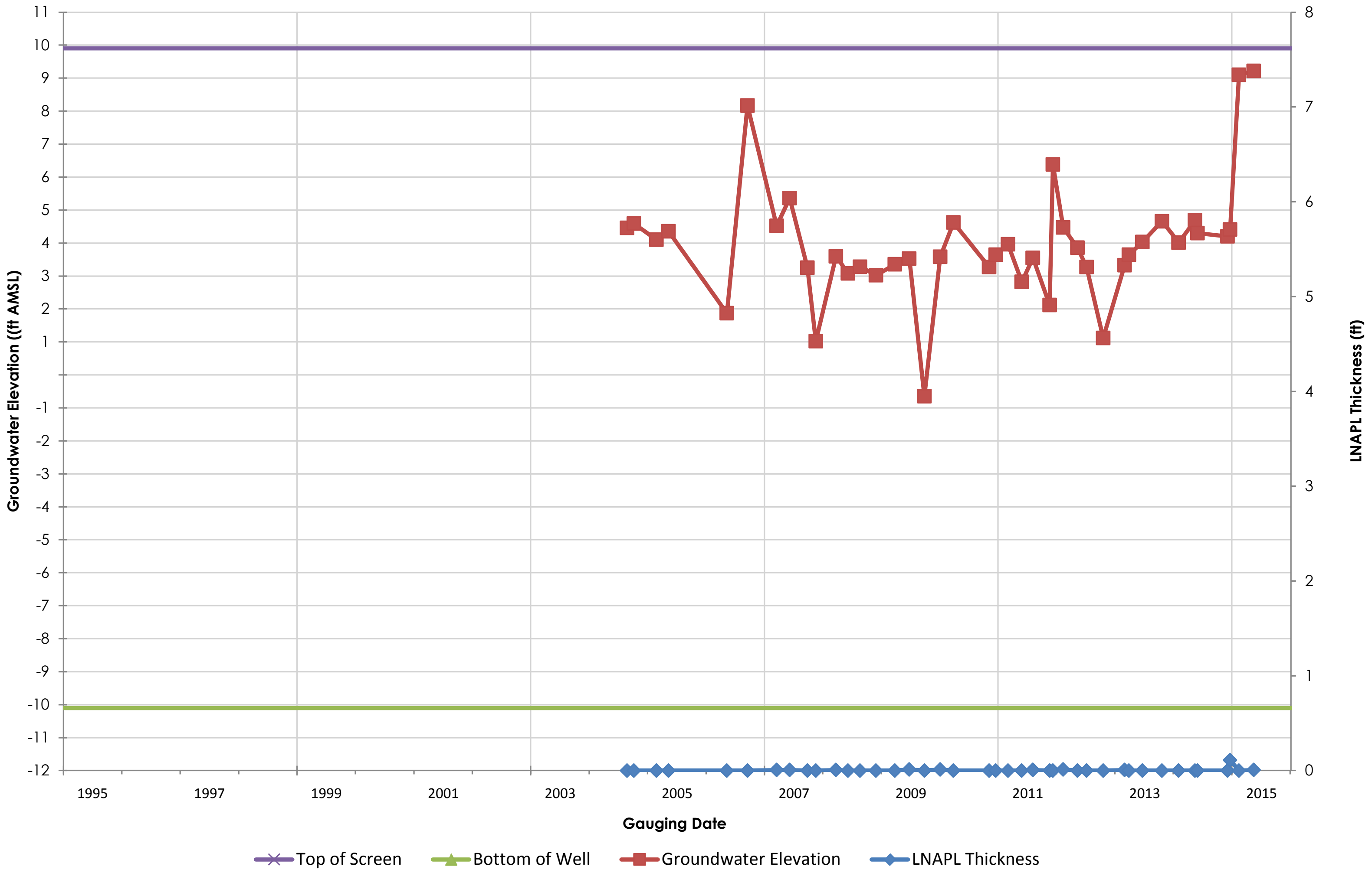
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-183

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

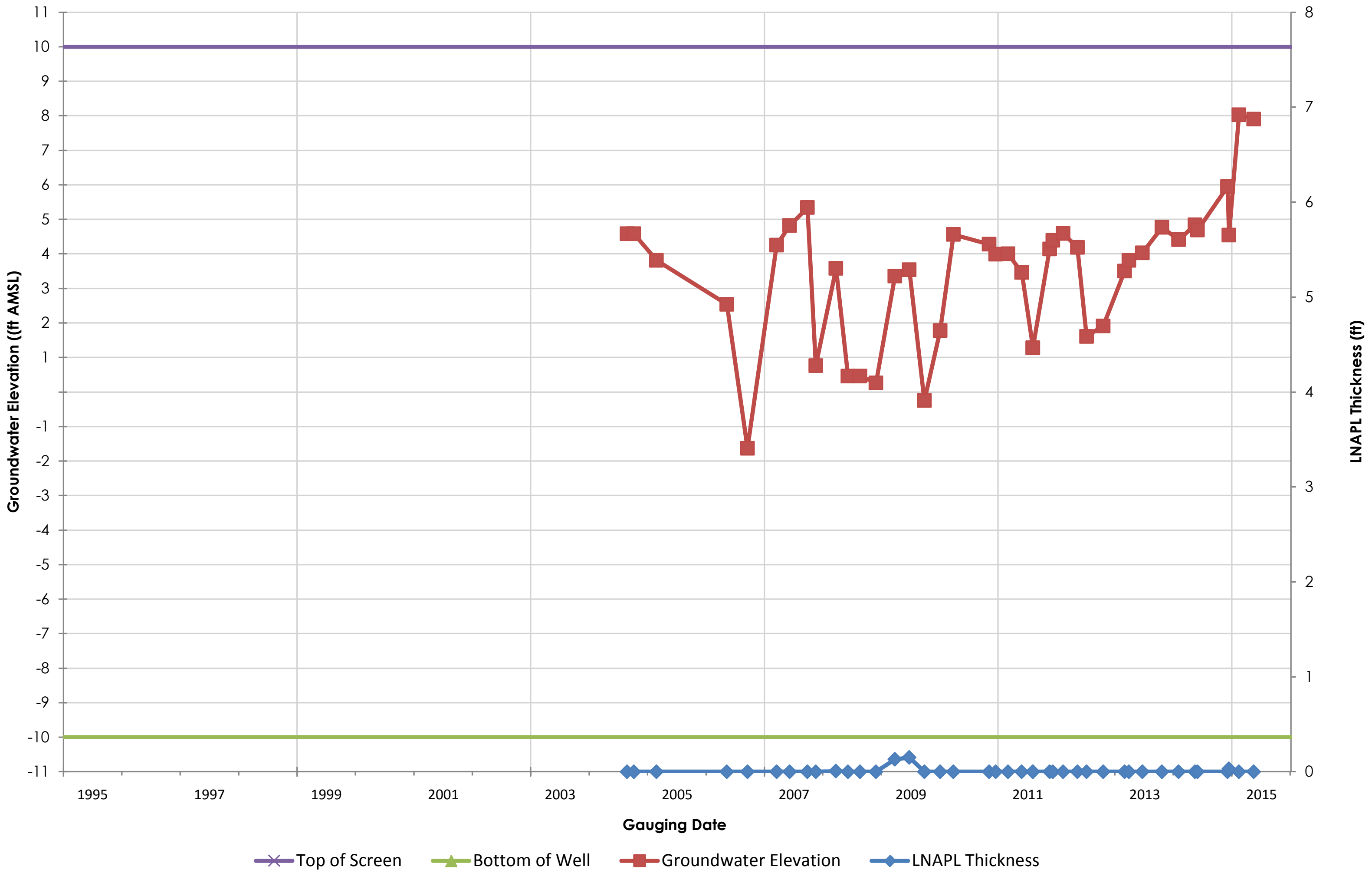
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-184

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

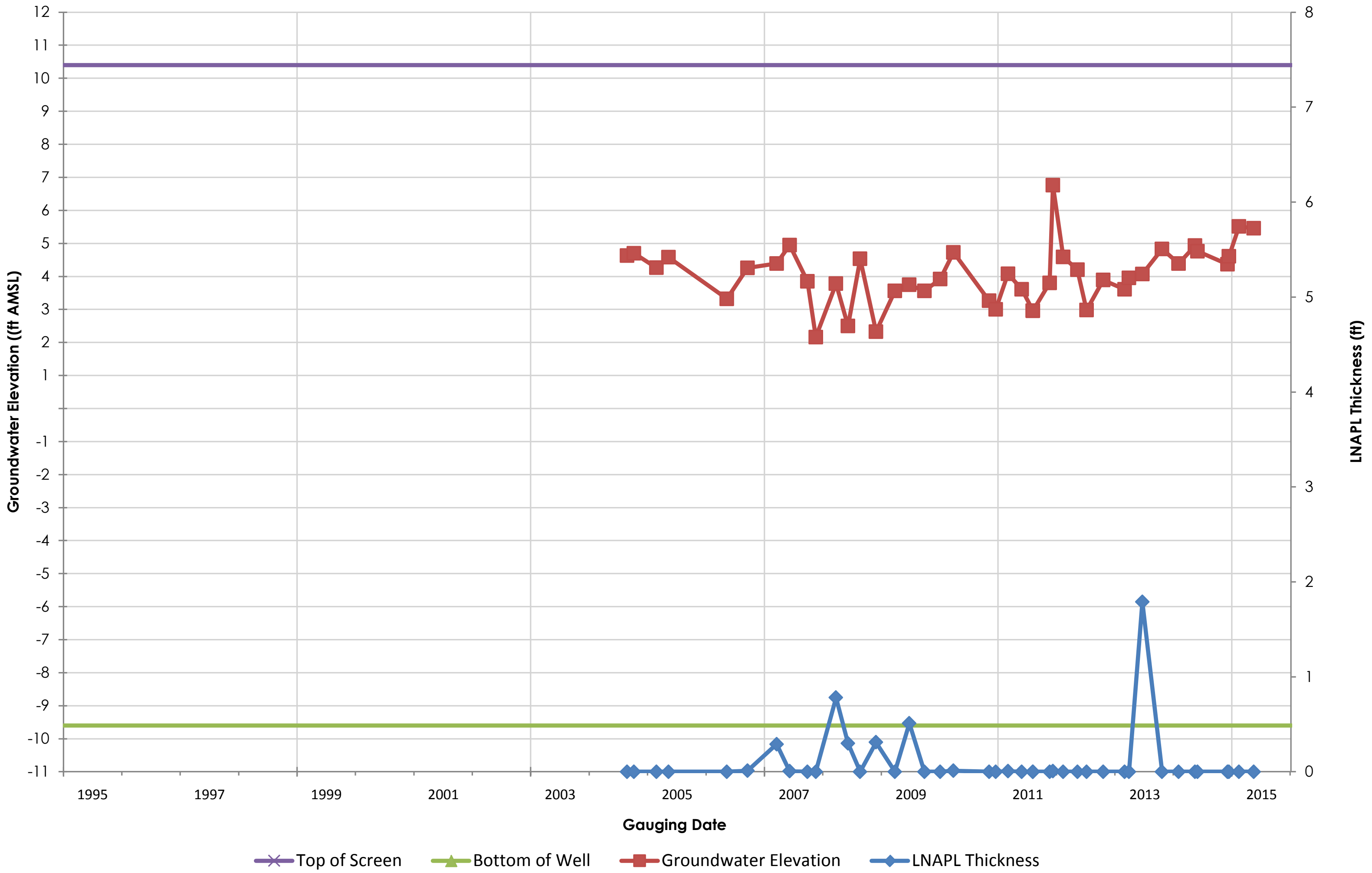
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-185

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

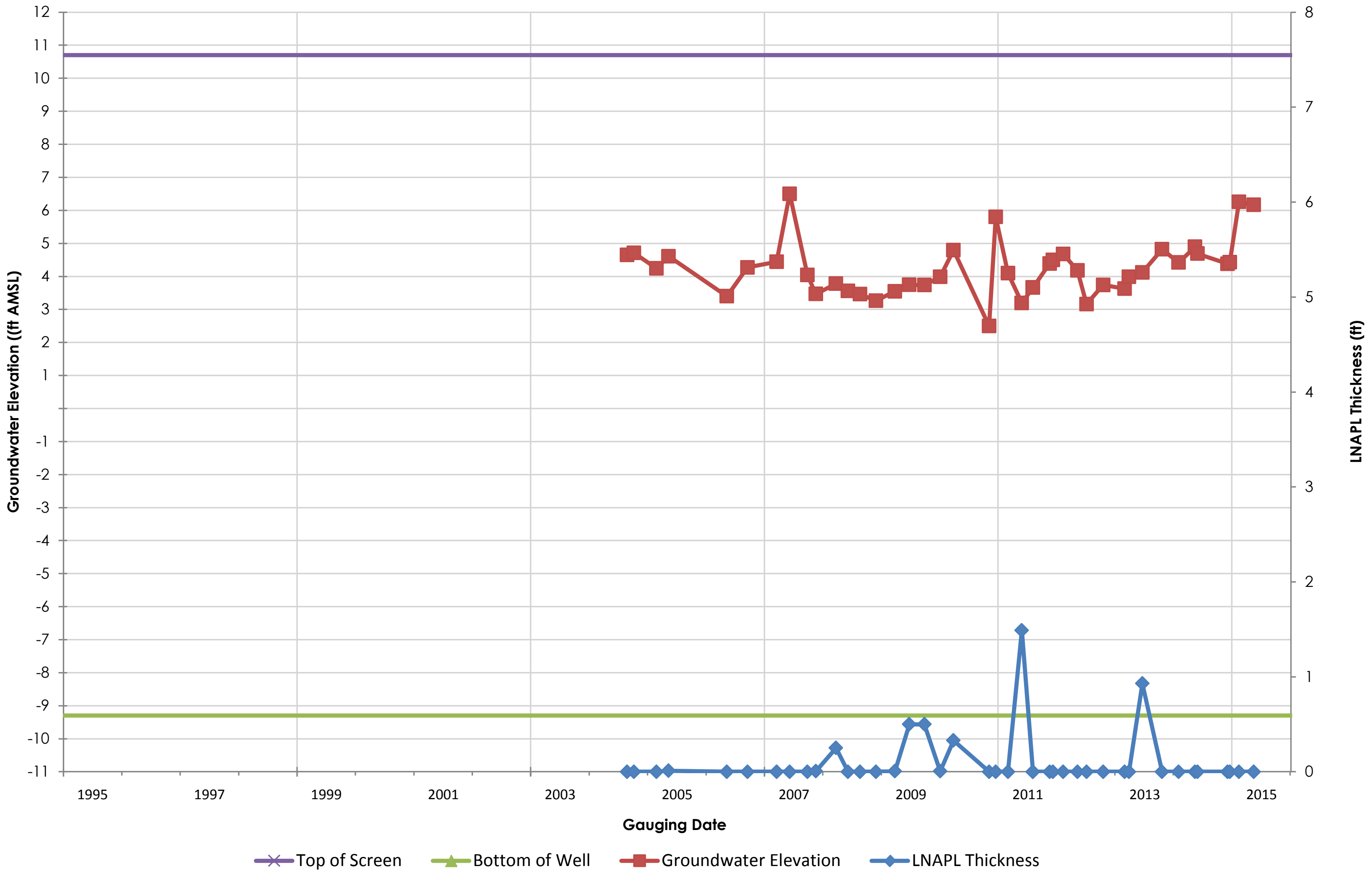
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-186

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

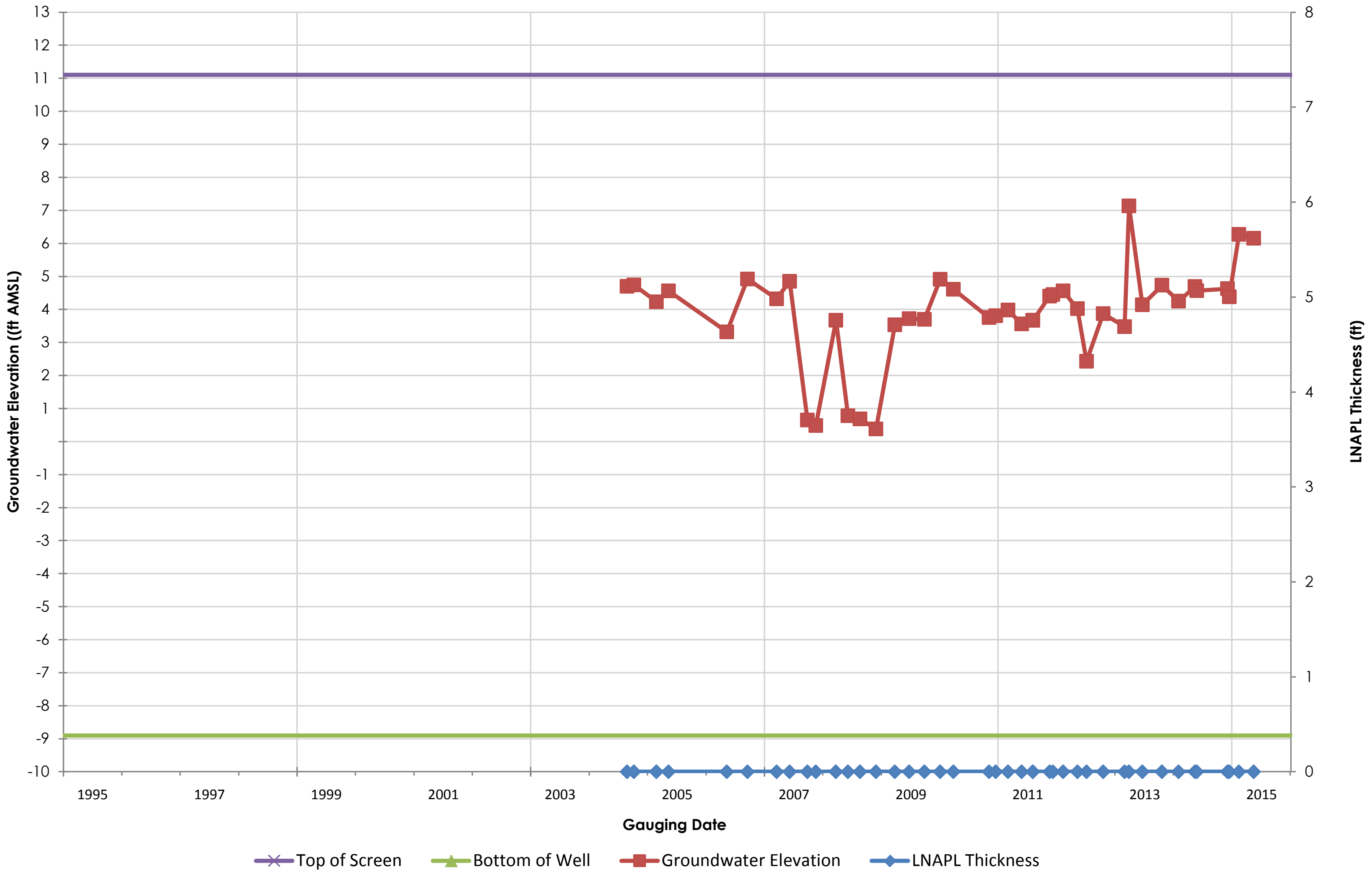
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-187

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

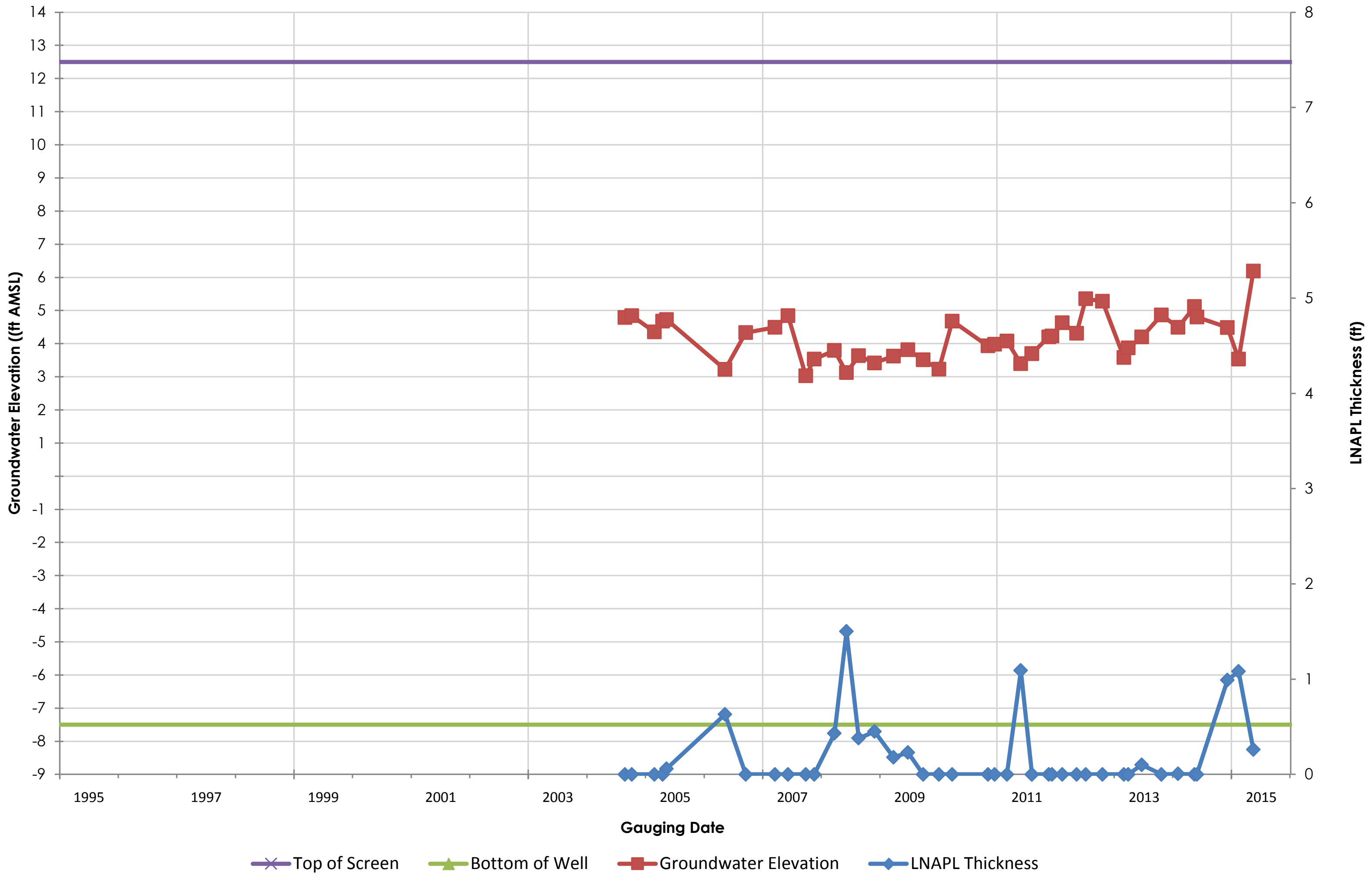
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-188

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

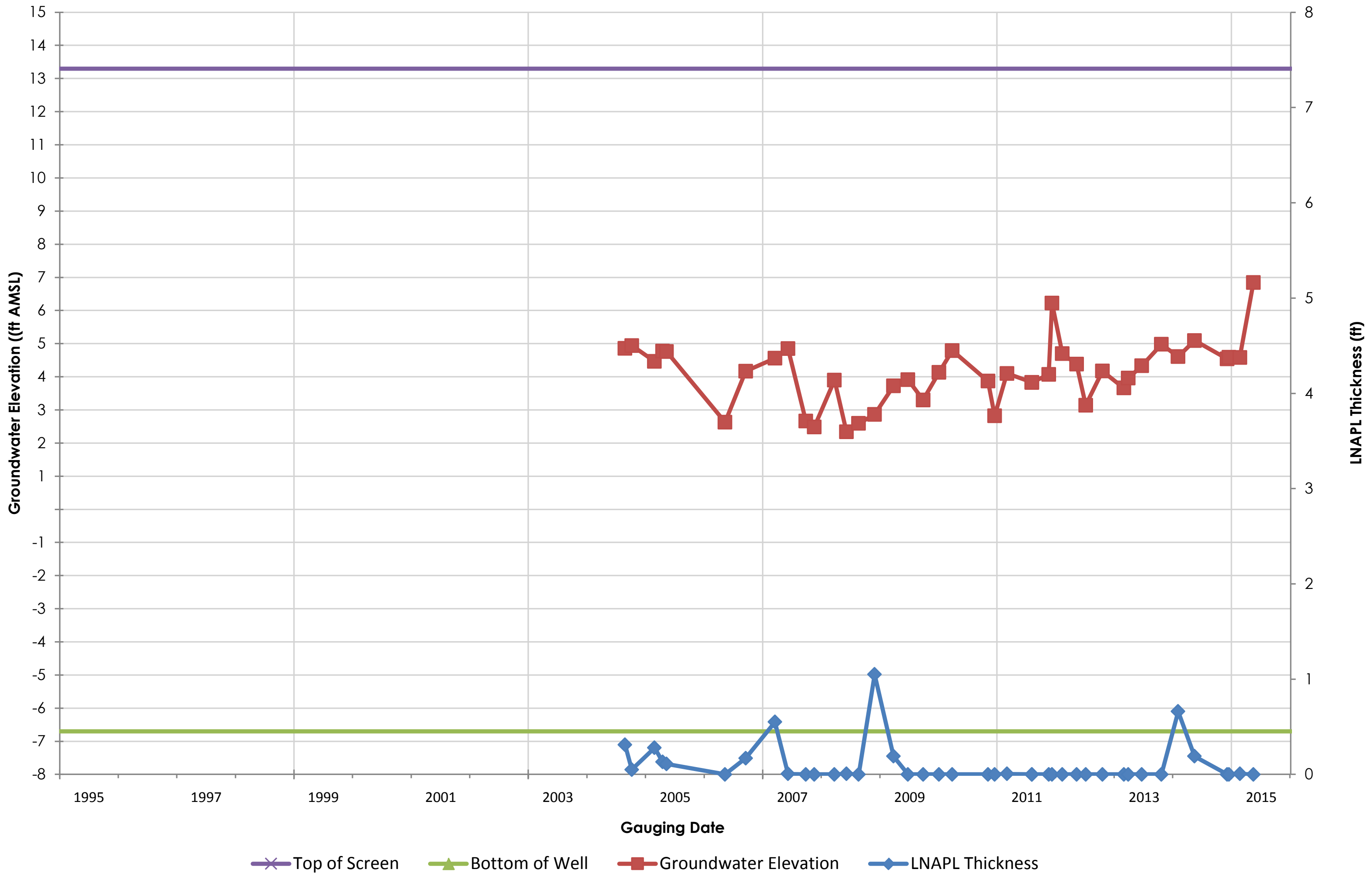
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-189

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

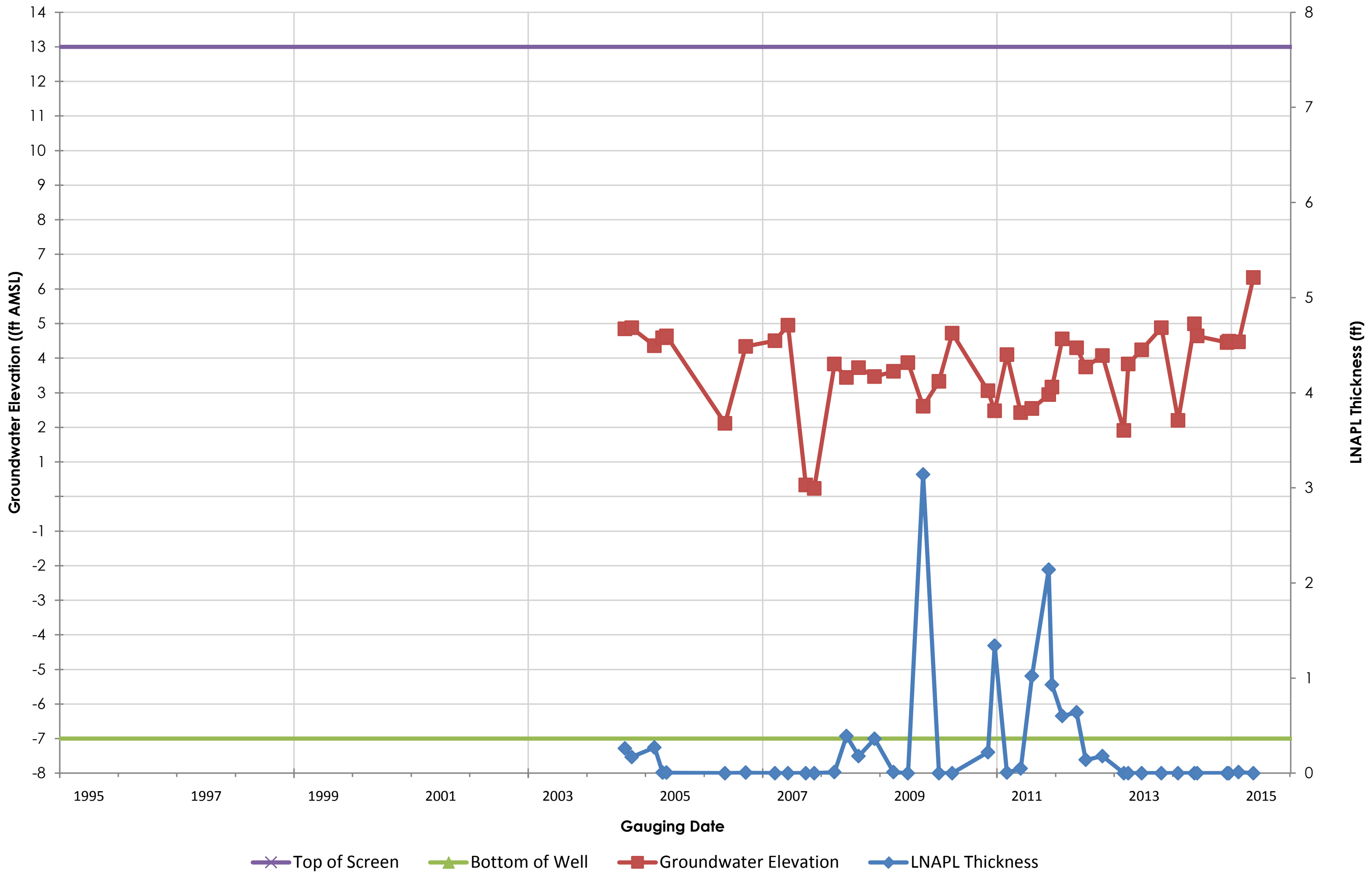
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-190

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

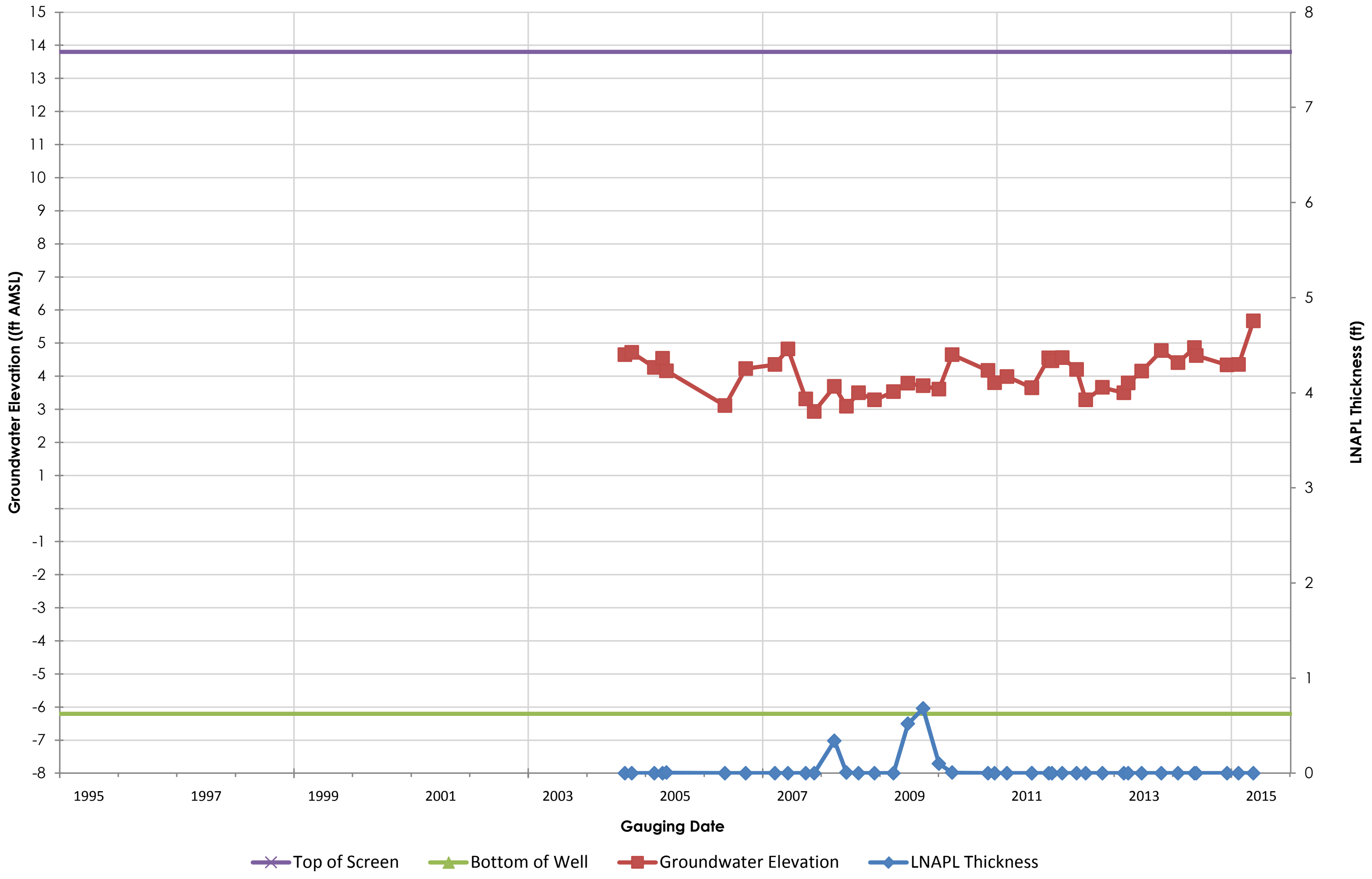
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-191

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

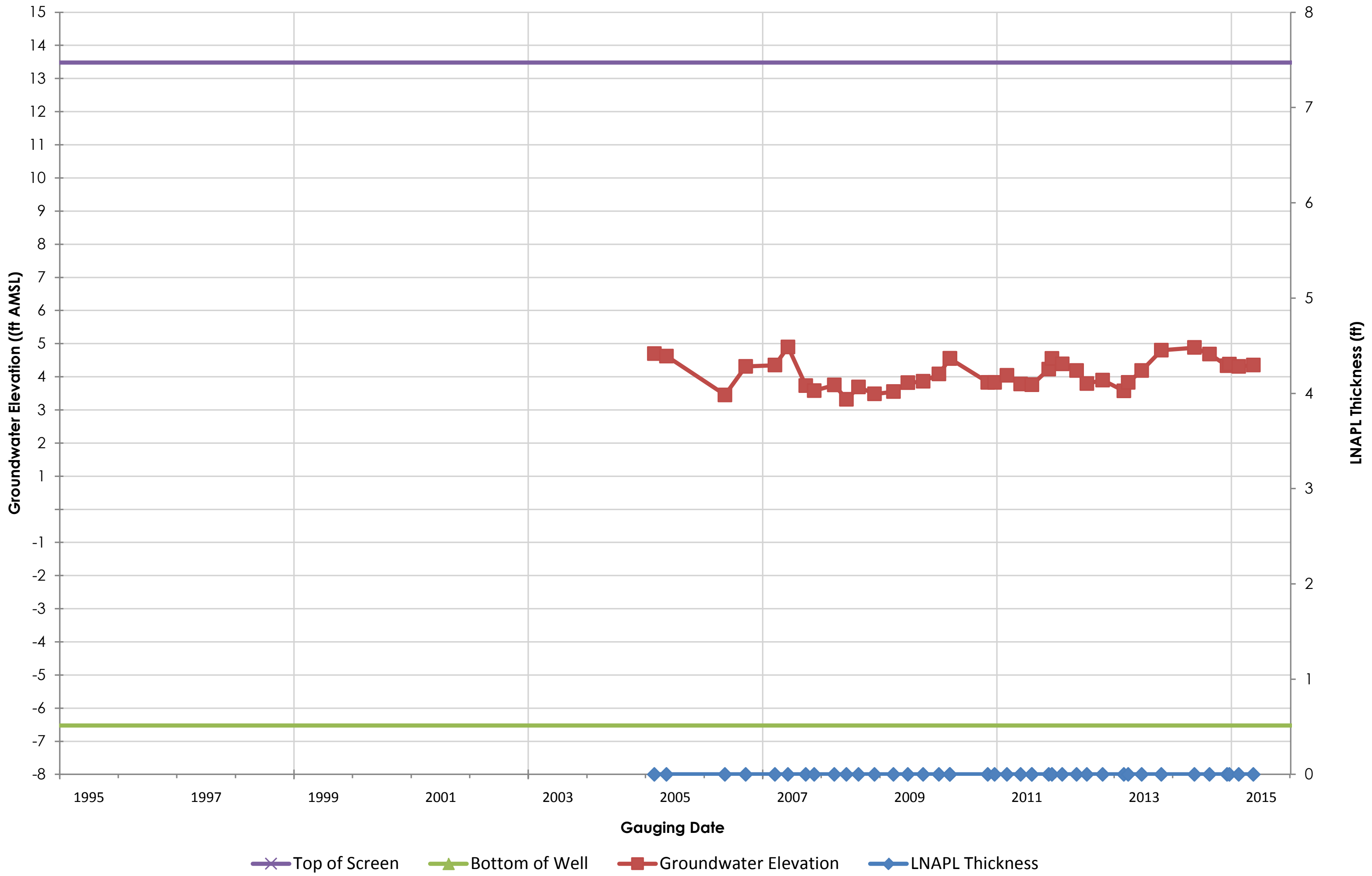
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-192

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

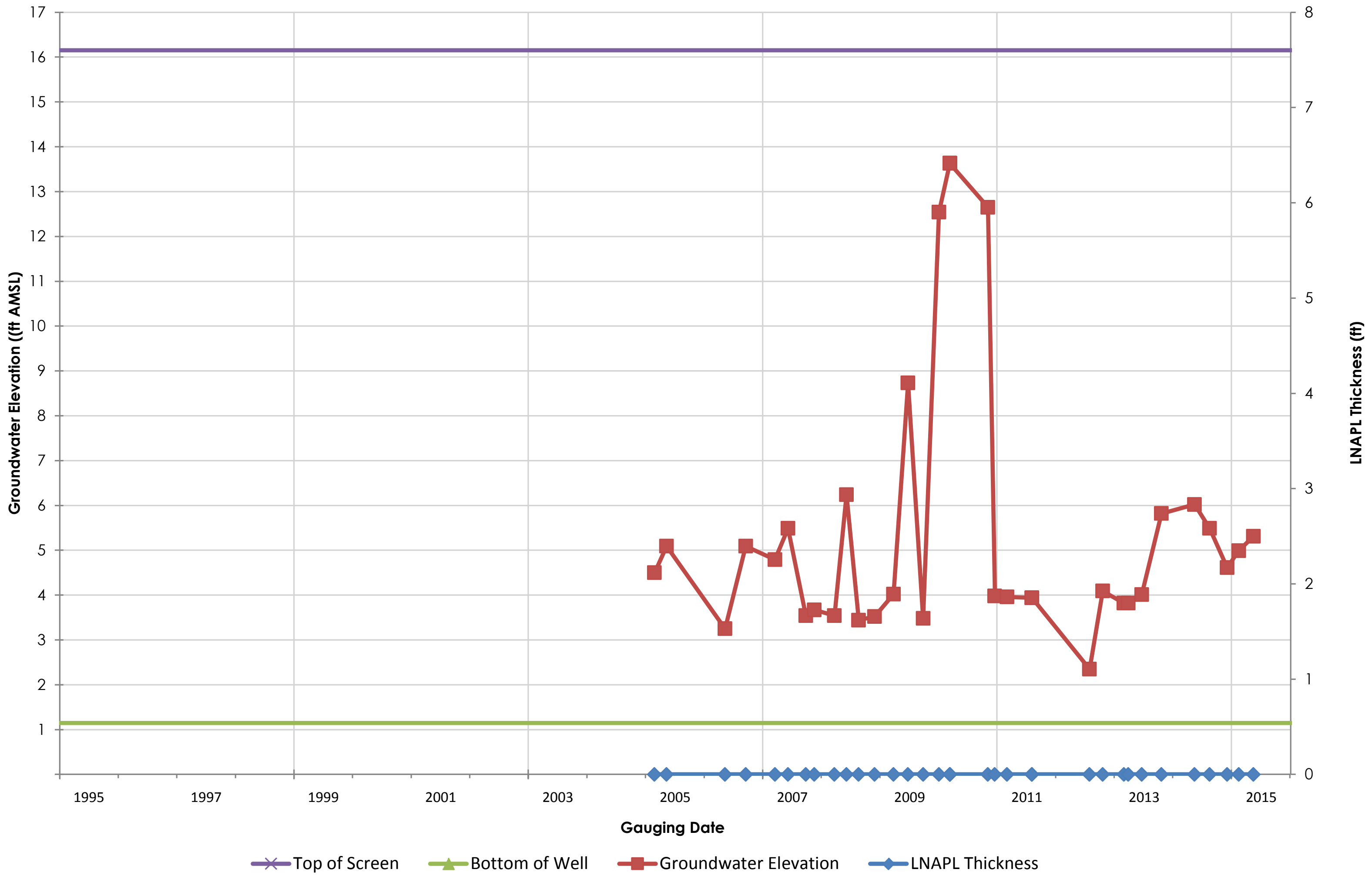
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-193

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

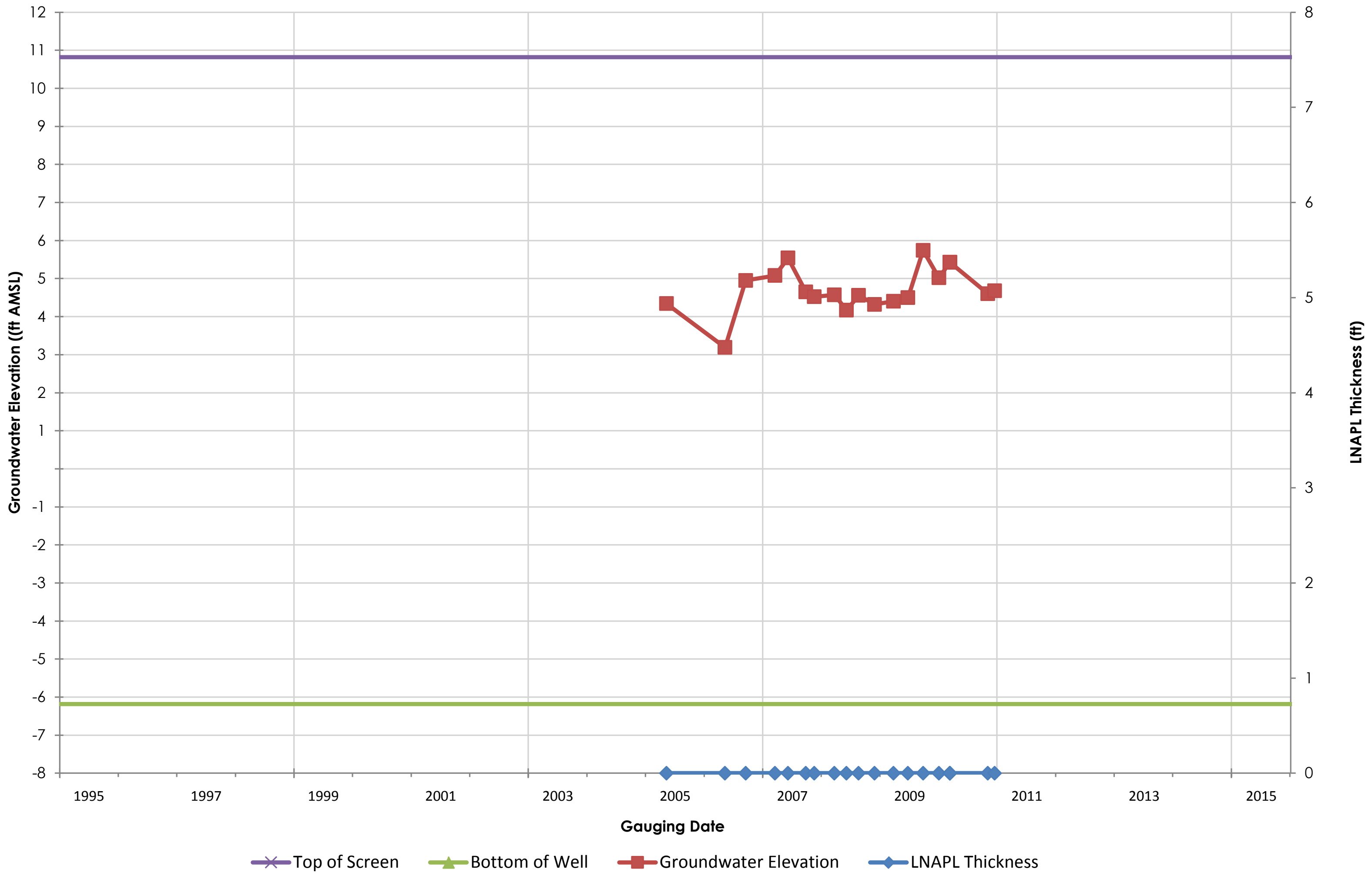
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-194

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

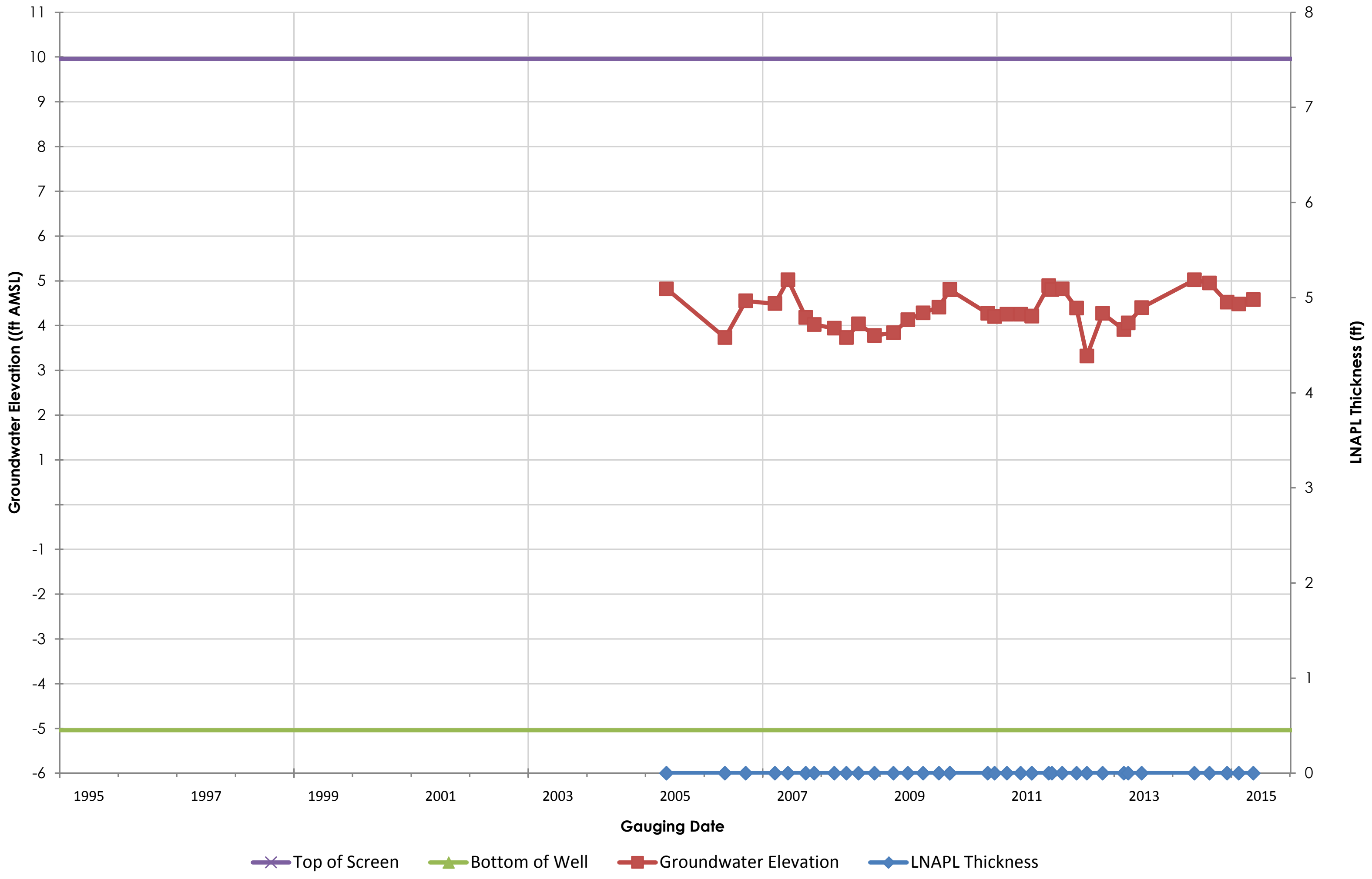
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-195

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

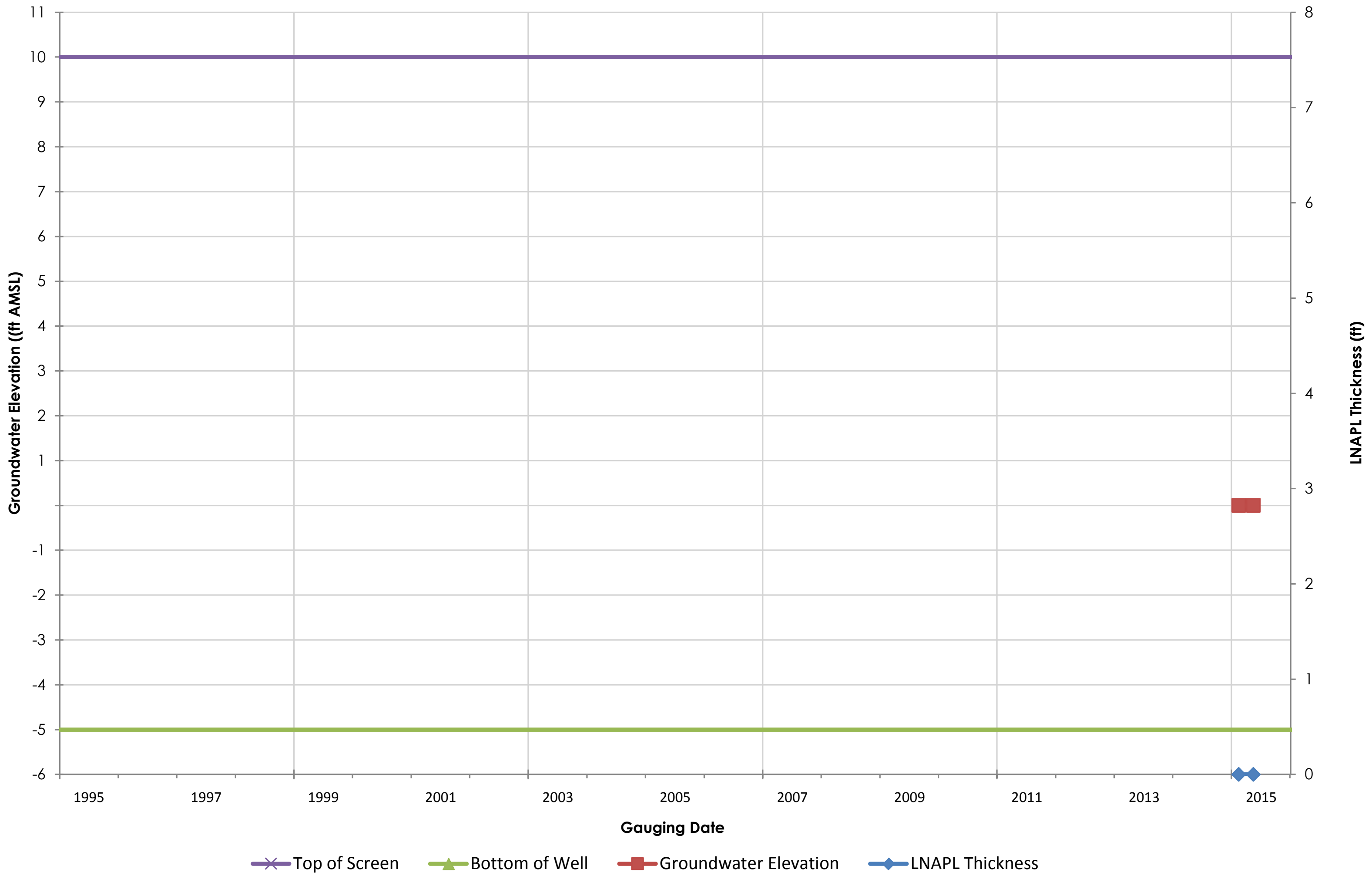
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-196

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

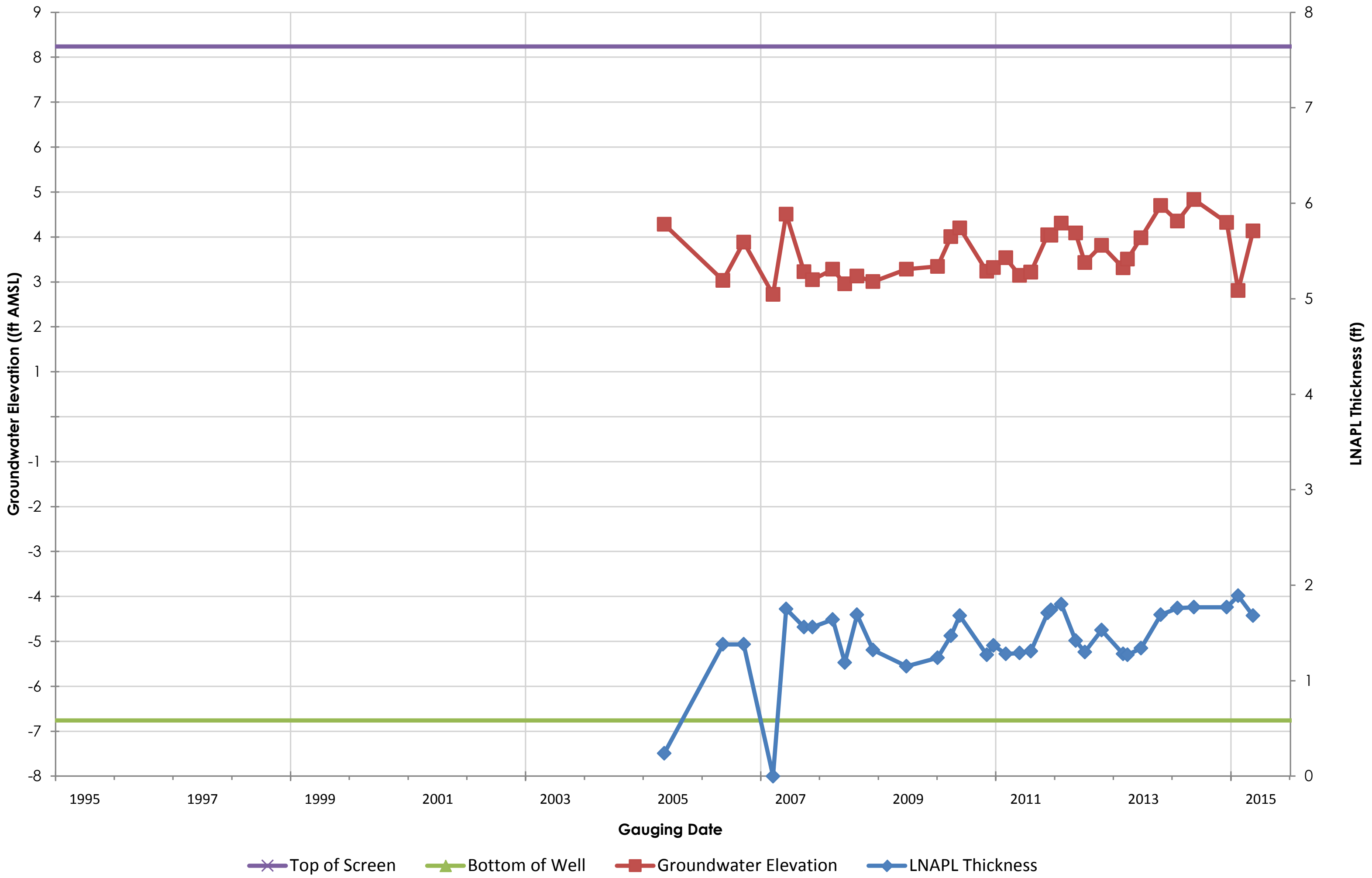
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-197

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

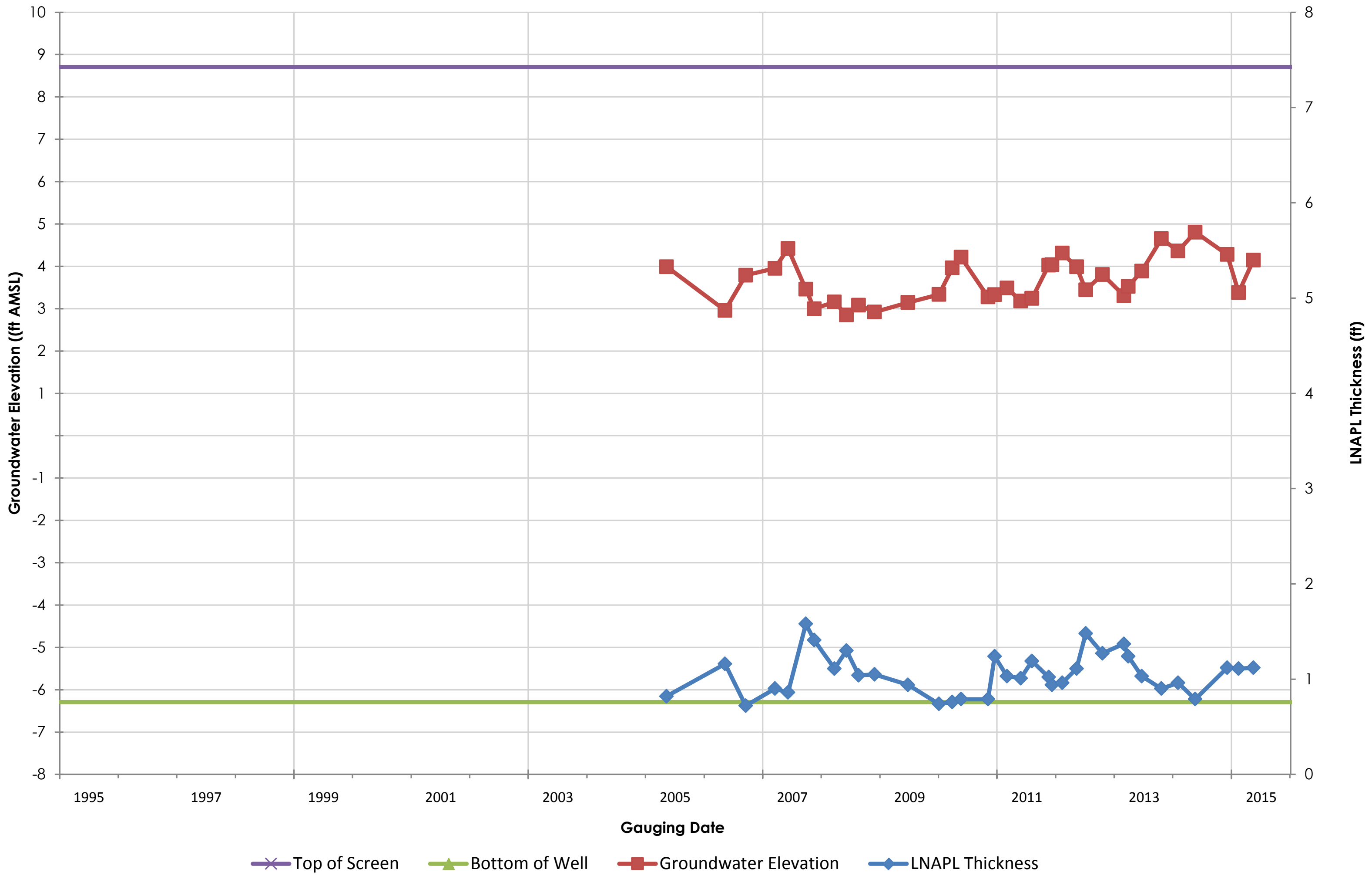
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-198

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

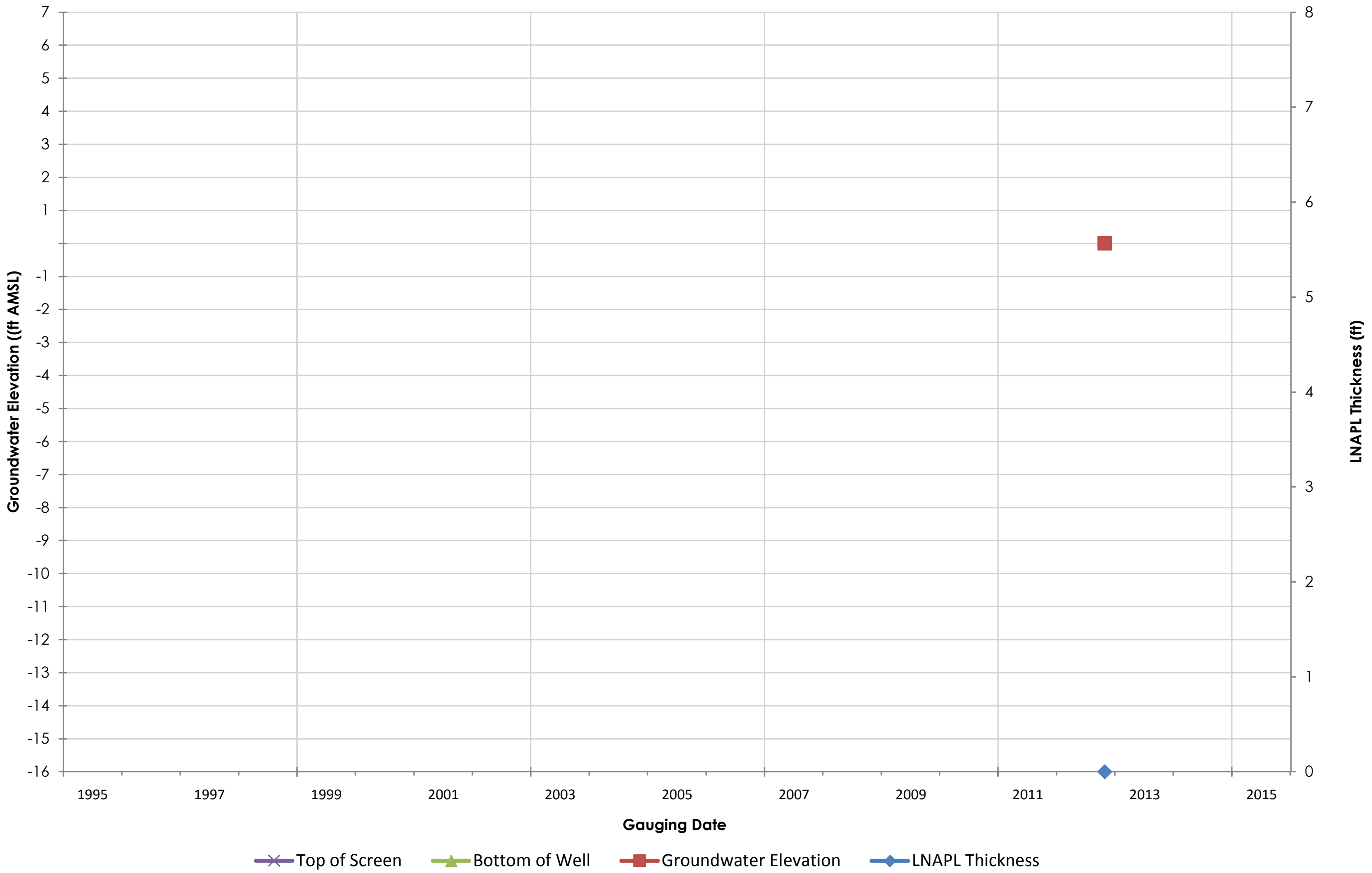
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-199

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

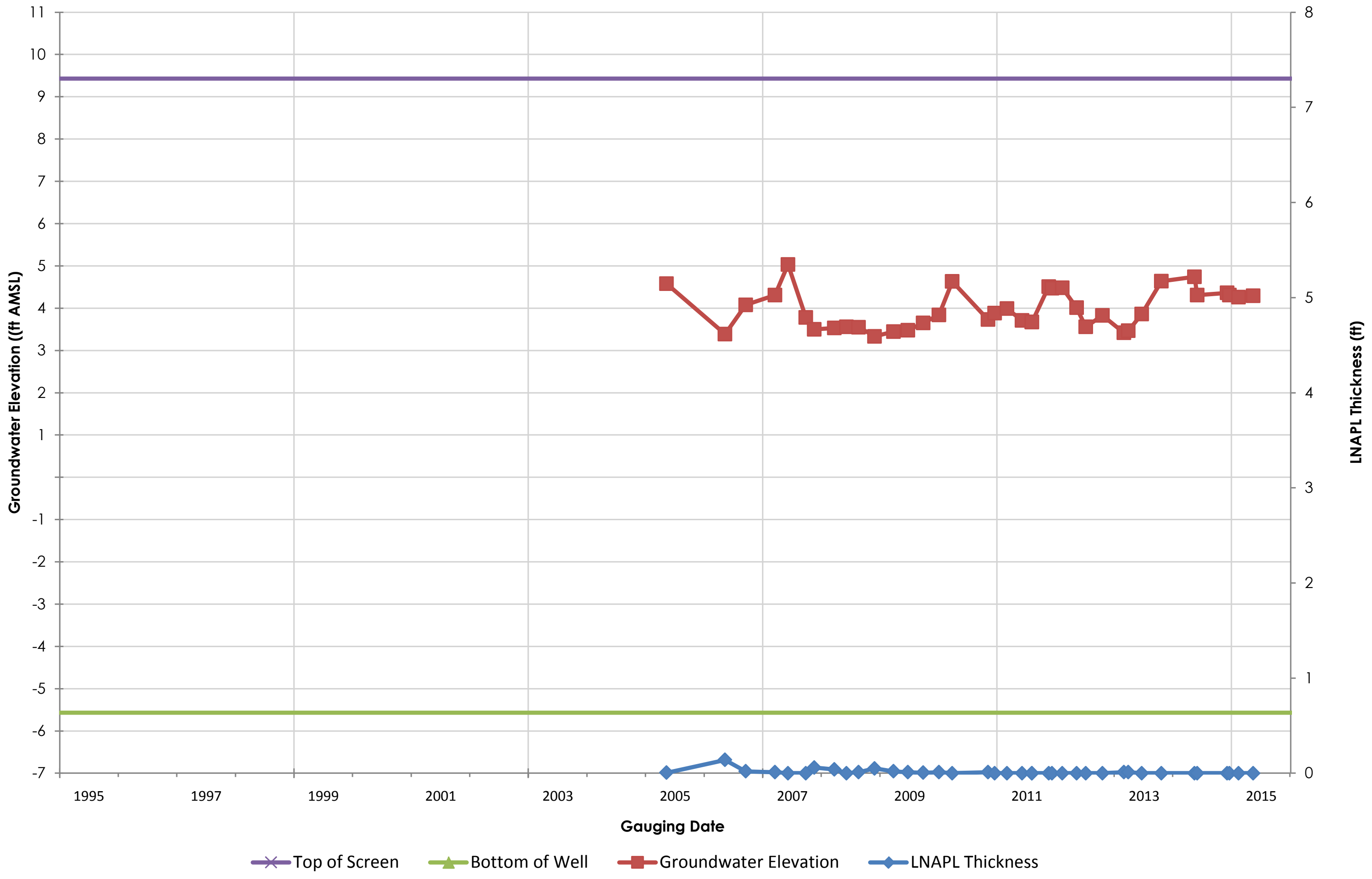
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-199D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

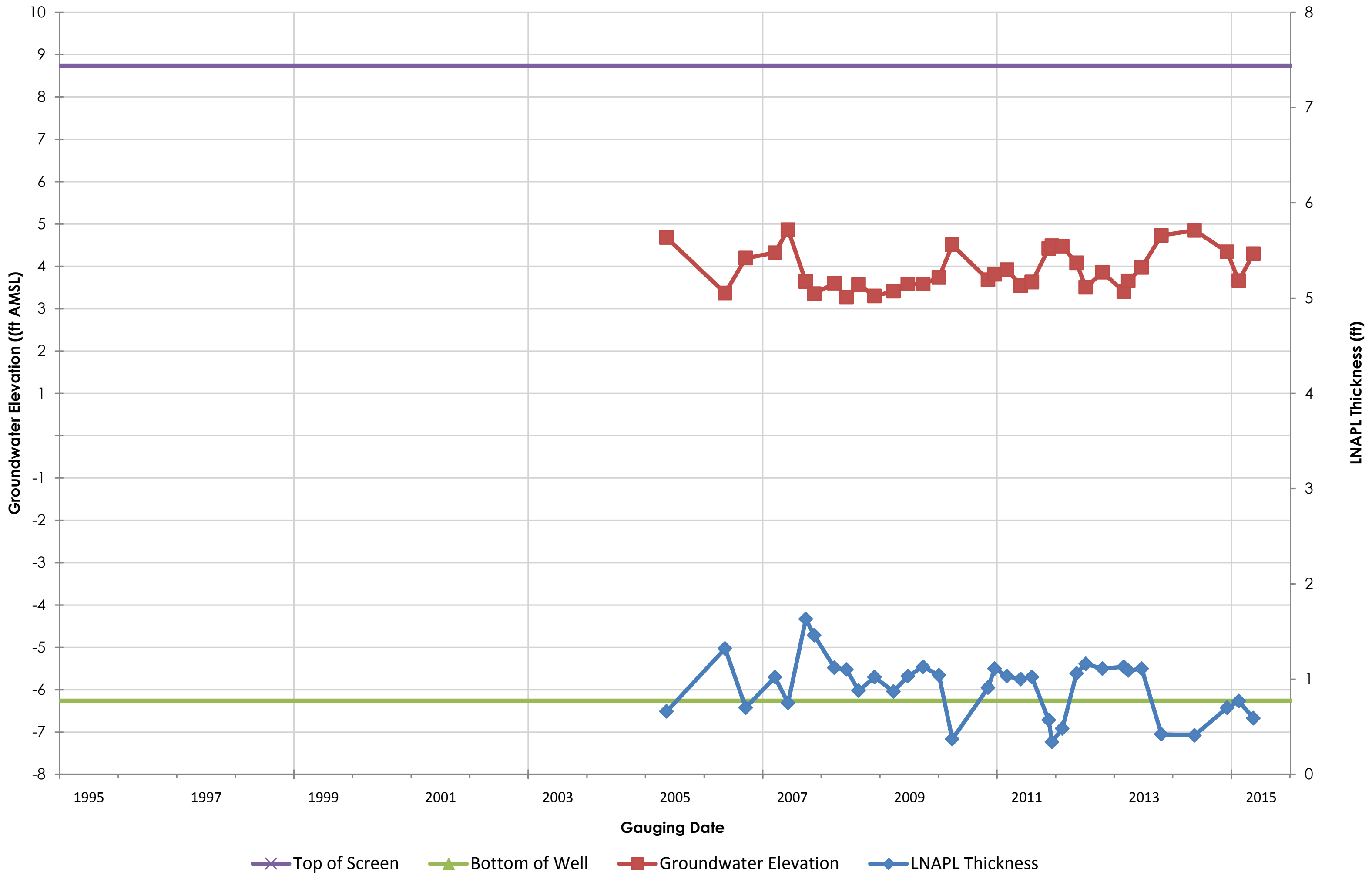
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-200

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

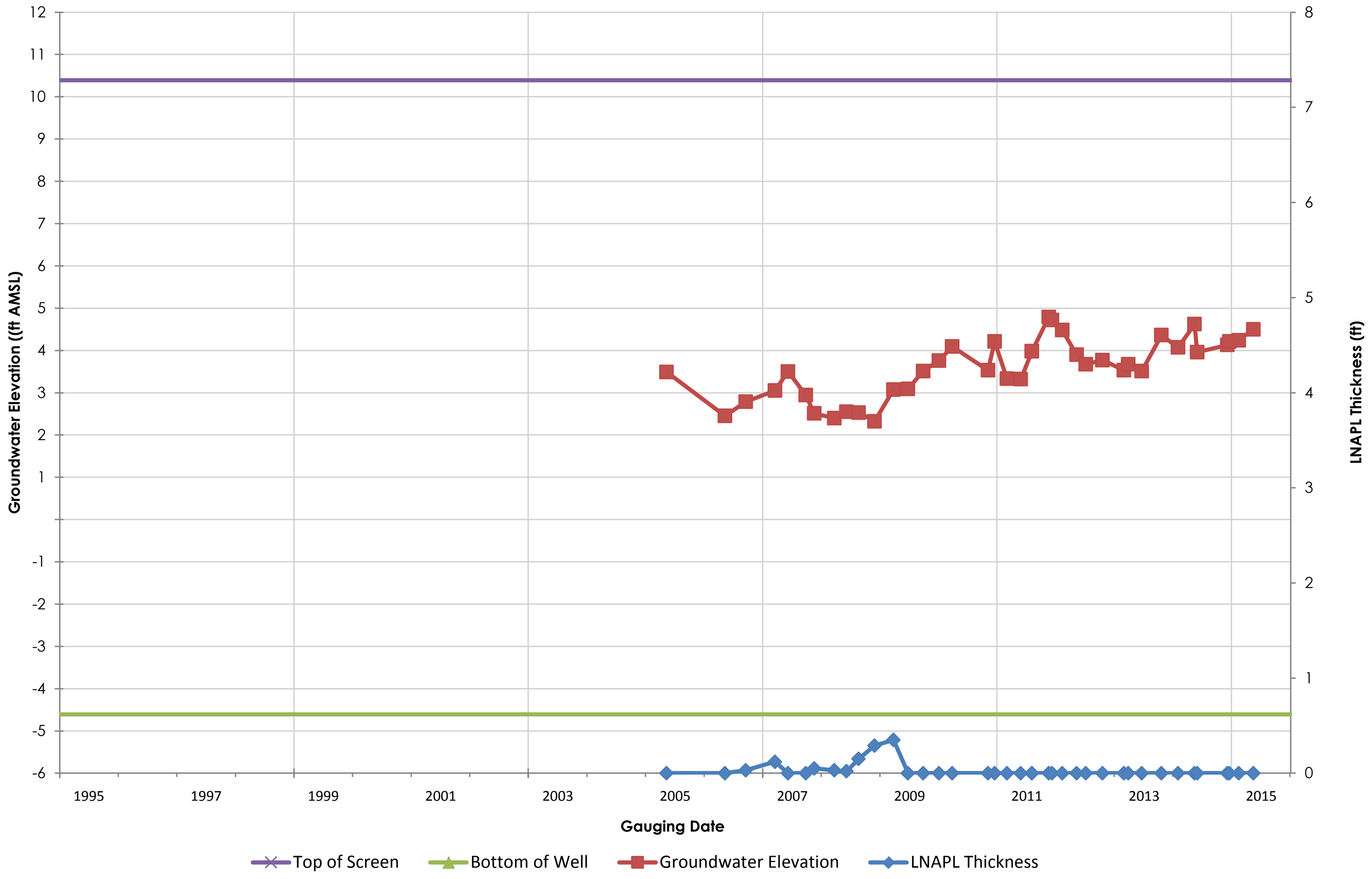
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-201

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

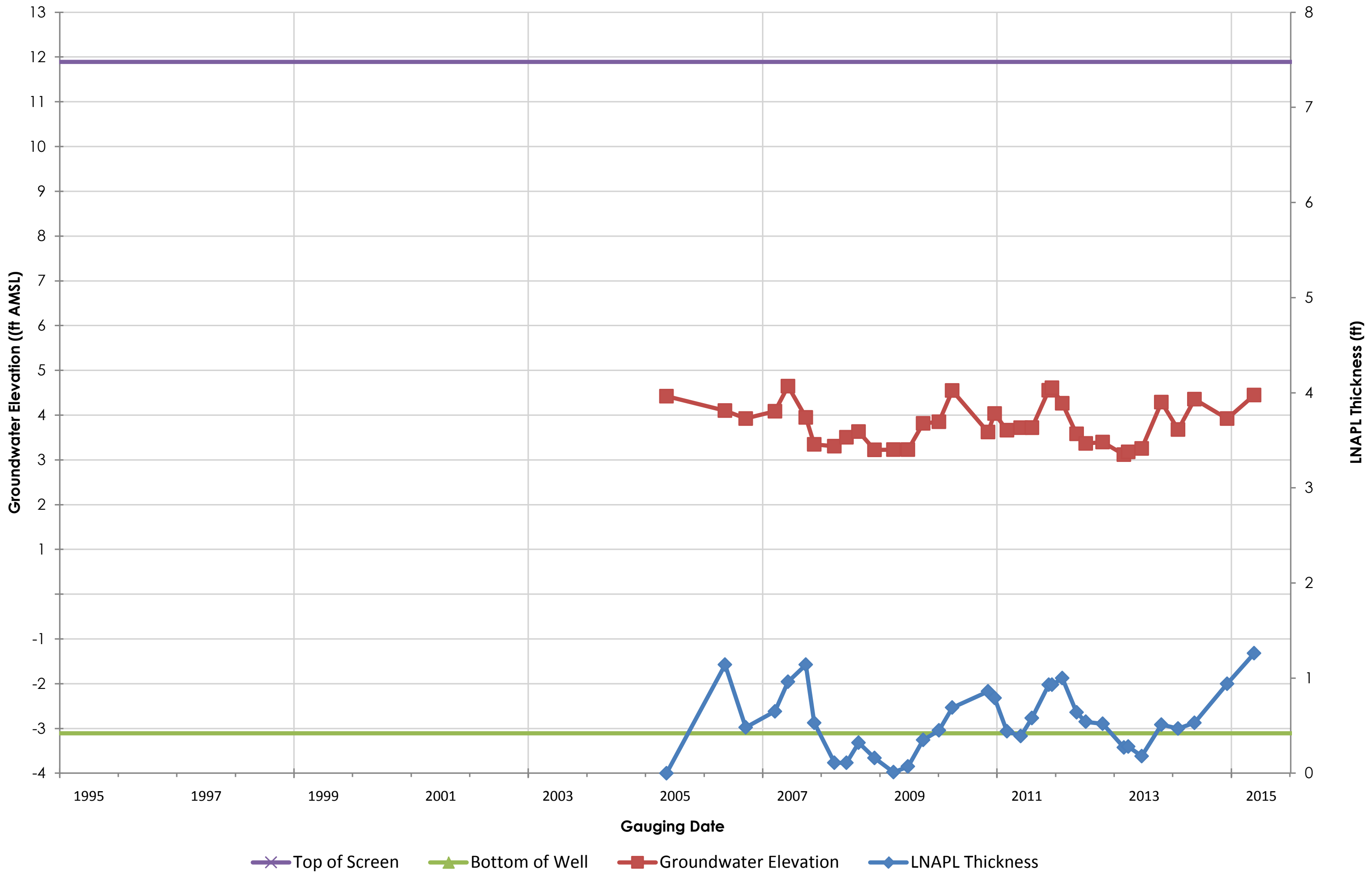
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-202

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

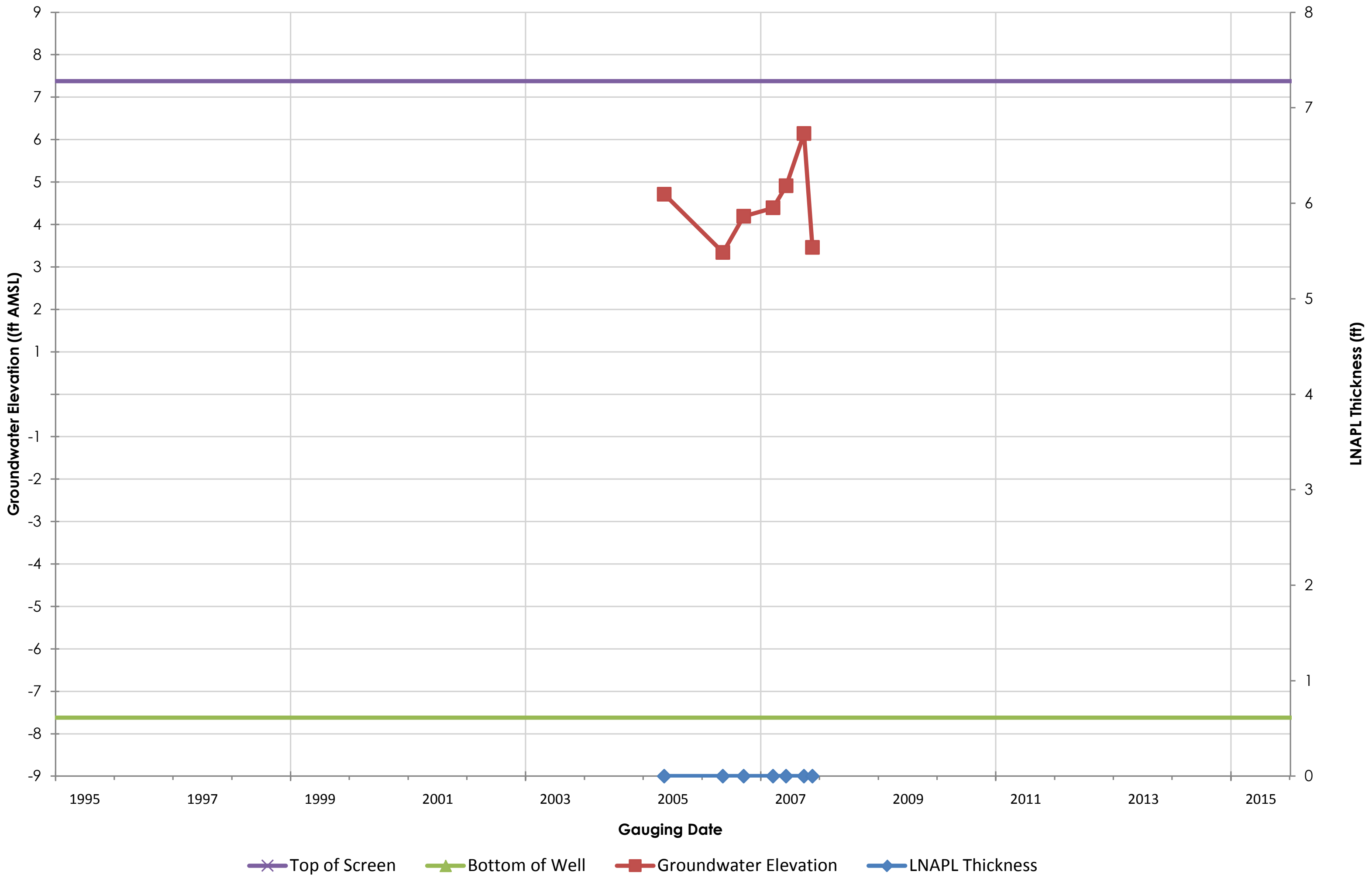
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-203

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

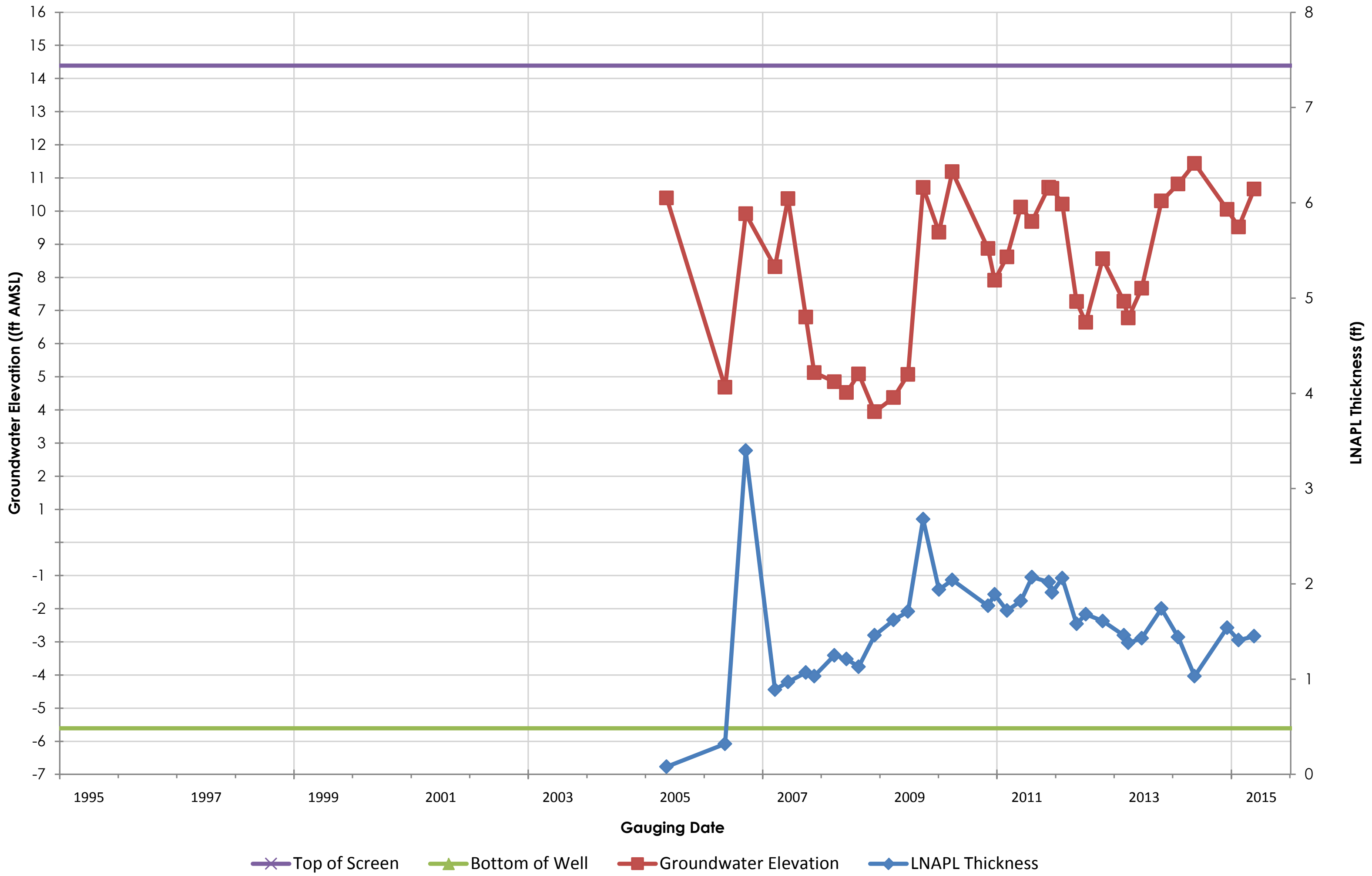
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-204

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

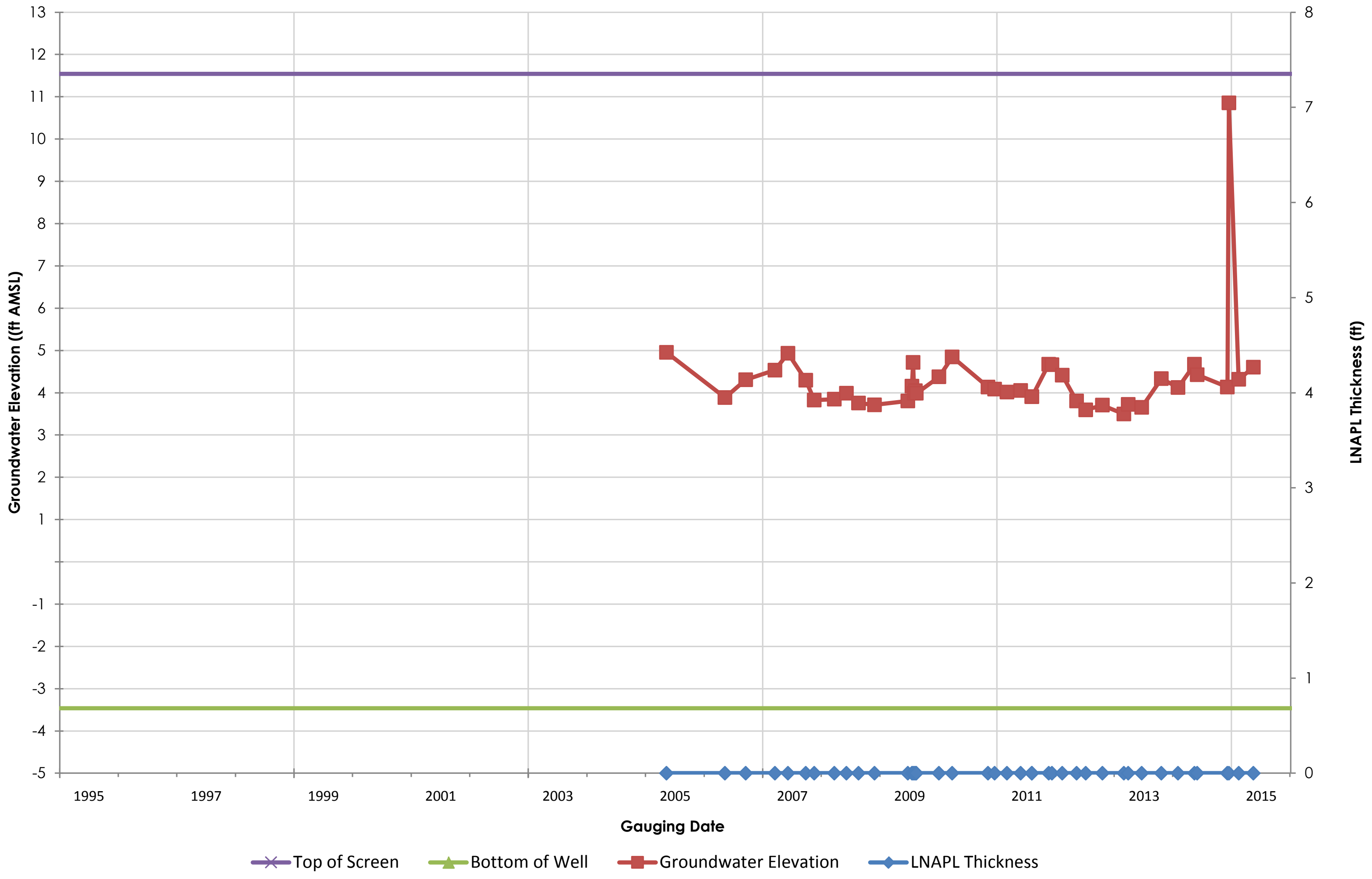
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-205

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

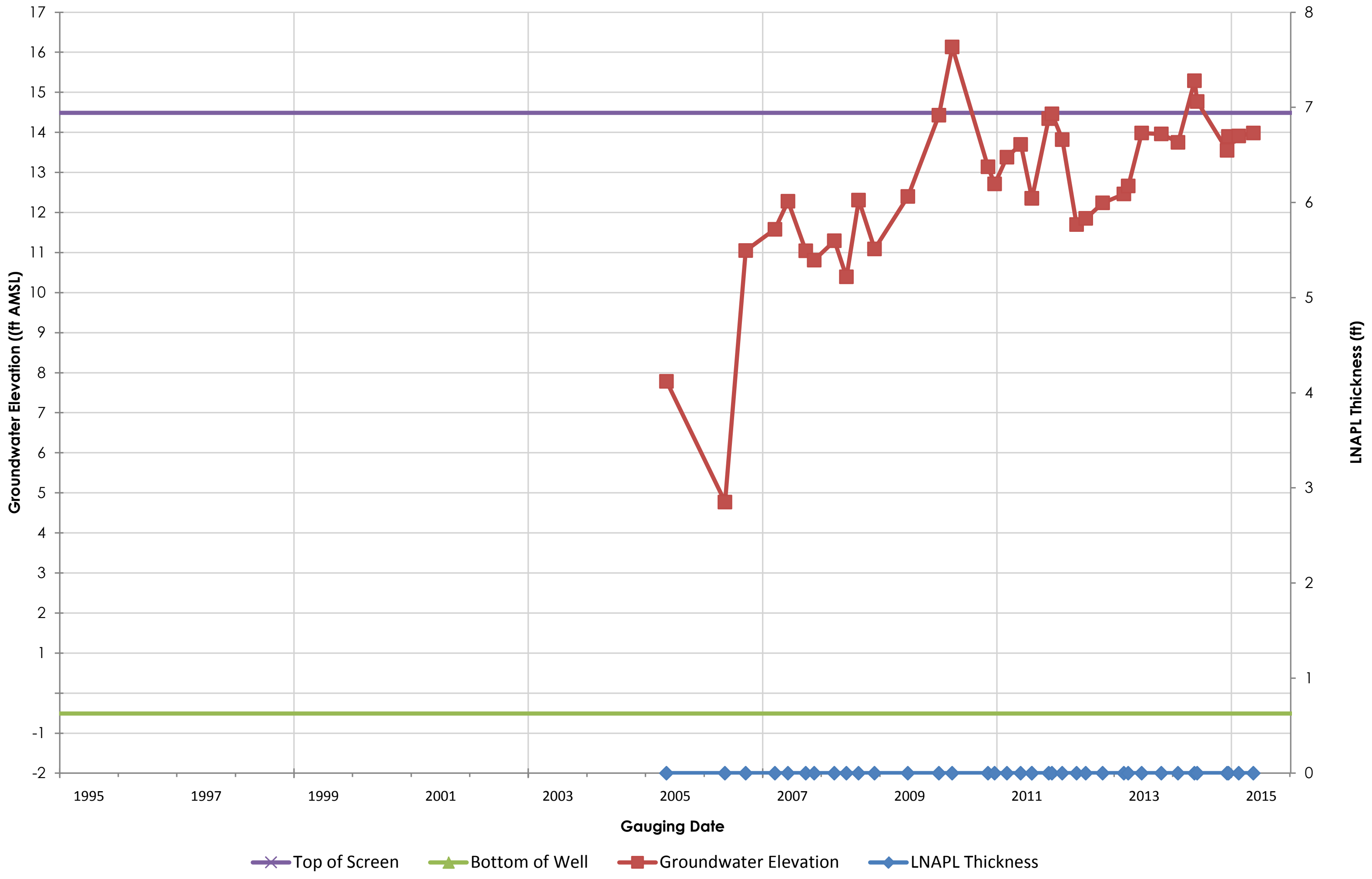
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-206

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

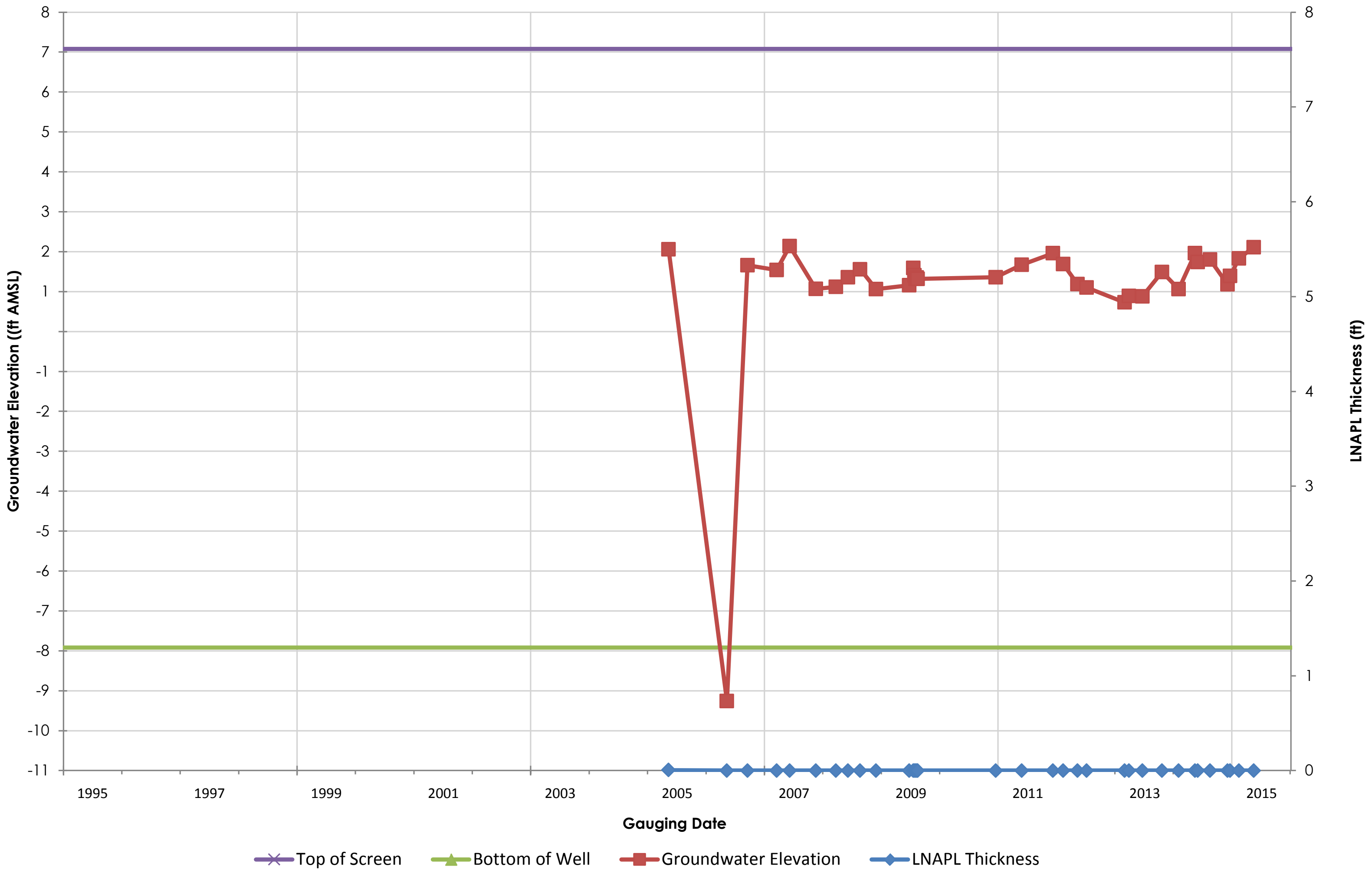
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-207

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

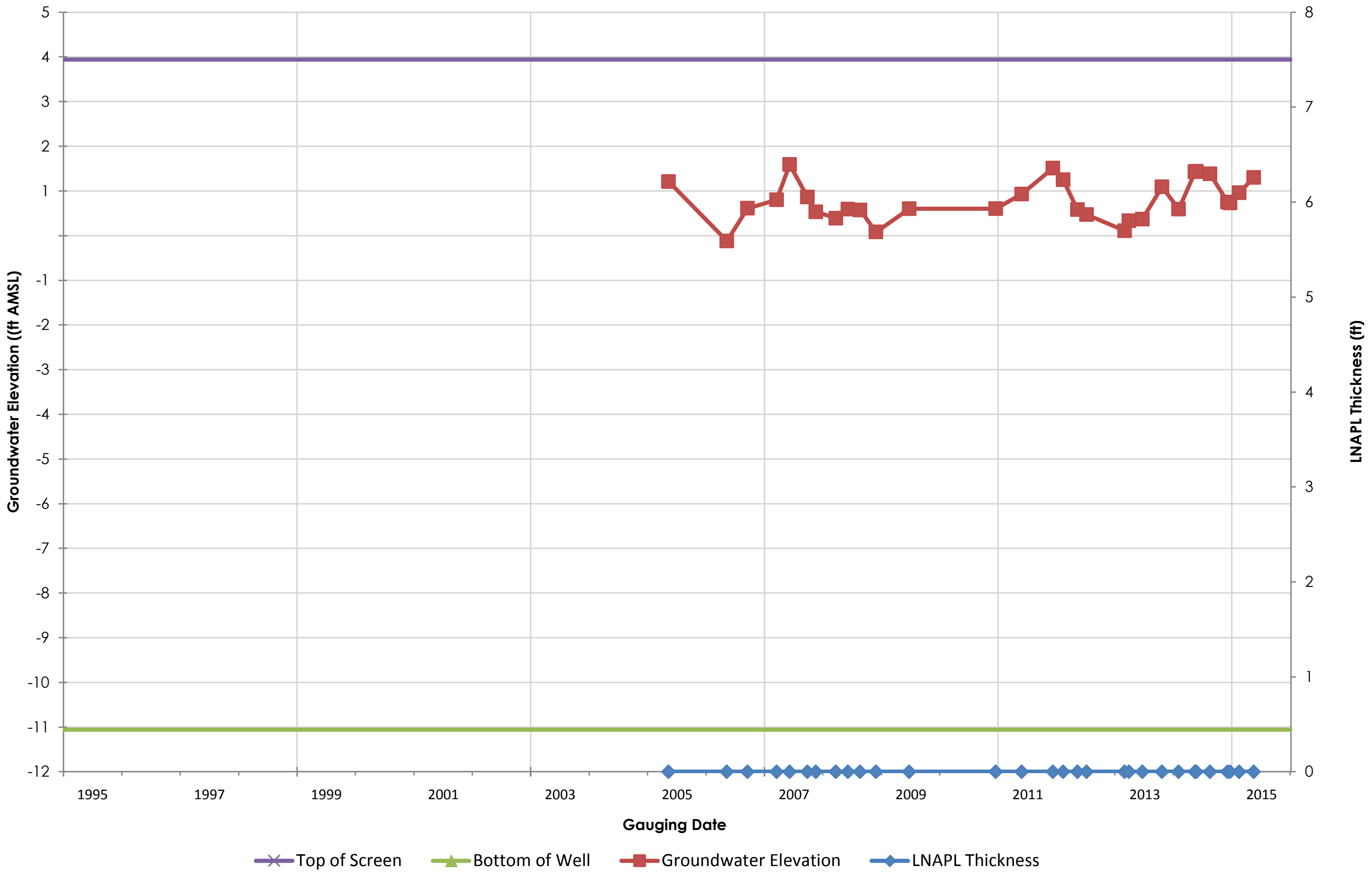
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-208

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

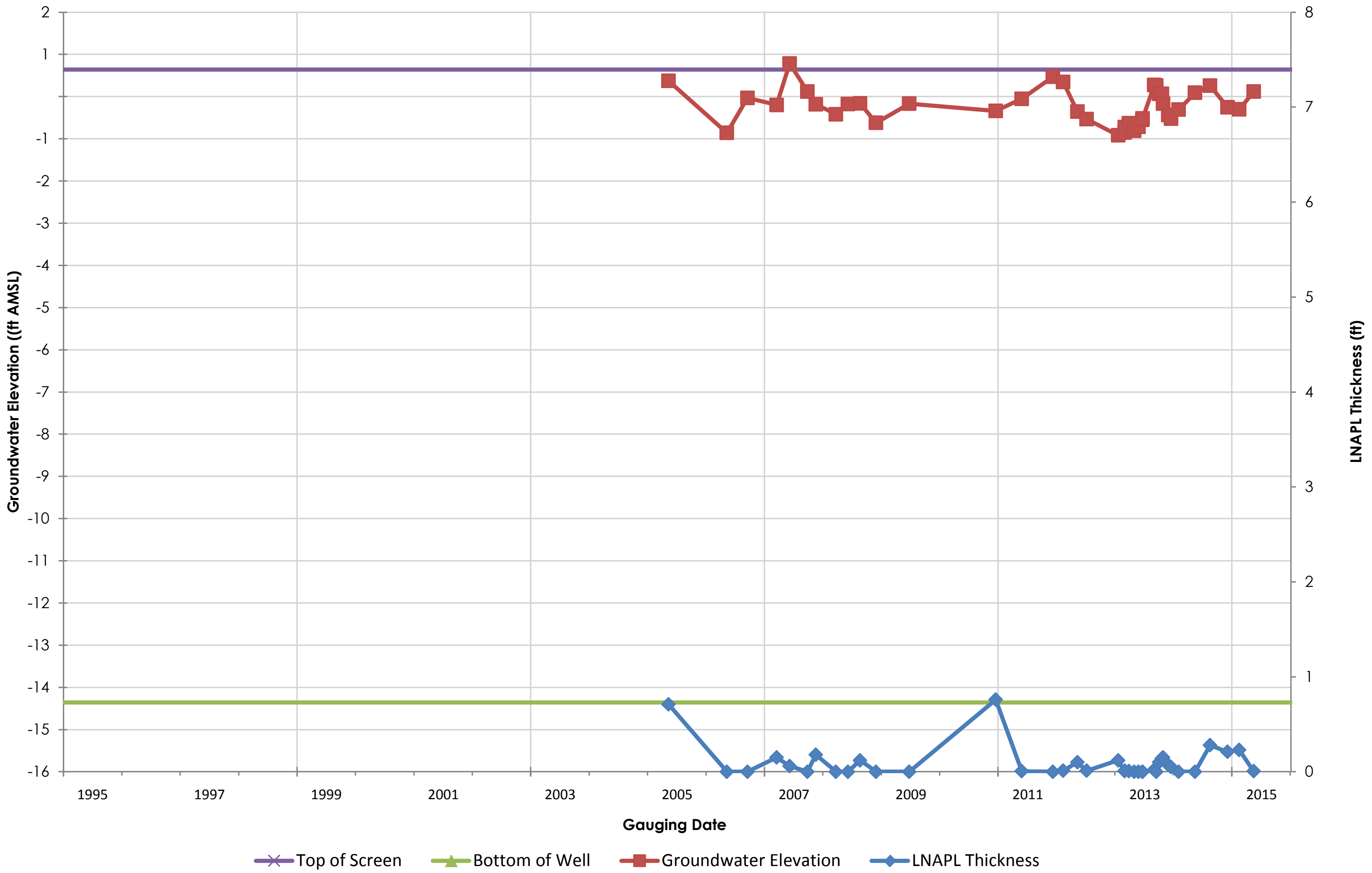
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-209

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

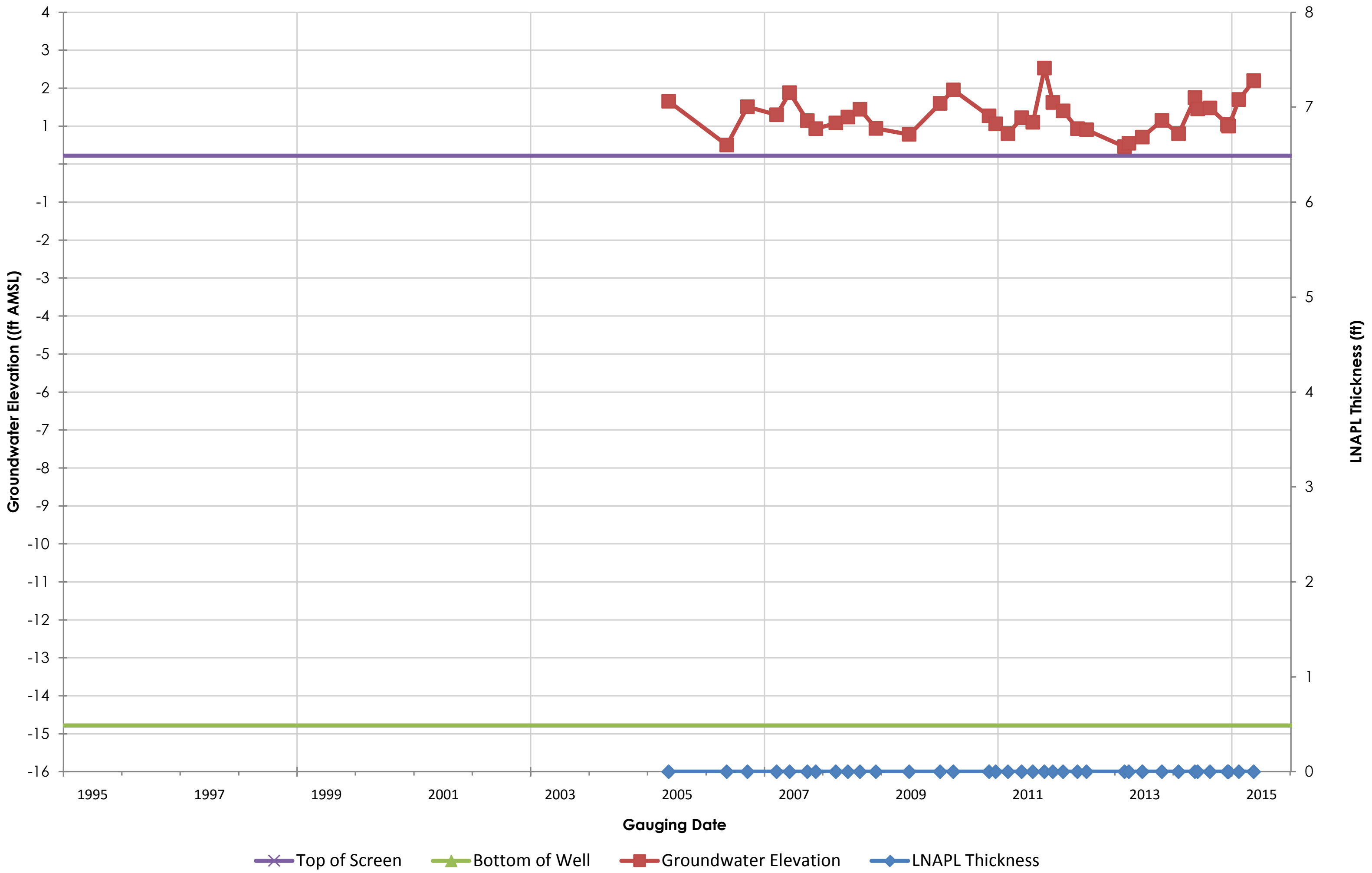
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-210

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

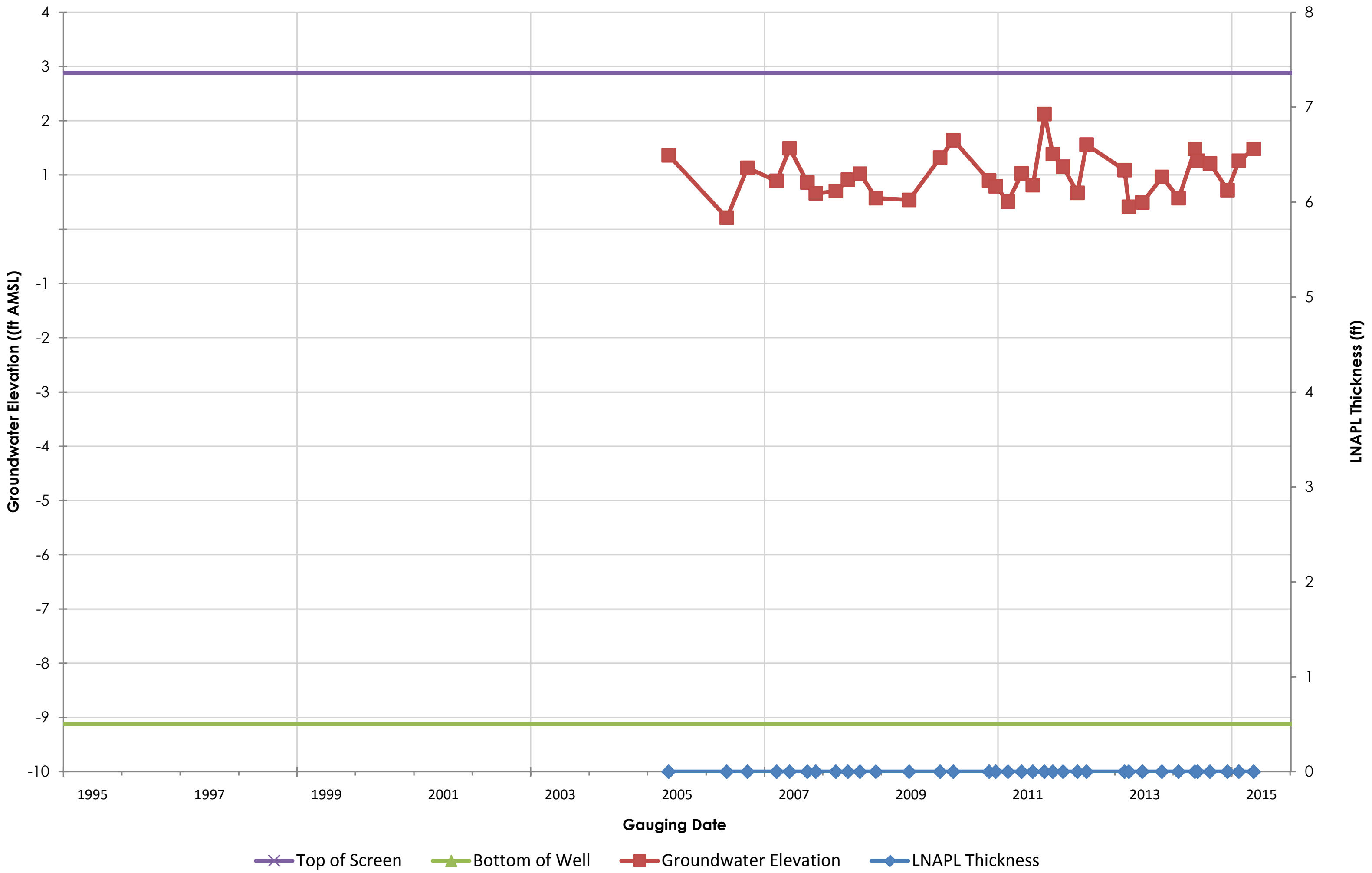
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-211

Title

**Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval**



Stantec

Client/Project

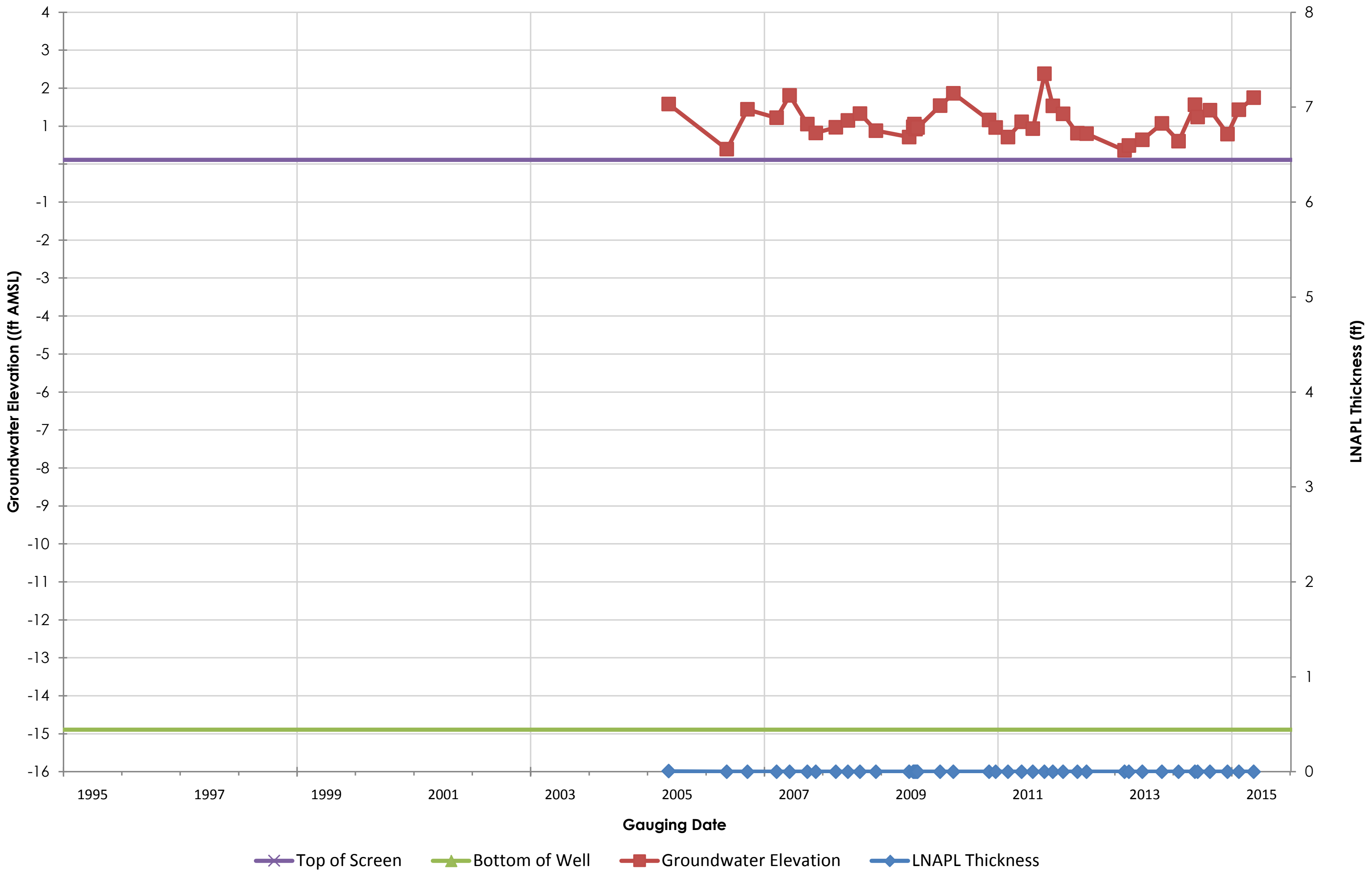
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-212

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

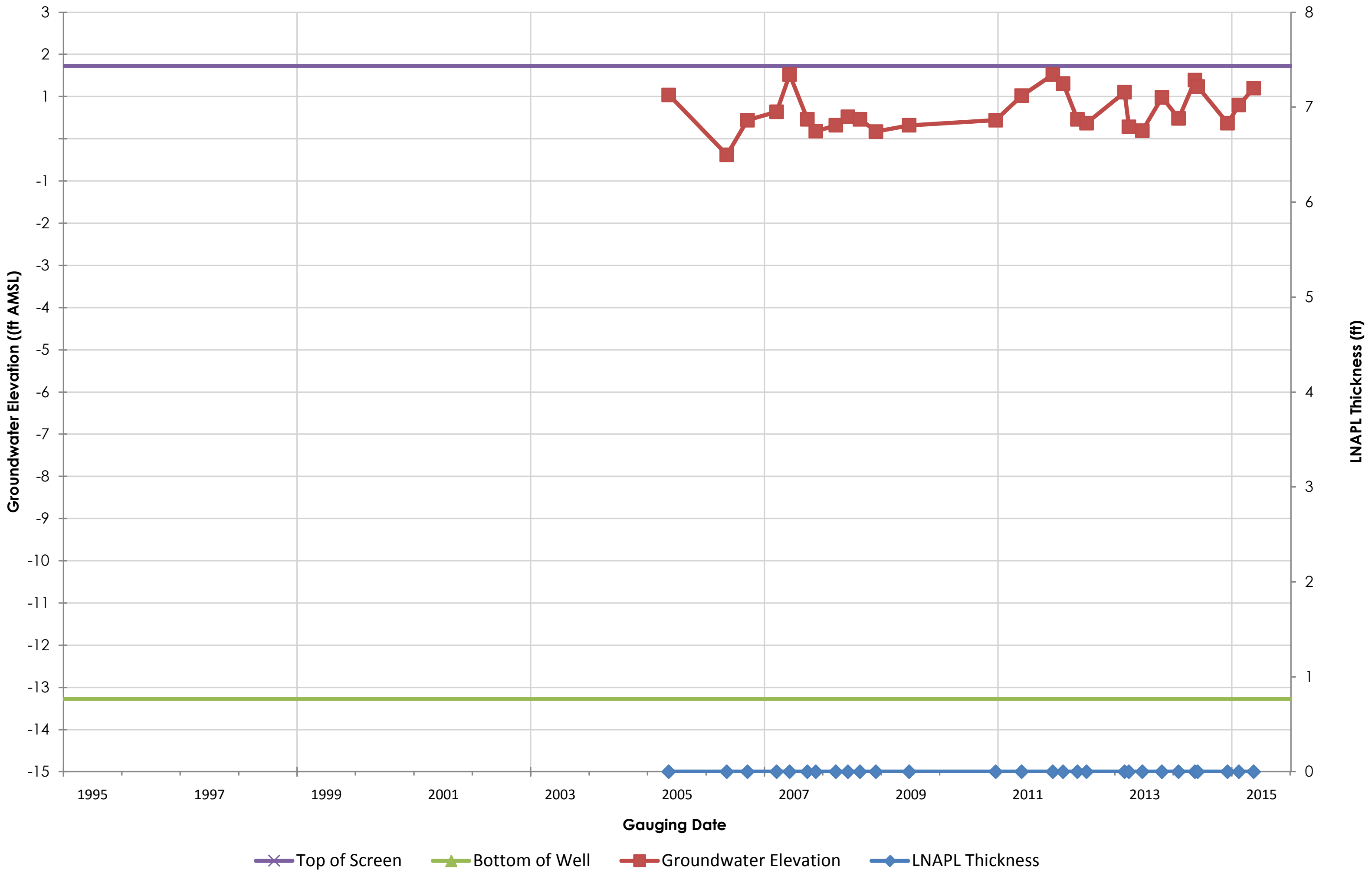
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-213

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

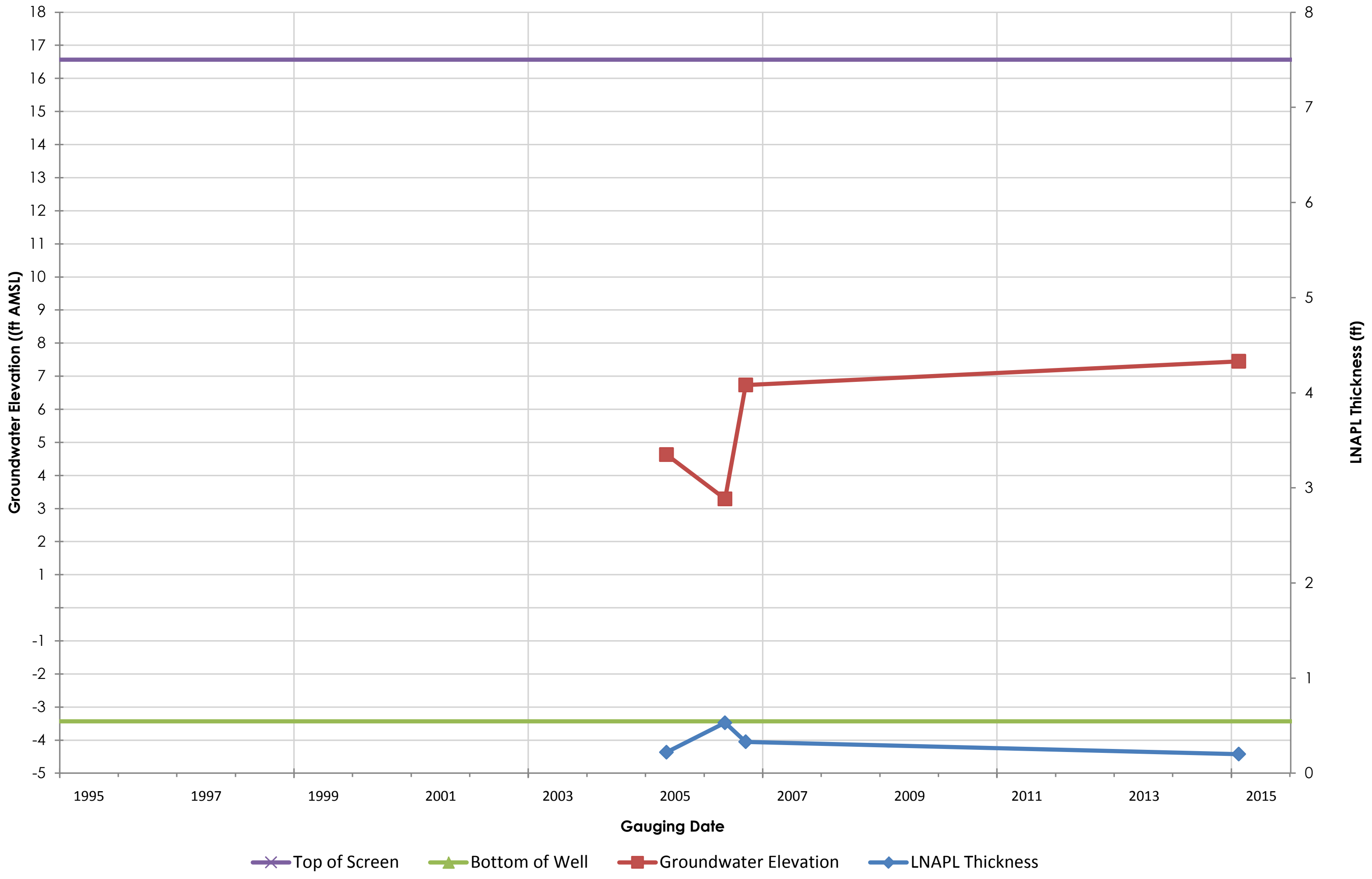
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-214

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

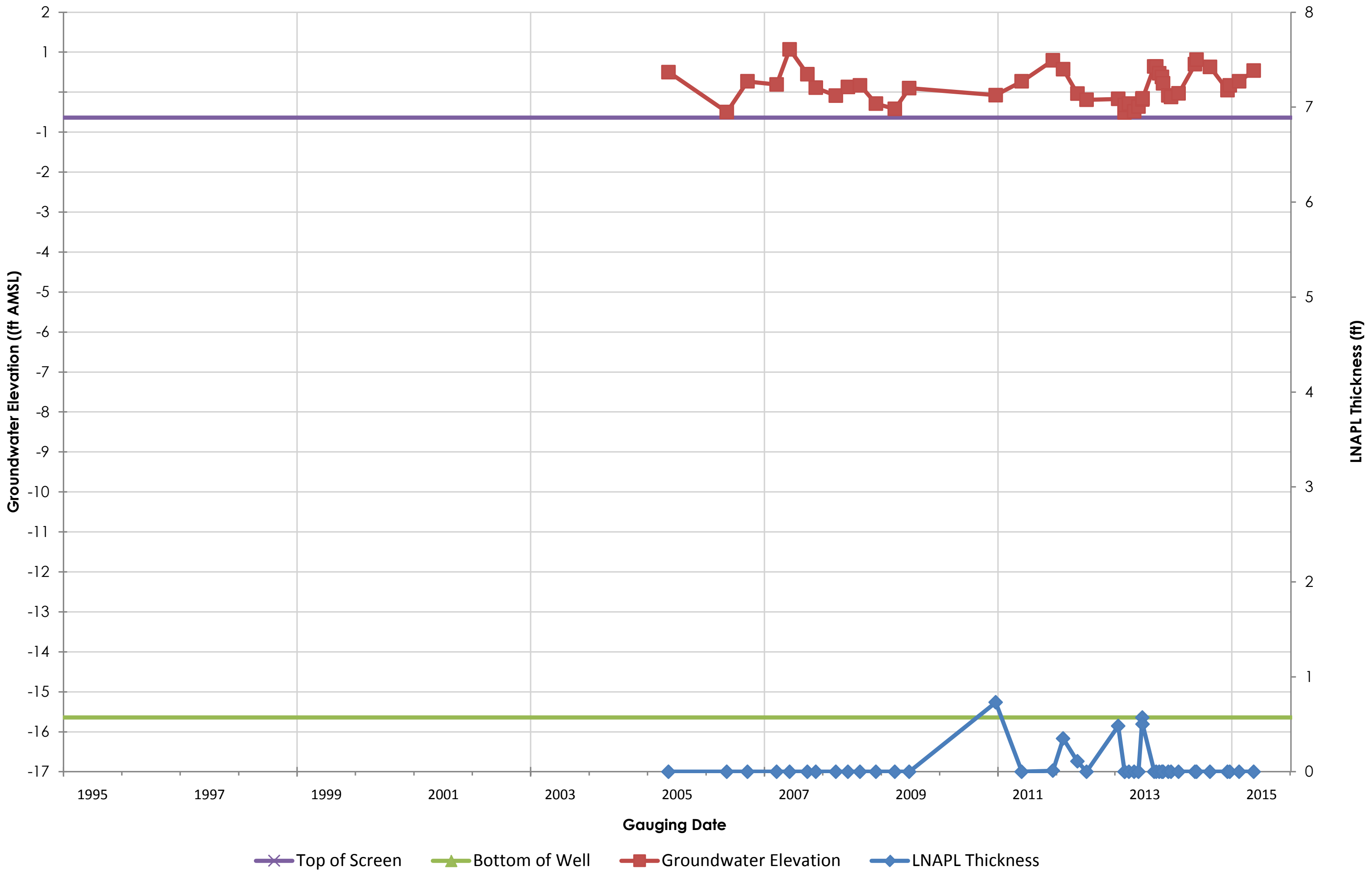
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-215

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

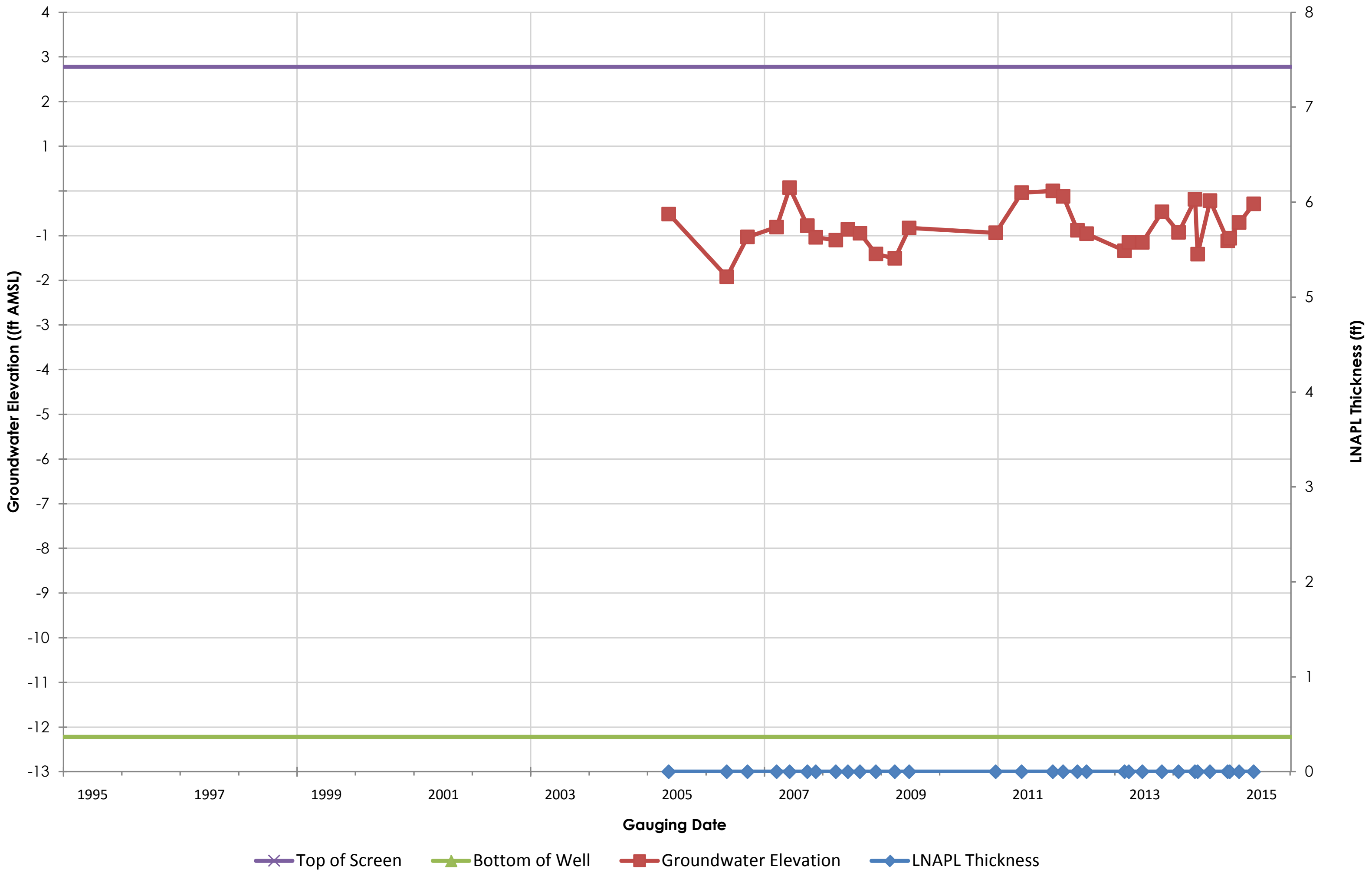
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-226

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

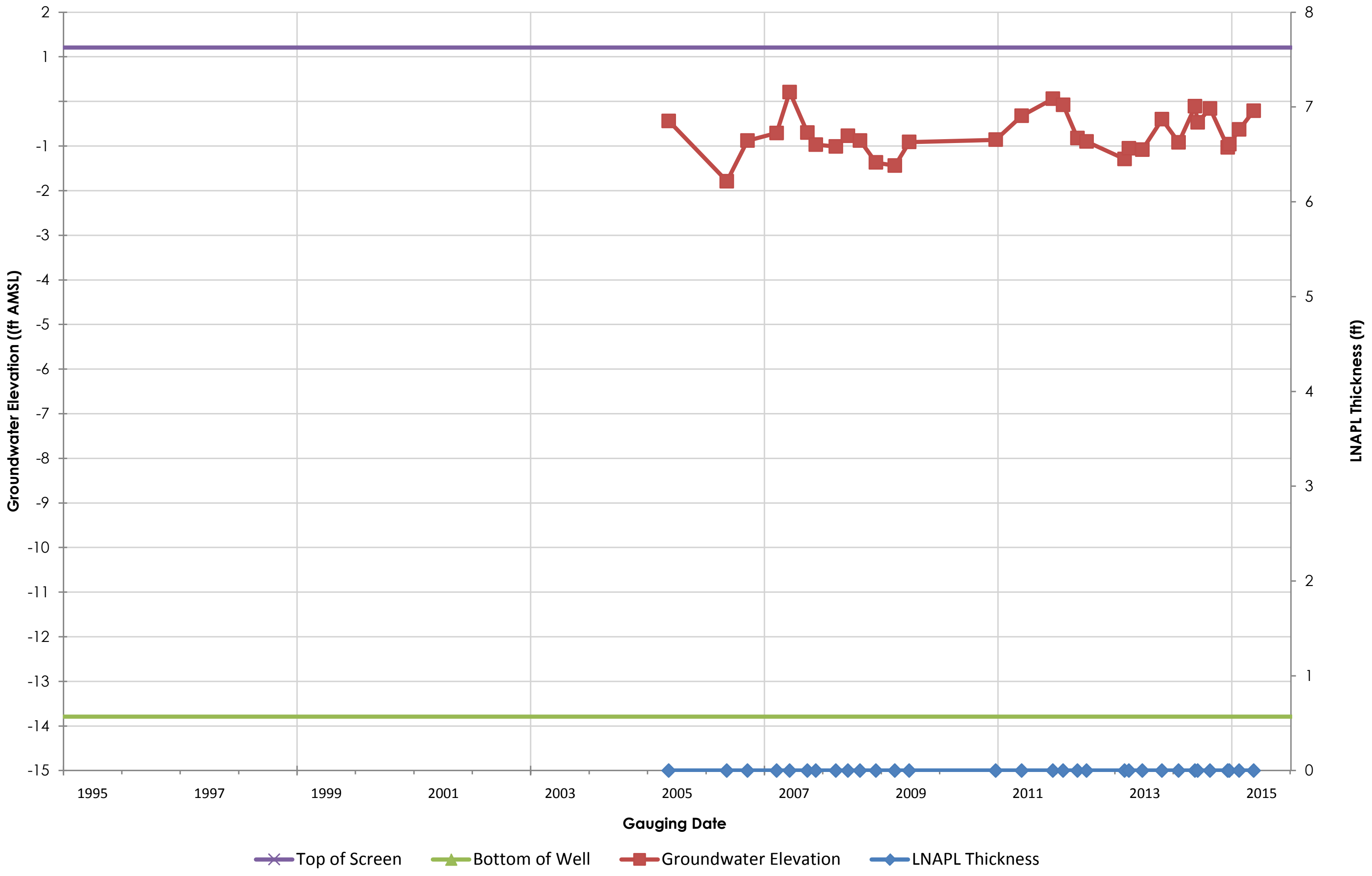
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-227

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

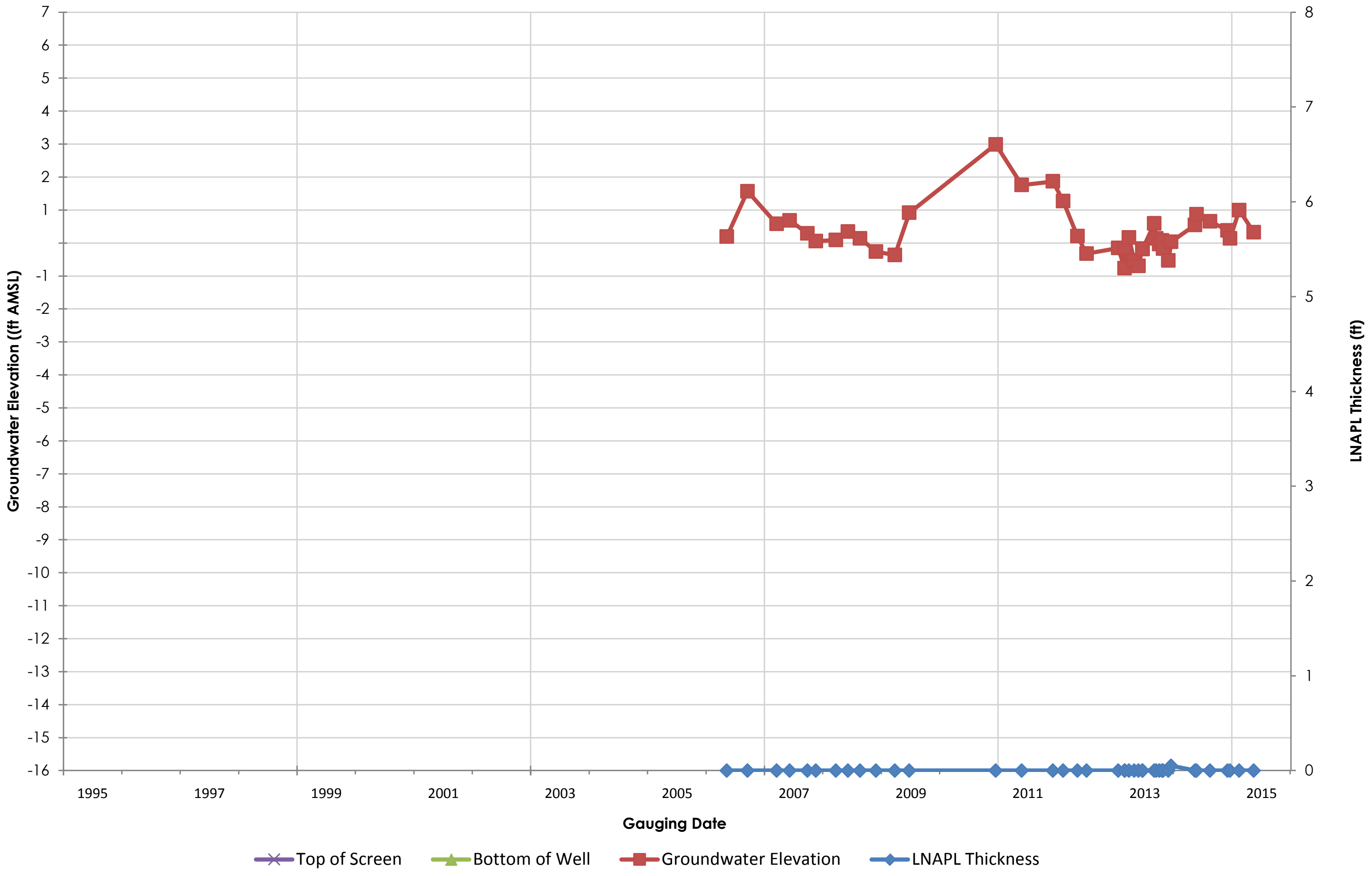
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-228

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

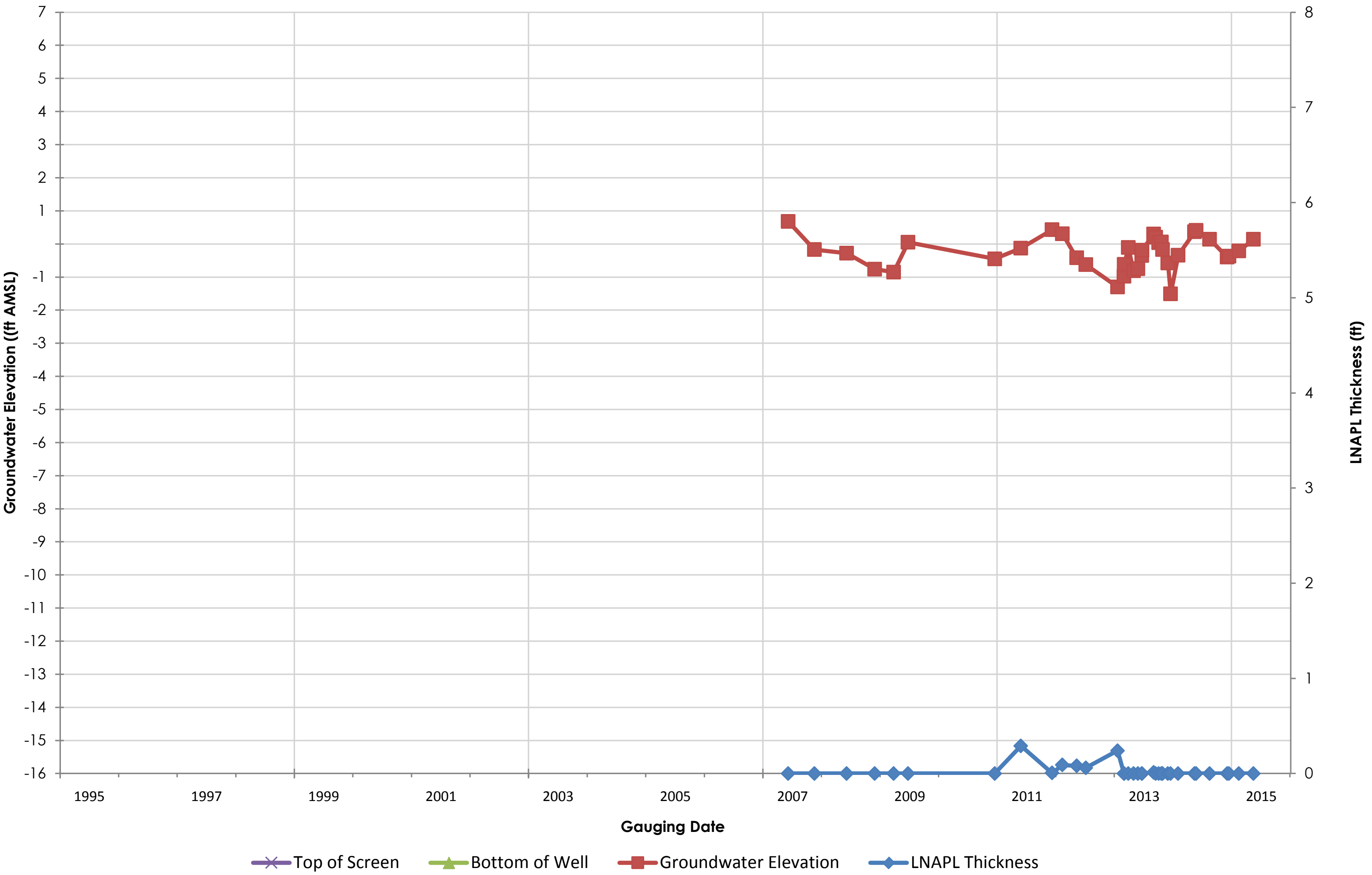
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-230

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

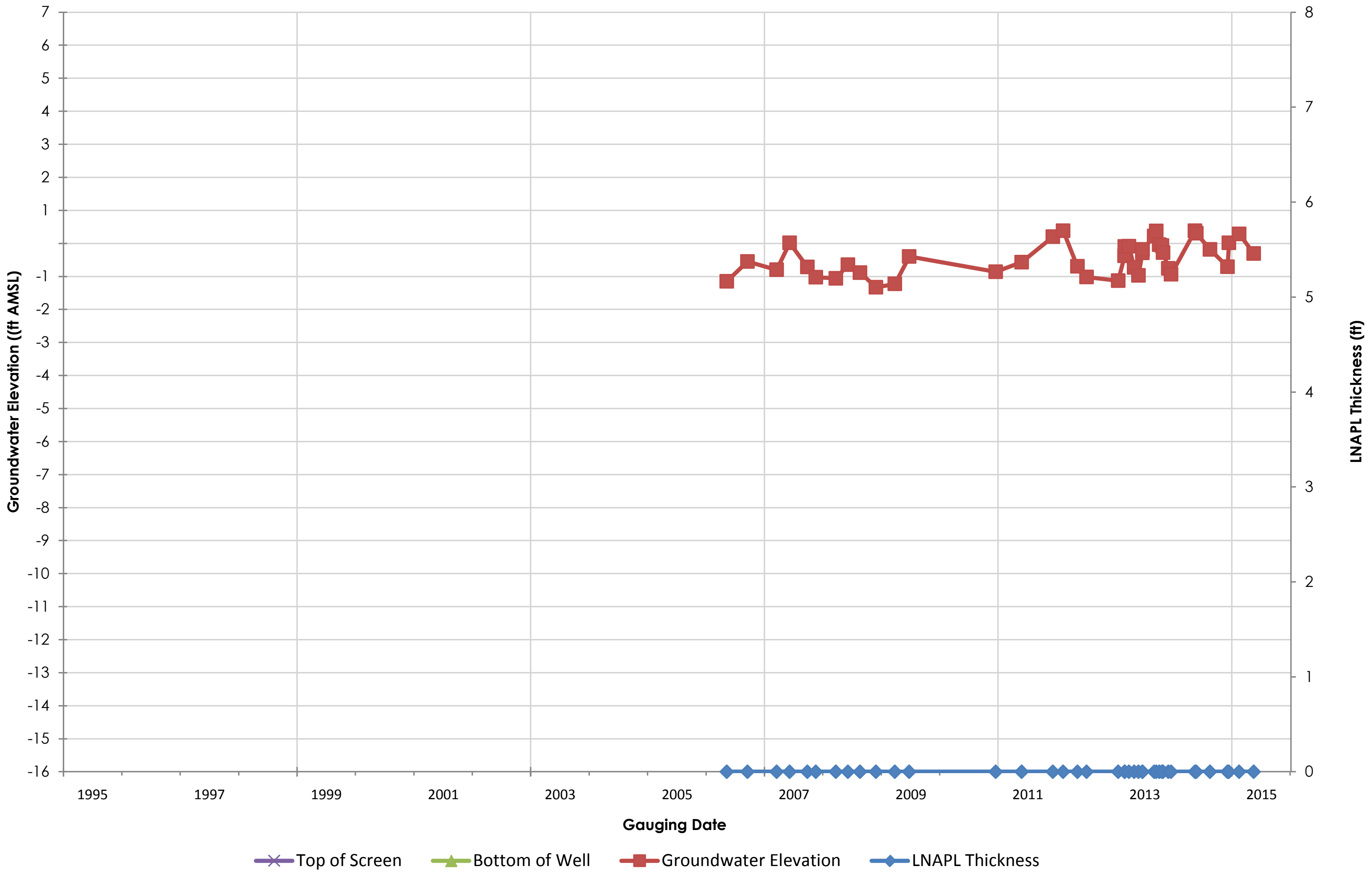
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-231

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

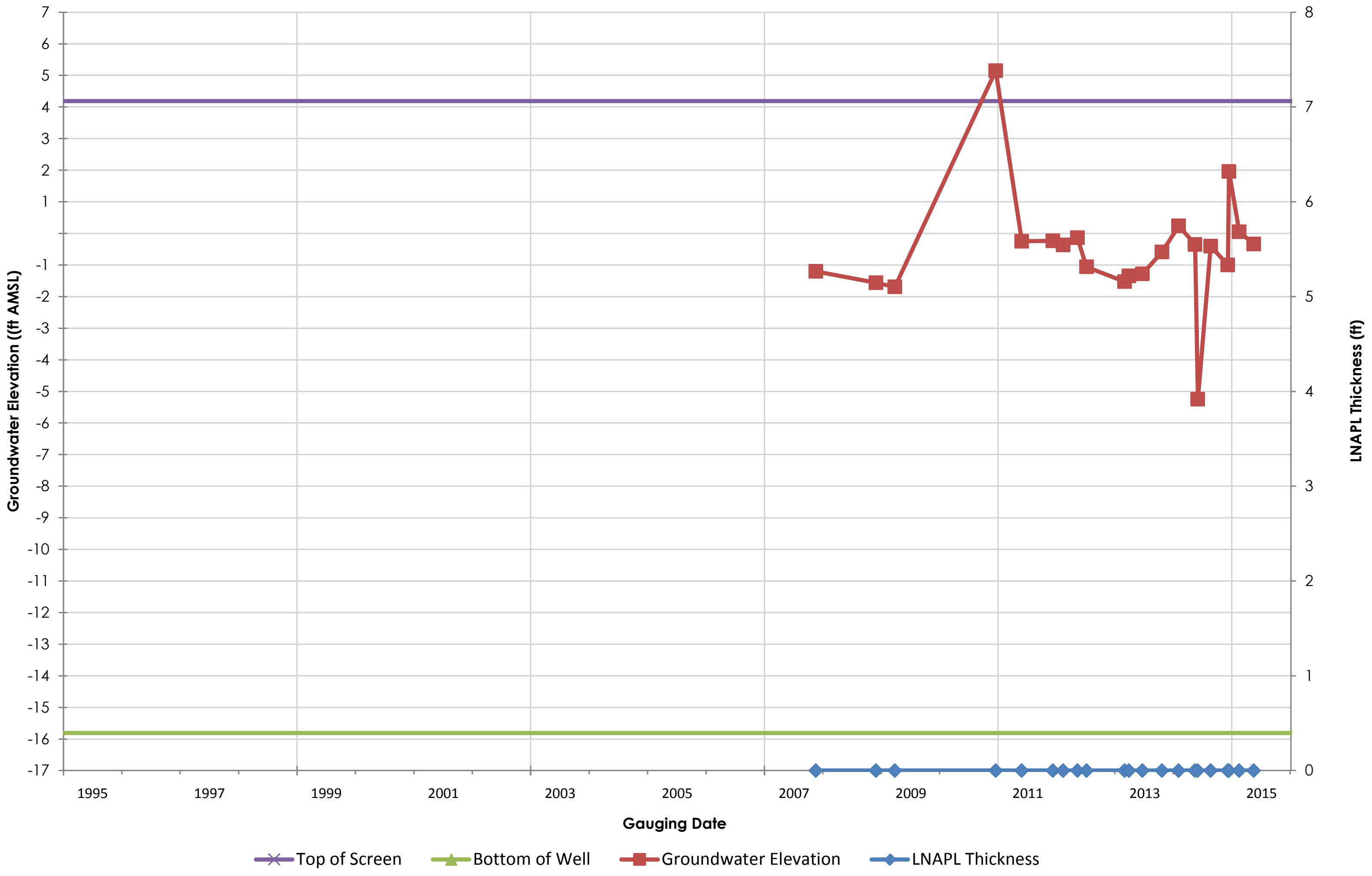
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-232

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

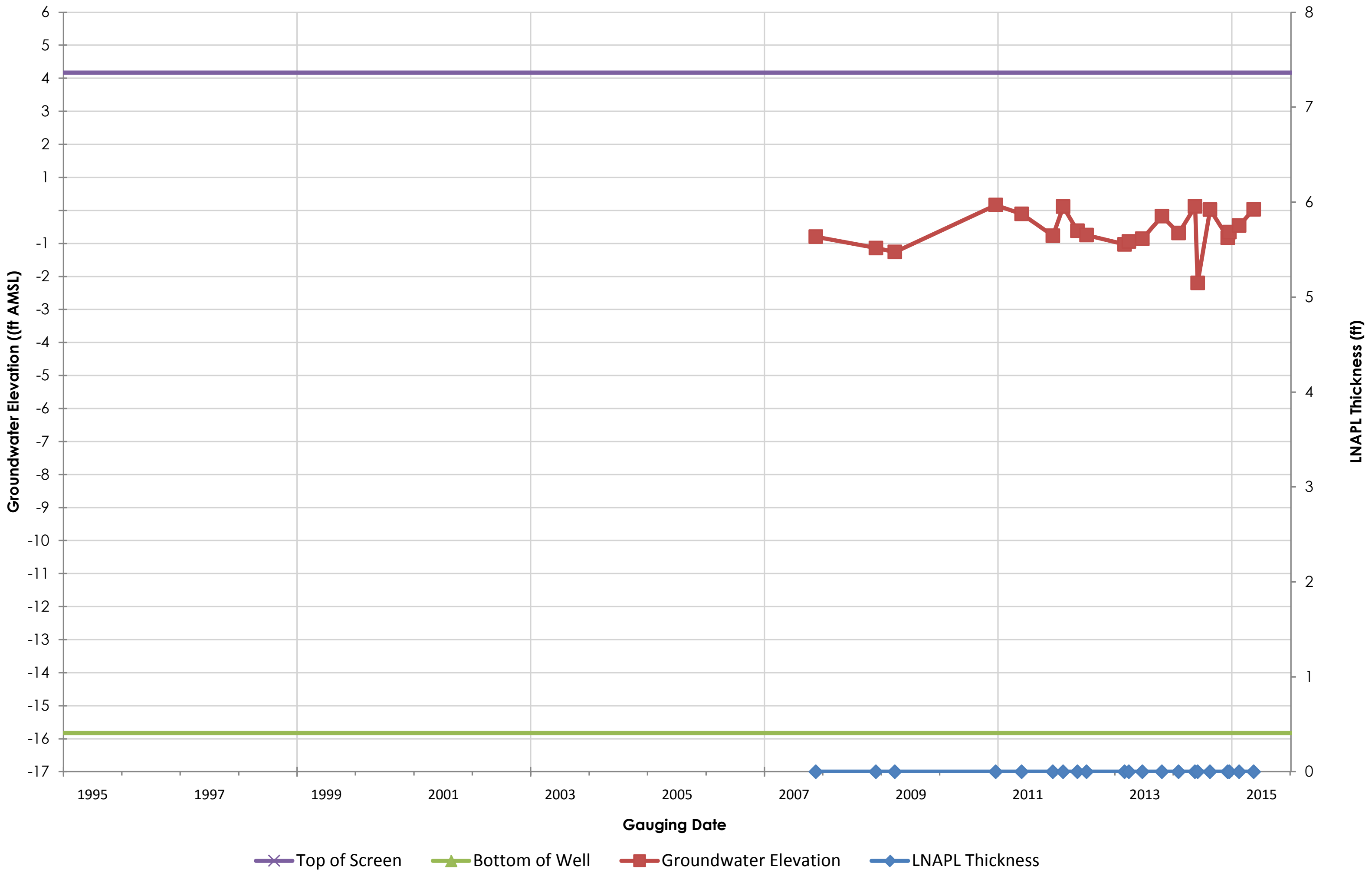
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-255

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

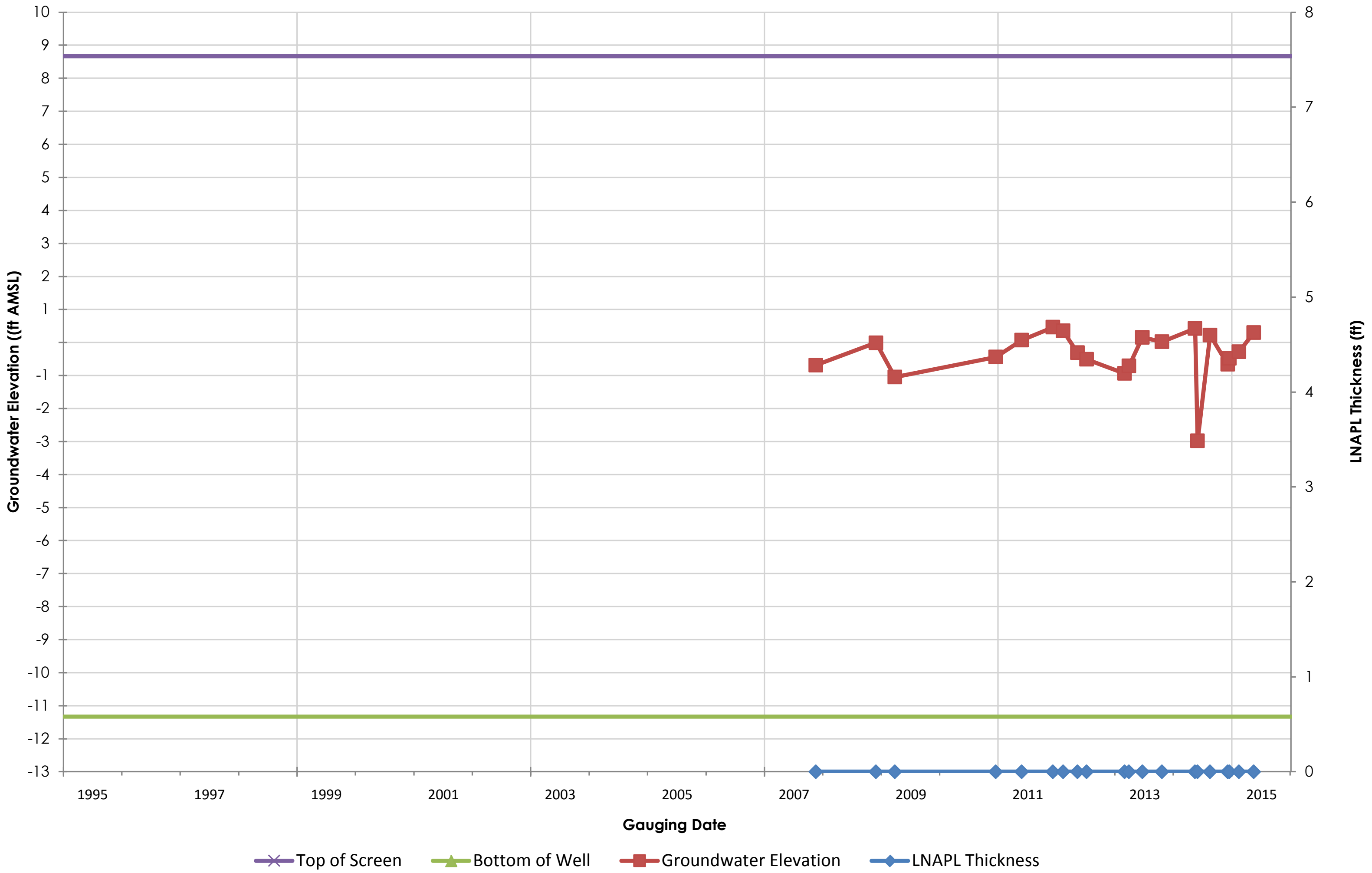
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-256

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

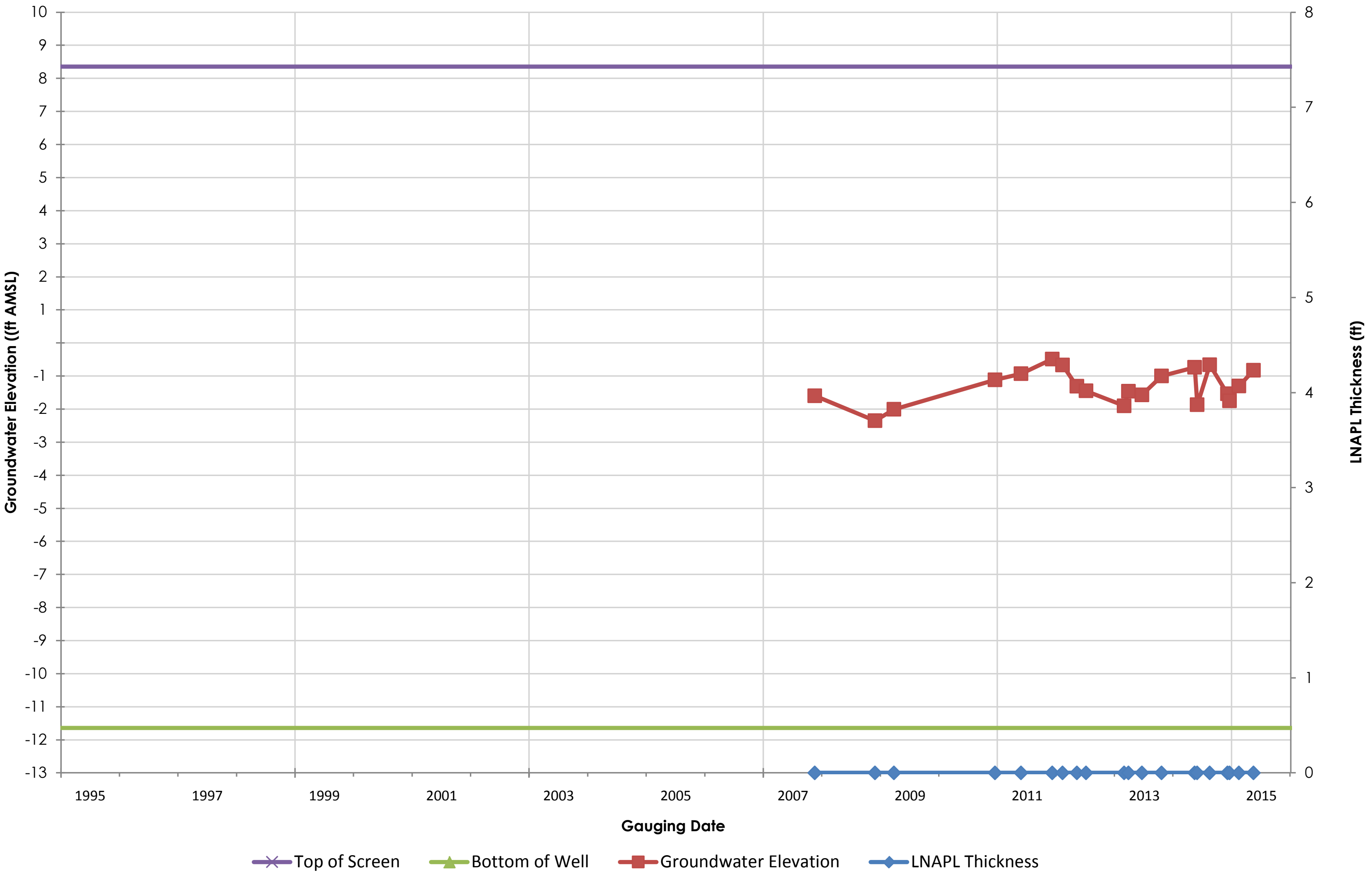
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-257

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

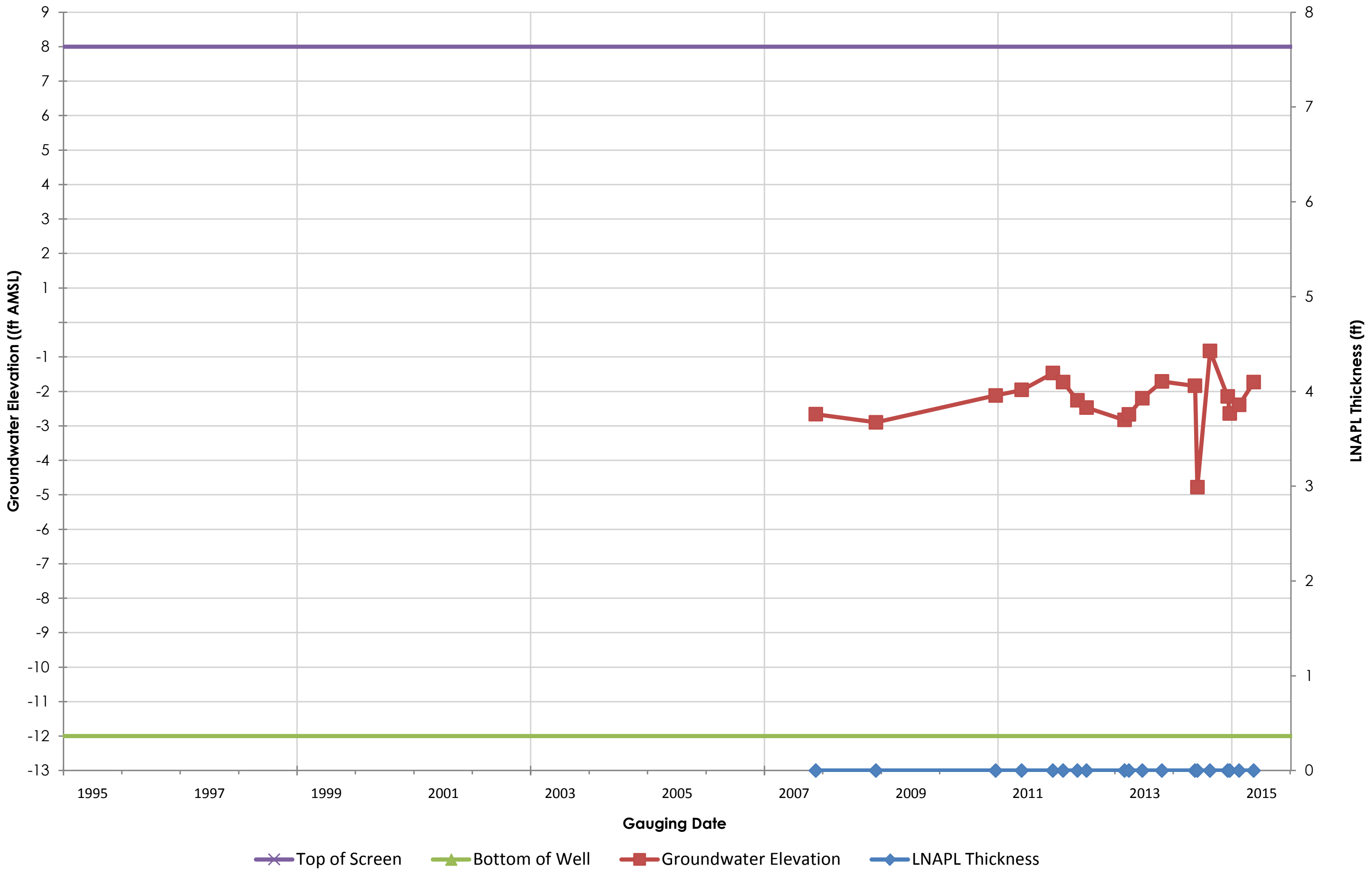
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-258

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

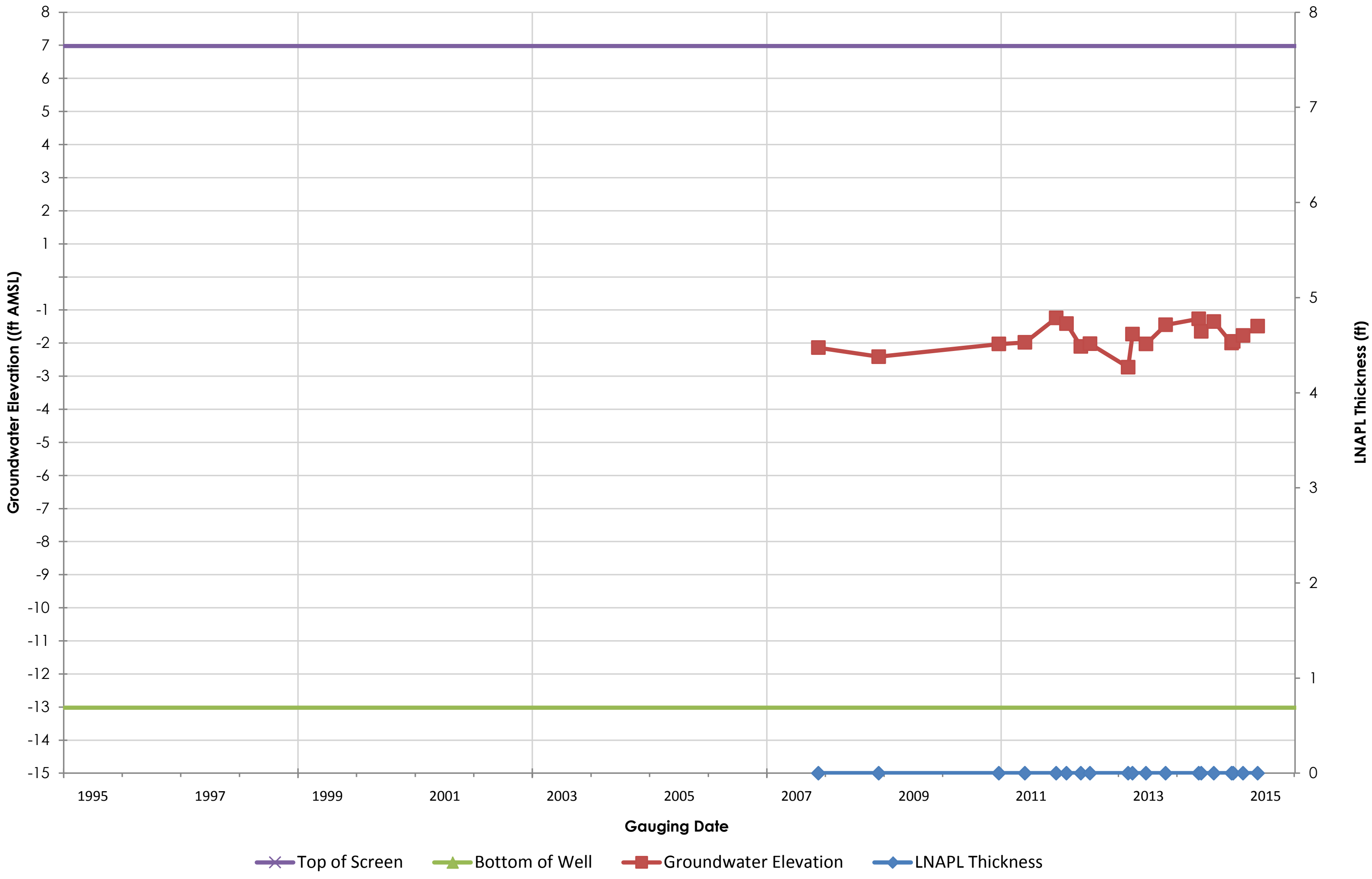
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-259

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

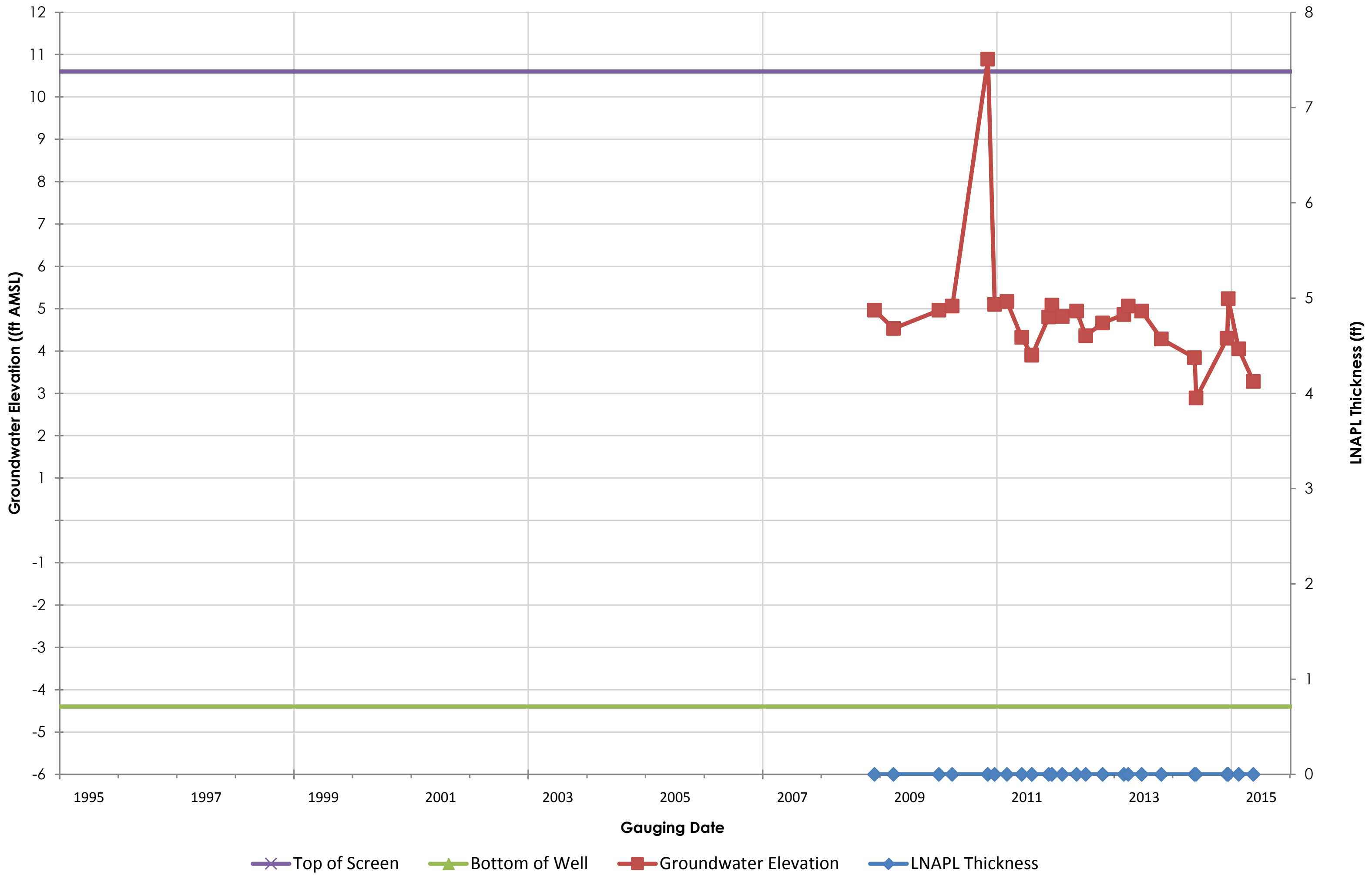
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-260

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

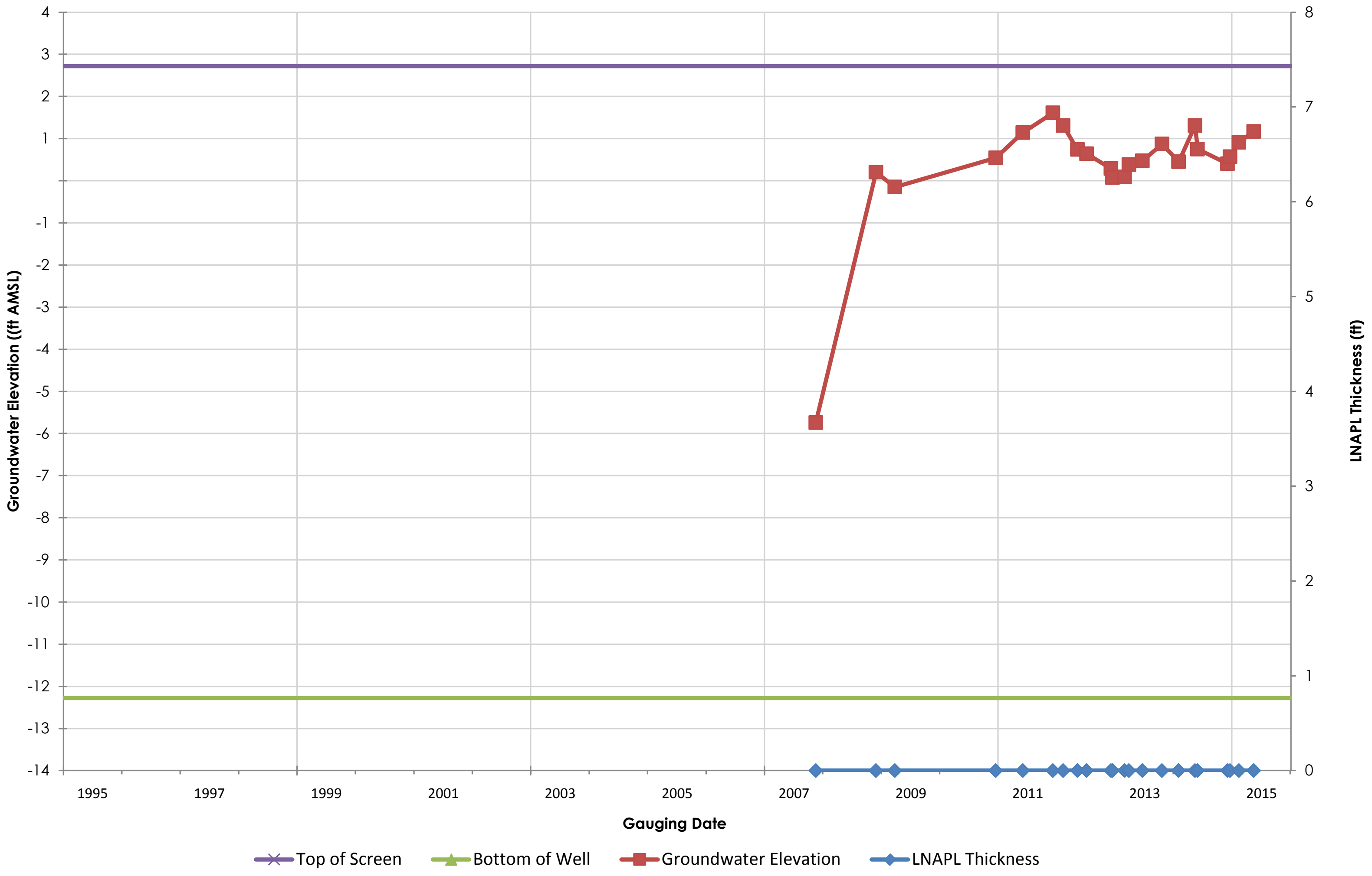
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-261

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

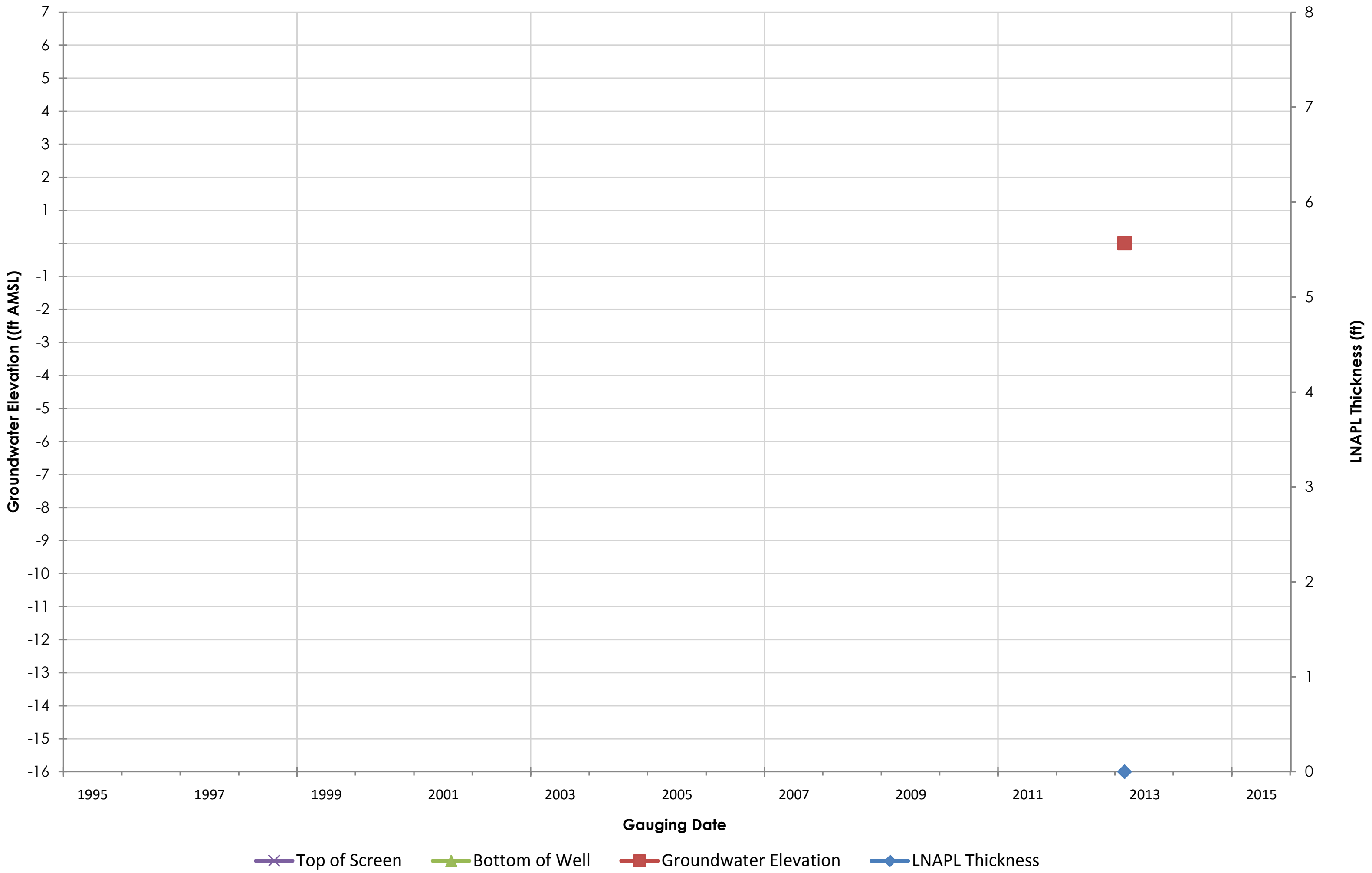
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-262

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

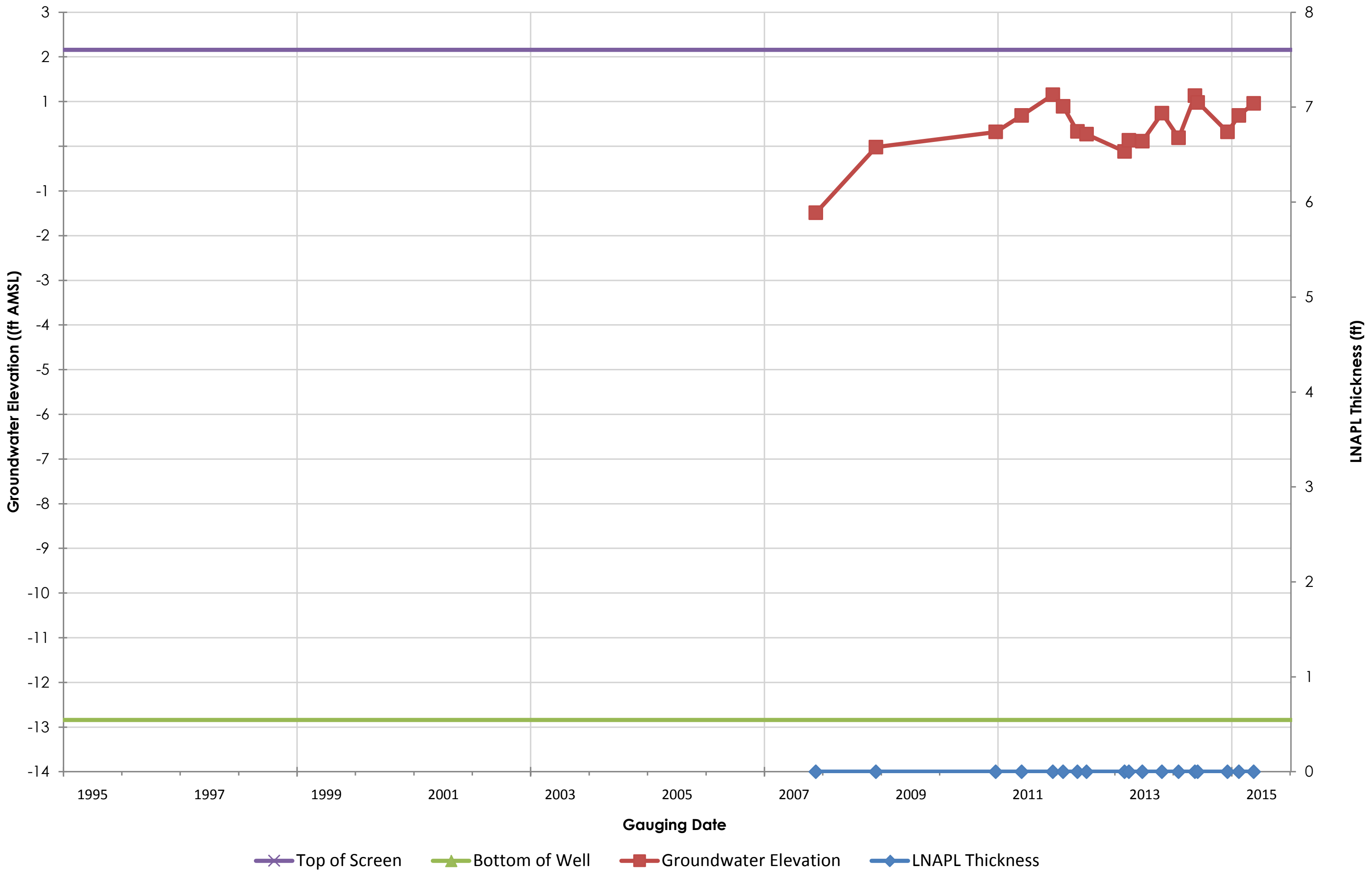
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-262D

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

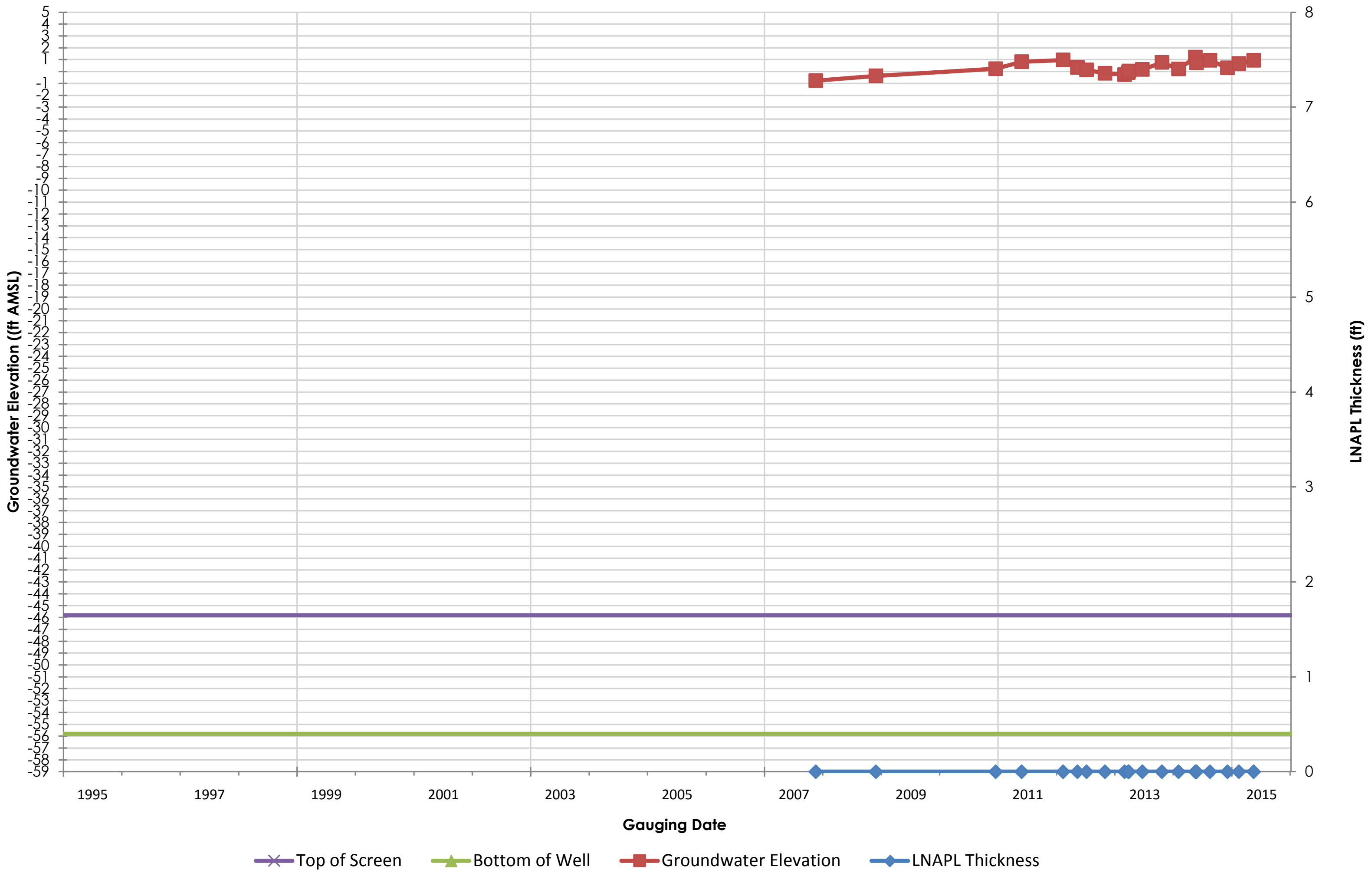
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-263

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

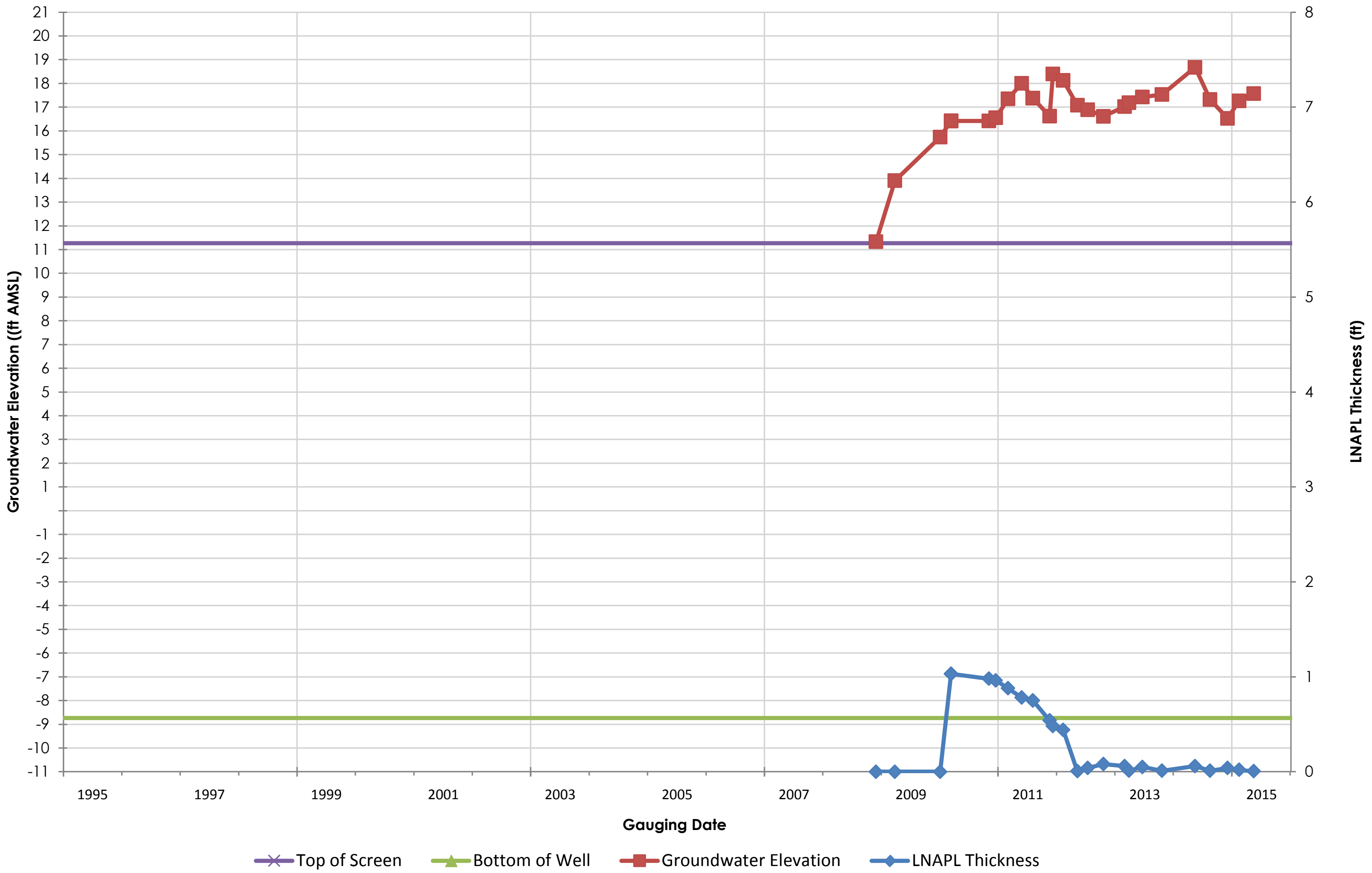
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-264D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

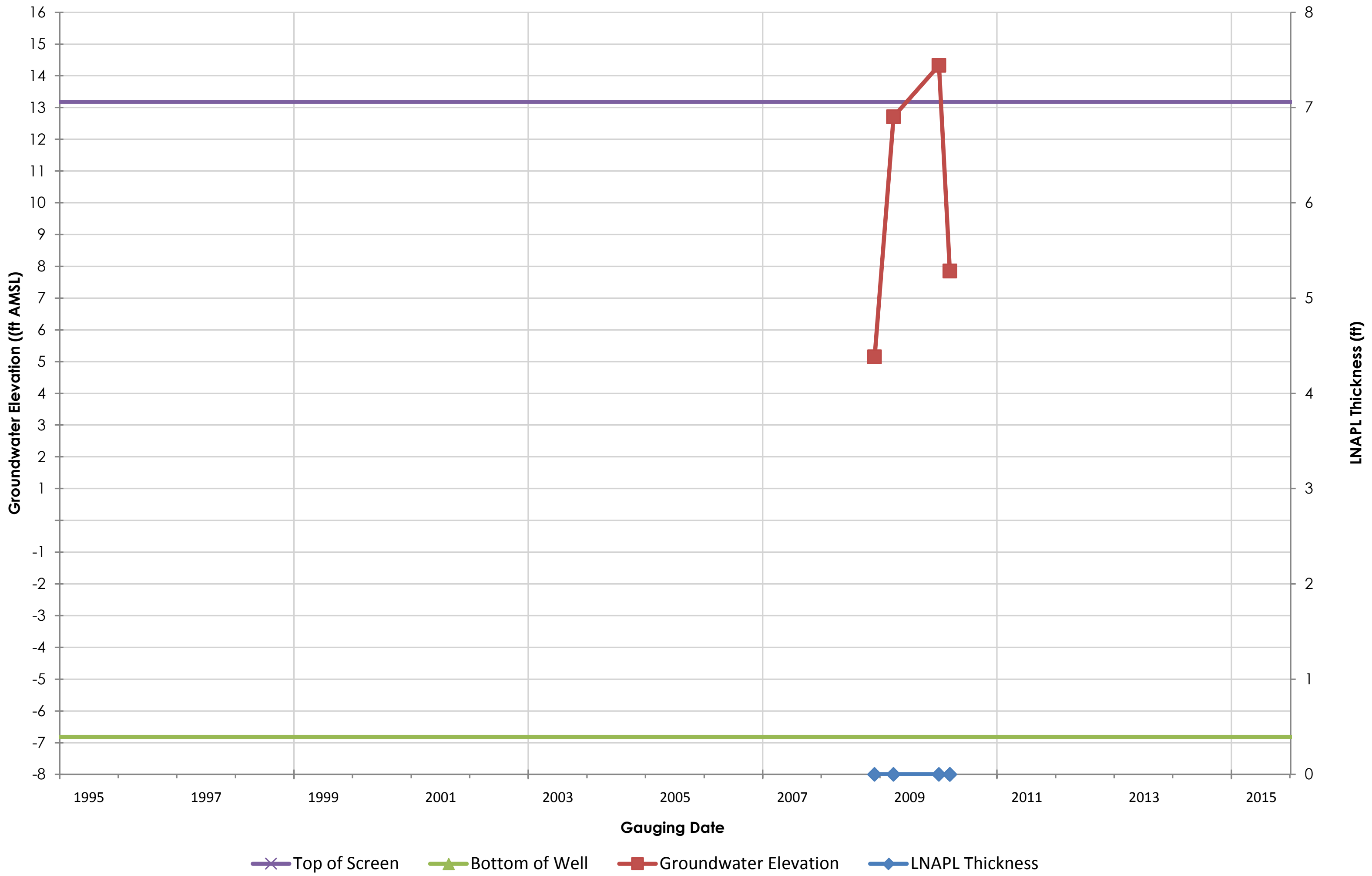
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-265

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

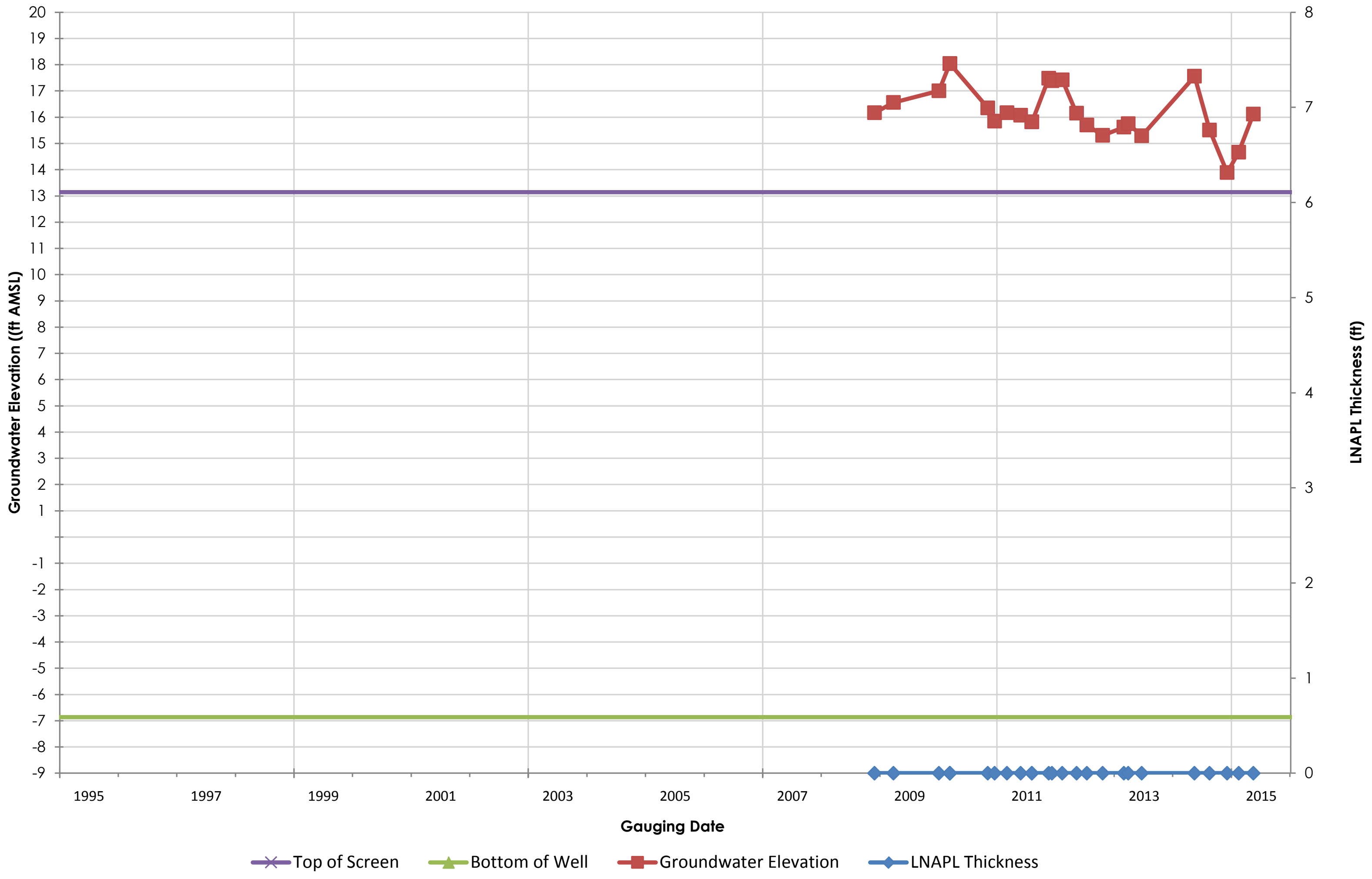
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-266

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

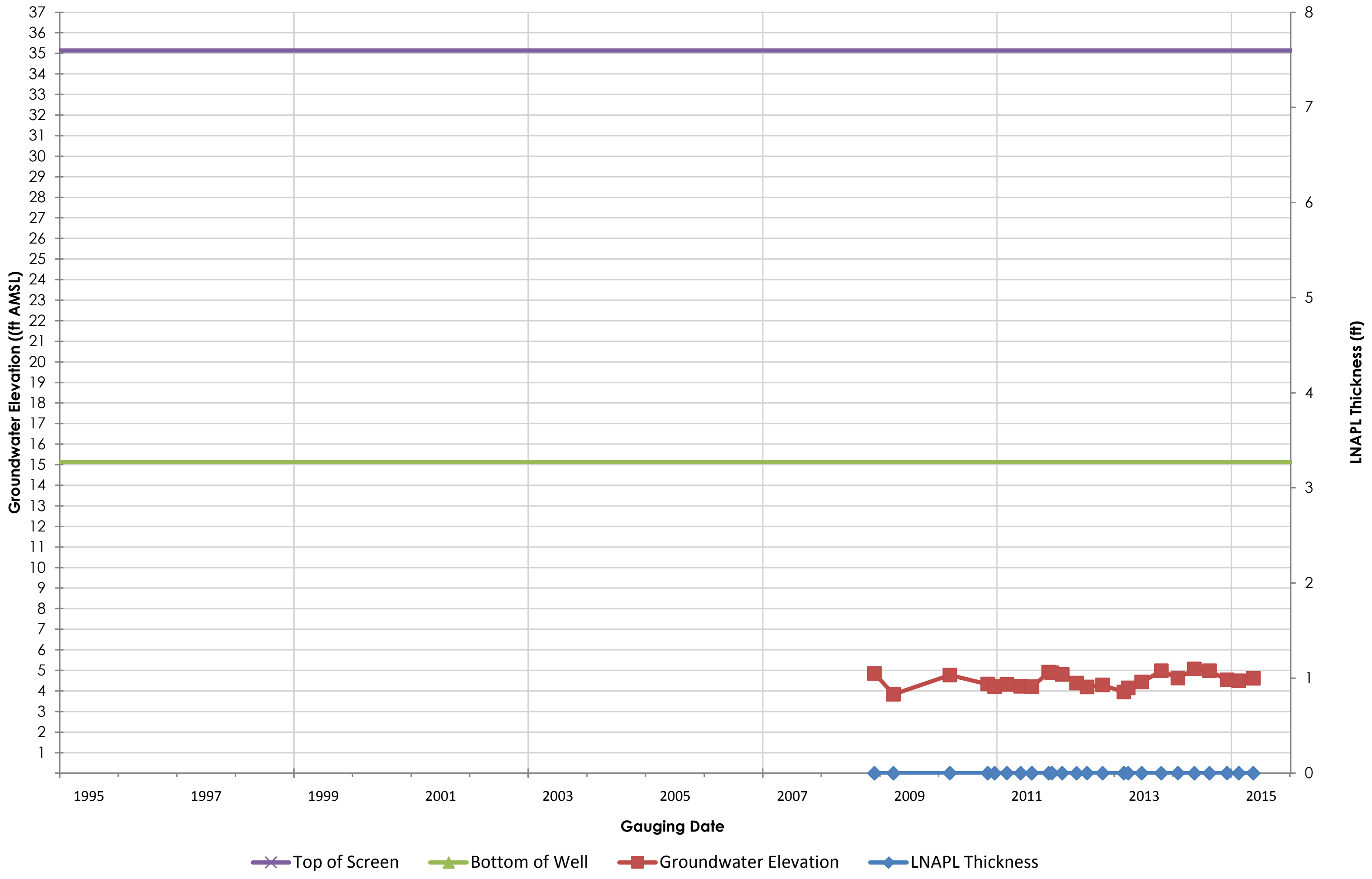
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-267

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

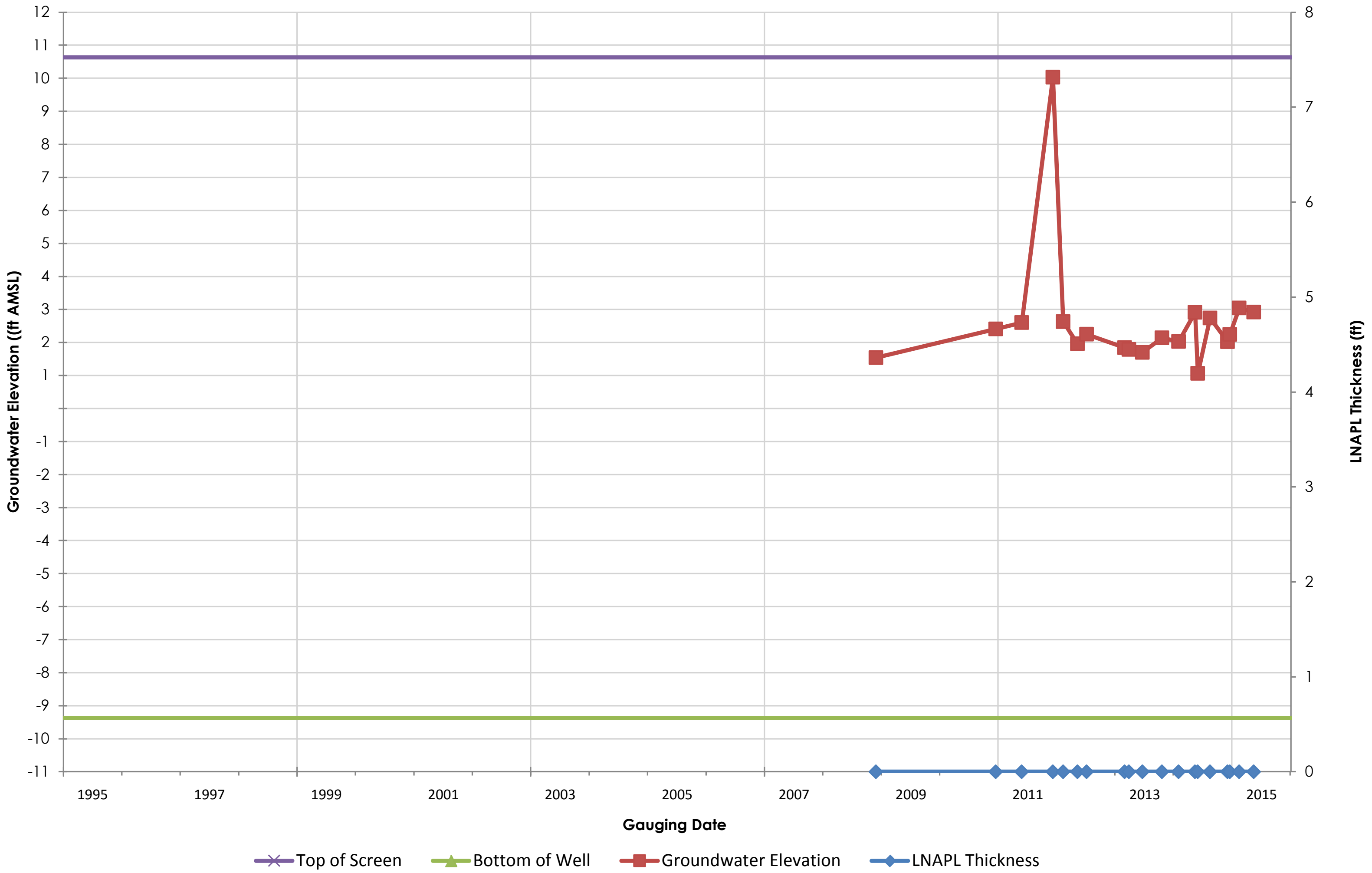
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-268

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

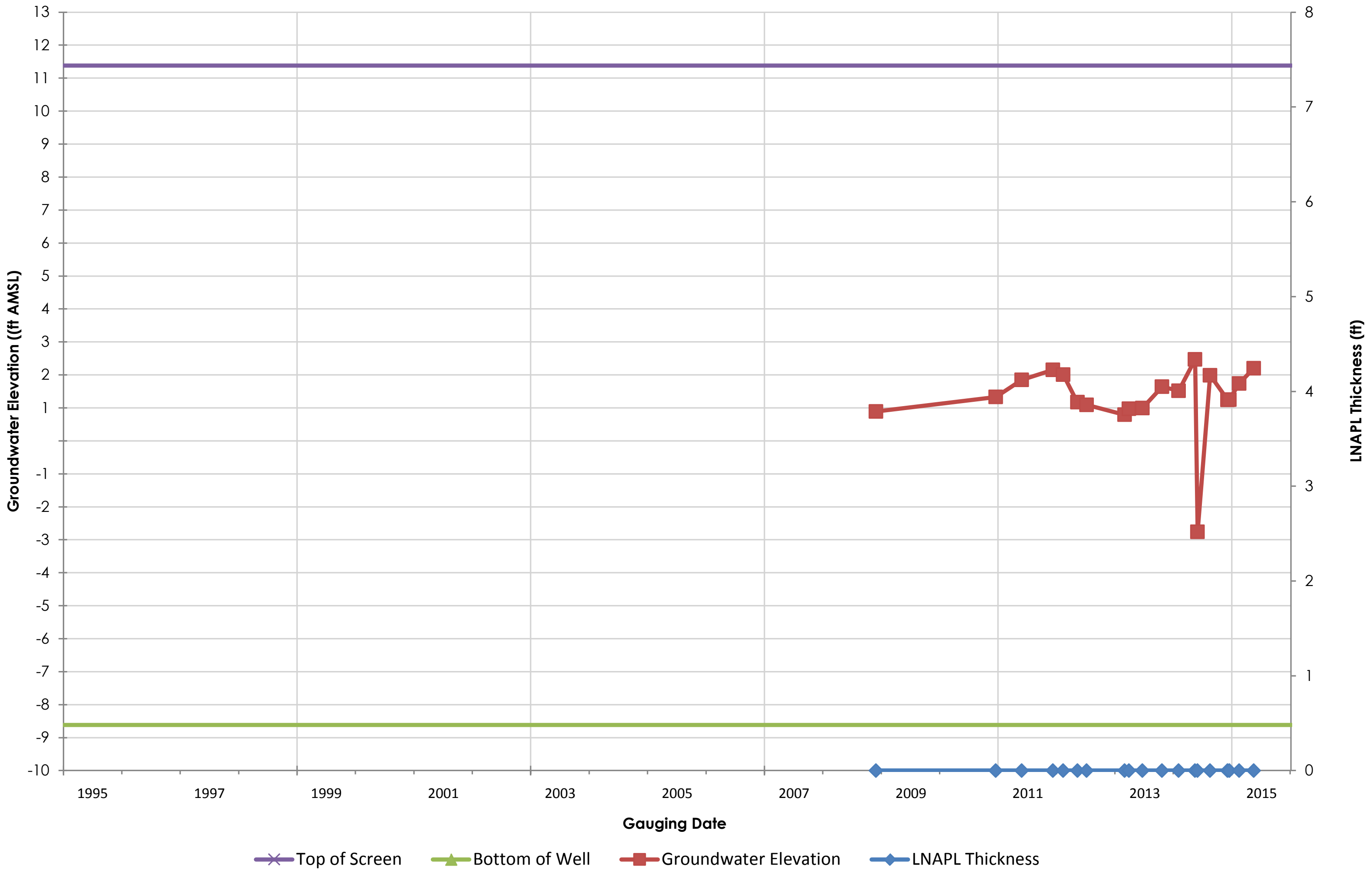
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-269

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

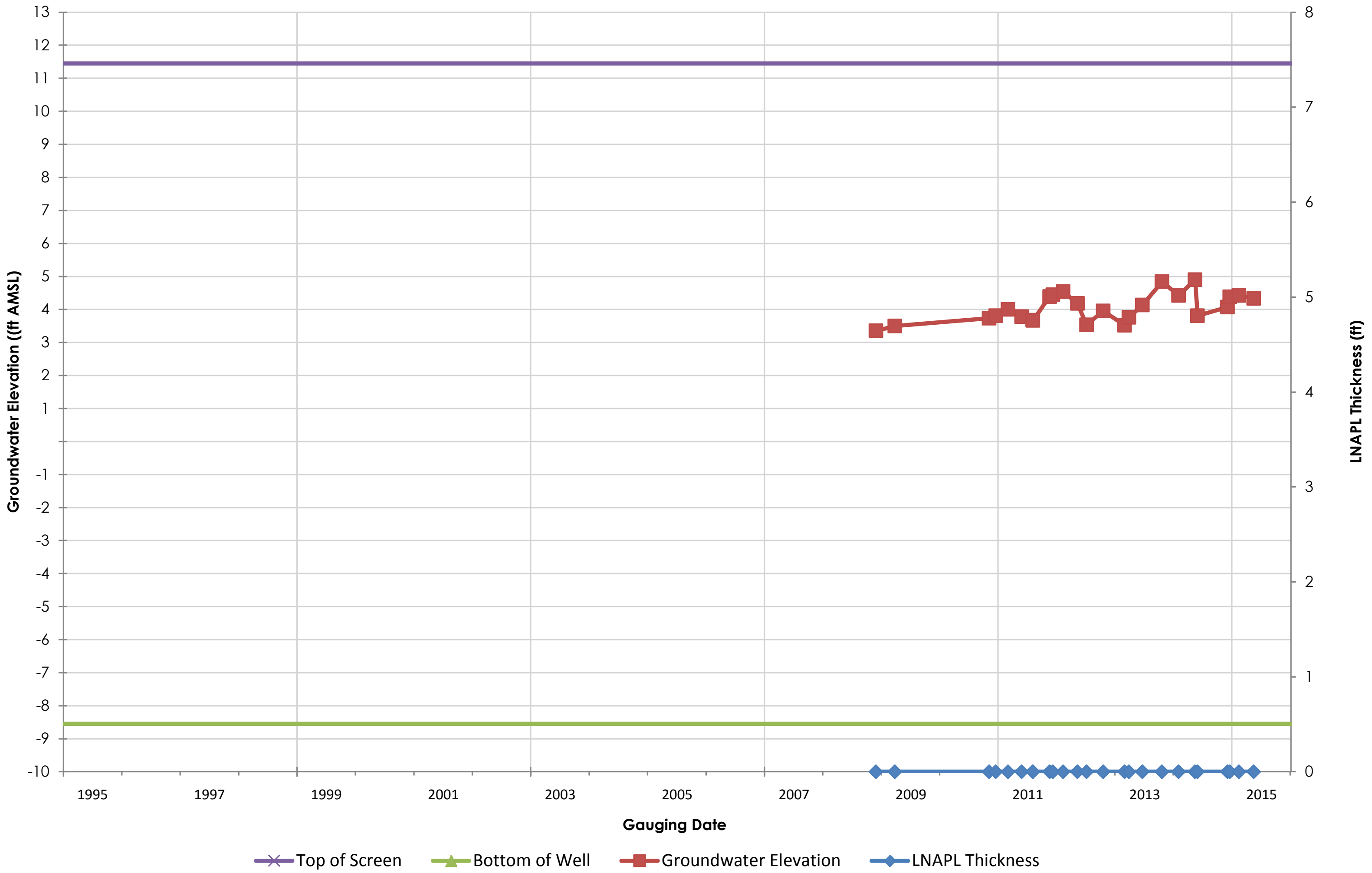
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-270

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

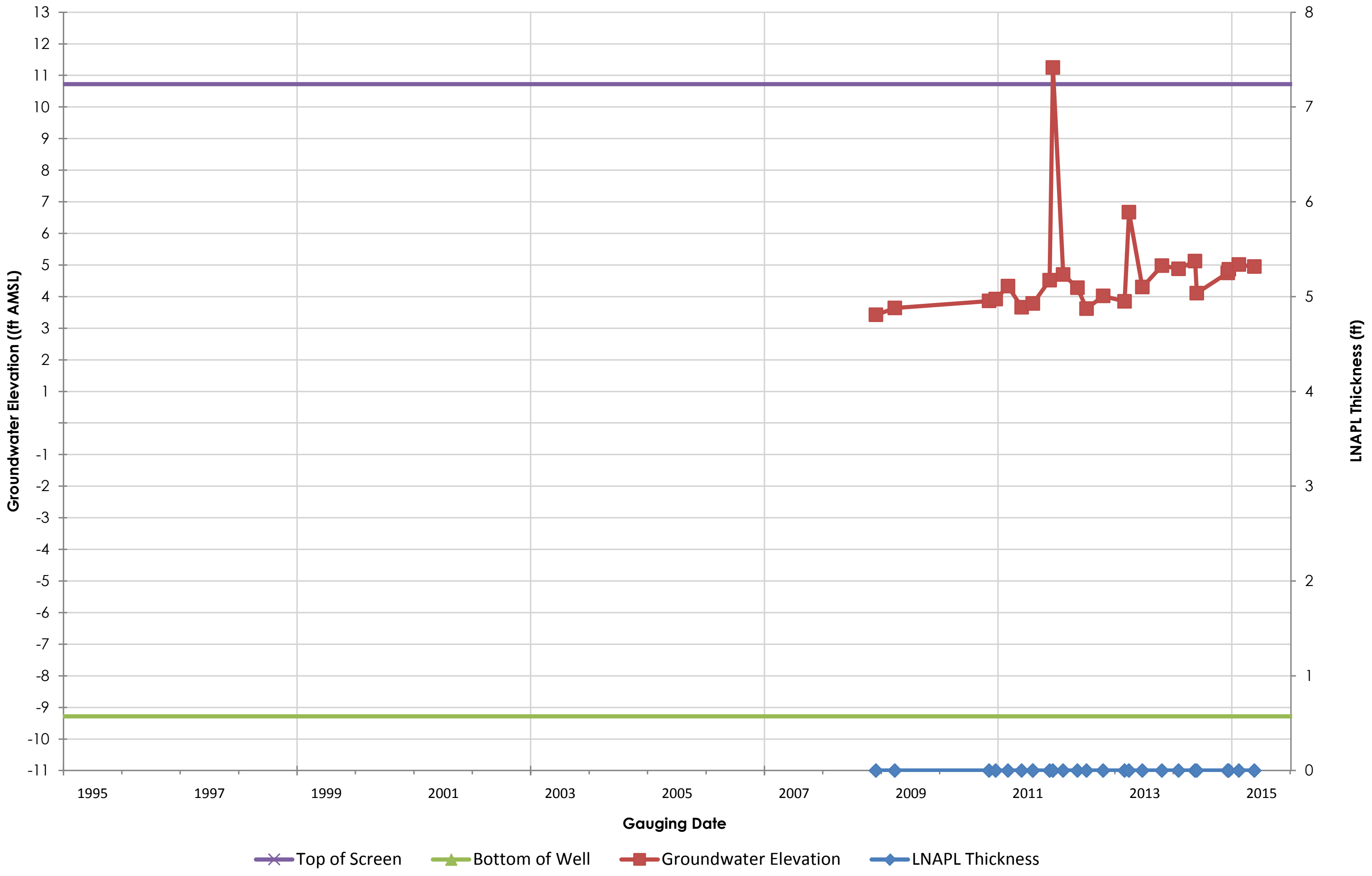
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-271

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

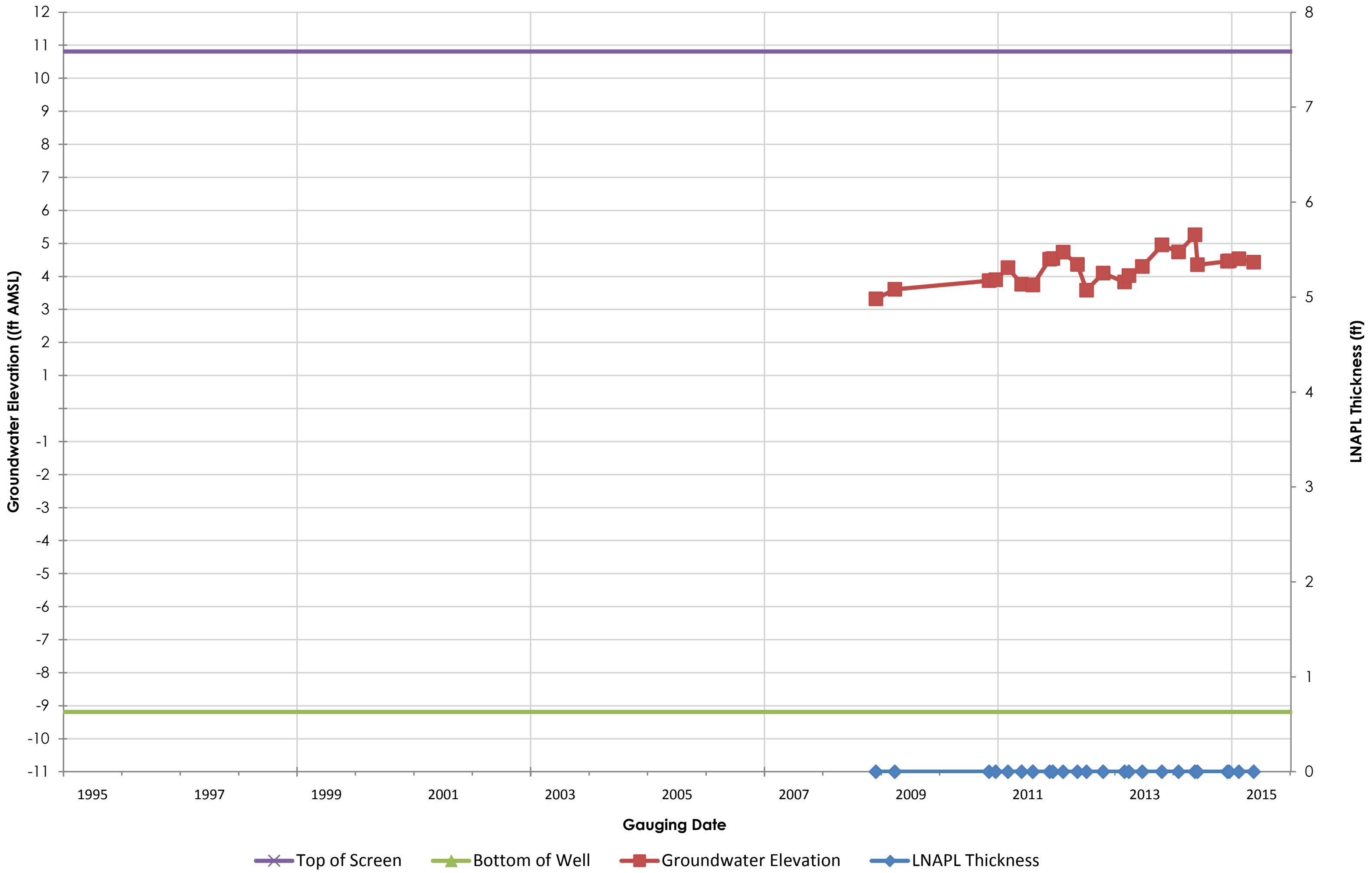
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-272

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

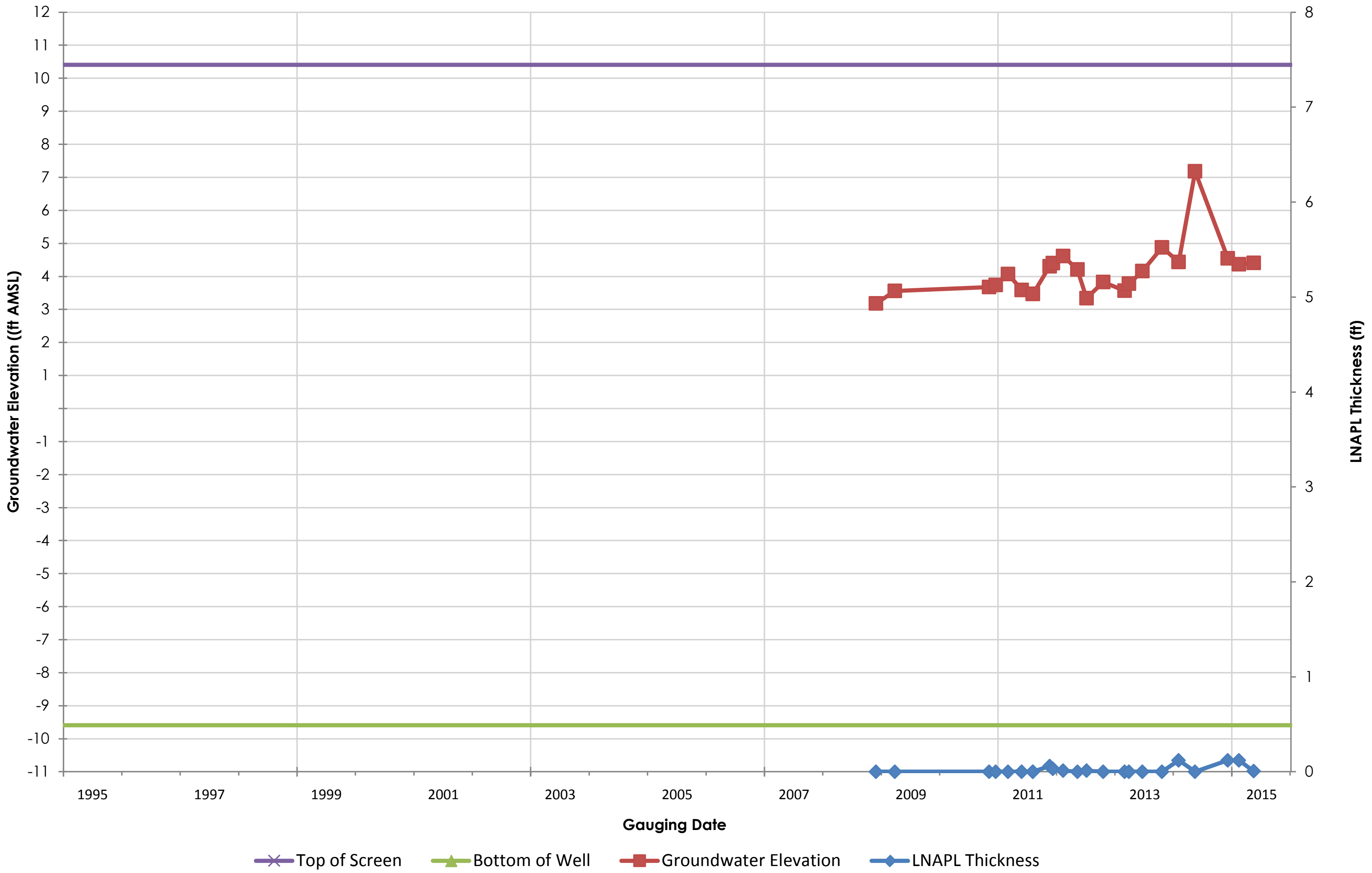
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-273

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

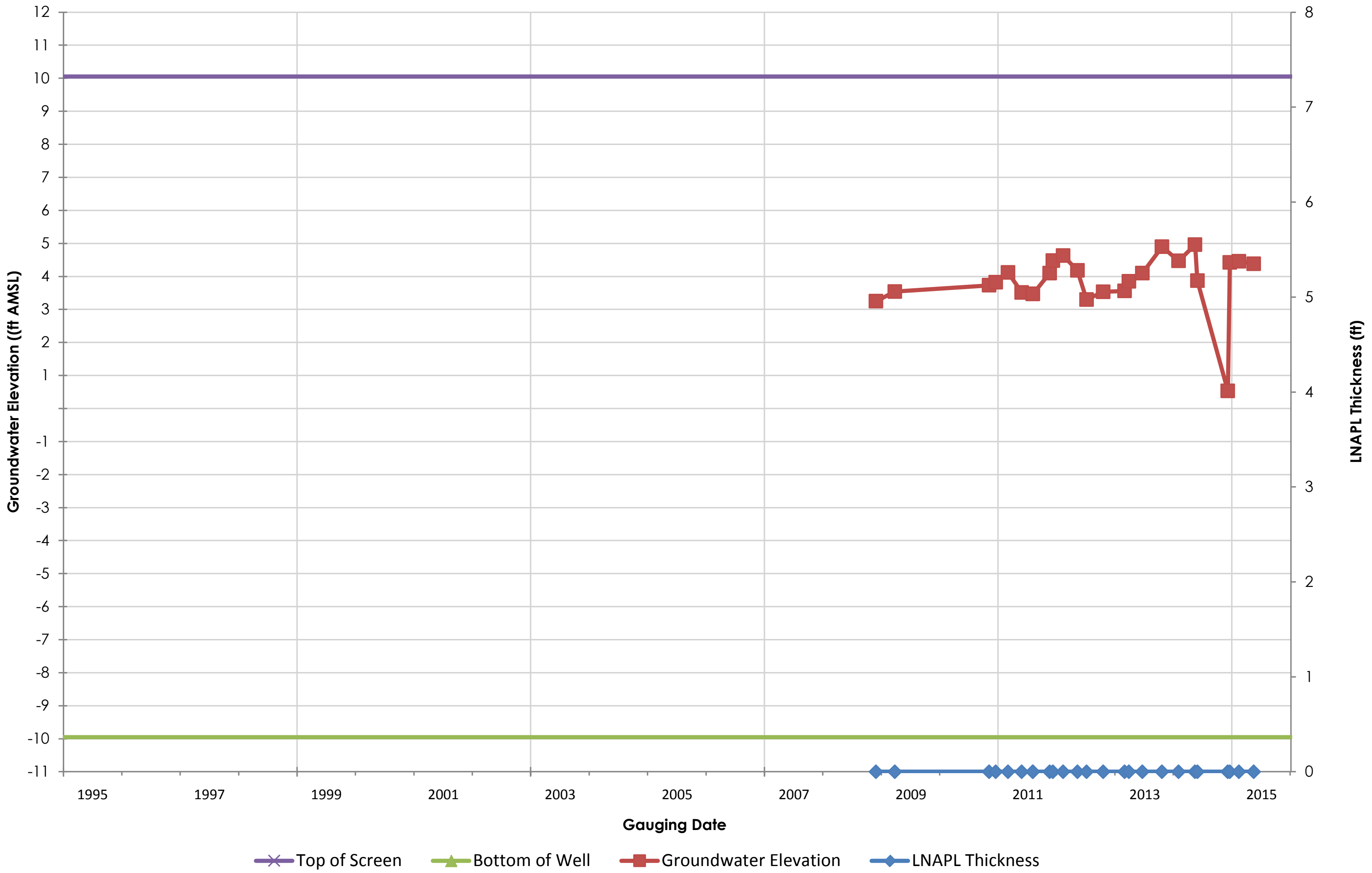
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-274

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

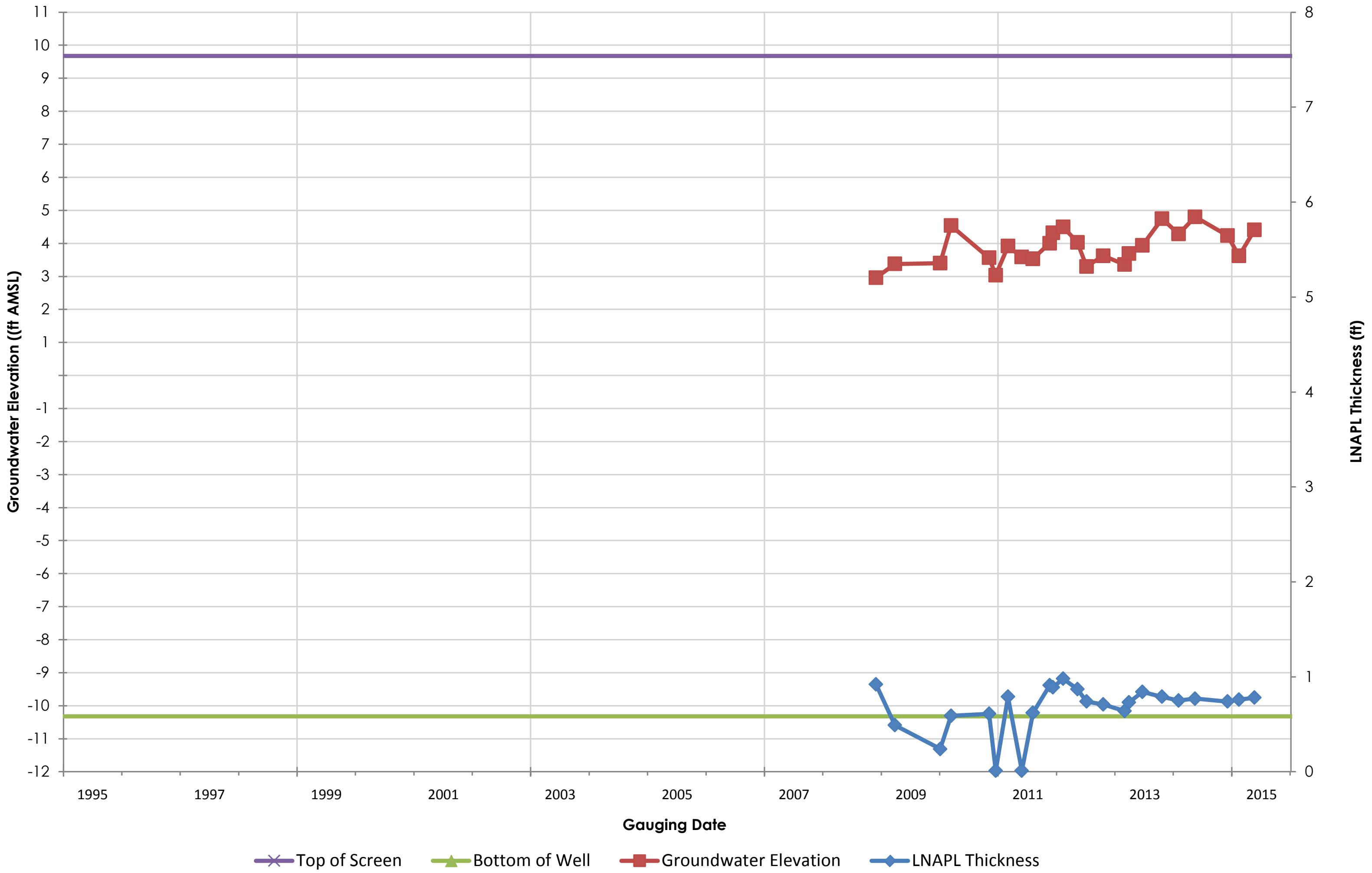
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-275

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

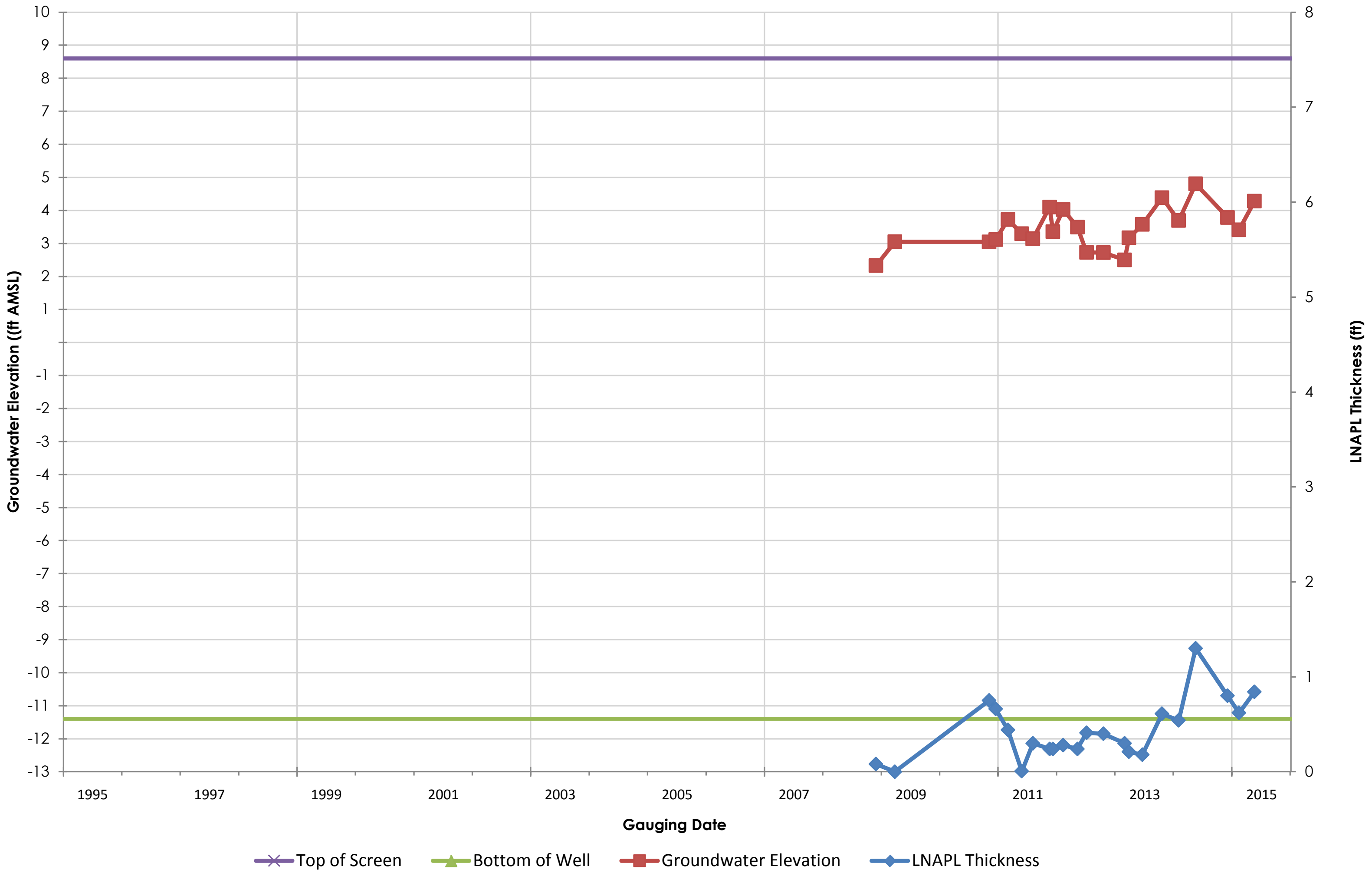
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-276

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

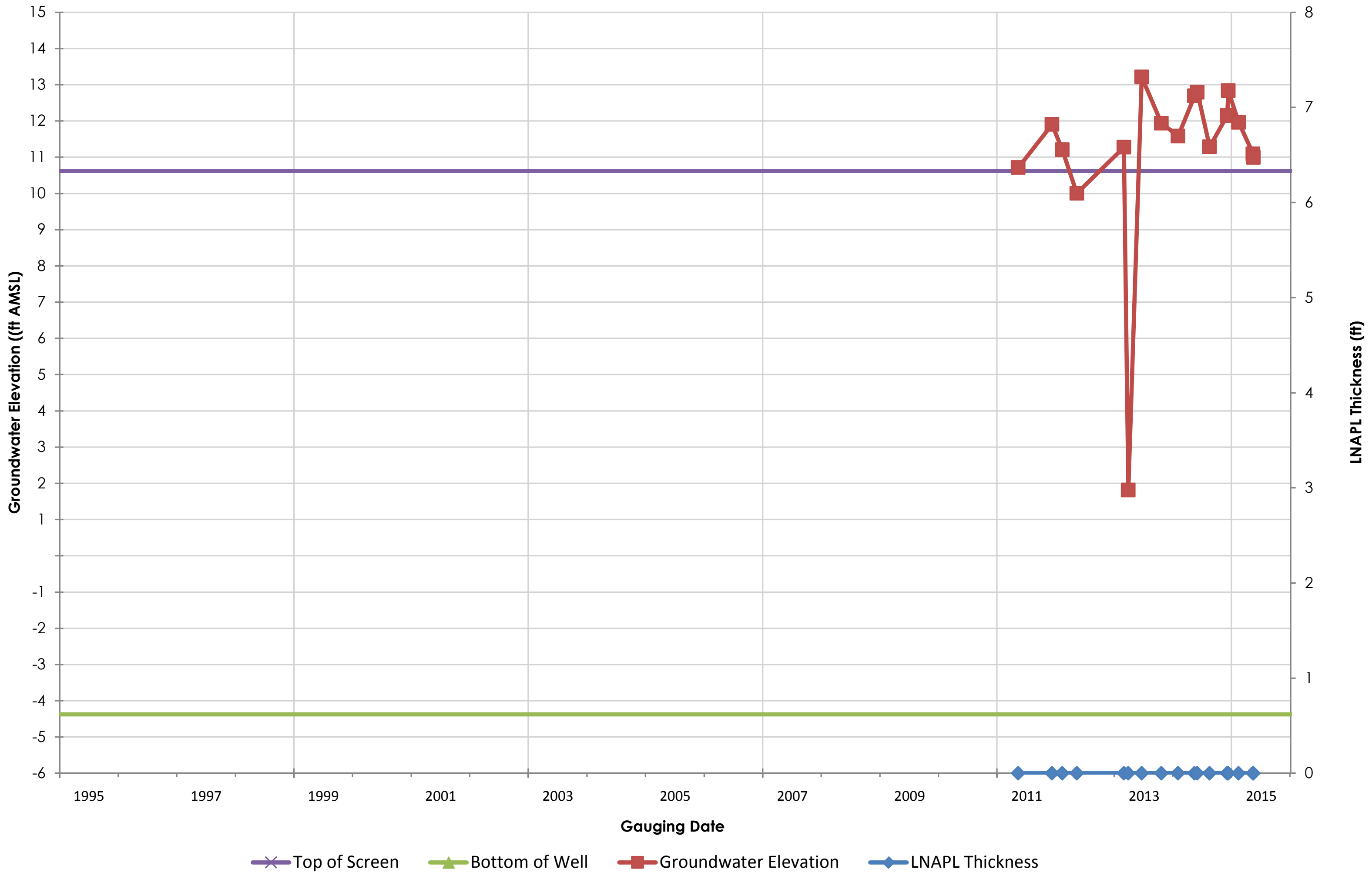
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-277

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

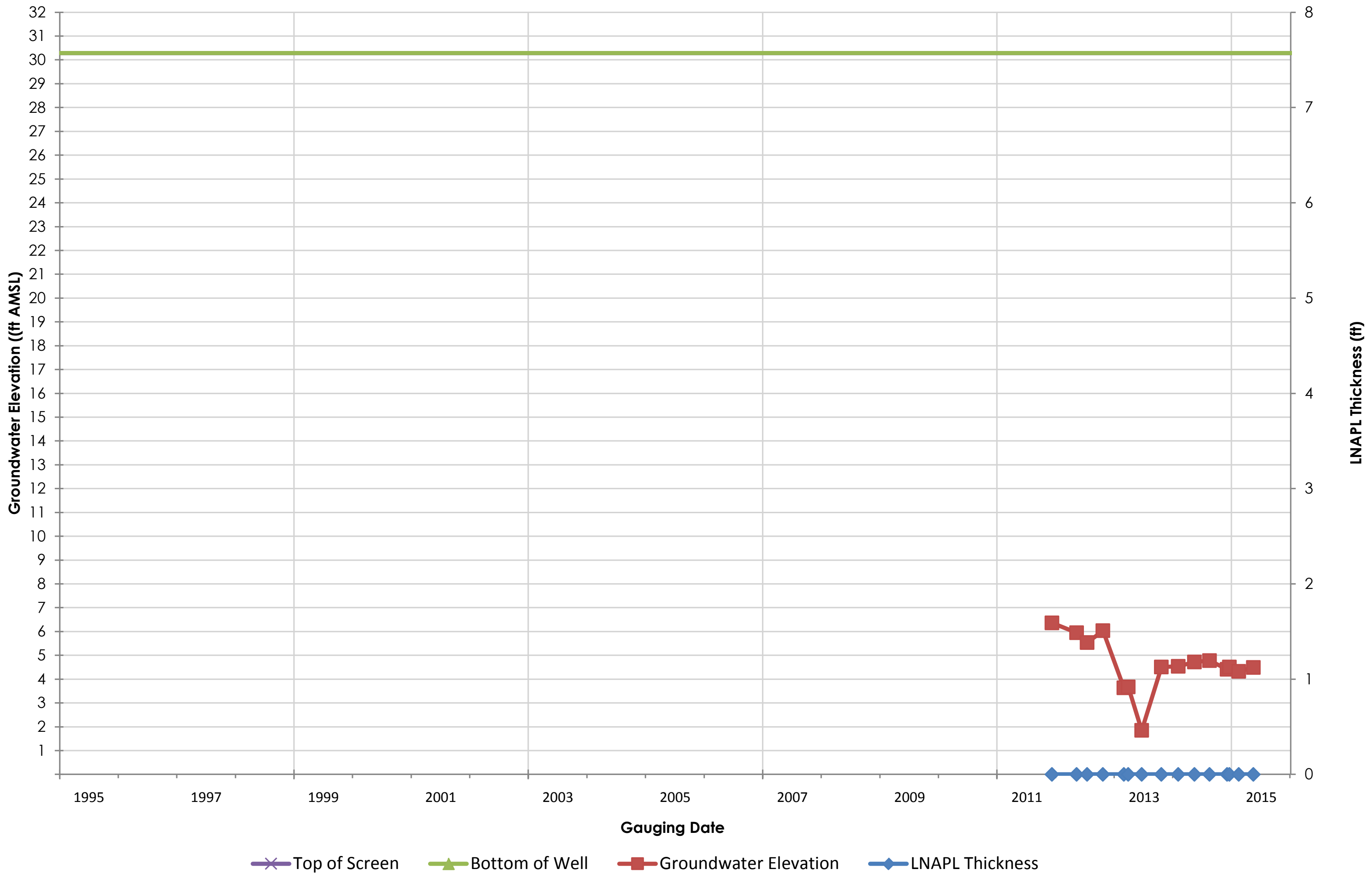
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-312

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

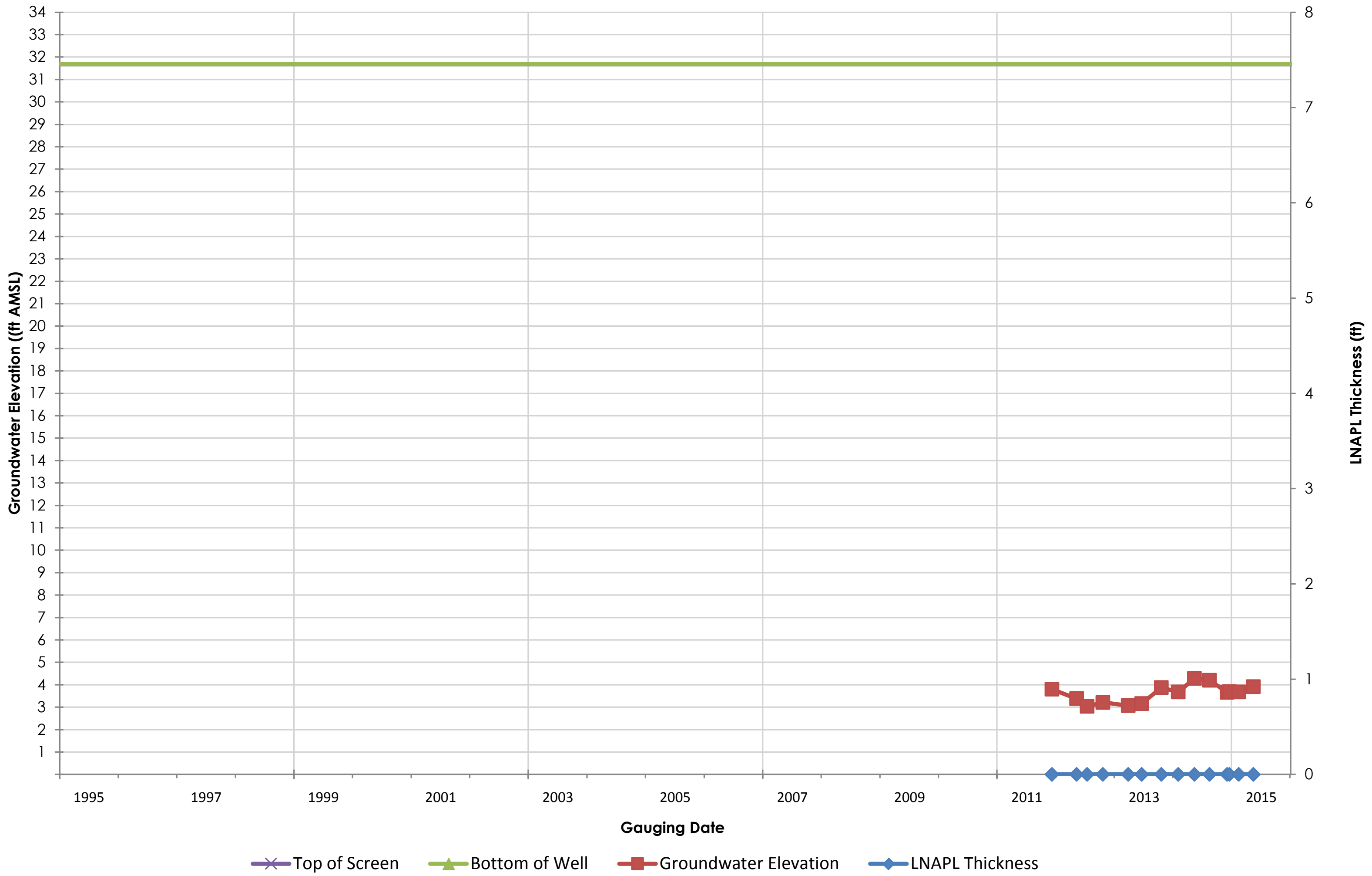
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-330

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

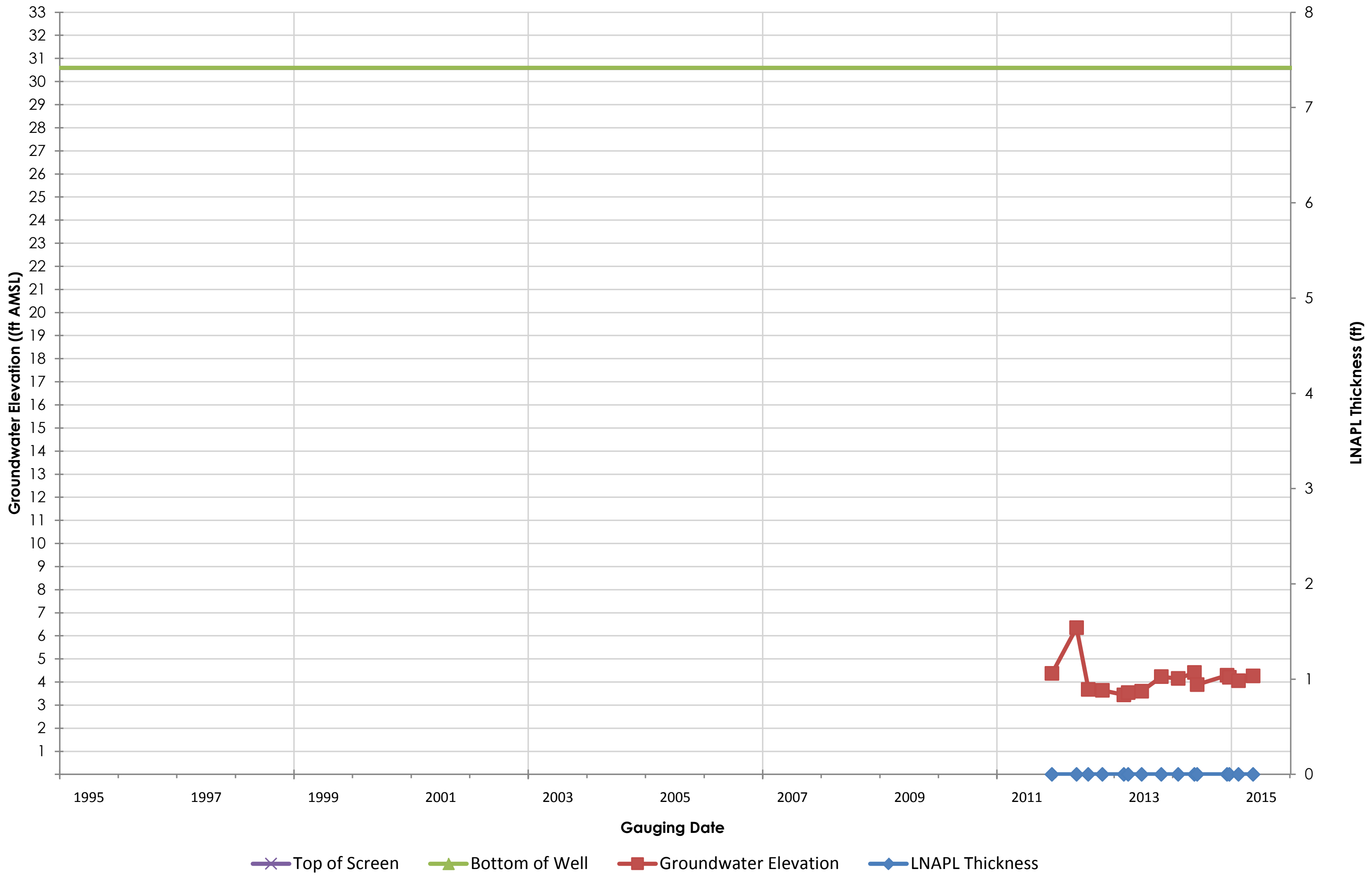
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-331

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

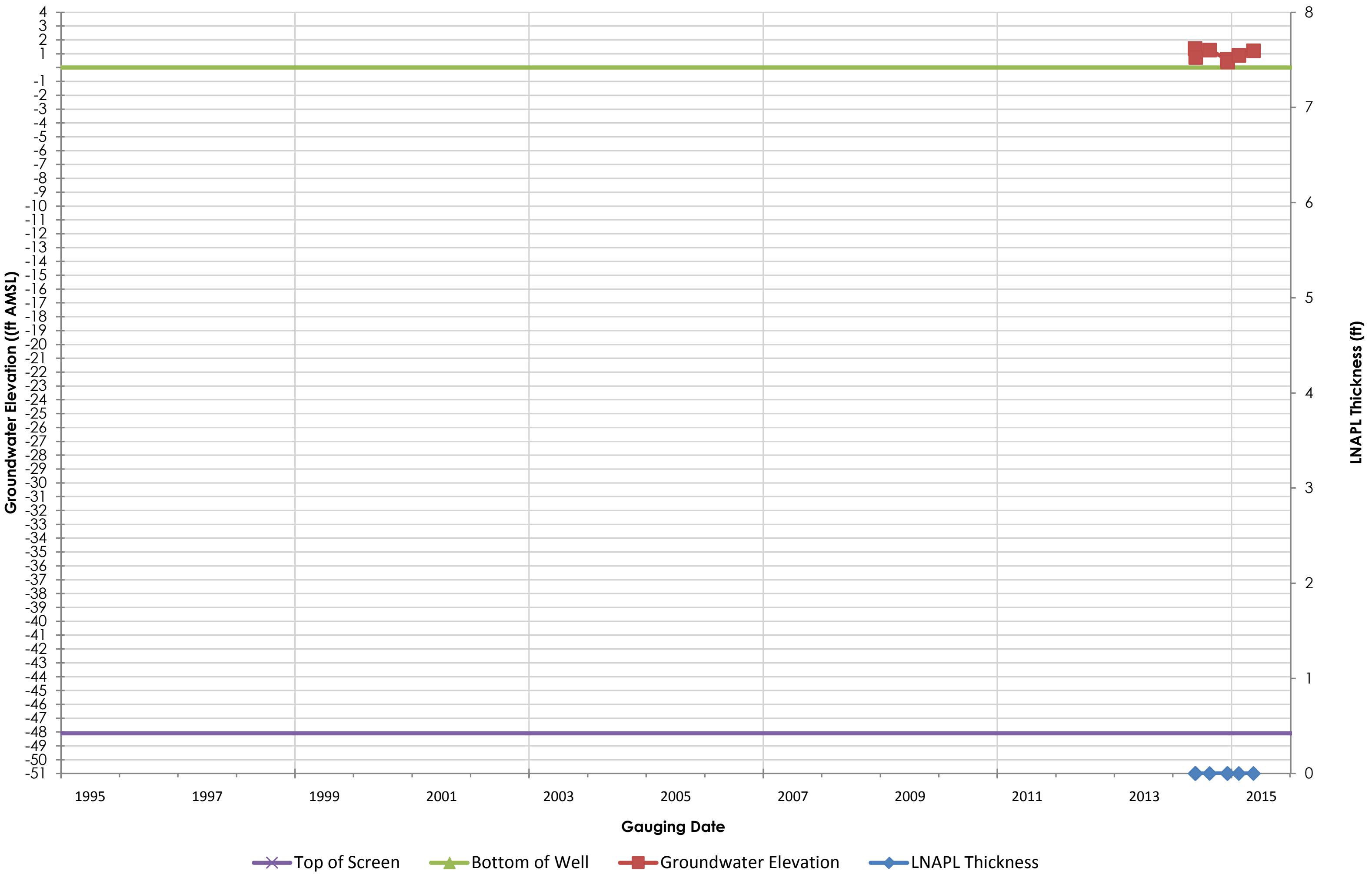
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-332

Title

**Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval**



Stantec

Client/Project

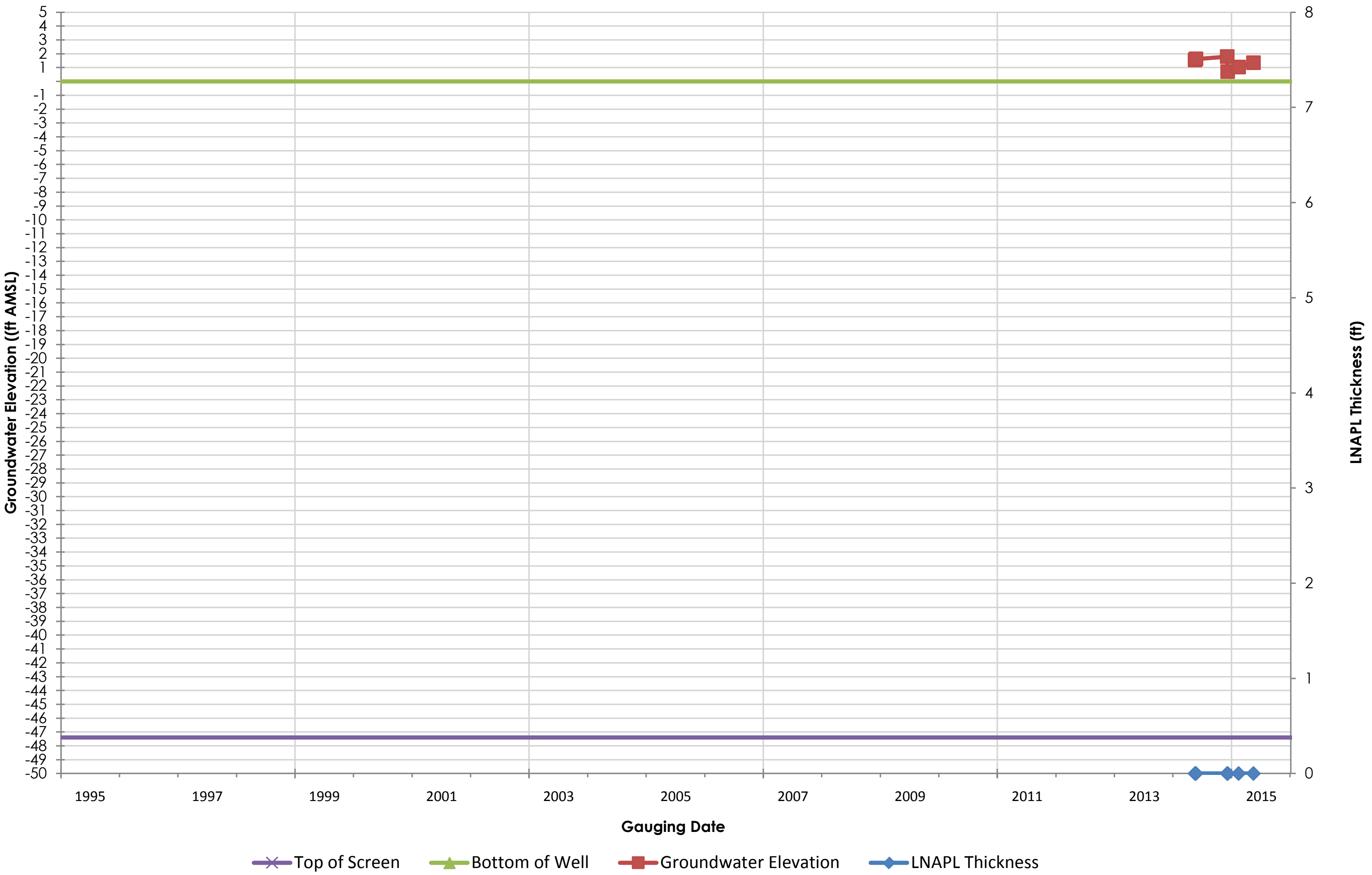
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-388D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

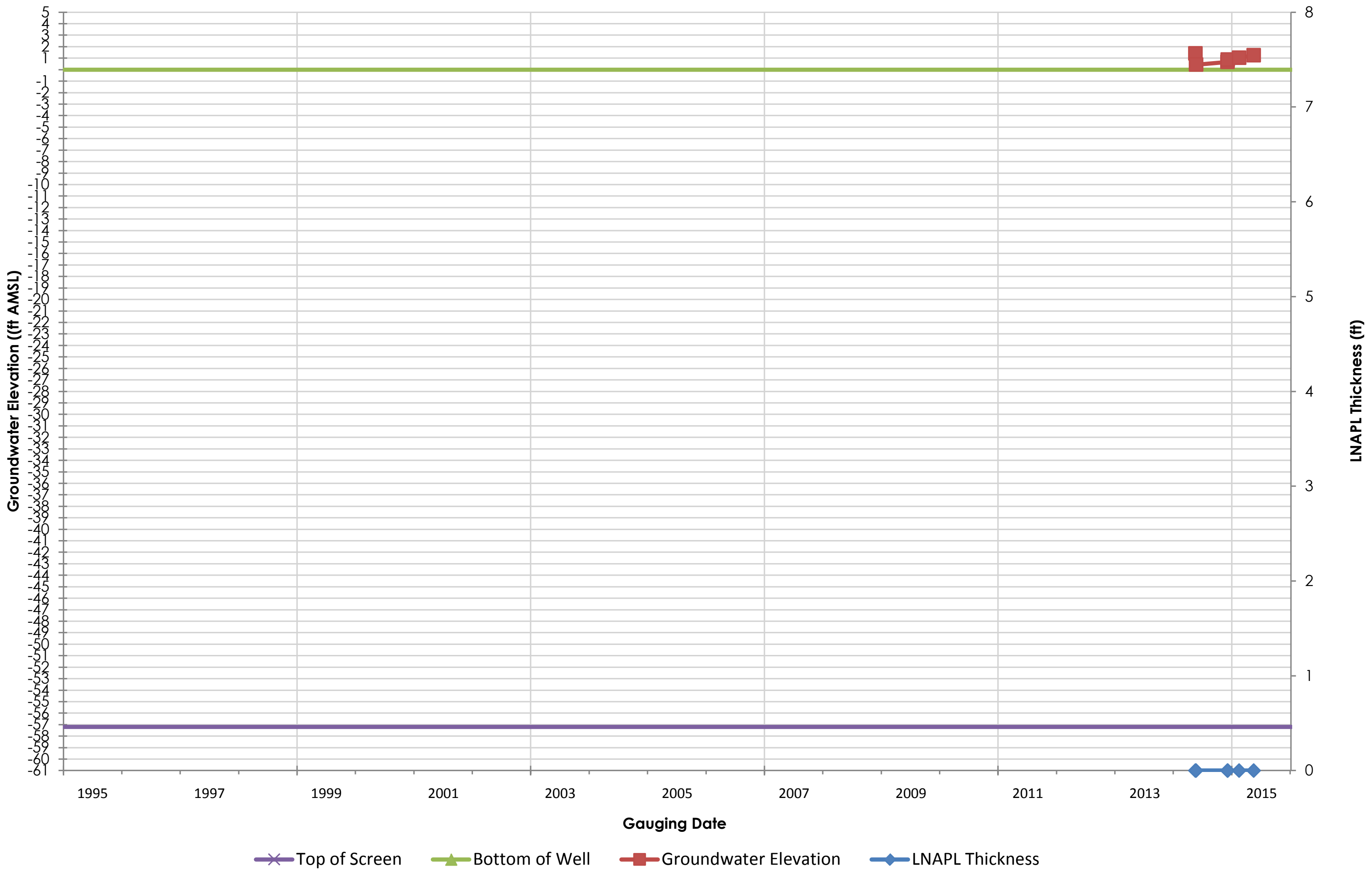
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-389D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

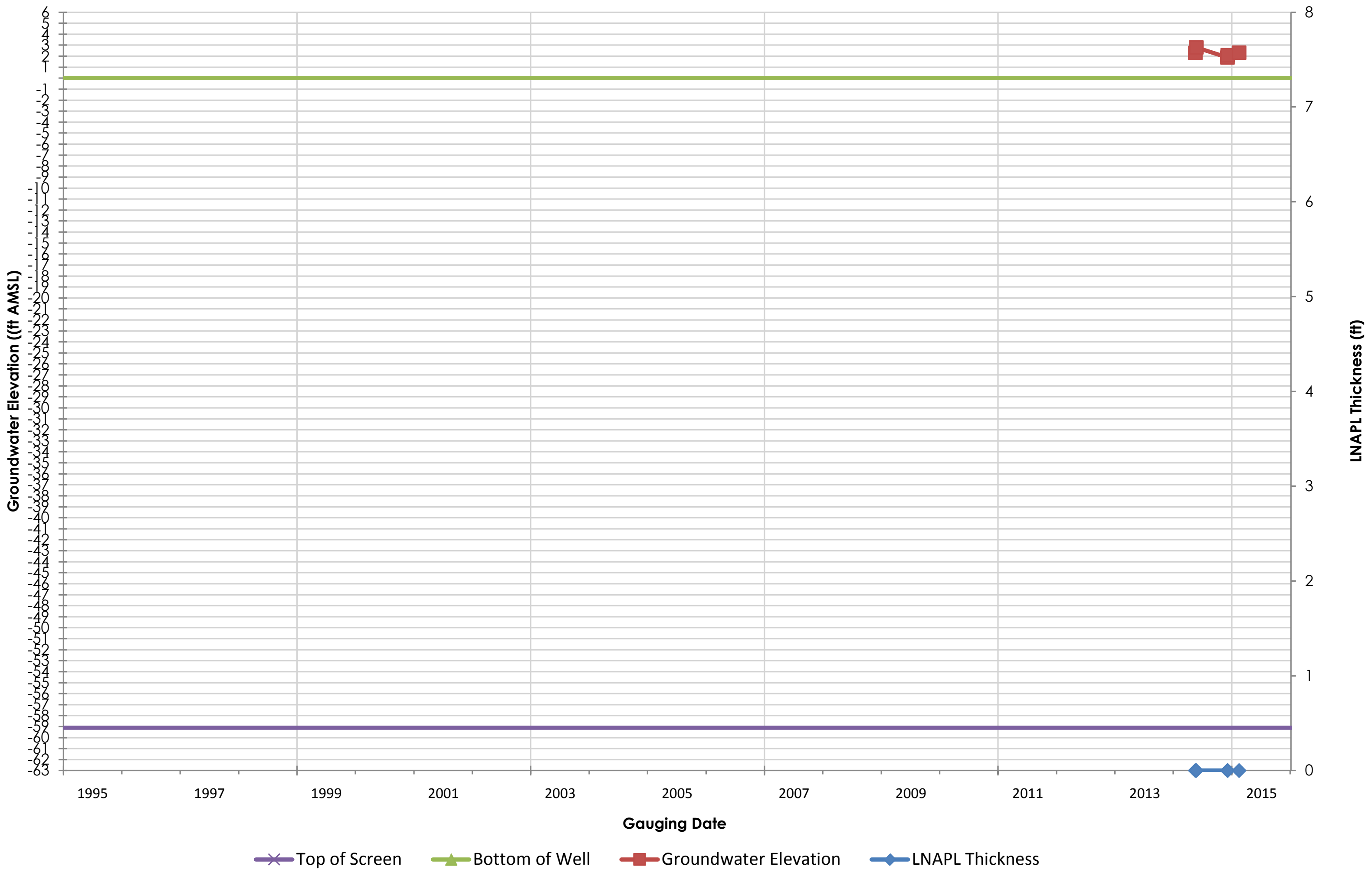
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-390D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

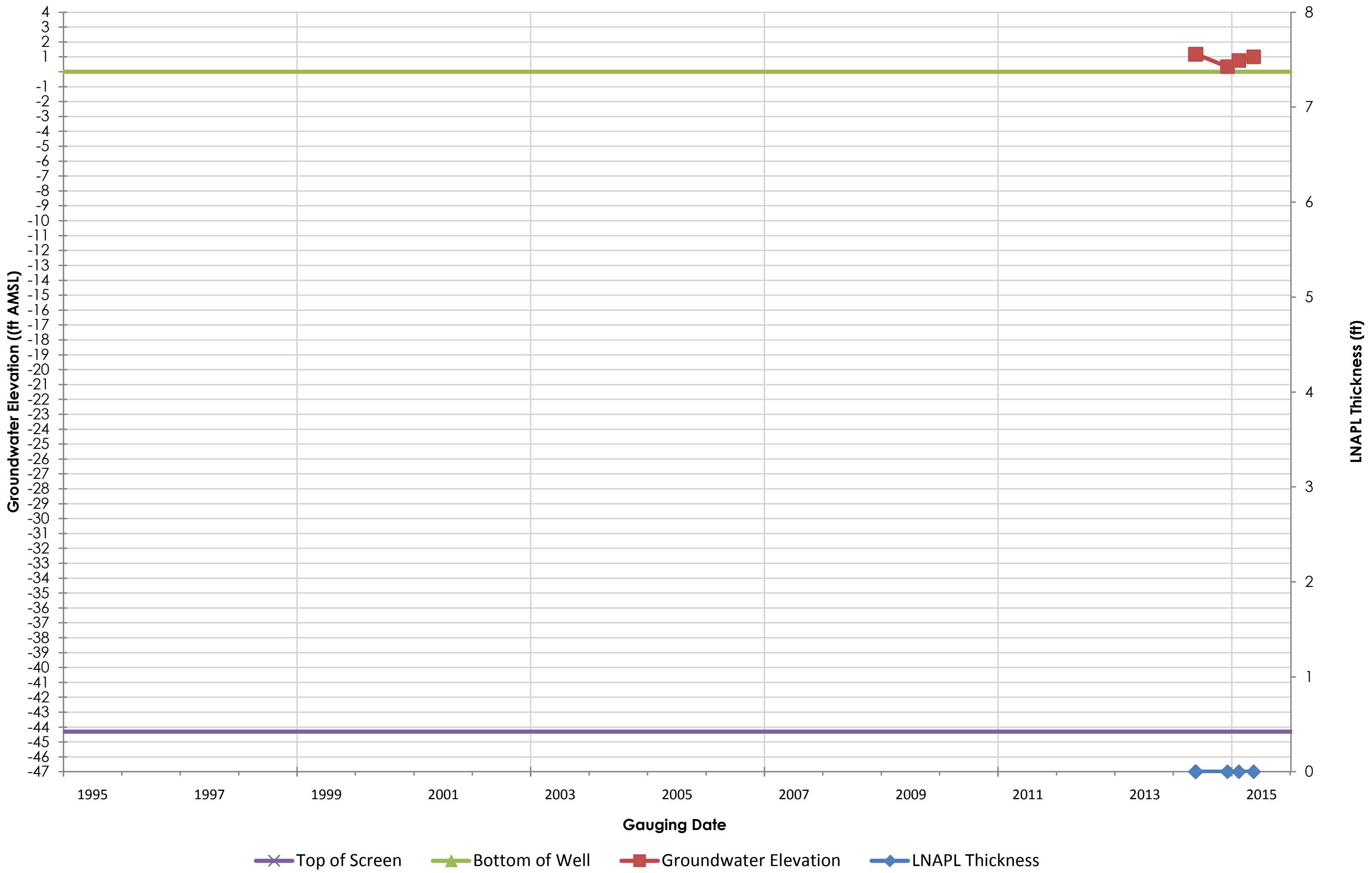
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-391D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

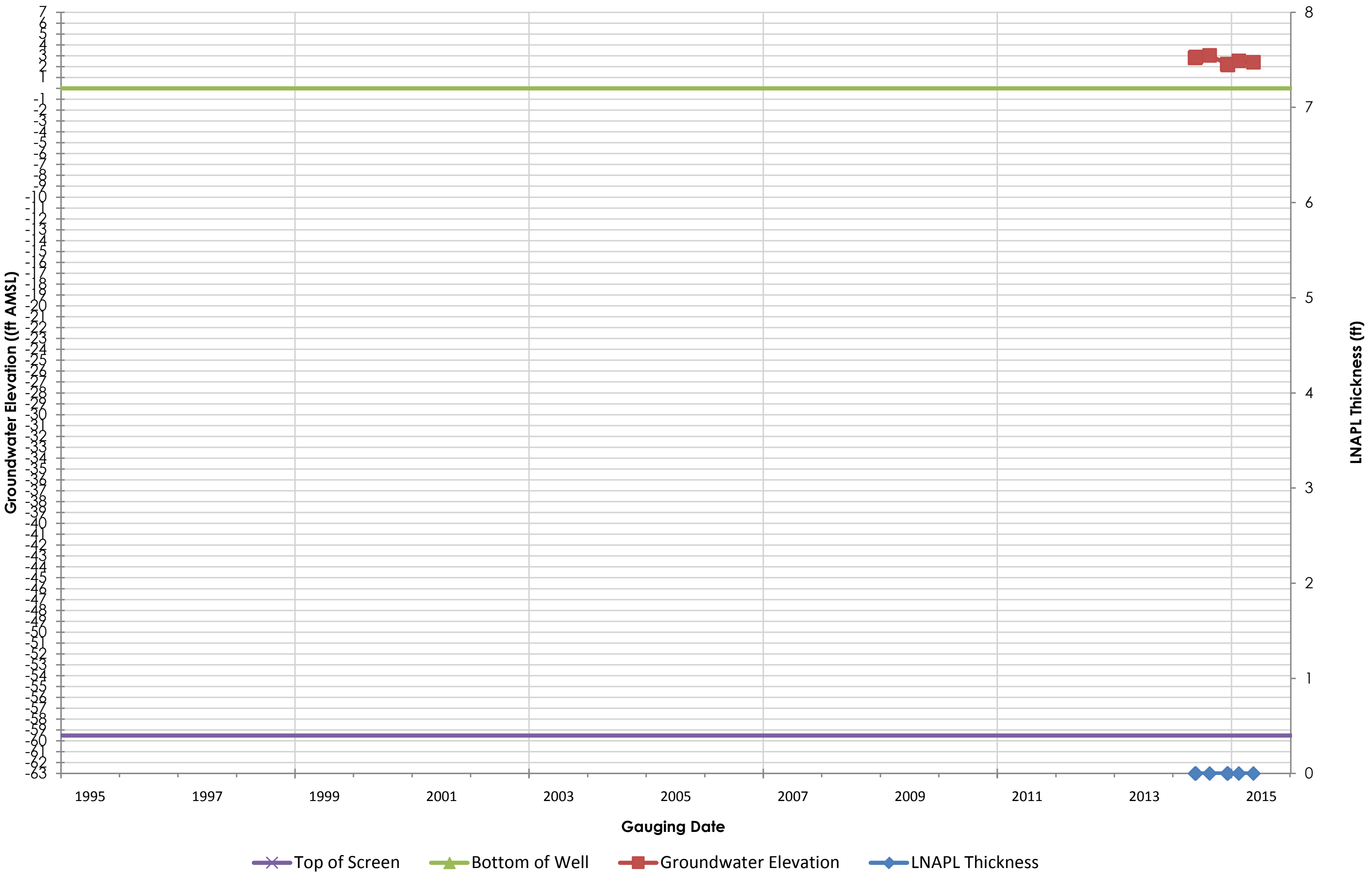
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-392D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

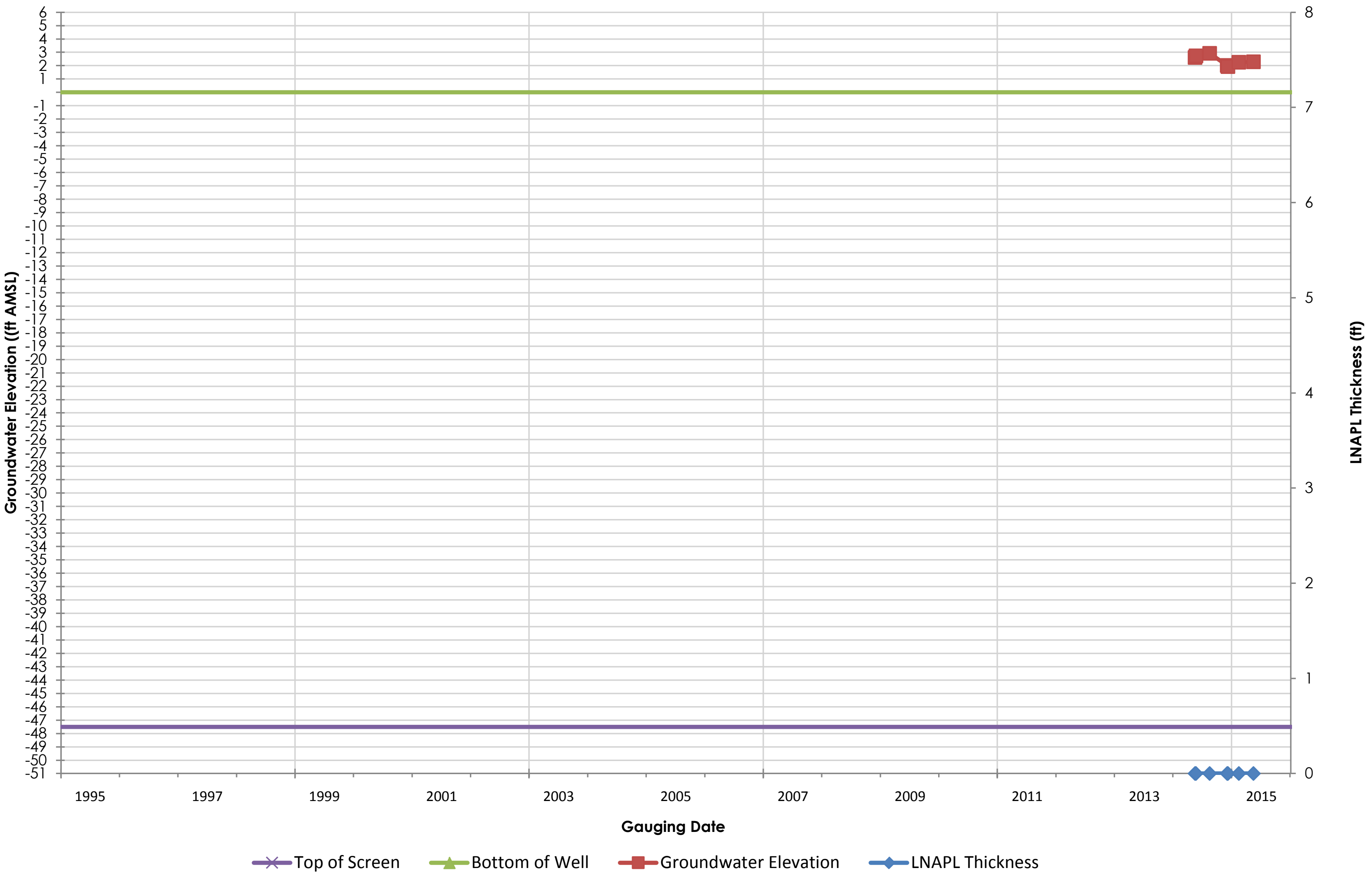
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-393D

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

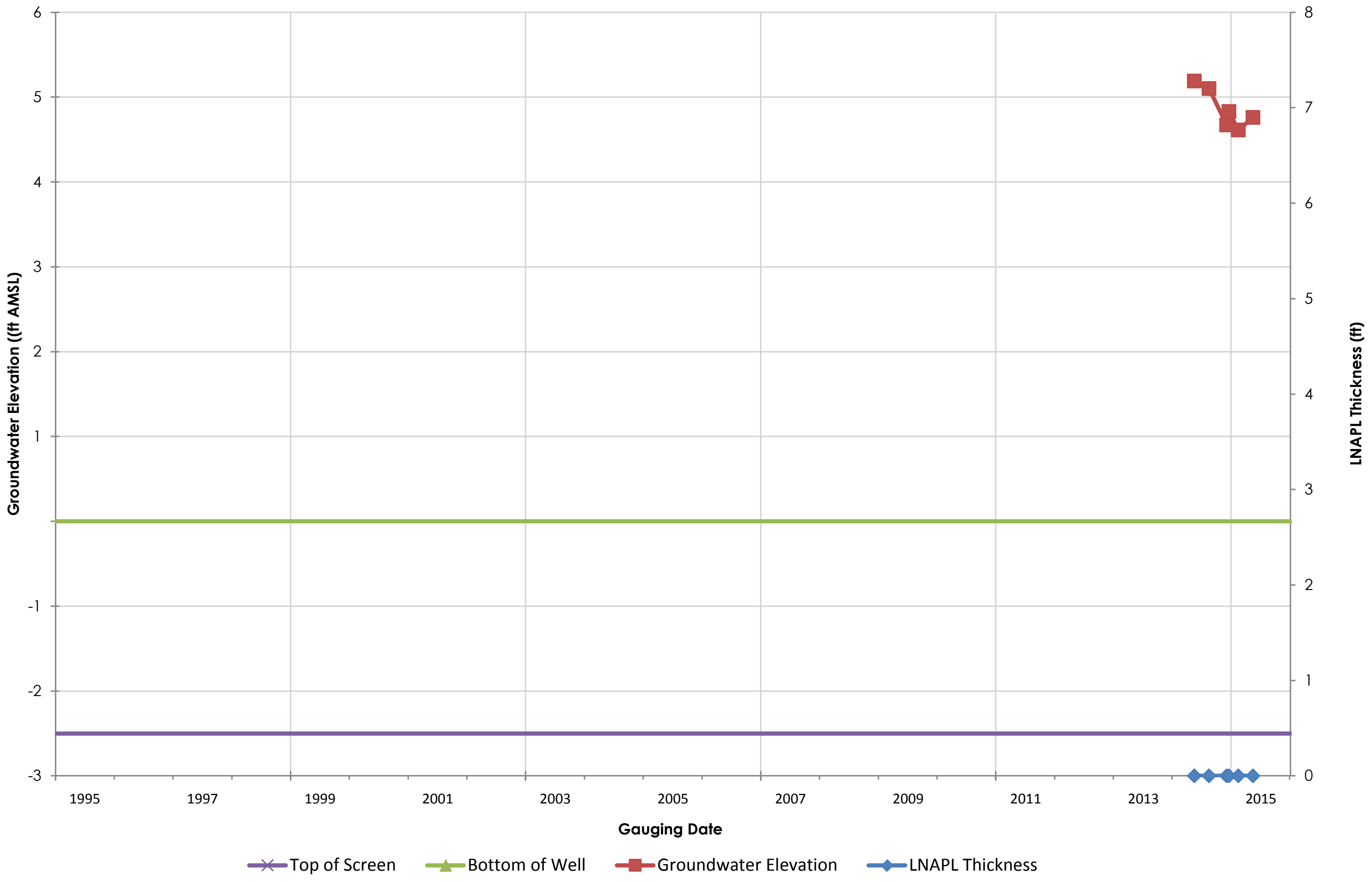
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-394

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

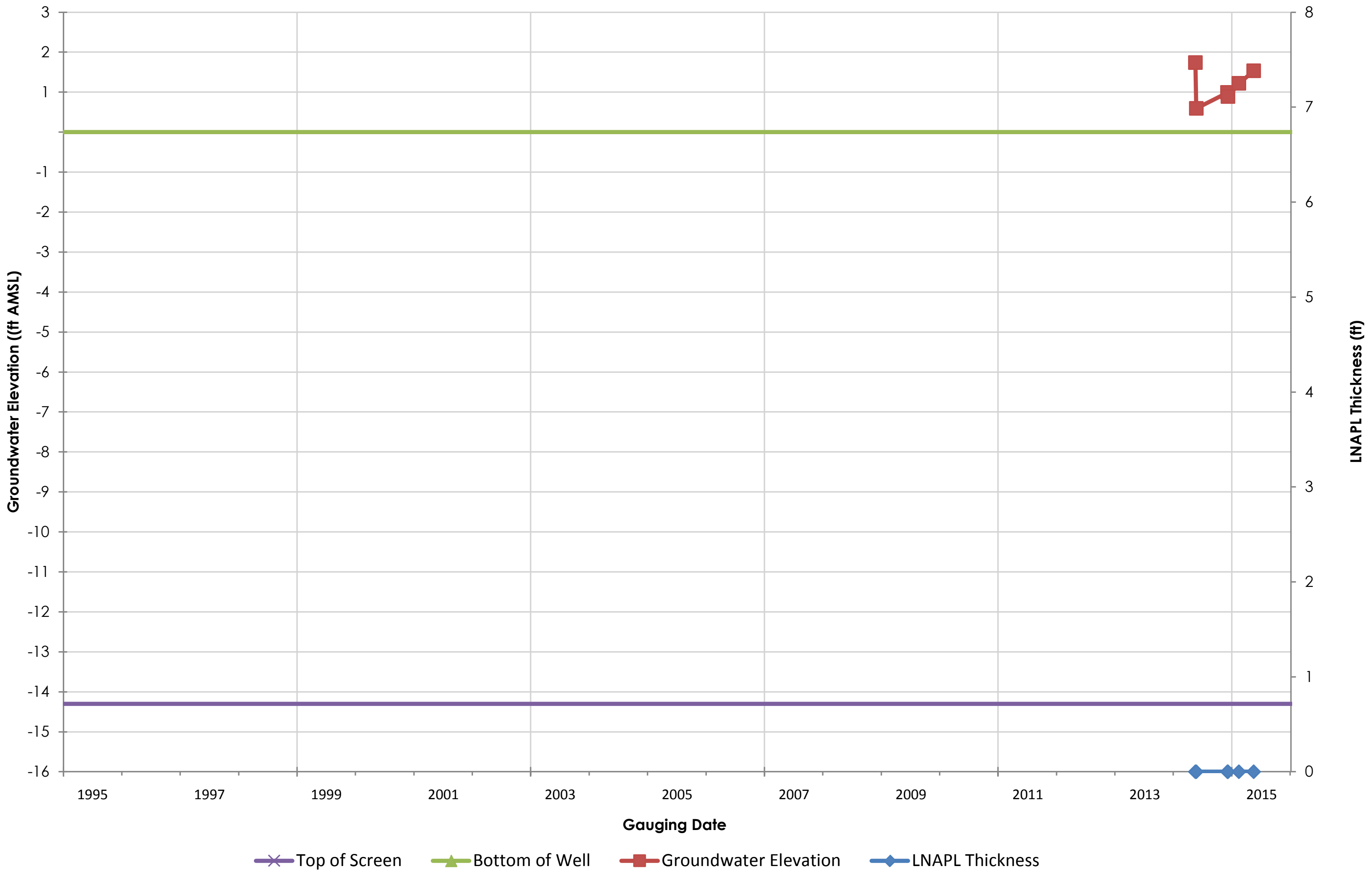
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-395

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

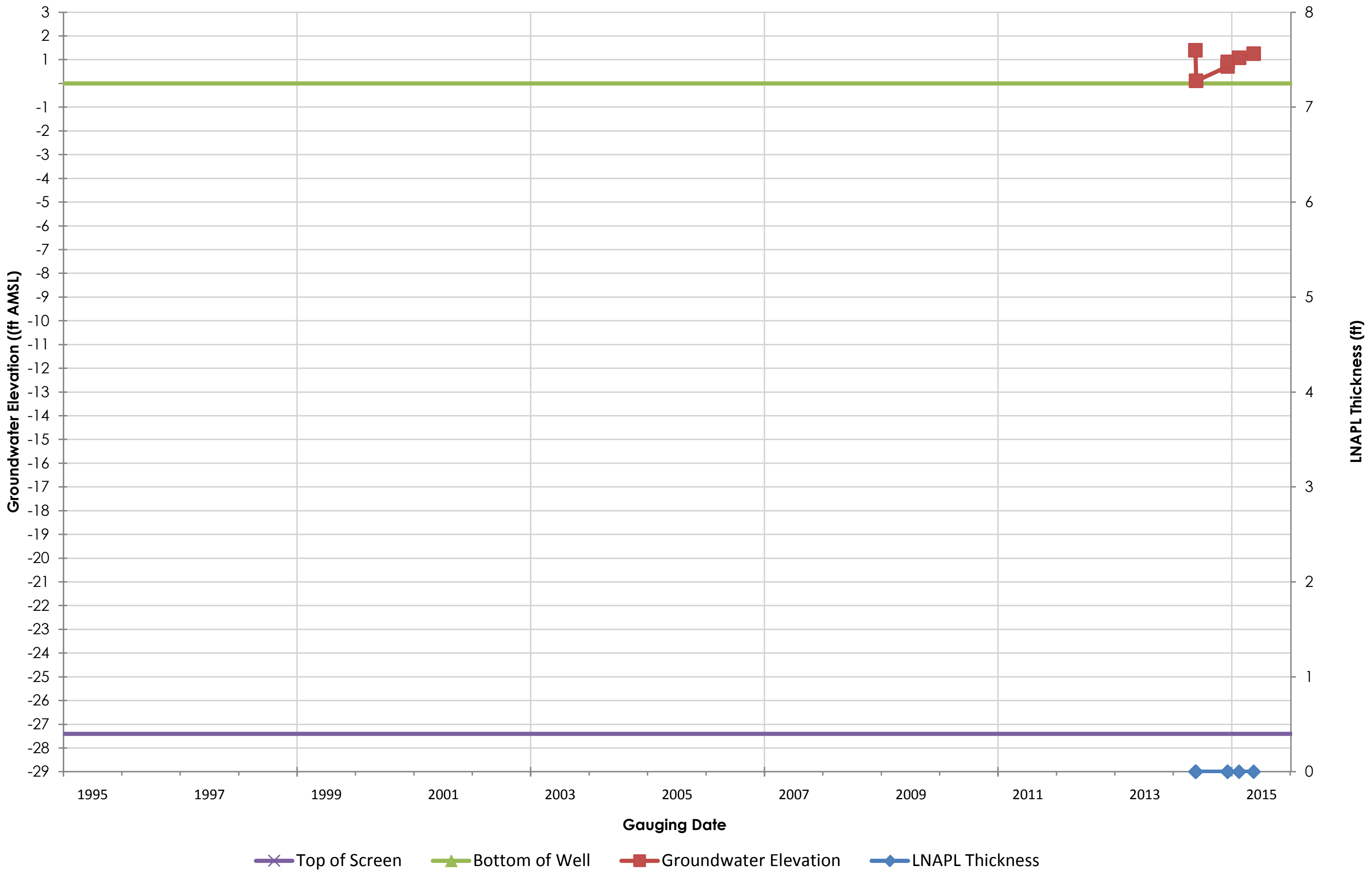
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-396

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

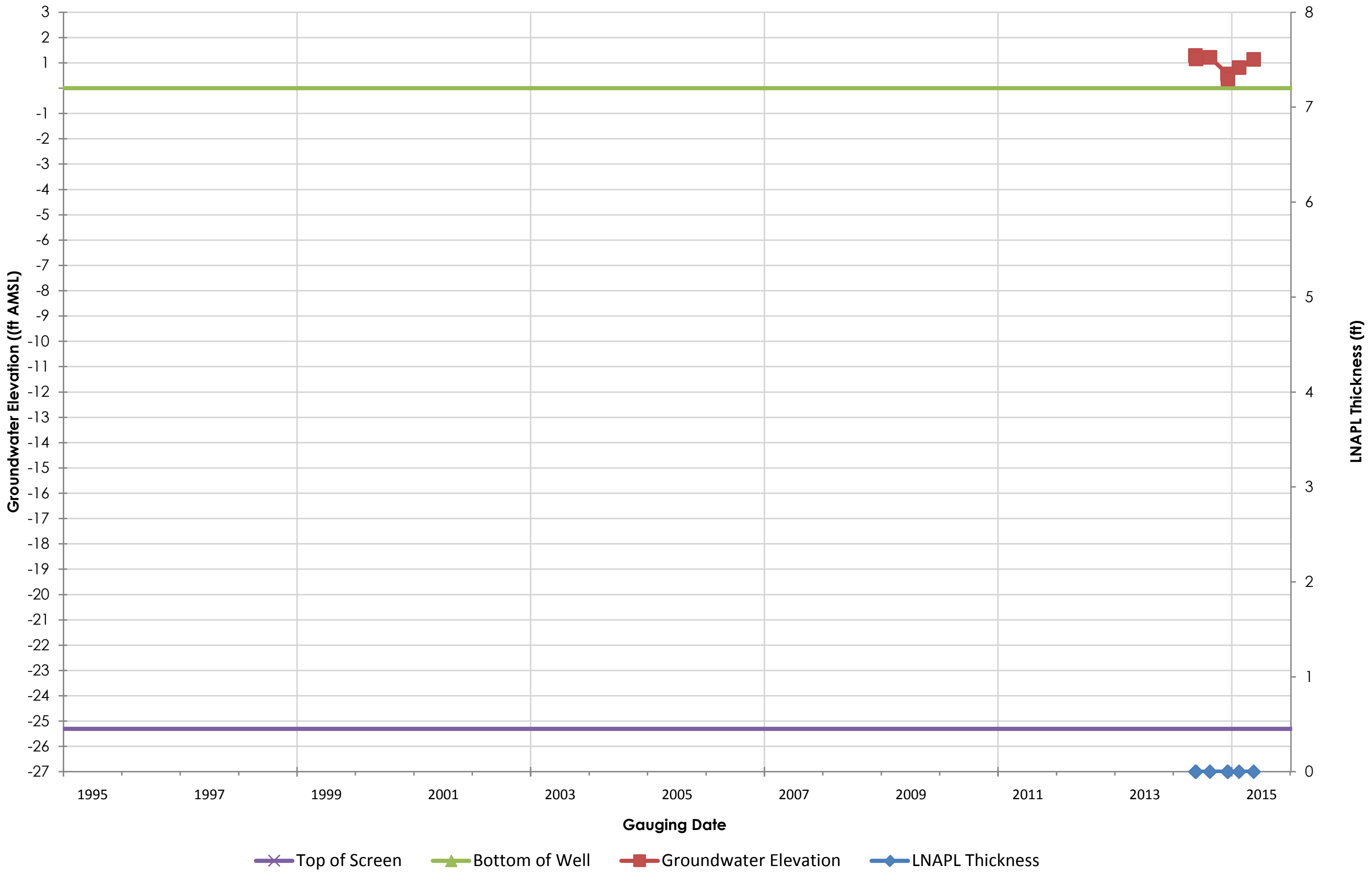
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-397

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

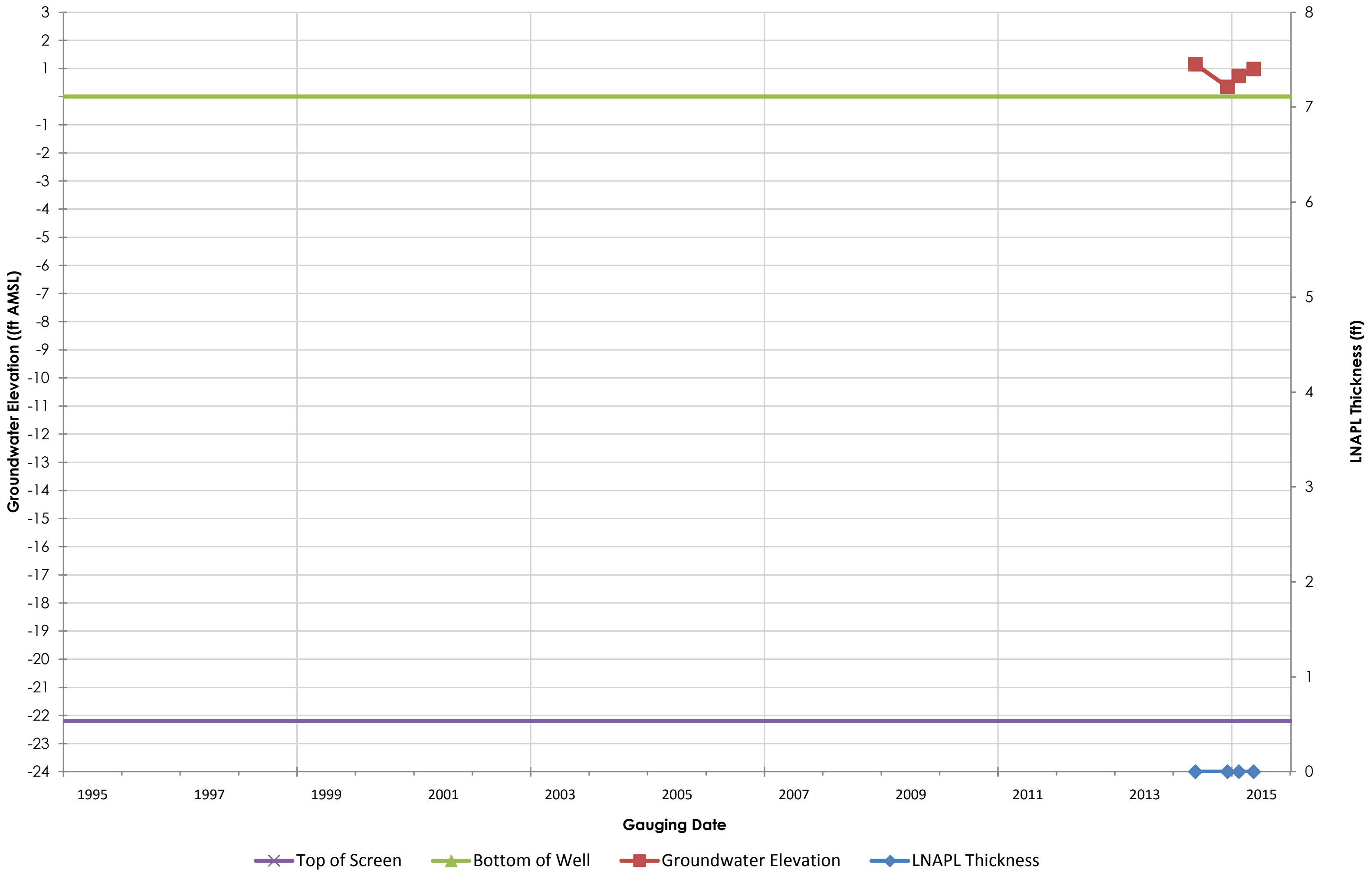
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-398

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

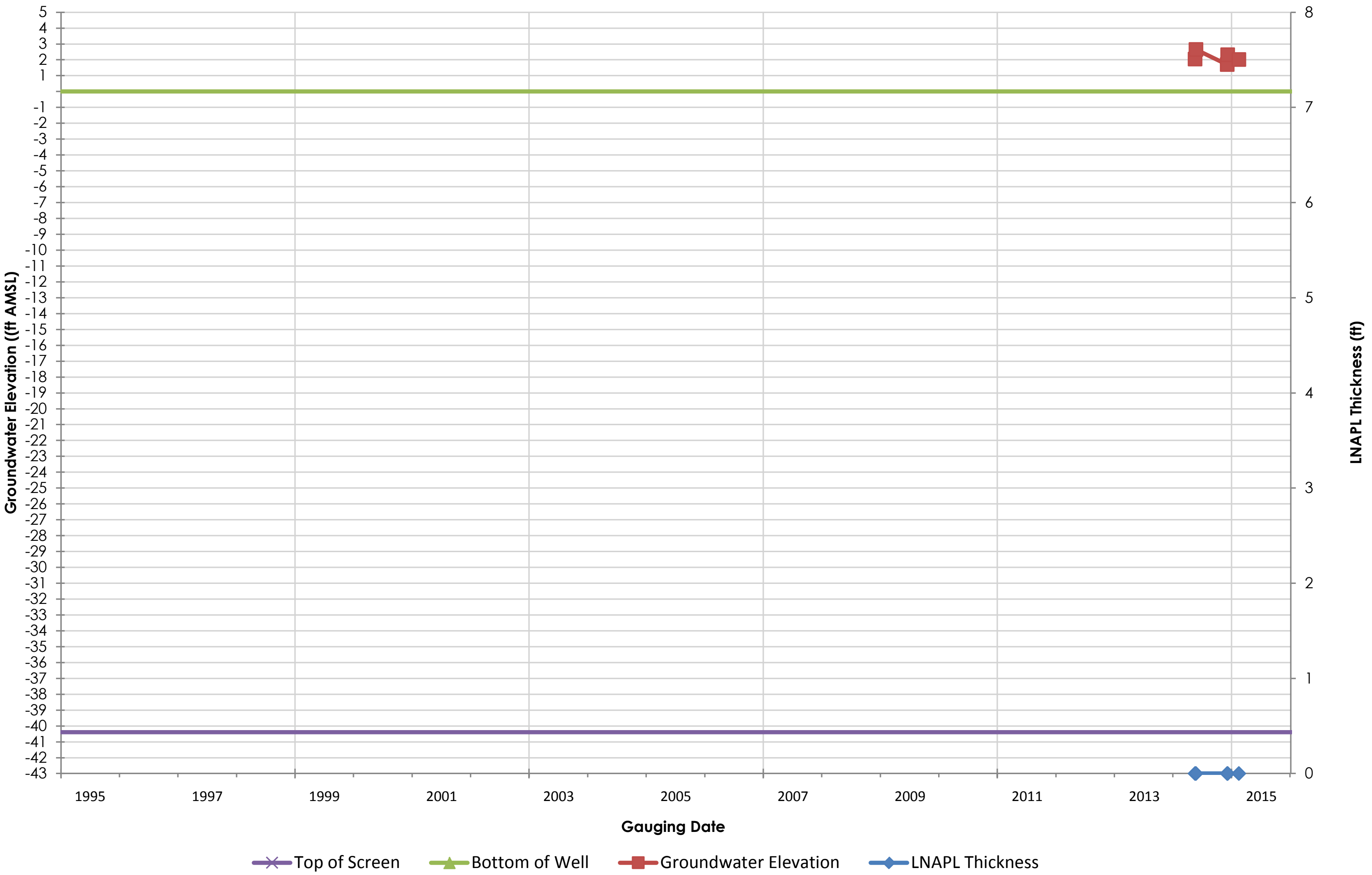
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-399

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

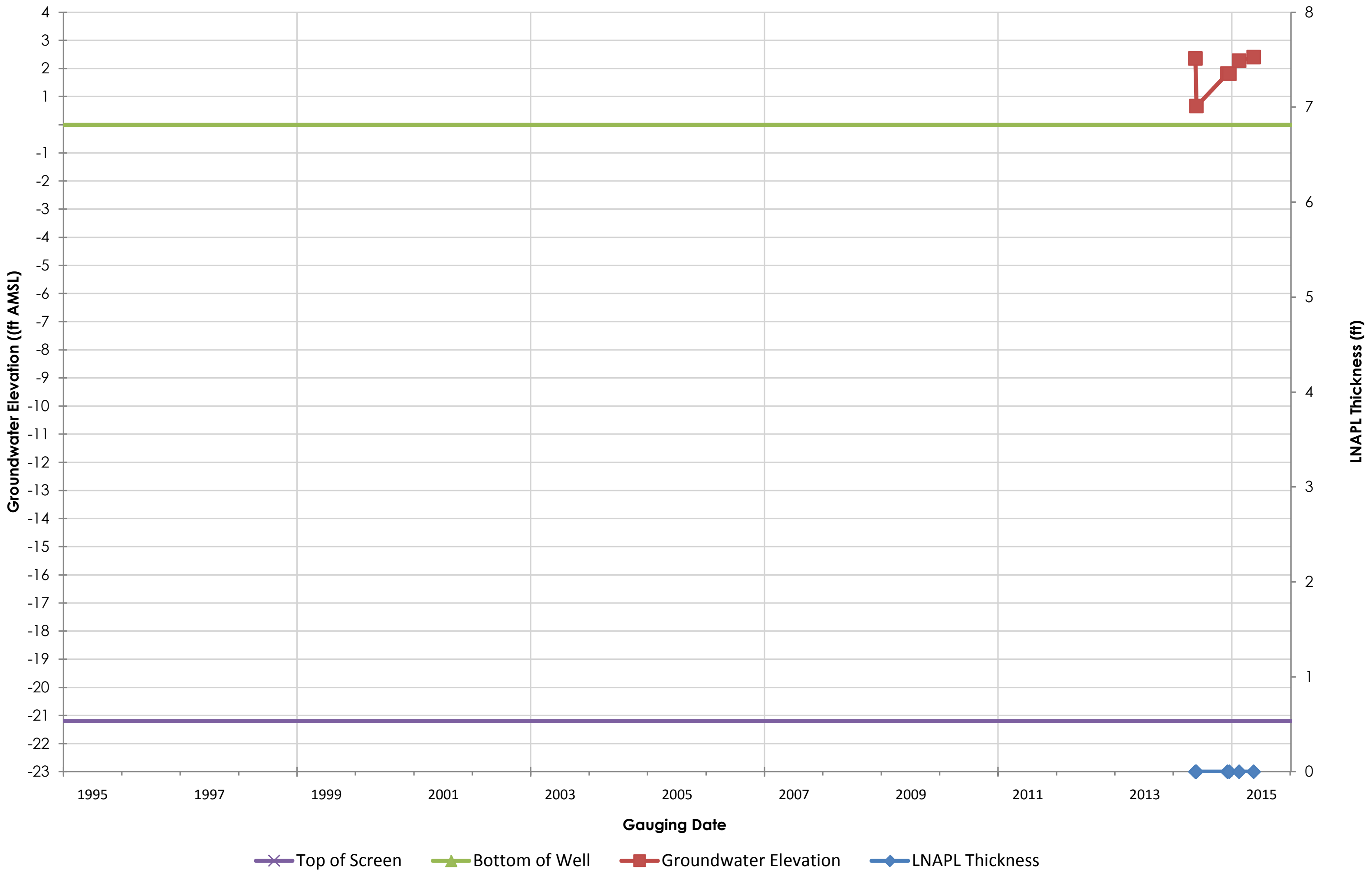
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-400

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

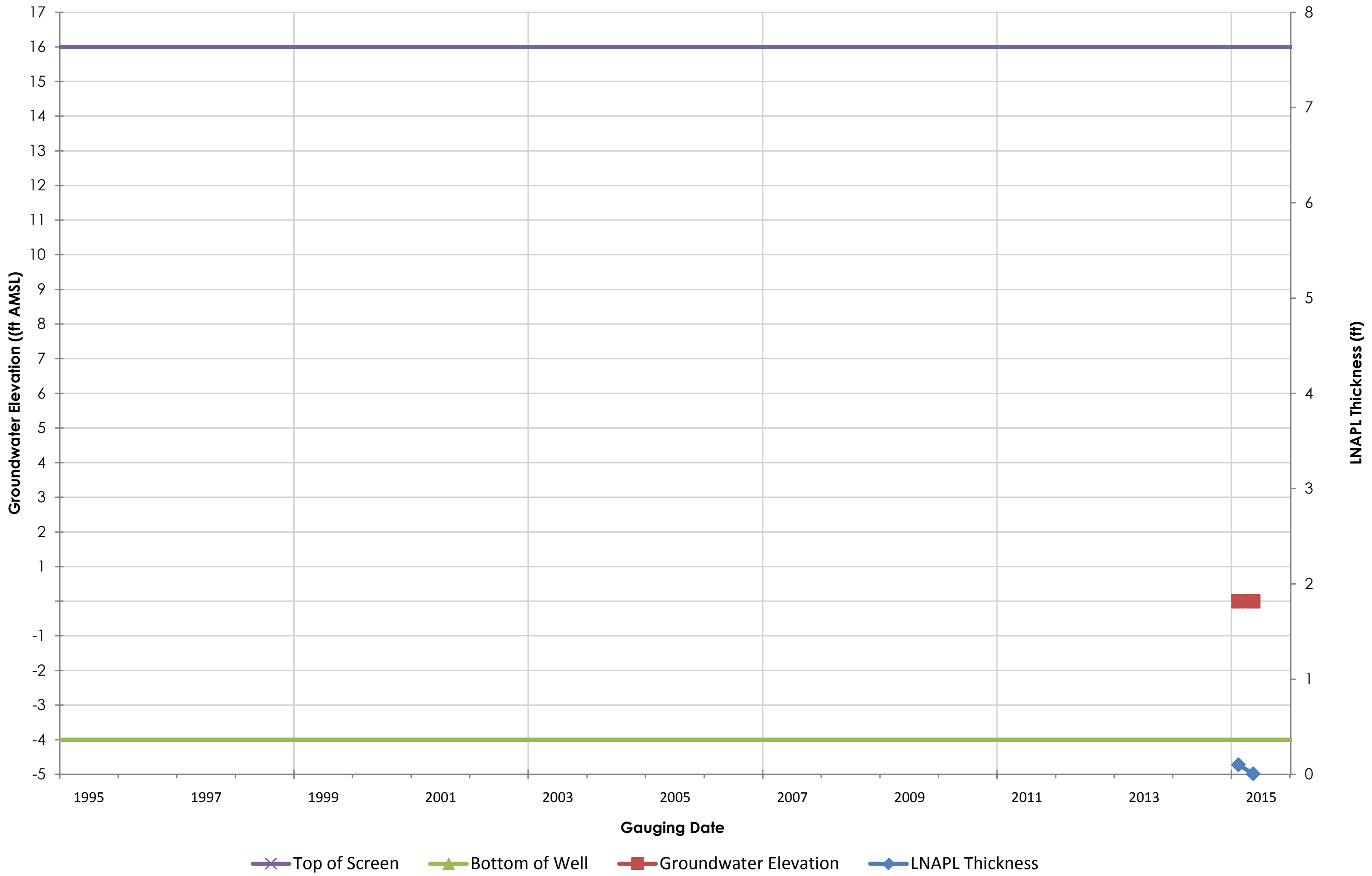
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-401

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

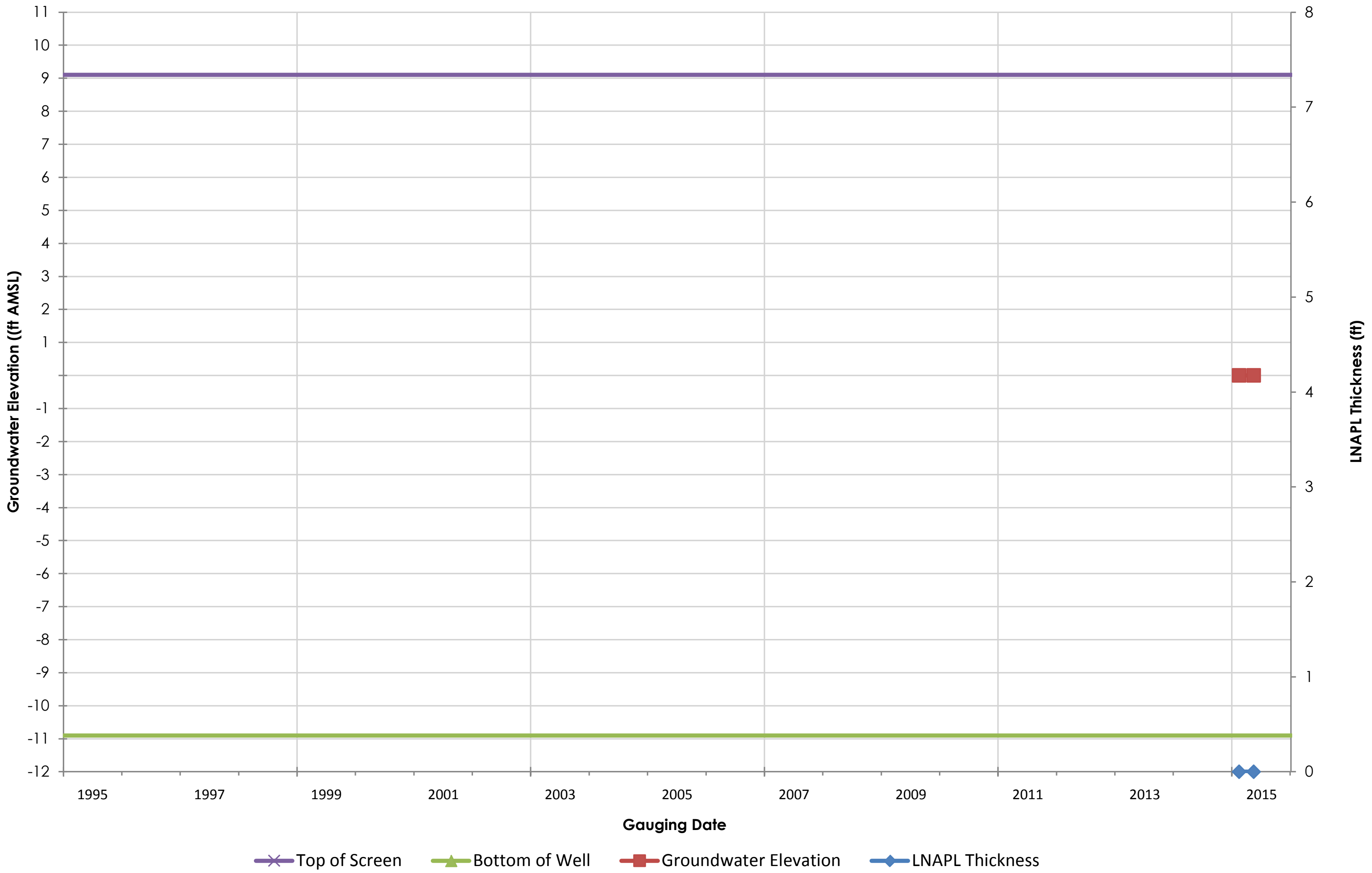
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-402

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

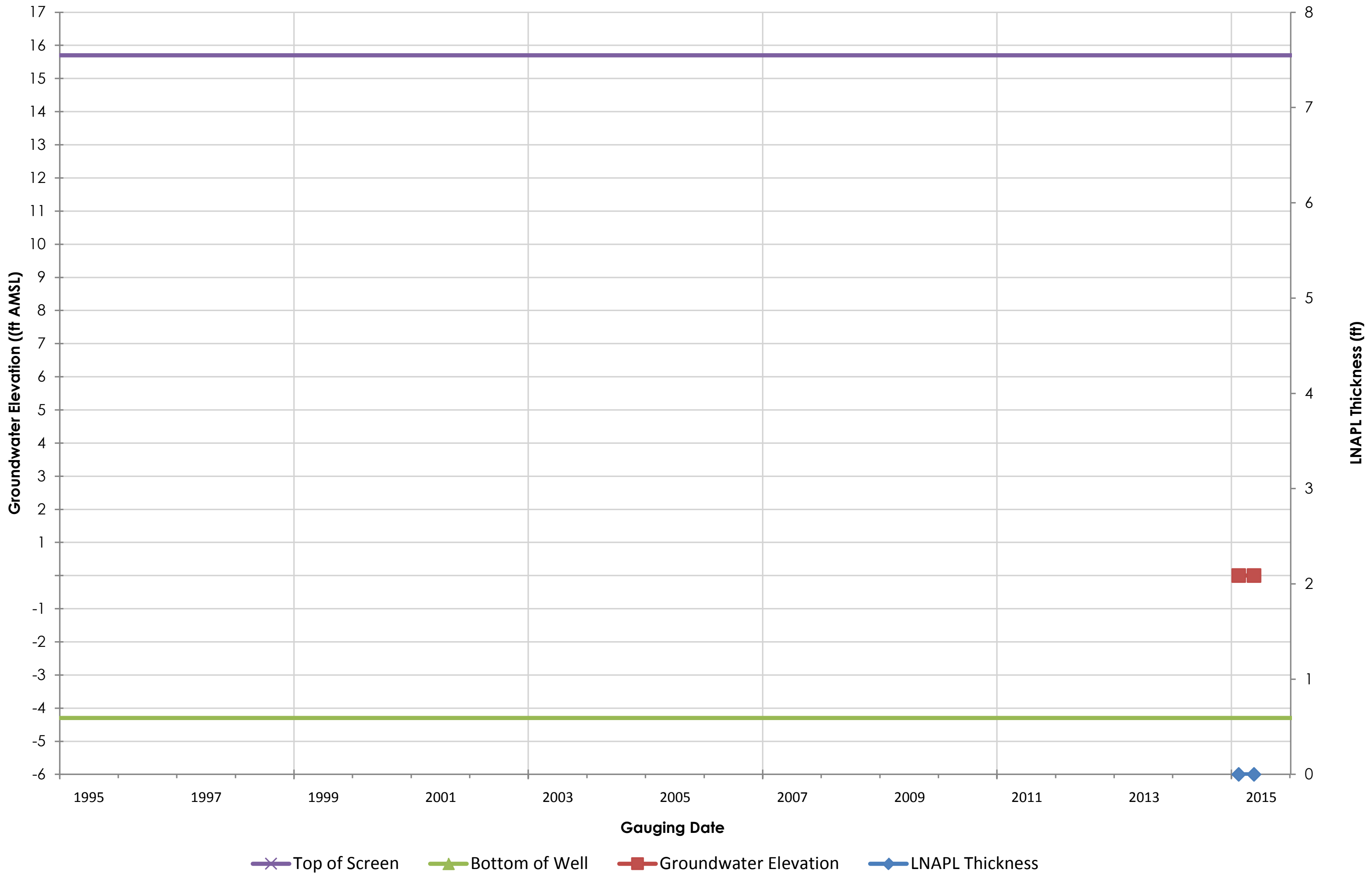
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-403

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

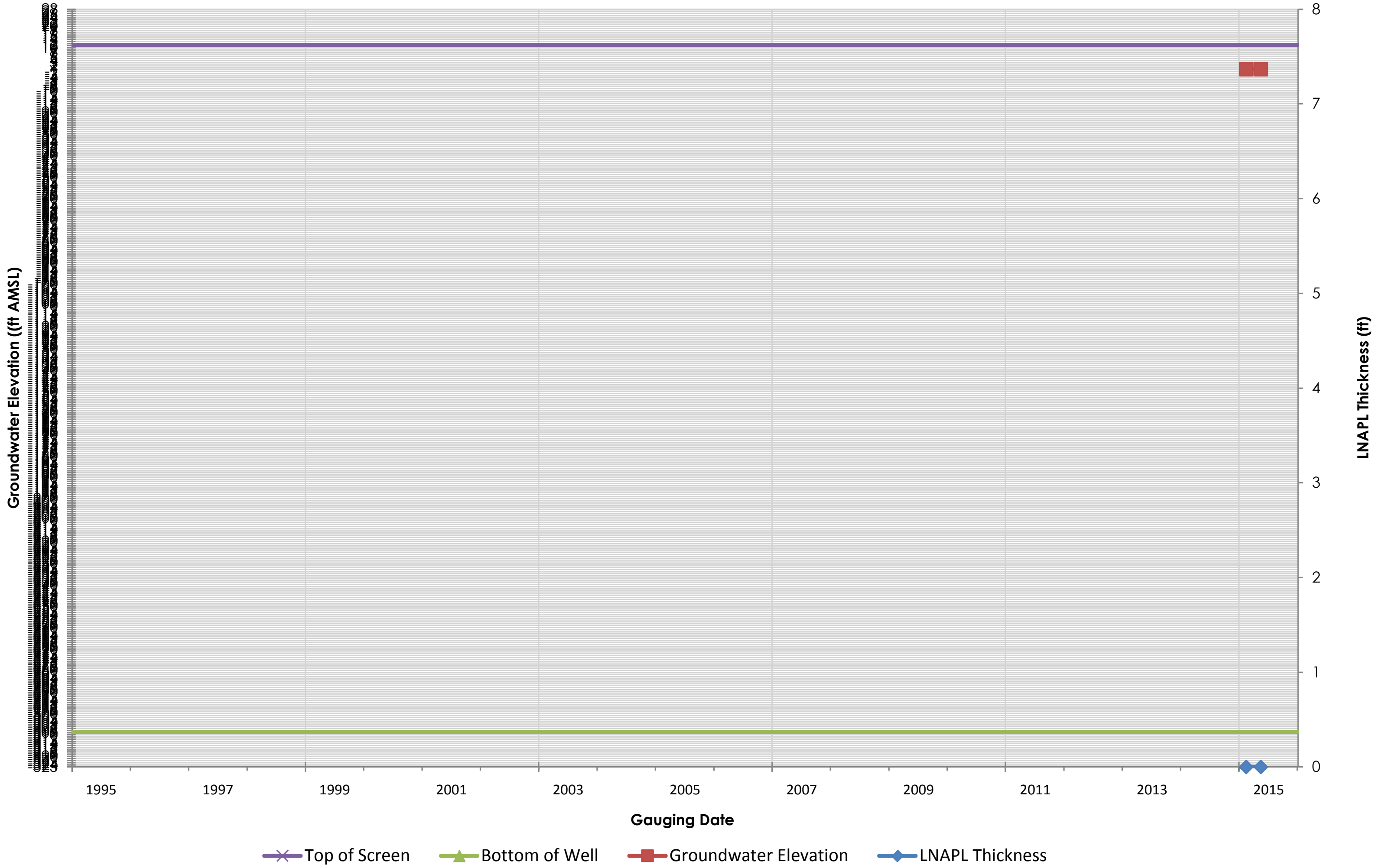
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-404

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

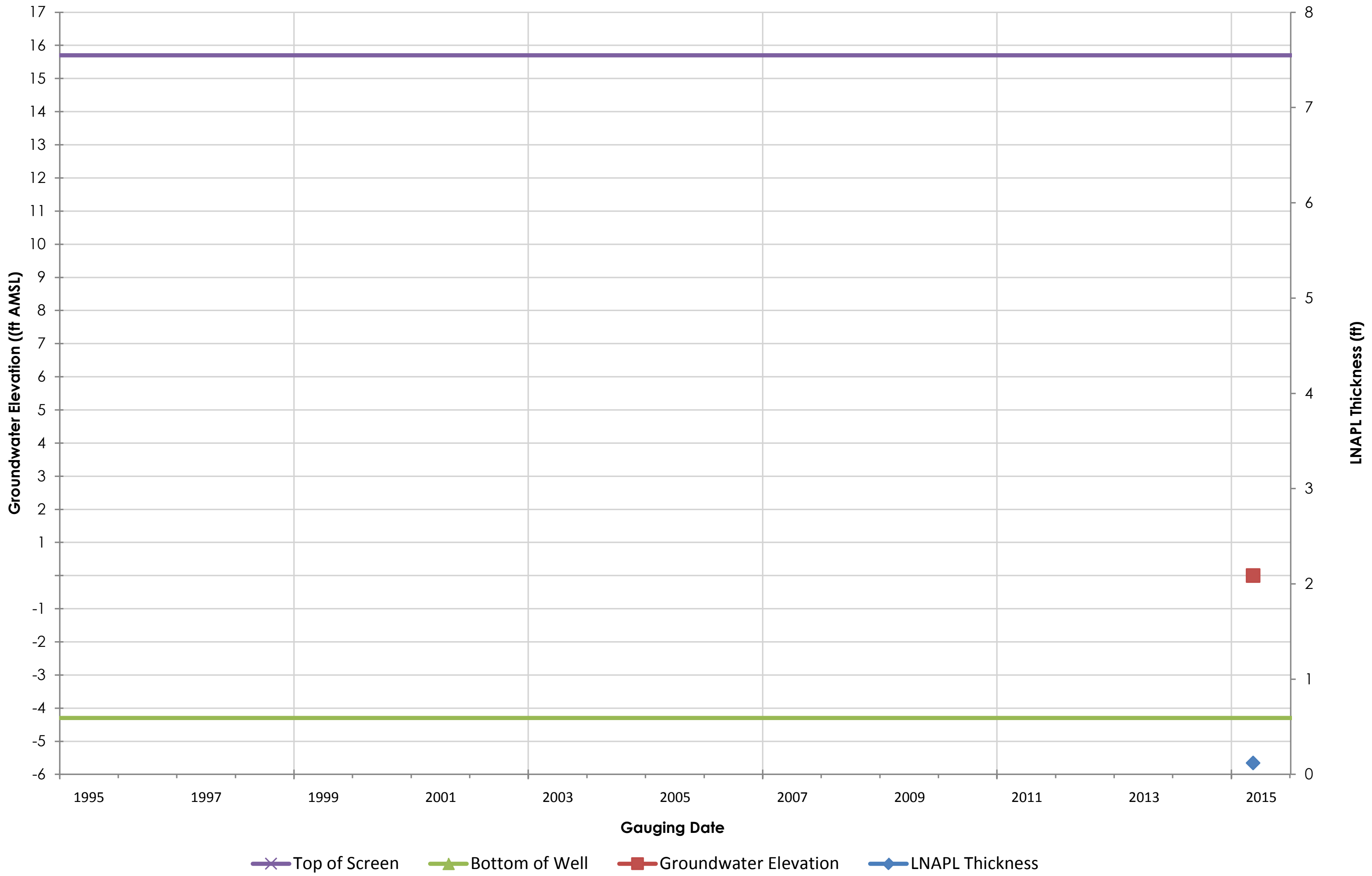
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-405

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

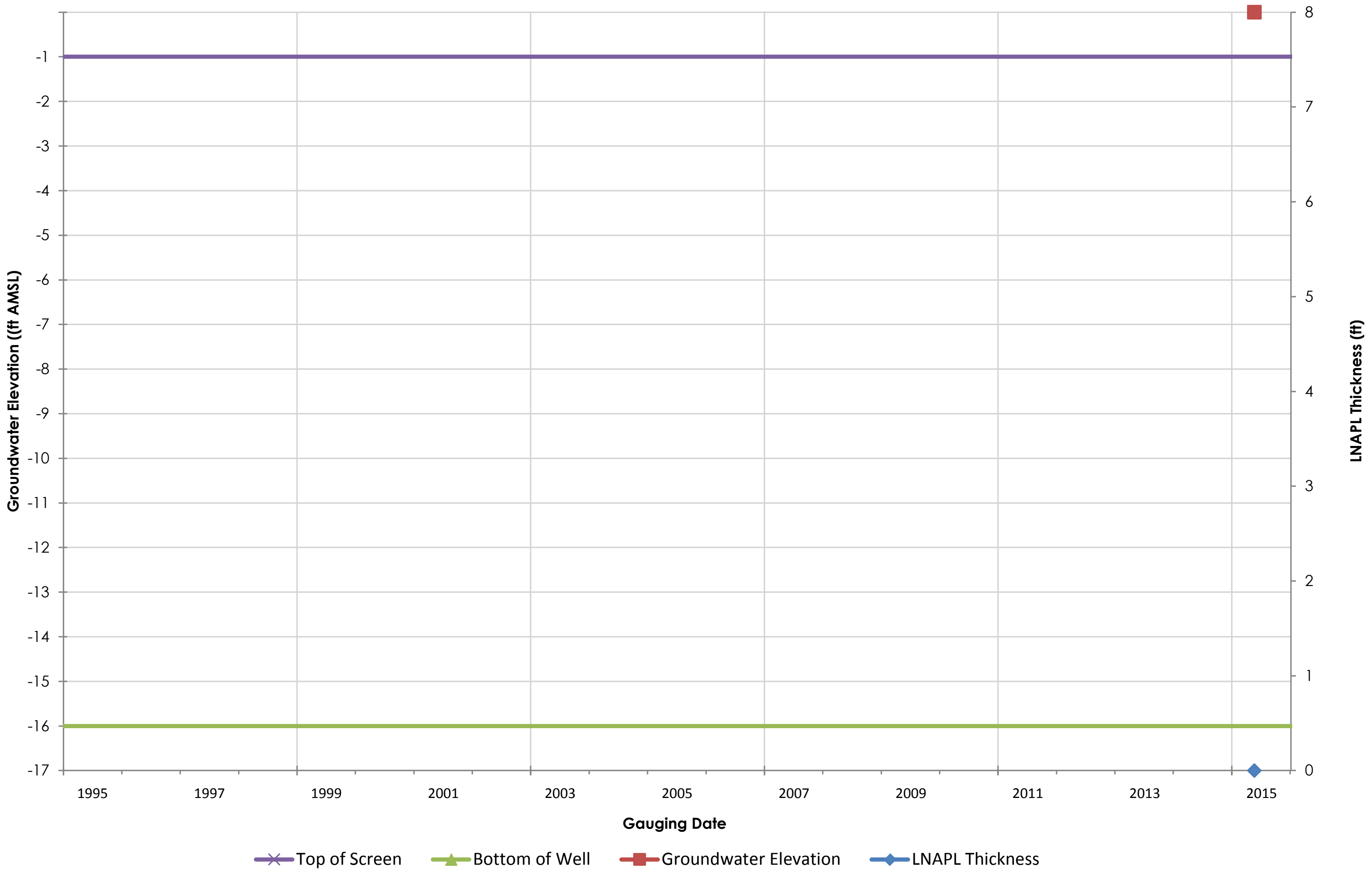
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-417

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

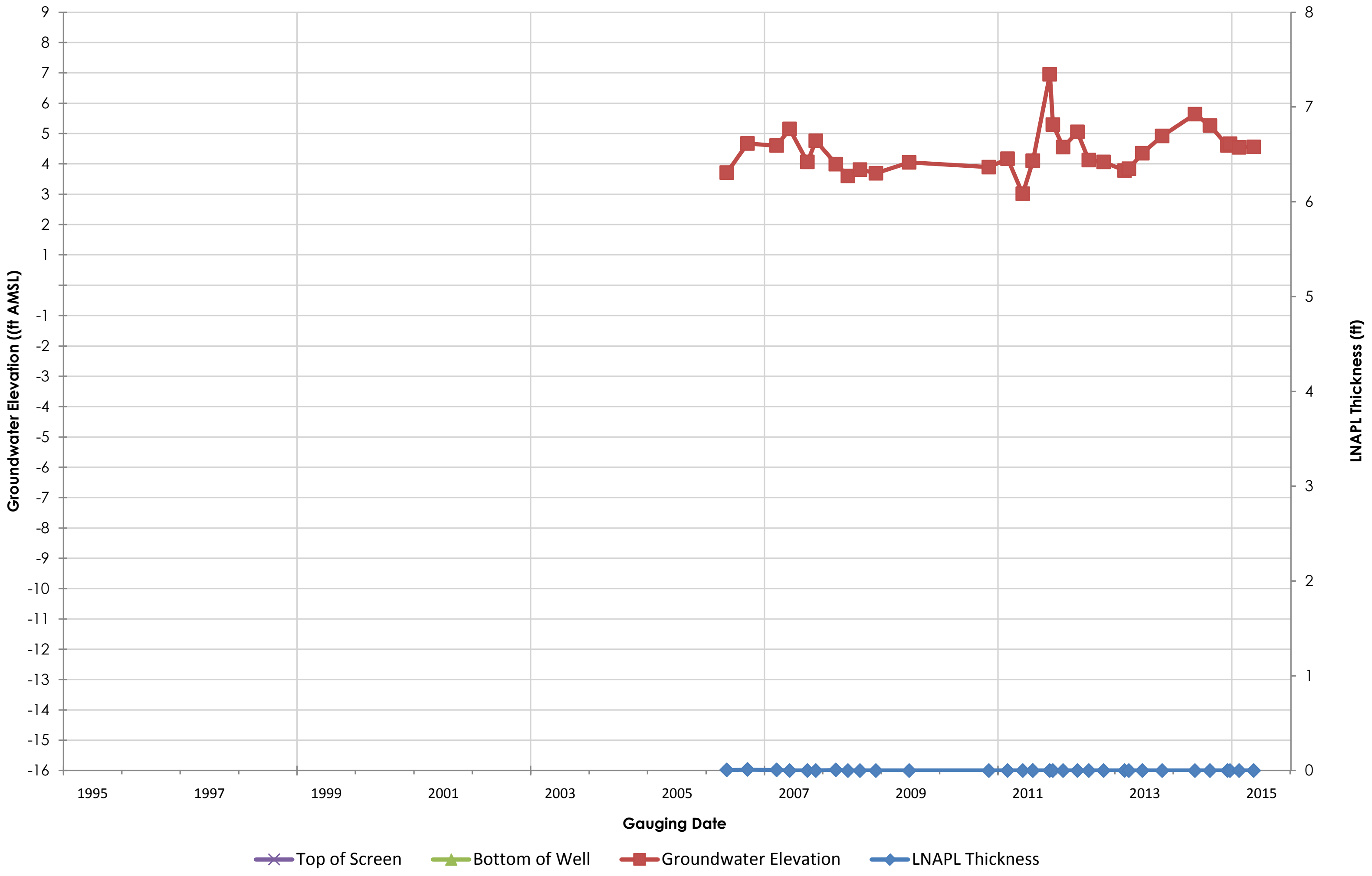
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

S-418

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

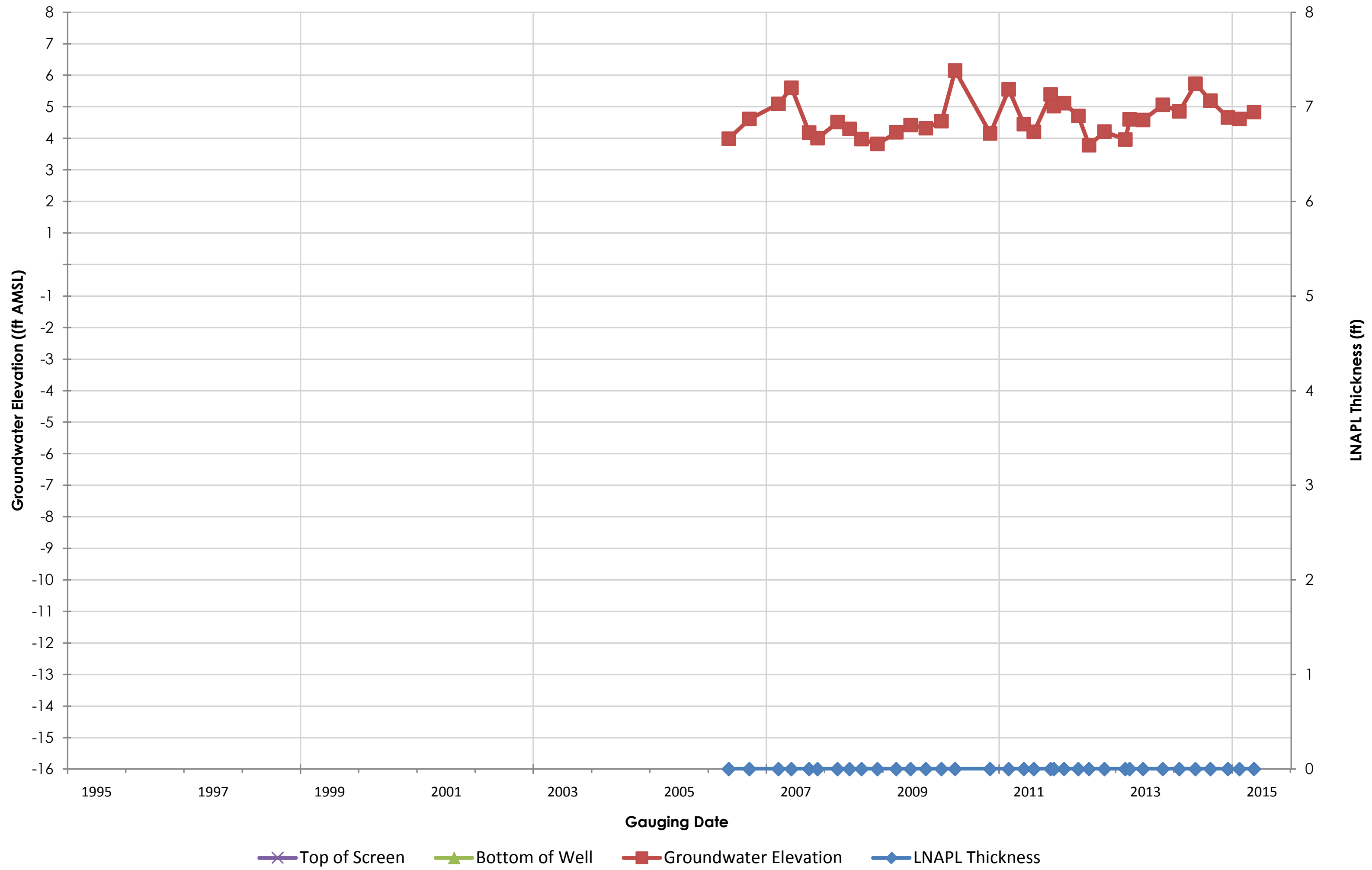
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

TW-3

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

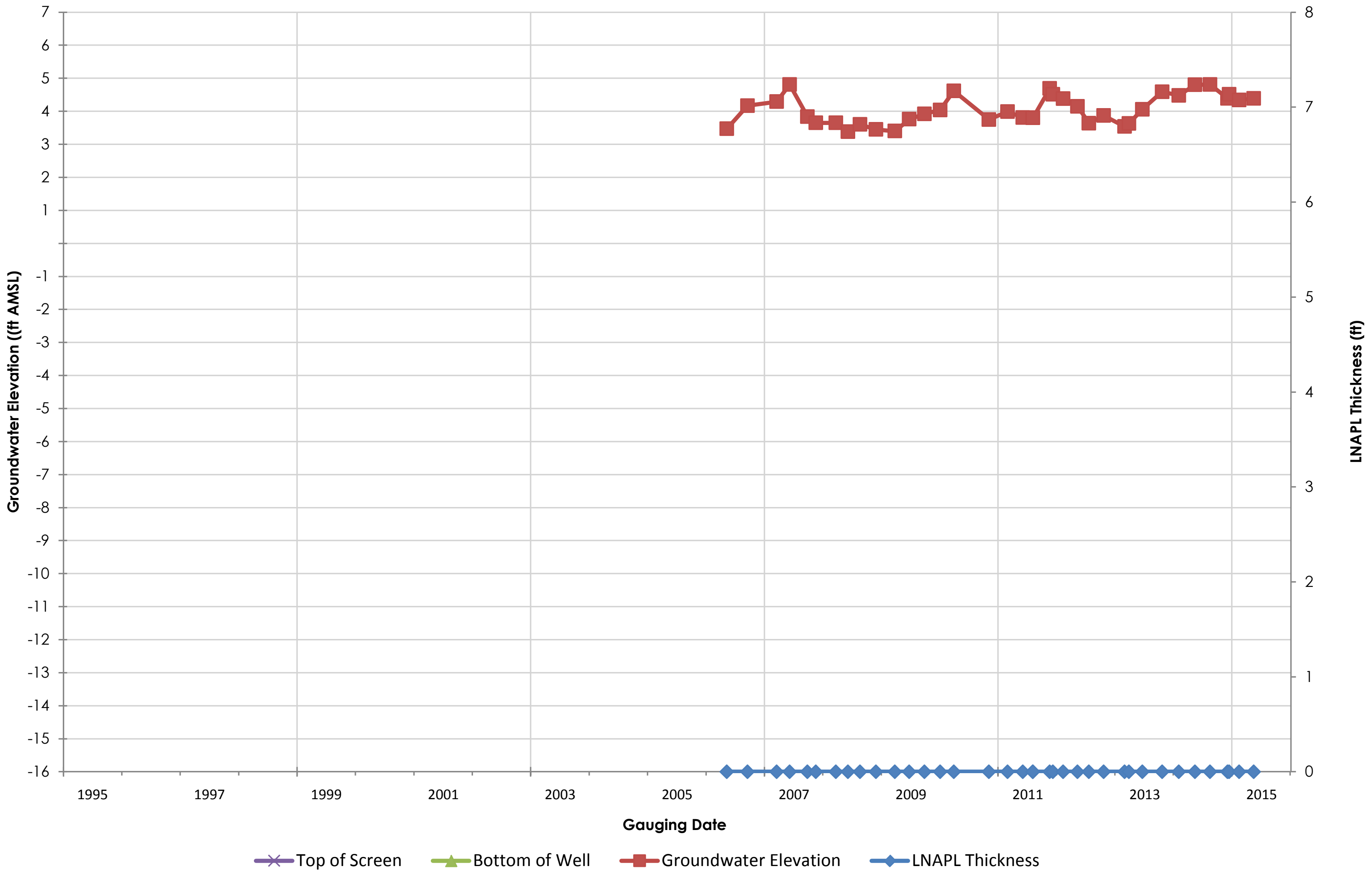
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

TW-5

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

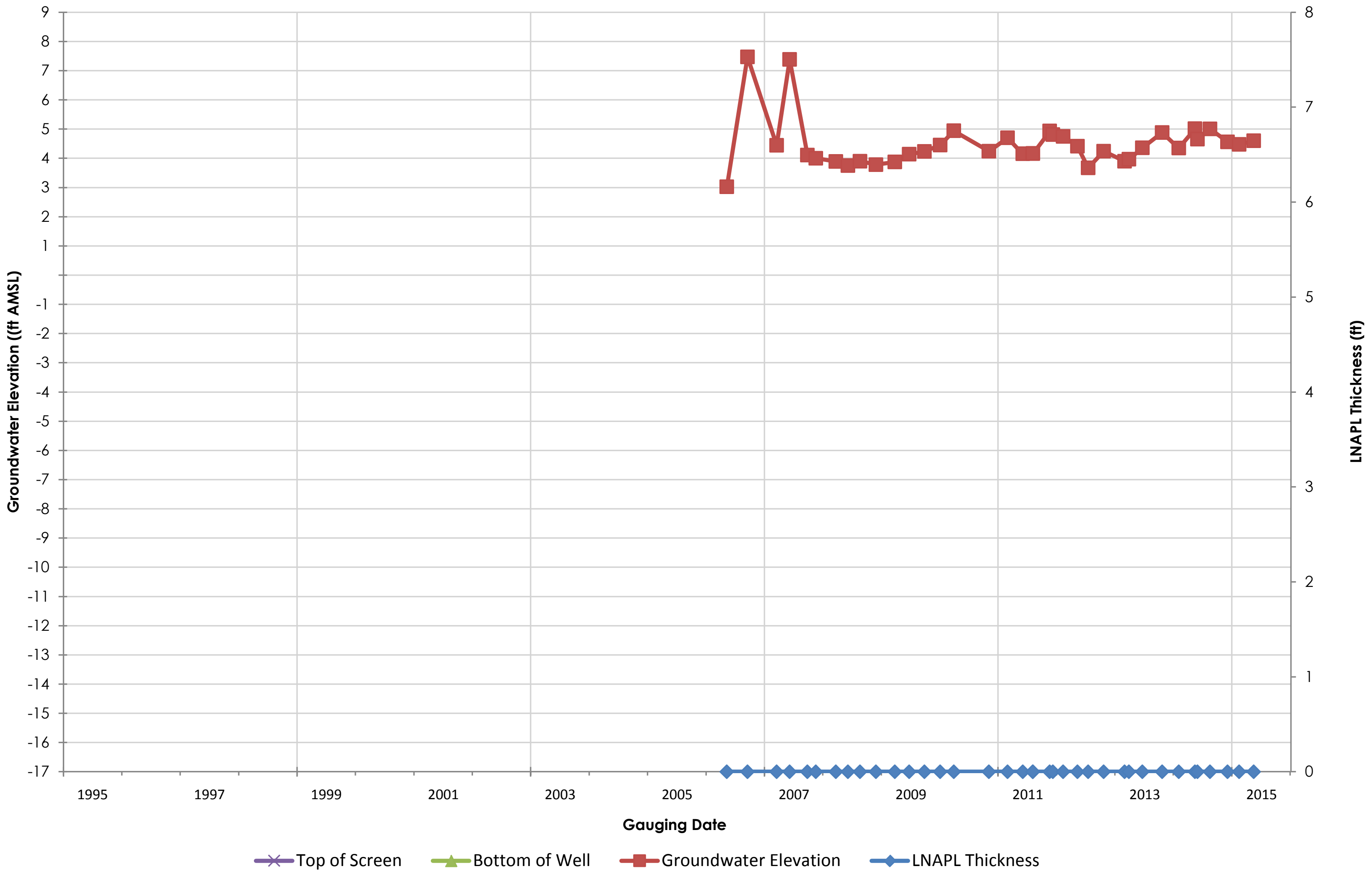
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

TW-8

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Client/Project

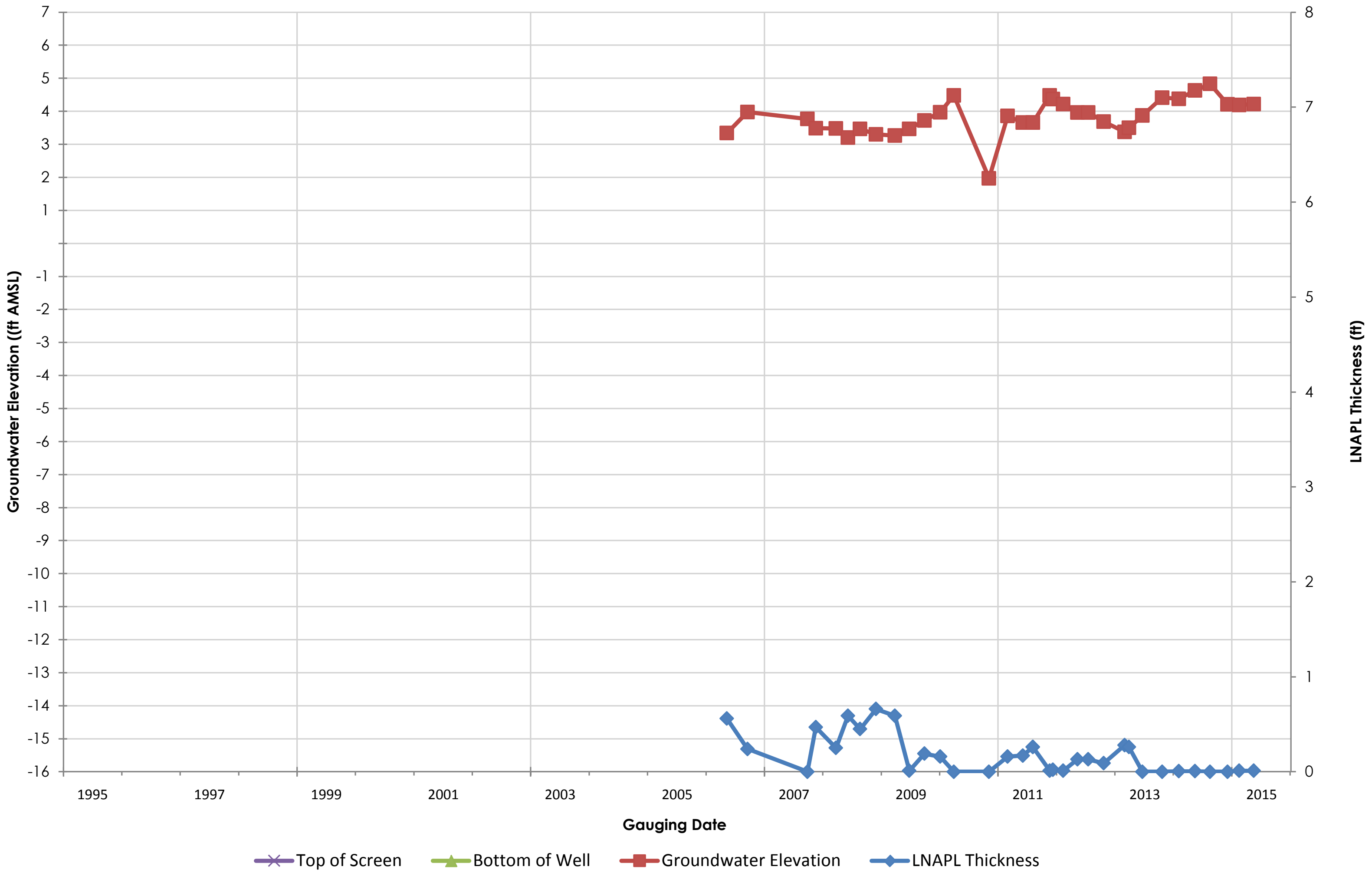
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

TW-9

Title

Groundwater Elevation Hydrograph with
LNAPL Thickness and Screened Interval



Client/Project

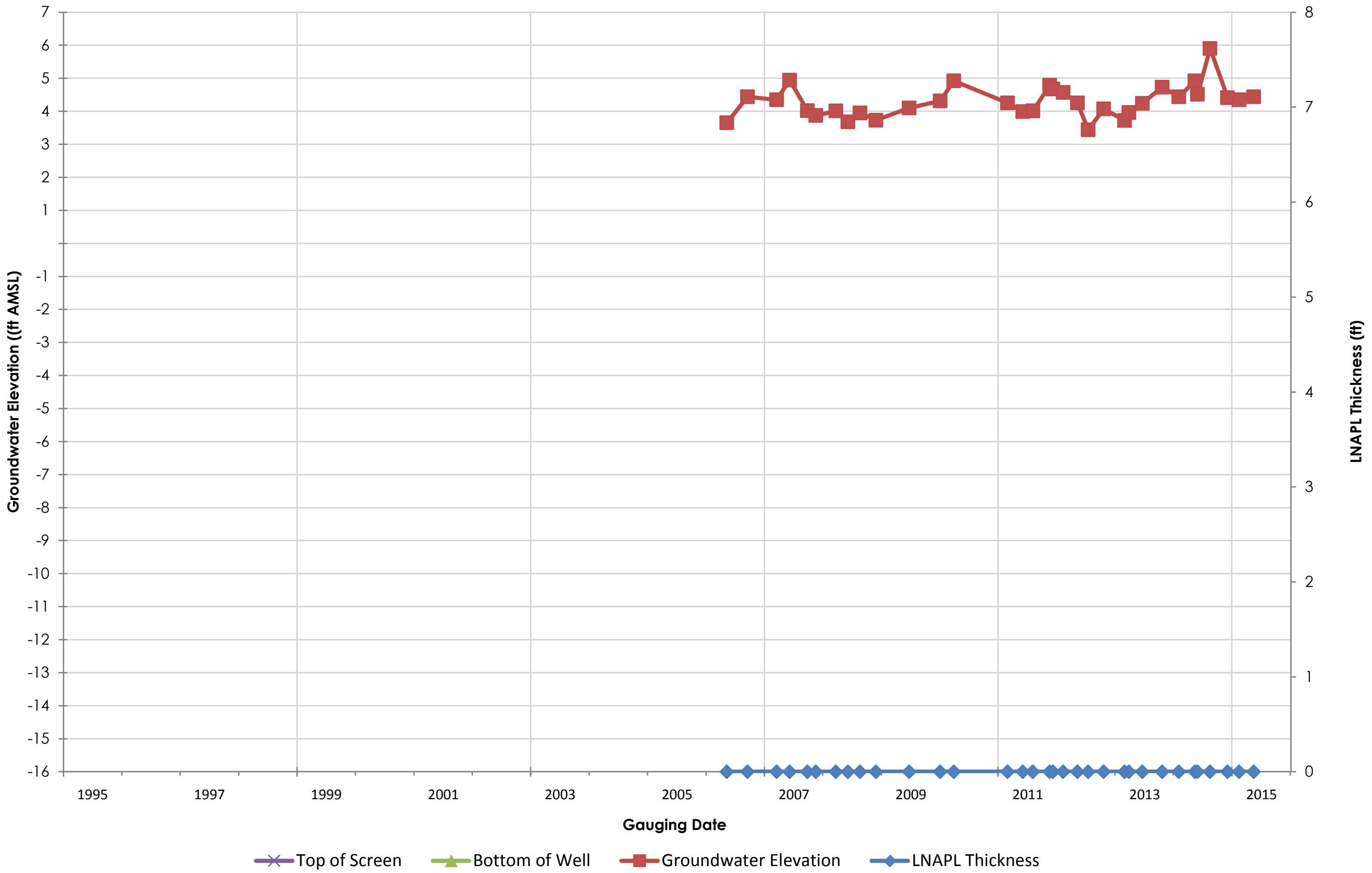
PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

TW-10

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval



Stantec

Client/Project

PHRO Corrective Measures Program
Philadelphia Refinery
3144 Passyunk Avenue

Figure/Well No.

TW-11

Title

Groundwater Elevation Hydrograph with LNAPL Thickness and Screened Interval

APPENDIX II
CONE PENETROMETER SUBSURFACE INVESTIGATION REPORT (HANDEX, 2000A)

Light Non-aqueous Phase Liquid (LNAPL) Site Conceptual Model (LCSM)
Area of Interest 1
PHILADELPHIA REFINERY COMPLEX
PHILADELPHIA, PENNSYLVANIA
PHILADELPHIA REFINERY OPERATIONS,
A SERIES OF EVERGREEN RESOURCES GROUP, LLC
3144 PASSYUNK AVENUE, PHILADELPHIA, PENNSYLVANIA

HANDEX®
Practical Environmental Solutions

CONE PENETROMETER SUBSURFACE INVESTIGATION REPORT

SUNNOCO, INC.
BELMONT TERMINAL
2700 PASSYUNK AVE.
PHILADELPHIA, PA

Jack Mannix
Senior Hydrogeologist

HANDEX CONE PENETROMETER DIVISION
61-C Carolyn Boulevard Farmingdale, New York 11735

TABLE OF CONTENTS

INTRODUCTION

Handex was retained by Sunoco Inc. to conduct a Cone Penetrometer Technology (CPT), characterization at 2700 Passyunk Ave., Philadelphia, PA. The CPT is used to assess and partially delineate the subsurface petroleum impacted areas of concern using electronic sensors and a Fuel Fluorescence Detector (FFD). The investigation was completed in September of 2000 and utilized the Handex CPT which is equipped with a Fuel Fluorescence Detector (FFD) to identify and delineate the presence of subsurface hydrocarbons. The following report, geologic logs and model output summarizes the results of the CPT / FFD soil investigation.

The Handex CPT is equipped with a fuel fluorescence detector that projects ultraviolet light through a sapphire window onto the soil as the tool is being advanced into the ground. If hydrocarbons are present they absorb the ultraviolet (UV) light and emit energy in the form of fluorescent light. This light passes back through the sapphire window and is collected by a fiber optic cable and transmitted to two photo-multipliers in the FFD probe. Here the optical signal is converted to two electric signals and transmitted through a cable into the truck, where the signals are amplified and logged by the on-board data acquisition system. The resulting output is two continuous FFD profiles displaying fluorescence intensity verses depth below the land surface.

The wavelength of the excitation light source located in the FFD module is 254 nanometers (nm) (Bratton and Shinn). If hydrocarbons are impacted by the excitation light source, they will fluoresce. The fluorescent response signal is split and then filtered at each photo-multiplier. One half of the signal is filtered to remove wavelengths below 280 nm and above 450 nm while the other half is filtered to remove wavelengths below 450 nm and above 575 nm. The fluorescence response signal for gasoline and fuel oil (diesel) range hydrocarbons is observed in the 280 to 400 nm wavelength range. The fluorescence response from heavier compounds such as creosote and coal tar residuals are observed at longer wavelengths, primarily impacting the photo-multiplier equipped with the long pass filter (only allowing 450nm to 575nm wavelength range of light to pass). Since all of the hydrocarbons encountered at this site had a more significant response from the higher wavelength FFD (HFFD) and are best represented by this signature, only the HFFD was used to generate the hydrocarbon distribution model shown in the Figures section of this report. The intensity of the FFD signals are expressed in volts and in previous applications have been found to be proportional to the amount of hydrocarbon present in the pore space in the sediments along with air and groundwater.

FIELD INVESTIGATION

CPT/FFD Sounding Program

A total of 22 CPT/FFD soundings were completed at the site to depths ranging from approximately 21 to 53 feet Below Land Surface (BLS). All locations were cleared to 5 feet with an air knife prior to the CPT/FFD sounding to insure that subsurface utilities were cleared before the work began. The locations of the CPT soundings are shown on the site plan (Figure 1).

Site Geology and CPT Soil Classification

The CPT data was collected in accordance with ASTM D 3441-1986 and was used to determine the subsurface stratigraphy. The CPT sounding profiles generated from the data are included as Appendix A.

The site is primarily underlain by sand and gravelly sand to a depth of about 30 feet BLS. Most of the soundings displayed 1 to 4 foot thick layer of sand mix or clayey silt between 20 and 30 feet BLS, which is within the primary sand layer. A fine grained sand mix, clayey silt and clay was detected under the primary sand layer in most soundings, starting between 31 and 41 feet BLS and extending to the bottom of the soundings.

Fuel Fluorescence Detector Results

The FFD tool was calibrated with a card that has a black area and a white area designed to give a known difference in FFD output from each of the colors, on each of the FFD detectors. The voltage output was in the same range as previous outputs for the same calibration card. The results of the FFD calibration are provided in Appendix B. In Appendix A, the columns labeled "LFFD" and "HFFD" represent the fluorescent light response, which is located 2.37 feet above the cone tip. This is the reason the FFD profiles are shorter than the terminal depth of the push.

High FFD responses were encountered in all soundings except CPT-19 which met refusal at 20.61 feet BLS, above the expected hydrocarbon level and CPT-20 which was the farthest point from the loading rack. Since the locations were cleared to 5 feet BLS prior to performing the soundings, most of the data above 5 feet BLS was lost. High FFD readings were observed at various depths from 5 feet BLS to approximately 38 feet BLS. The responses were not detected at uniform depths in all soundings, but the following trends in the data should be noted.

As shown on Figure 4 (3D Hydrocarbon Distribution Model), the Hydrocarbons were detected predominantly within two elevation intervals. The upper interval is between 10 and 30 feet in elevation (at grade to 20 feet below grade) and the lower interval is between negative 10 and -5 feet in elevation (20 to 35 feet below grade). Figure 4 also shows a connection between the two levels near the western-most loading rack. The hydrocarbon connection can be observed in this area where elevated FFD readings exist between the two levels. Three good example soundings where hydrocarbons were detected between these two elevations are CPT-3, CPT-8, and CPT-12. The lower level FFD readings generally occur within the primary sand layer and below the 1 to 4 foot thick sand mix or clayey silt layer. Two different hydrocarbons were detected in the lower level that are distinguished primarily by their fluorescent properties. The LFFD readings are higher near the top of the hydrocarbon impacted zone while the HFFD readings are higher near the bottom of the zone. These two lower level hydrocarbon saturated zones are separate in some soundings and they run together in others.

The upper level hydrocarbons (between 10 and 30 feet in elevation) were detected primarily under the loading racks, under the paved area between the loading racks and the main parking lot and just to the south of the main entrance. The lower level hydrocarbons produced the highest FFD readings in three areas. The first was just to the south of the loading racks, the second was approximately 140 feet south of the main parking lot in sounding CPT-6 and the third was just south of the main entrance in CPT-22. Please note that the two eastern-most areas of lower level hydrocarbons may be connected as the sounding separating the two areas (CPT-4) did not go deep enough to detect the lower level hydrocarbons.

Conclusions / Recommendations

Based on the interpolated fuel fluorescence intensity maps shown on Figure 2 and Figure 3, the upper level hydrocarbons and the lower level hydrocarbons are centered along two different lines. Figure 2 shows the upper level hydrocarbons' intensity at it's highest on a line from CPT-7 to CPT-16. Figure 3 shows the lower level hydrocarbons' intensity at it's highest farther to the southwest, on a line from CPT-13 to CPT-22.

In order to fully delineate the extent of hydrocarbons on this site, additional delineation should be performed on the western portion of the site.

FIGURES

LEGEND

Ⓜ MANHOLE

▣ RECOVERY WELL

⊕ OBSERVATION WELL

◈ TEMPORARY WELL

● CPT SOUNDING LOCATION

o—o FENCE

▨ SHUNK STREET SEWER

≡≡≡≡ PRODUCT LINES BELOW GRADE

0 120 240 360 480

SCALE IN FEET

NO.	BY	DATE	REVISION	APP'D.
1.				

PROJECT:

SUNOCO, INC. (R&M)
BELMONT TERMINAL
2700 PASSYUNK AVENUE
PHILADELPHIA, PENNSYLVANIA

SHEET TITLE:

FIGURE # 1 - SITE PLAN

DRAWN BY: F. DeVITA
REVISED BY: F. DeVITA
CHECKED BY: J. MANNIX
DATE: SEPTEMBER 12, 2000
SCALE: 1 " = 120 '
PROJECT NUMBER: 110535.001
FILE NAME: S:/ DRAFTING/CLIENTS/HNDX-MRY/110535/110535-1.DWG

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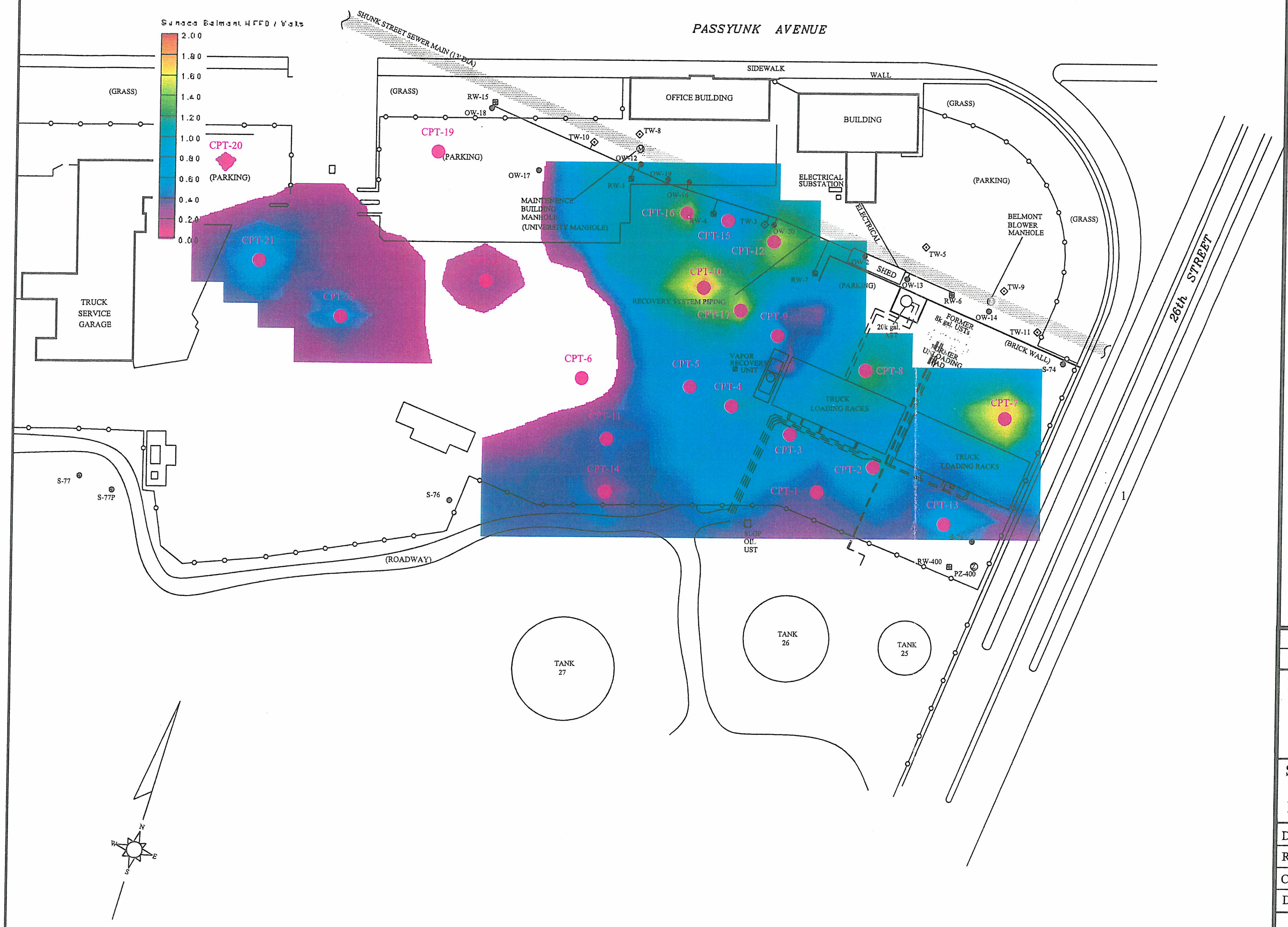
61C CAROLYN BOULEVARD
FARMINGDALE, NEW YORK
Phone: 631/ 752-7878
Fax: 631/752-7890



LEGEND

Ⓜ MANHOLE

◪ RECOVERY WELL

⊕ OBSERVATION WELL

◇ TEMPORARY WELL

● CPT SOUNDING LOCATION

—o—o— FENCE

▨ SHUNK STREET SEWER

≡ ≡ ≡ ≡ PRODUCT LINES BELOW GRADE

0 120 240 360 480

SCALE IN FEET

NO.	BY	DATE	REVISION	APP'D.
1.				

PROJECT:

SUNOCO, INC. (R&M)
BELMONT TERMINAL
2700 PASSYUNK AVENUE
PHILADELPHIA, PENNSYLVANIA

SHEET TITLE:

FIGURE # 2 - SITE PLAN WITH INTERPOLATED FUEL FLUORESCENCE INTENSITY @ UPPER LEVEL (10 - 30 ft ELEVATION)

DRAWN BY: F. DeVITA	SCALE: 1 " = 120 '	PROJECT NUMBER: 110535.001
REVISED BY: F. DeVITA		
CHECKED BY: J. MANNIX	FILE NAME: S:/ DRAFTING/CLIENTS/HNDX-MRY/110535/110535-1.DWG	
DATE: SEPTEMBER 12, 2000		

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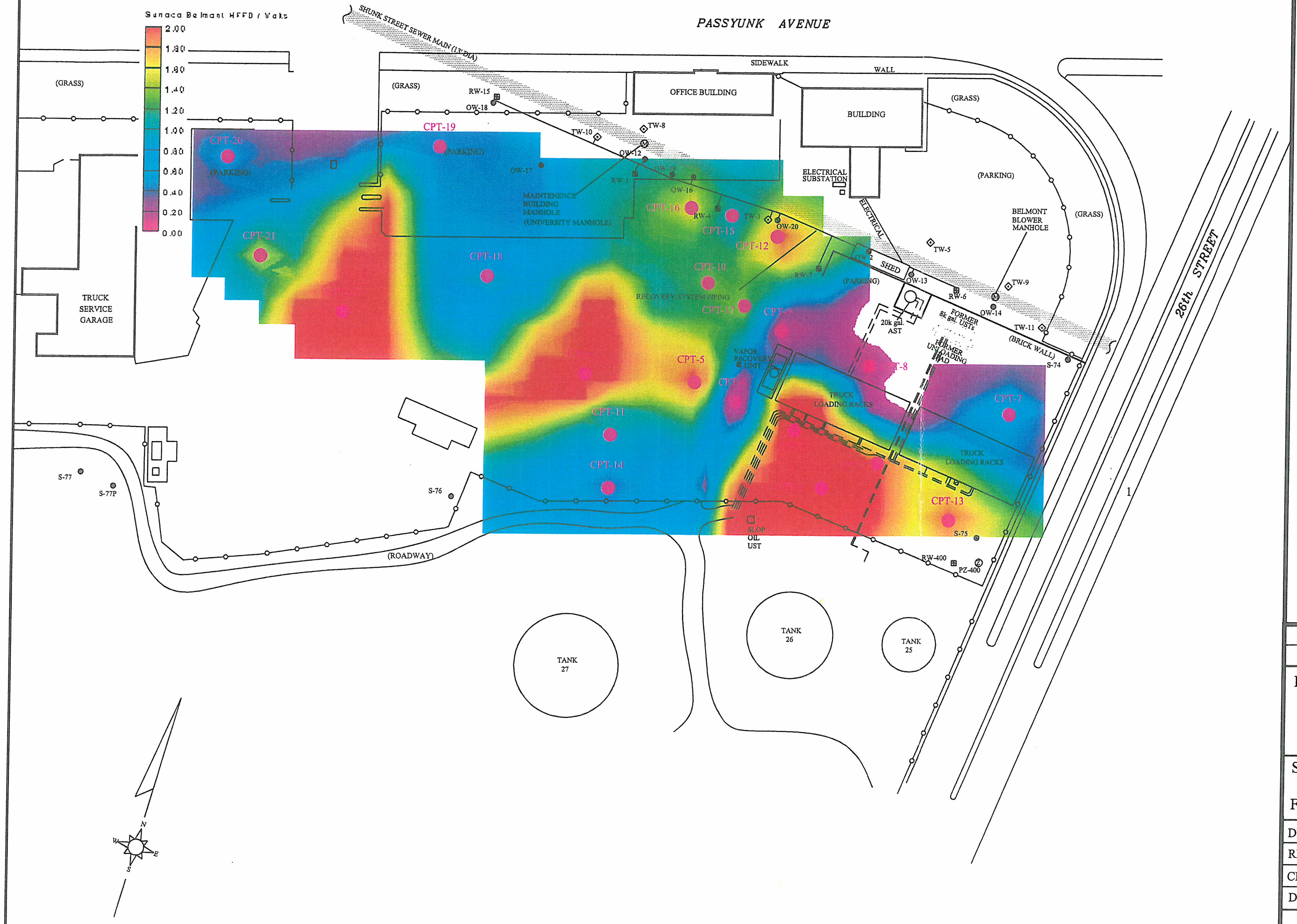
61C CAROLYN BOULEVARD
FARMINGDALE, NEW YORK
Phone: 631/ 752-7878
Fax: 631/752-7890



LEGEND

Ⓜ MANHOLE

⊞ RECOVERY WELL

⊕ OBSERVATION WELL

◇ TEMPORARY WELL

● CPT SOUNDING LOCATION

-o-o- FENCE

▨ SHUNK STREET SEWER

≡≡≡≡ PRODUCT LINES BELOW GRADE

0 120 240 360 480

SCALE IN FEET

1.				
NO.	BY	DATE	REVISION	APP'D.

PROJECT:
SUNOCO, INC. (R&M)
BELMONT TERMINAL
2700 PASSYUNK AVENUE
PHILADELPHIA, PENNSYLVANIA

SHEET TITLE:
FIGURE # 3 - SITE PLAN WITH INTERPOLATED FUEL FLUORESCENCE INTENSITY @ LOWER LEVEL (10 to -5 ft ELEVATION)

DRAWN BY: F. DeVITA
REVISED BY: F. DeVITA
CHECKED BY: J. MANNIX
DATE: SEPTEMBER 12, 2000
SCALE: 1 " = 120 '
PROJECT NUMBER: 110535.001
FILE NAME: S:/ DRAFTING/CLIENTS/HNDX-MRY/110535/110535-1.DWG

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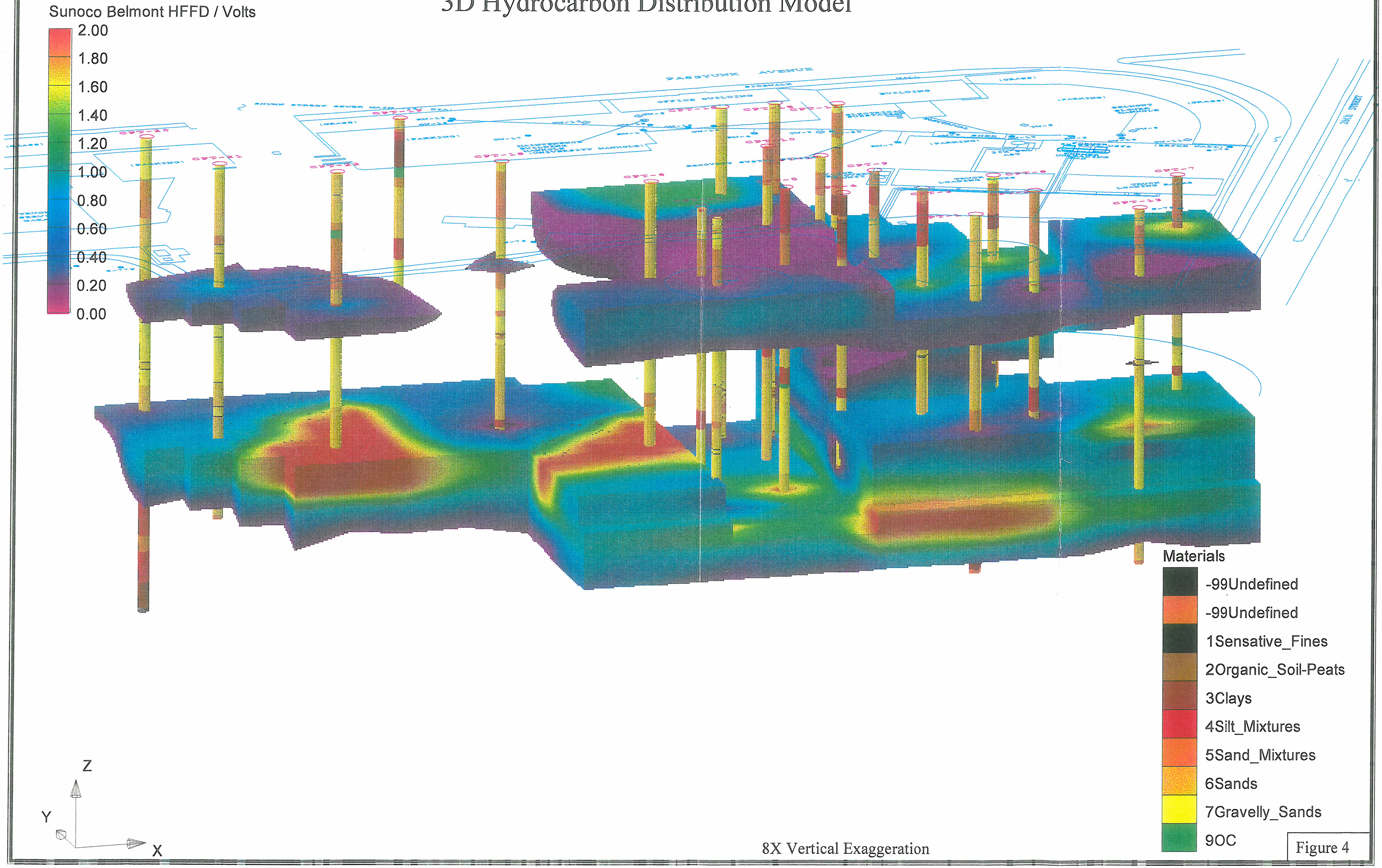
3D Hydrocarbon Distribution Model



8X Vertical Exaggeration

Figure 4

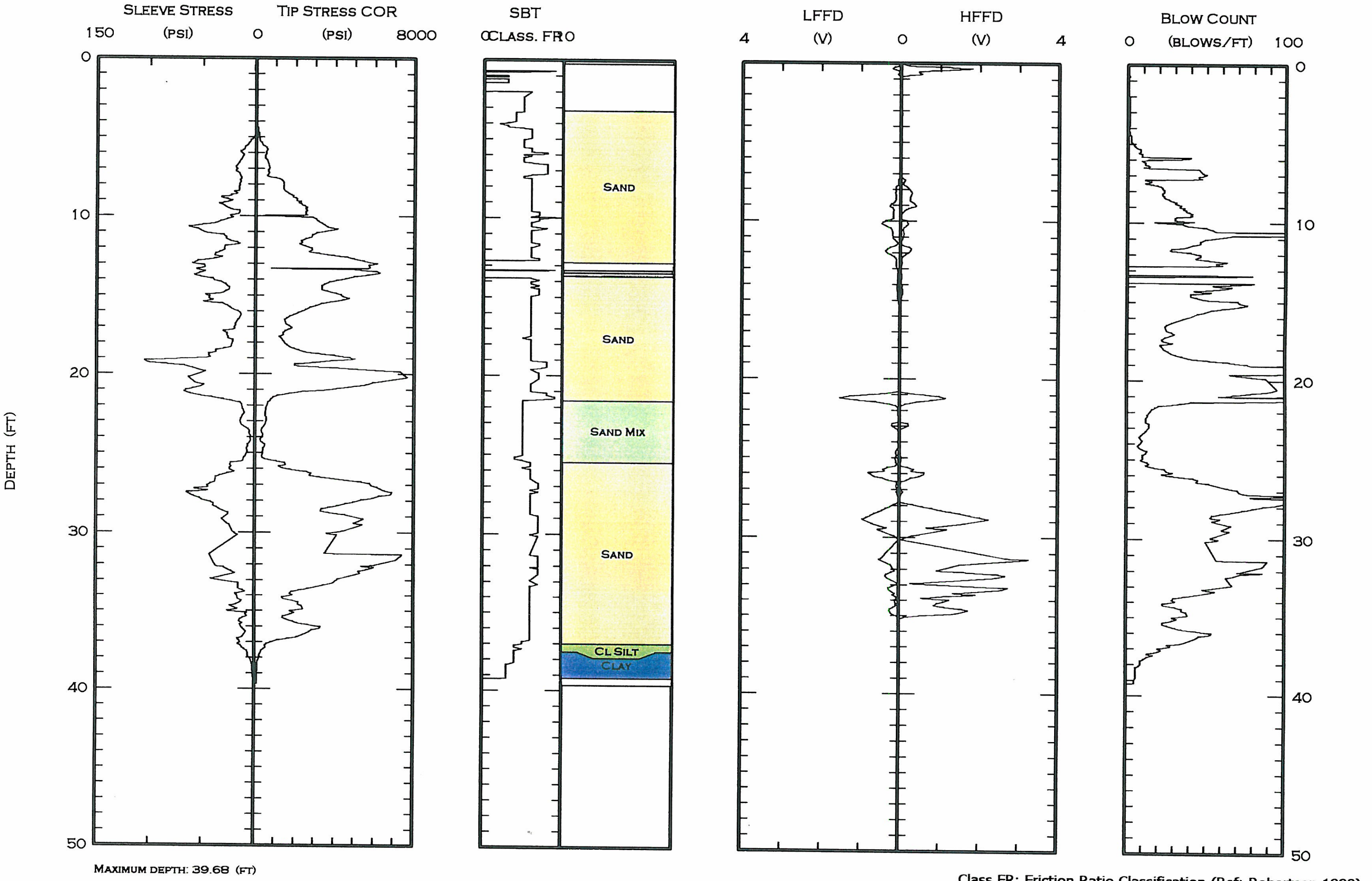
APPENDIX A

CPT SOUNDING PROFILES

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:
Client: Sun
Site: Sunoco Belmont Refinery

Date: 28/Aug/2000
Test ID: CPT-1
Project: PhlSun



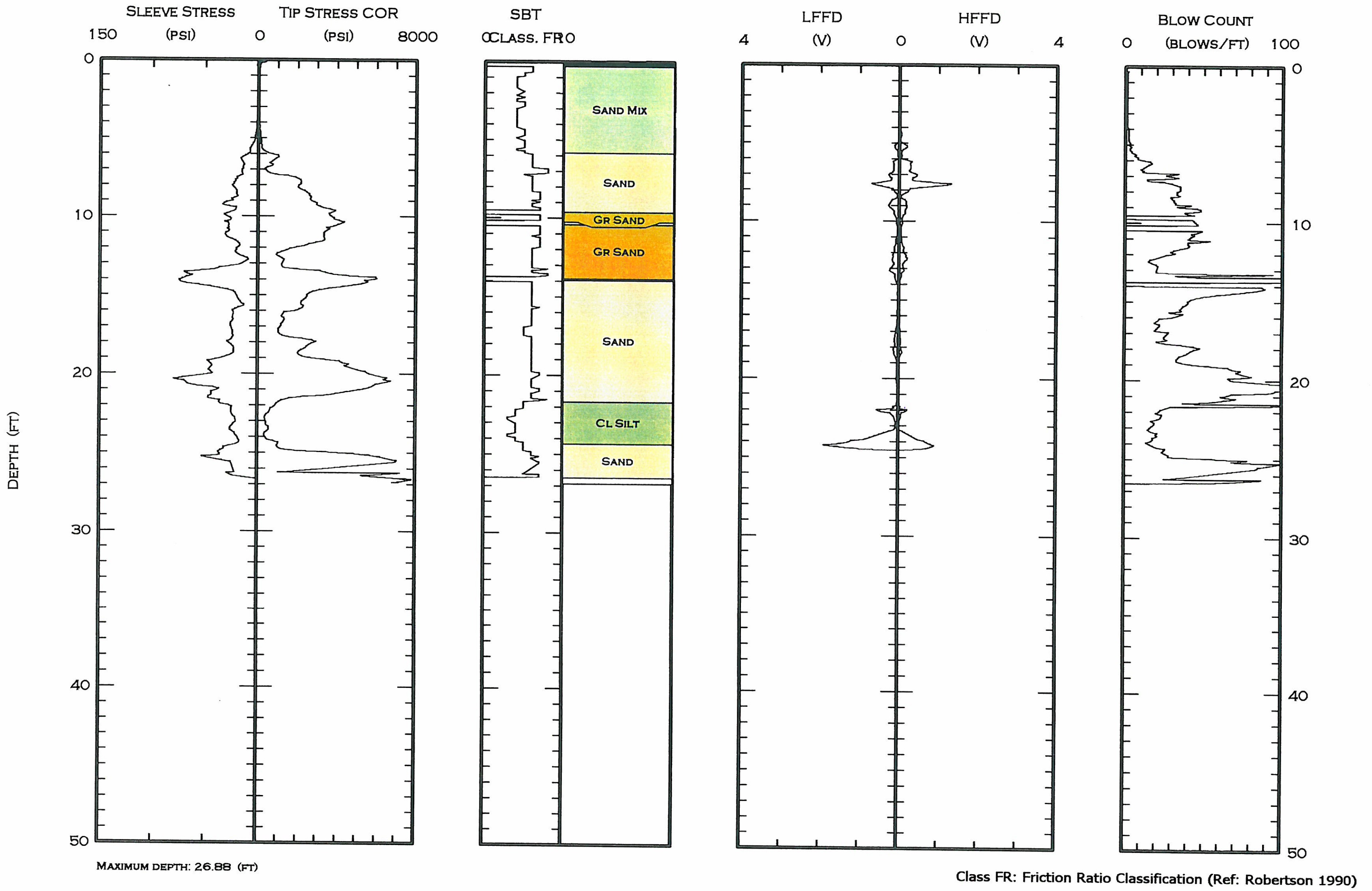
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

TEST ID: CPT-1
FILE: z28G0003C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:
Client: Sun
Site: Sunoco Belmont Refinery

Date: 28/Aug/2000
Test ID: CPT-2
Project: PhlSun



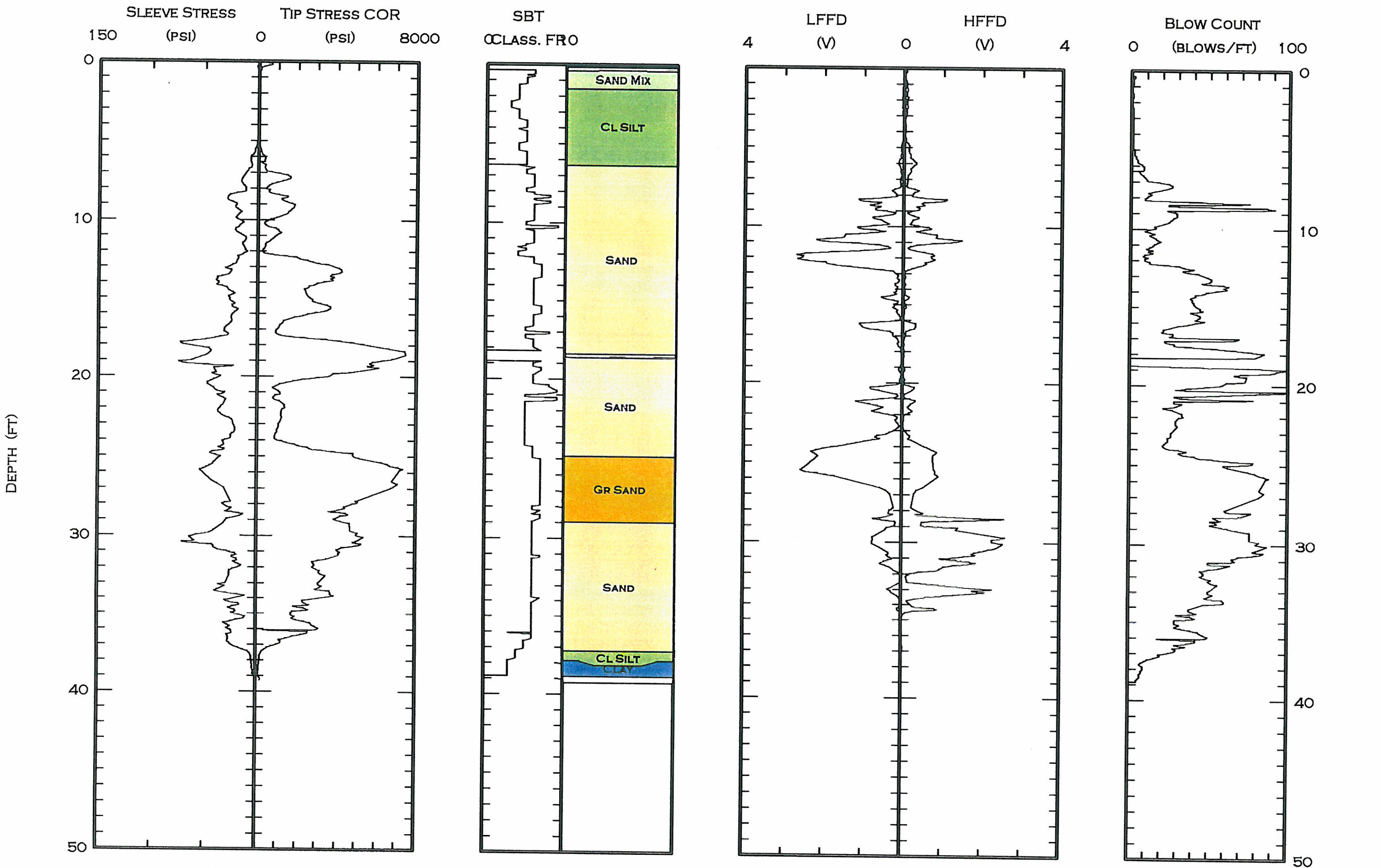
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-2
File: 228G0004C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:
Client: Sun
Site: Sunnoco Belmont Refinery

Date: 28/Aug/2000
Test ID: CPT-3
Project: PhlSun



Maximum depth: 39.28 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

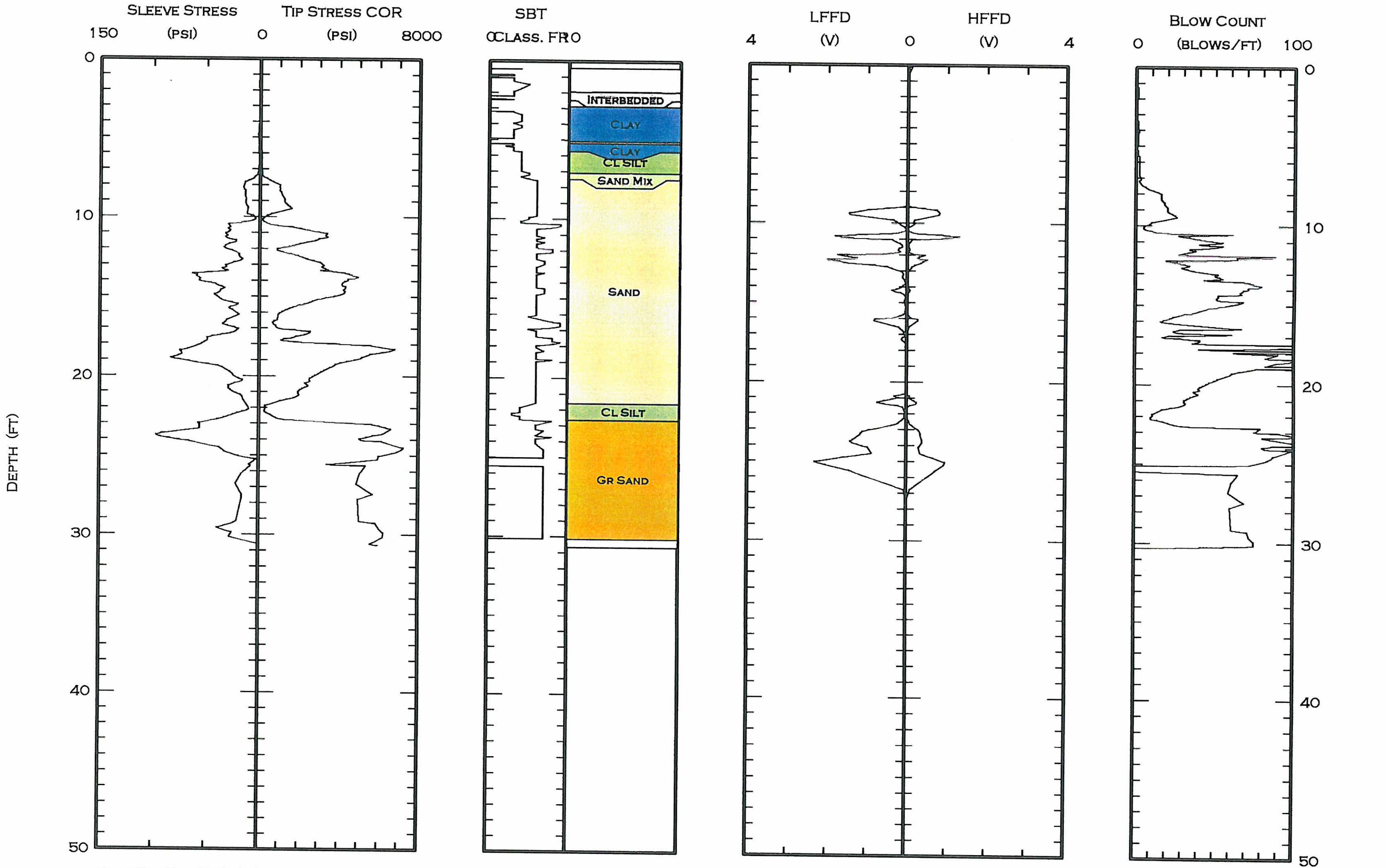
Test ID: CPT-3
File: z28g0005c.ecp

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 28/Aug/2000
Test ID: CPT-4
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery

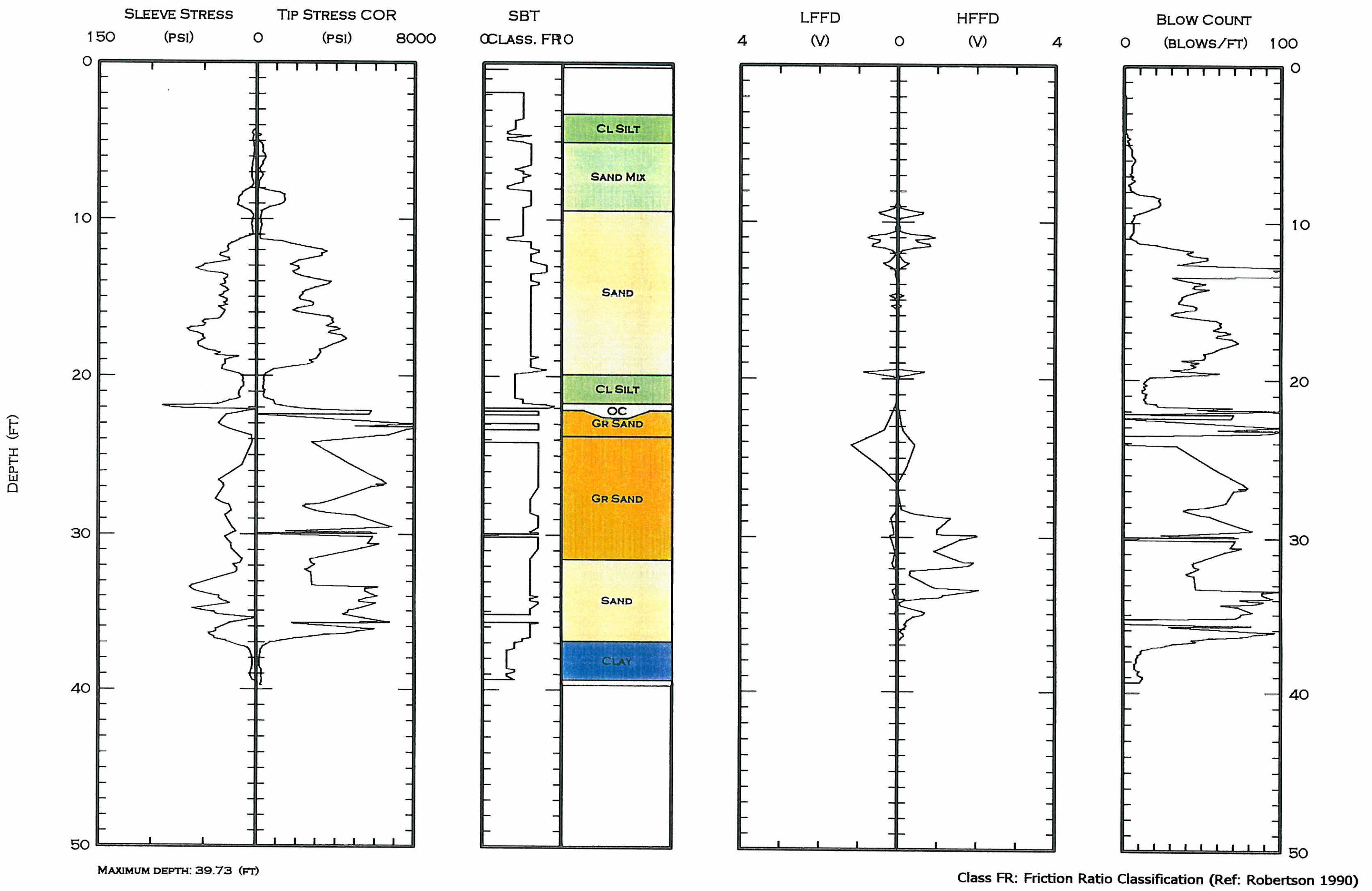


MAXIMUM DEPTH: 30.69 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

TEST ID: CPT-4
FILE: Z28G0007C.ECP

Handex Farmingdale, NY 11735 (631)-752-7878 Email: JMannix@Handexmail.com http://www.Handex.com	Northing: Easting: Elevation:	Date: 28/Aug/2000 Test ID: CPT-5 Project: PhlSun
	Client: Sun Site: Sunnoco Belmont Refinery	



Maximum depth: 39.73 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

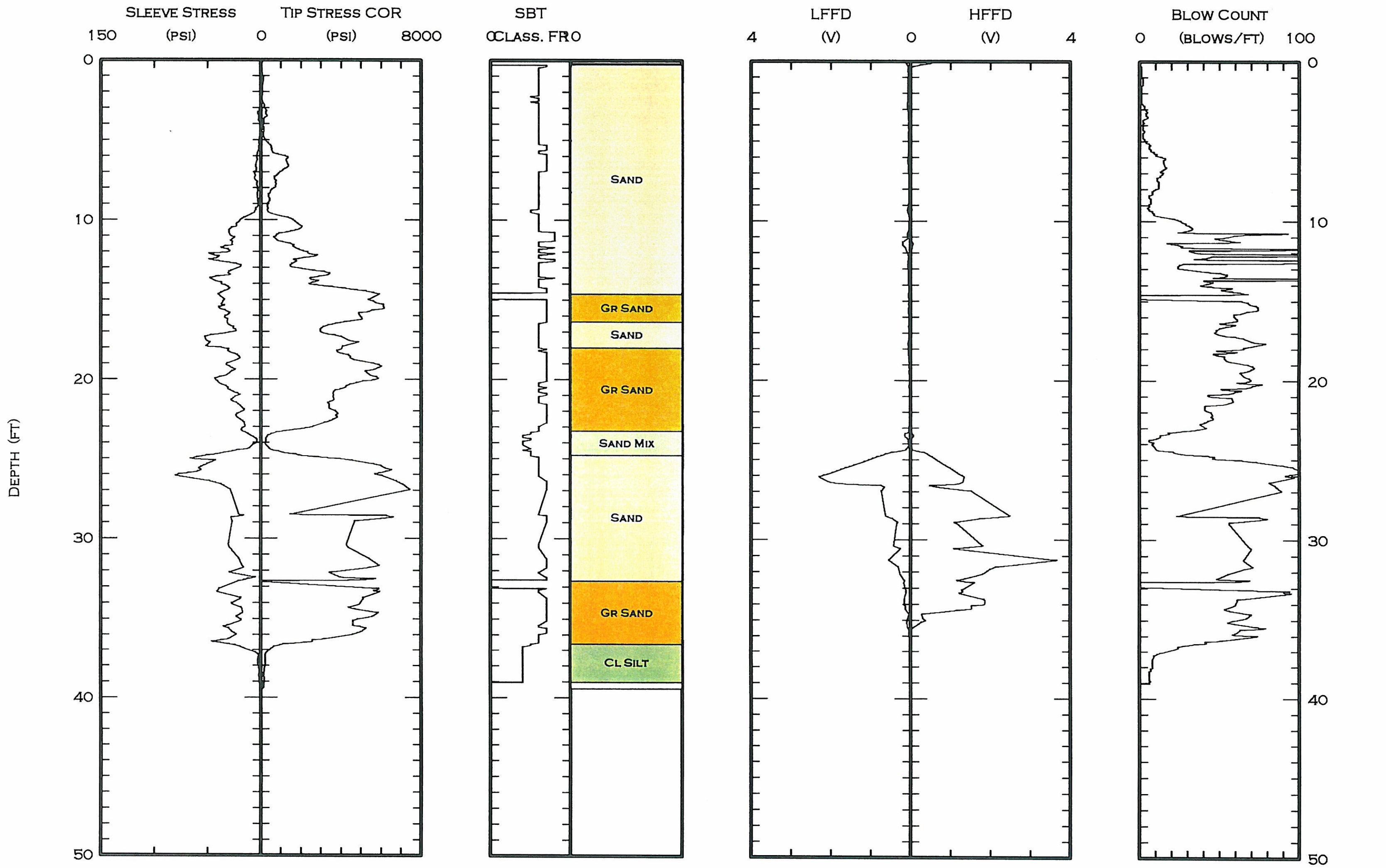
Test ID: CPT-5
File: z28g0009c.ecp

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 28/Aug/2000
Test ID: CPT-6
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 39.45 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

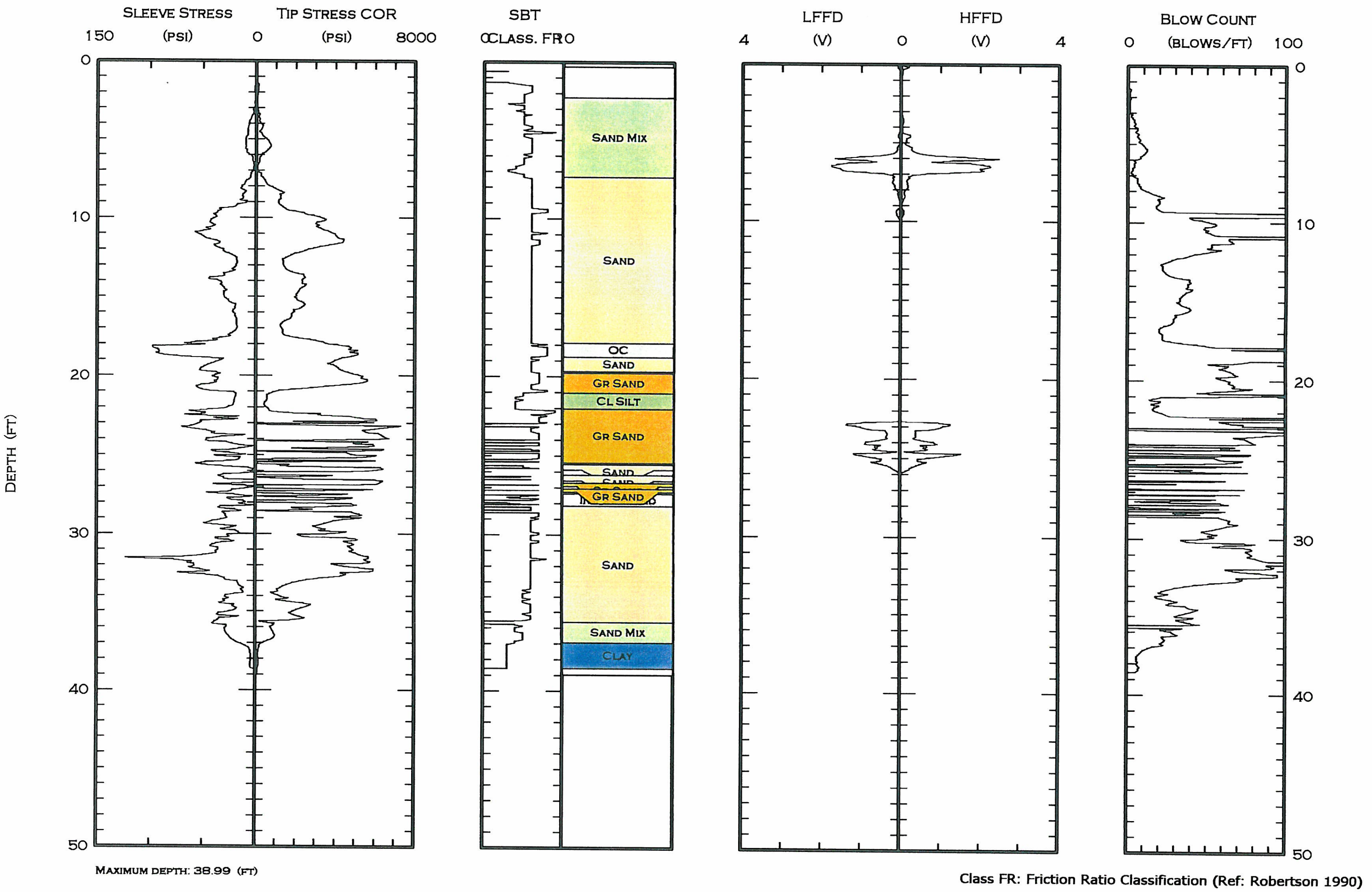
TEST ID: CPT-6
FILE: Z28G0010C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 29/Aug/2000
Test ID: CPT-7
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery

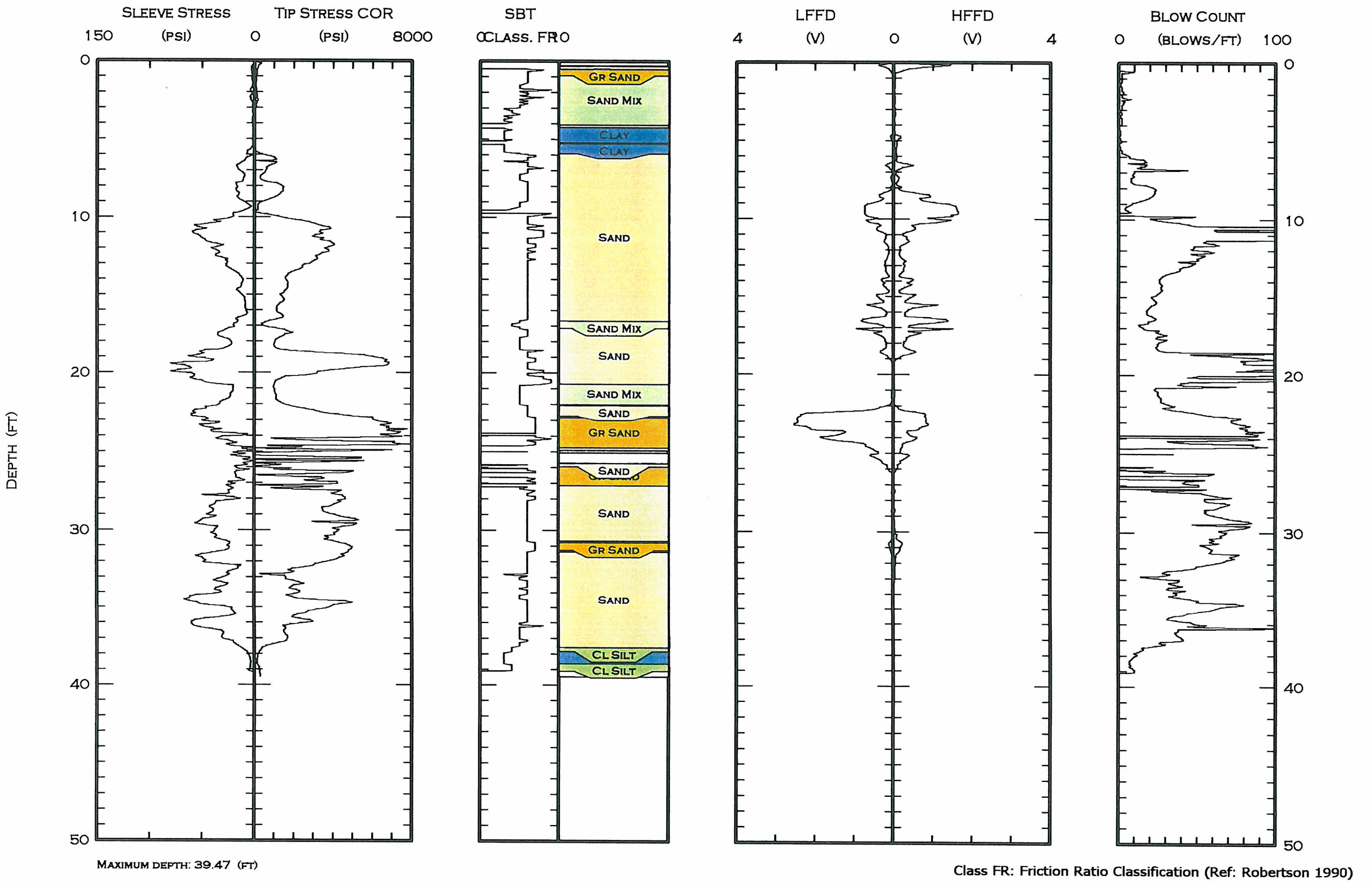


MAXIMUM DEPTH: 38.99 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

TEST ID: CPT-7
FILE: z29g00014c.ECP

Handex Farmingdale, NY 11735 (631)-752-7878 Email: JMannix@Handexmail.com http://www.Handex.com	Northing: Easting: Elevation:	Date: 29/Aug/2000 Test ID: CPT-8 Project: PhlSun
	Client: Sun Site: Sunnoco Belmont Refinery	



Maximum depth: 39.47 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

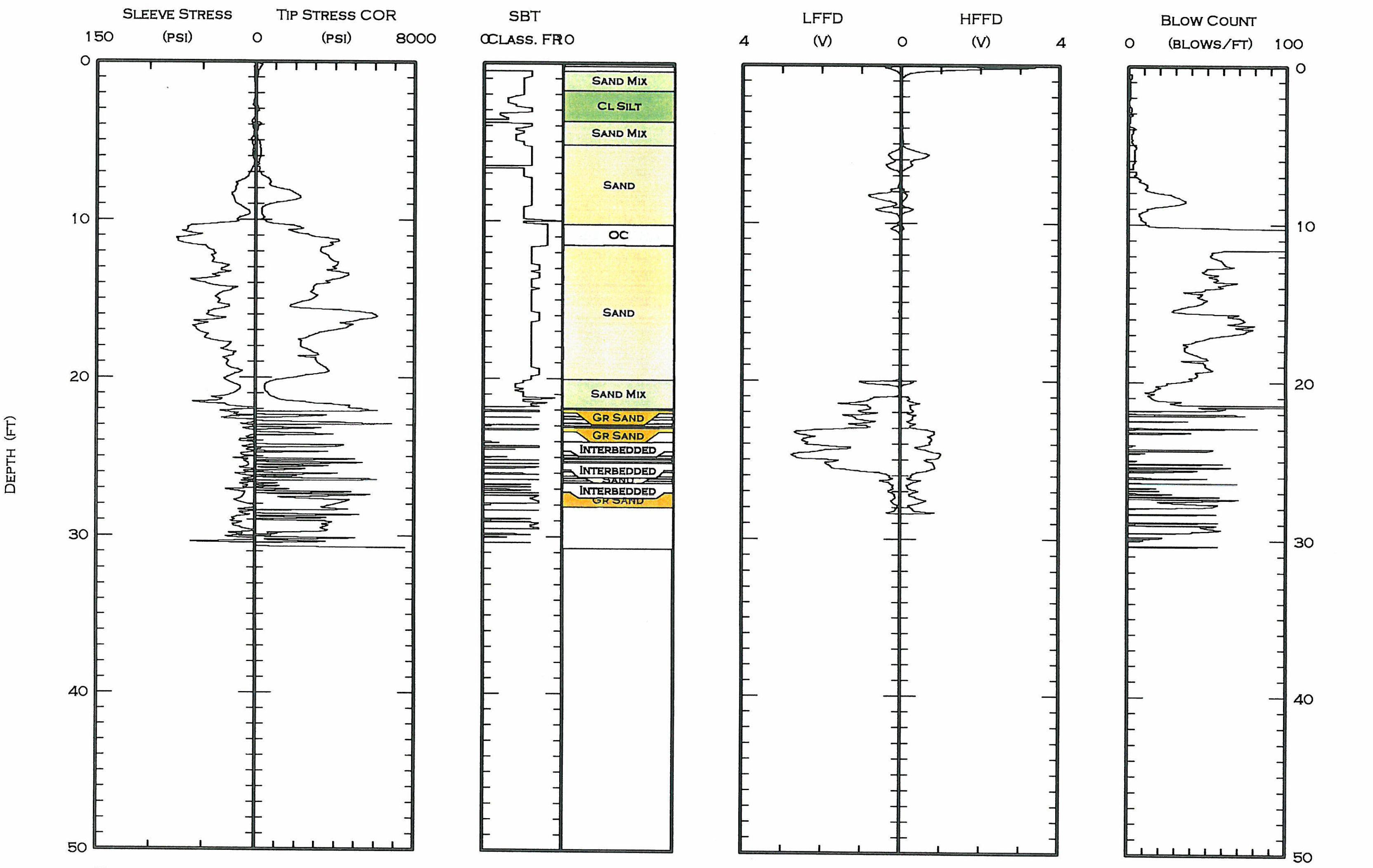
Test ID: CPT-8
File: z29g0003c.ecp

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 29/Aug/2000
Test ID: CPT-9
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



Class FR: Friction Ratio Classification (Ref: Robertson 1990)

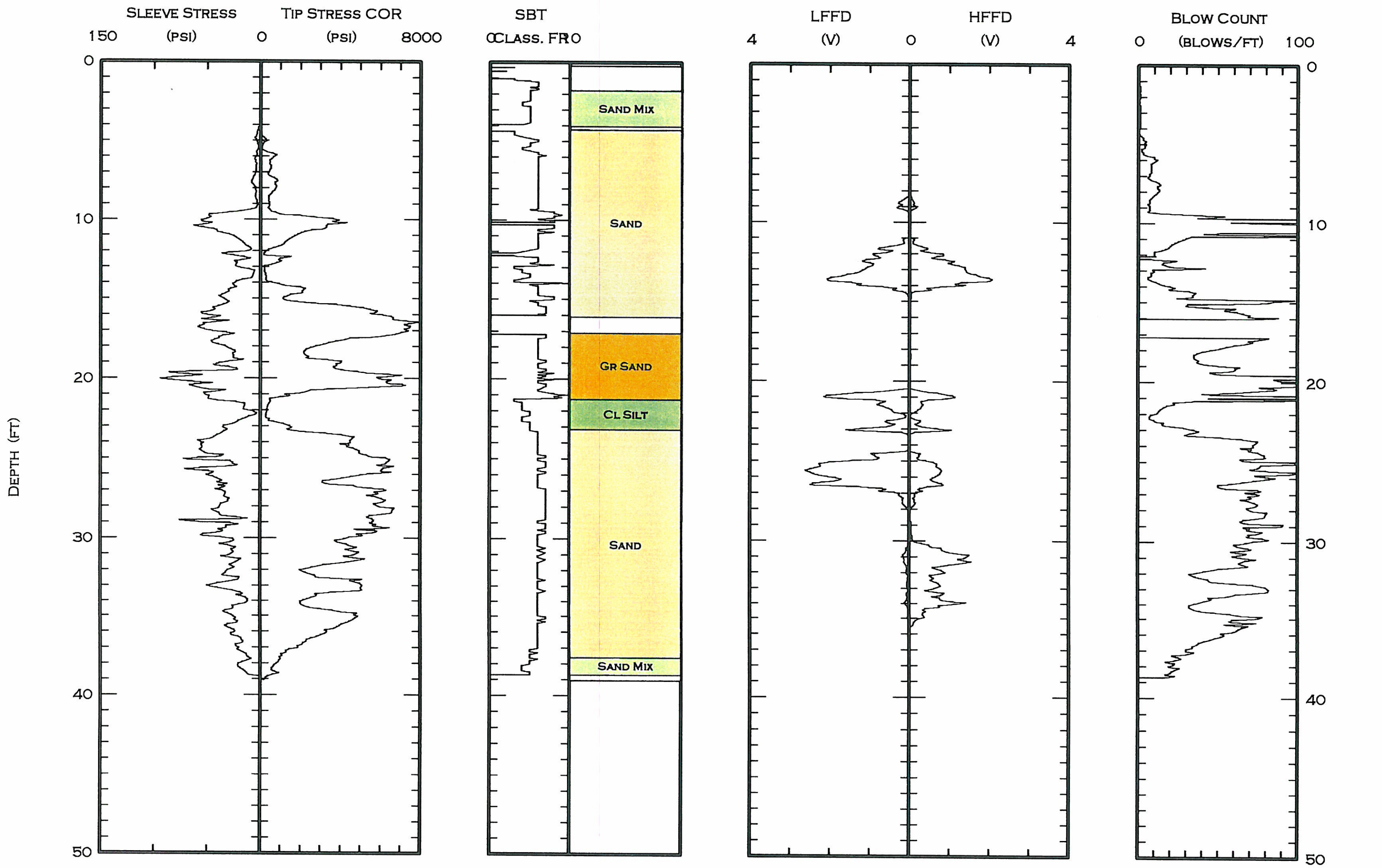
TEST ID: CPT-9
FILE: z29G0004C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 28/Aug/2000
Test ID: CPT-10
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



Maximum depth: 39.08 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

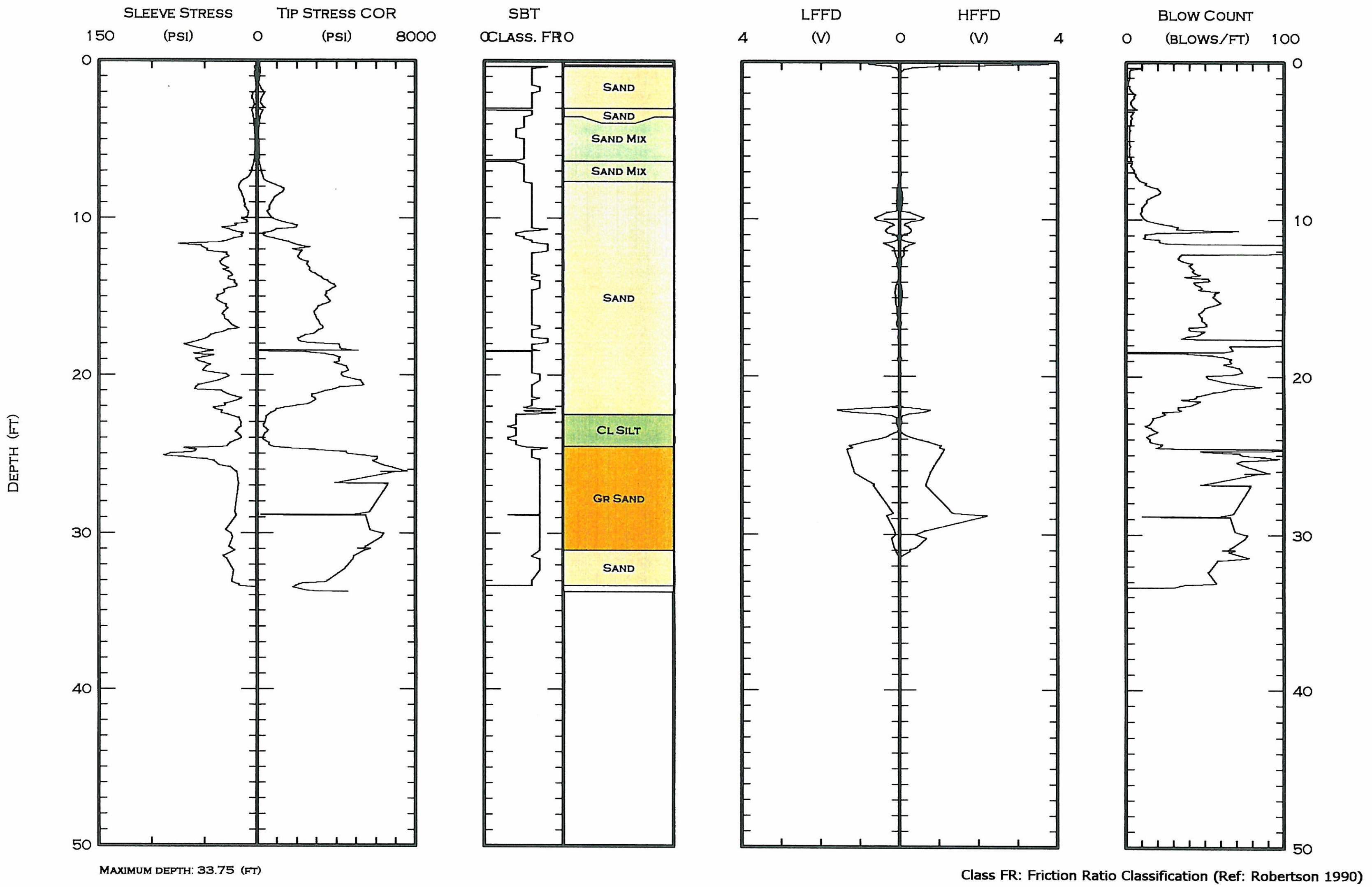
Test ID: CPT-10
File: z28g0012c.ecp

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 28/Aug/2000
Test ID: CPT-11
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



Maximum depth: 33.75 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

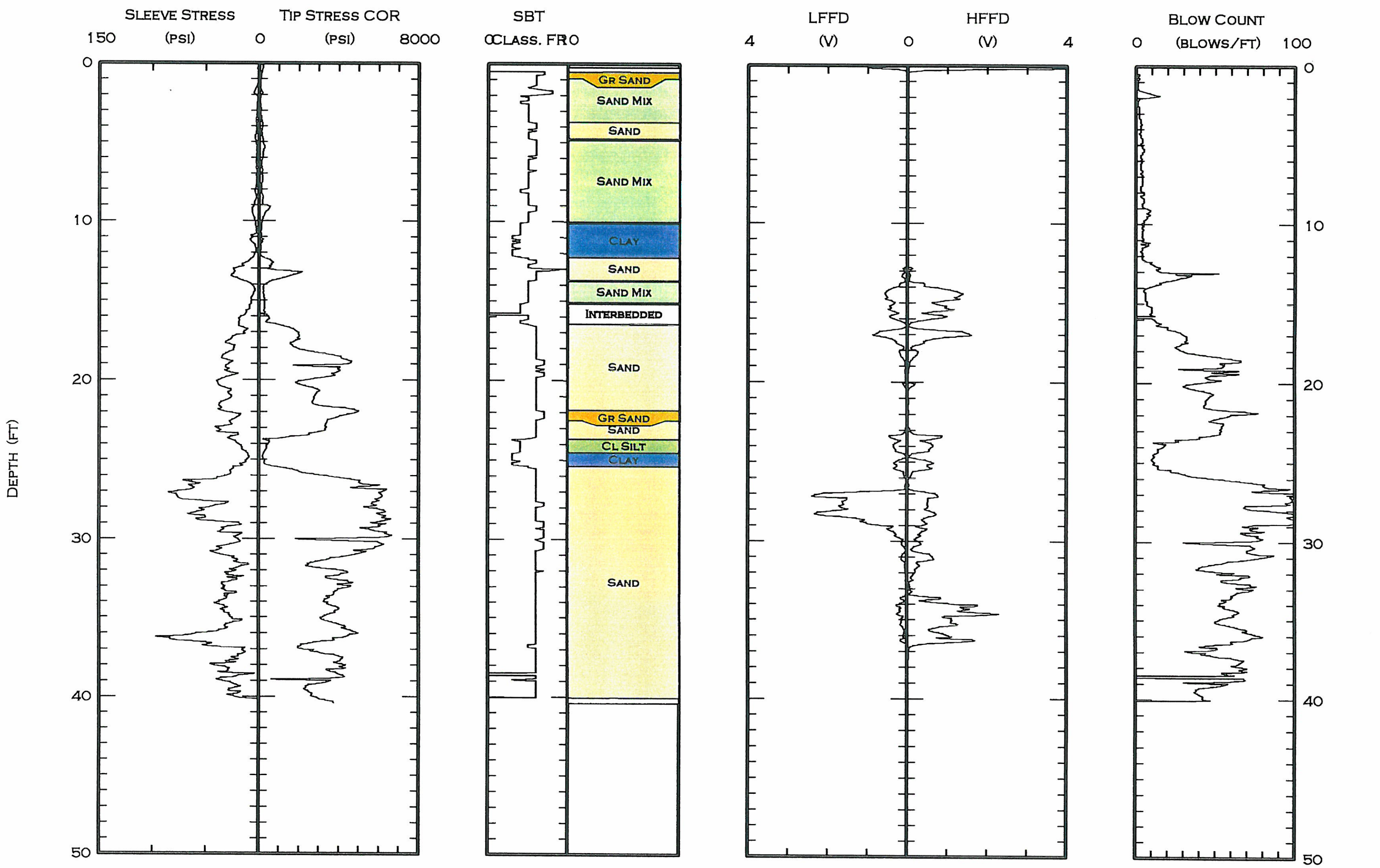
Test ID: CPT-11
File: z28g0011c.ecp

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 29/Aug/2000
Test ID: CPT-12
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 40.41 (FT)

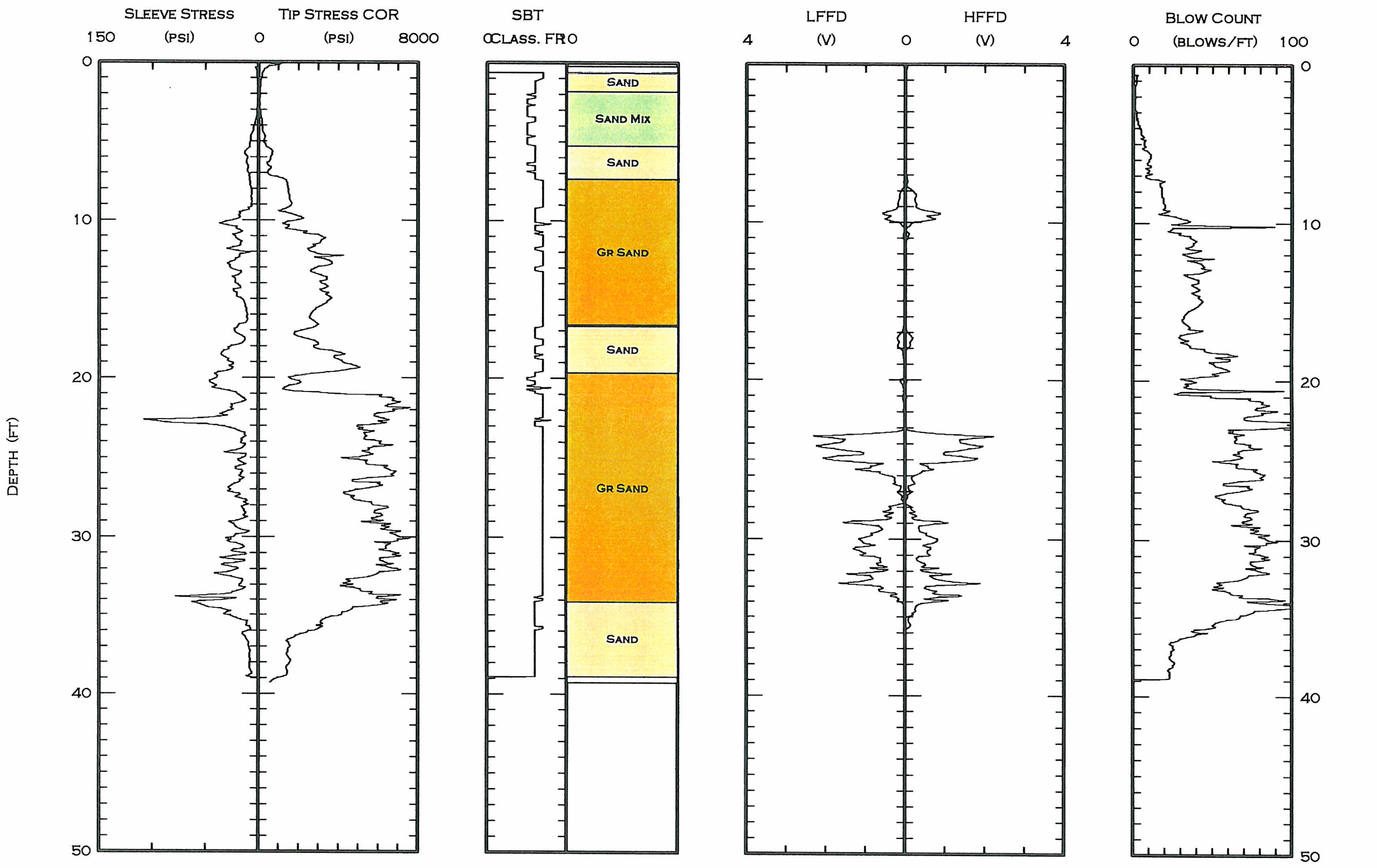
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

TEST ID: CPT-12
FILE: Z29G0005C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:
Client: Sun
Site: Sunnoco Belmont Refinery

Date: 30/Aug/2000
Test ID: CPT-13
Project: PhlSun



Maximum depth: 39.29 (ft)

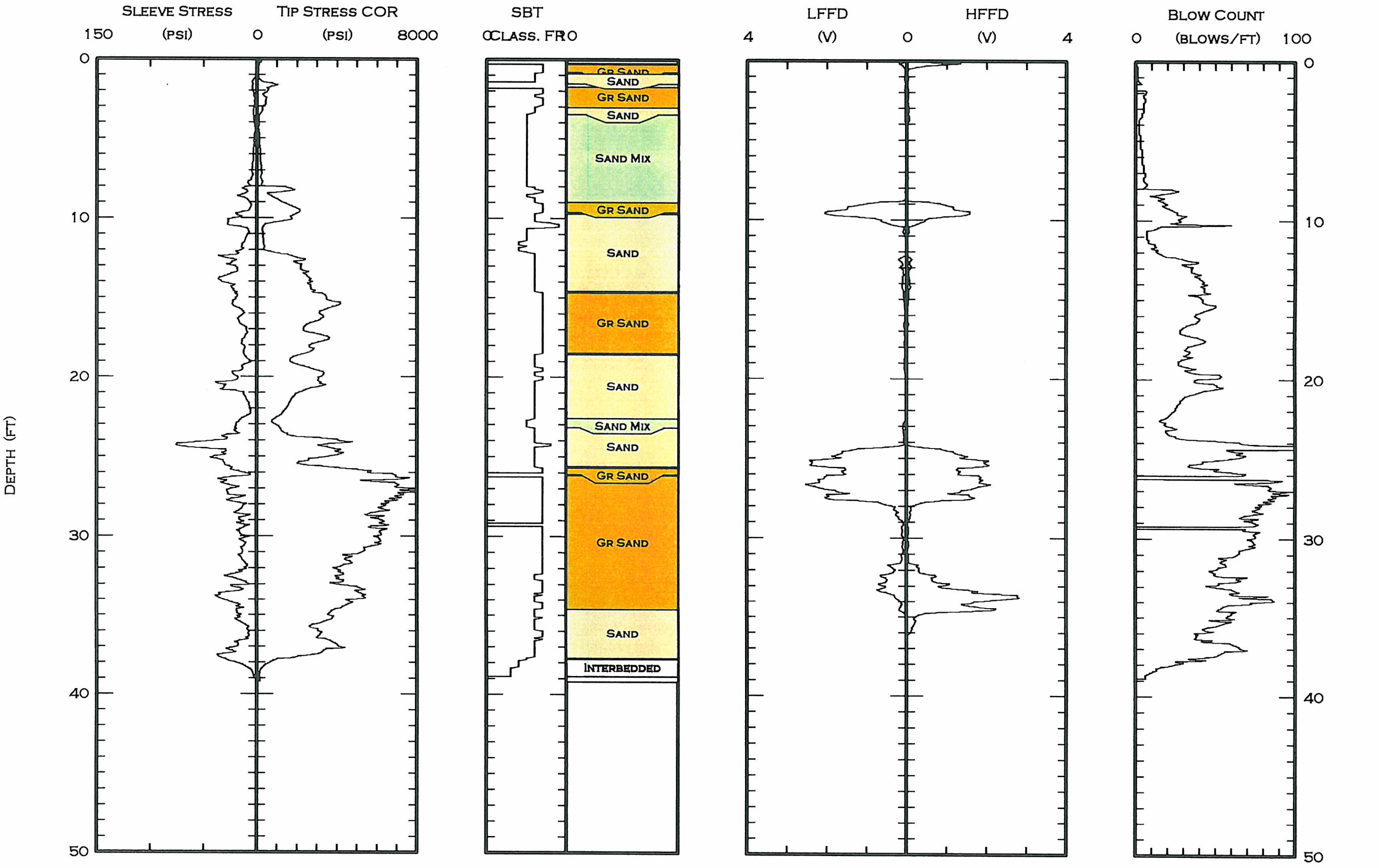
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 30/Aug/2000
Test ID: CPT-14
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



Maximum depth: 39.23 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

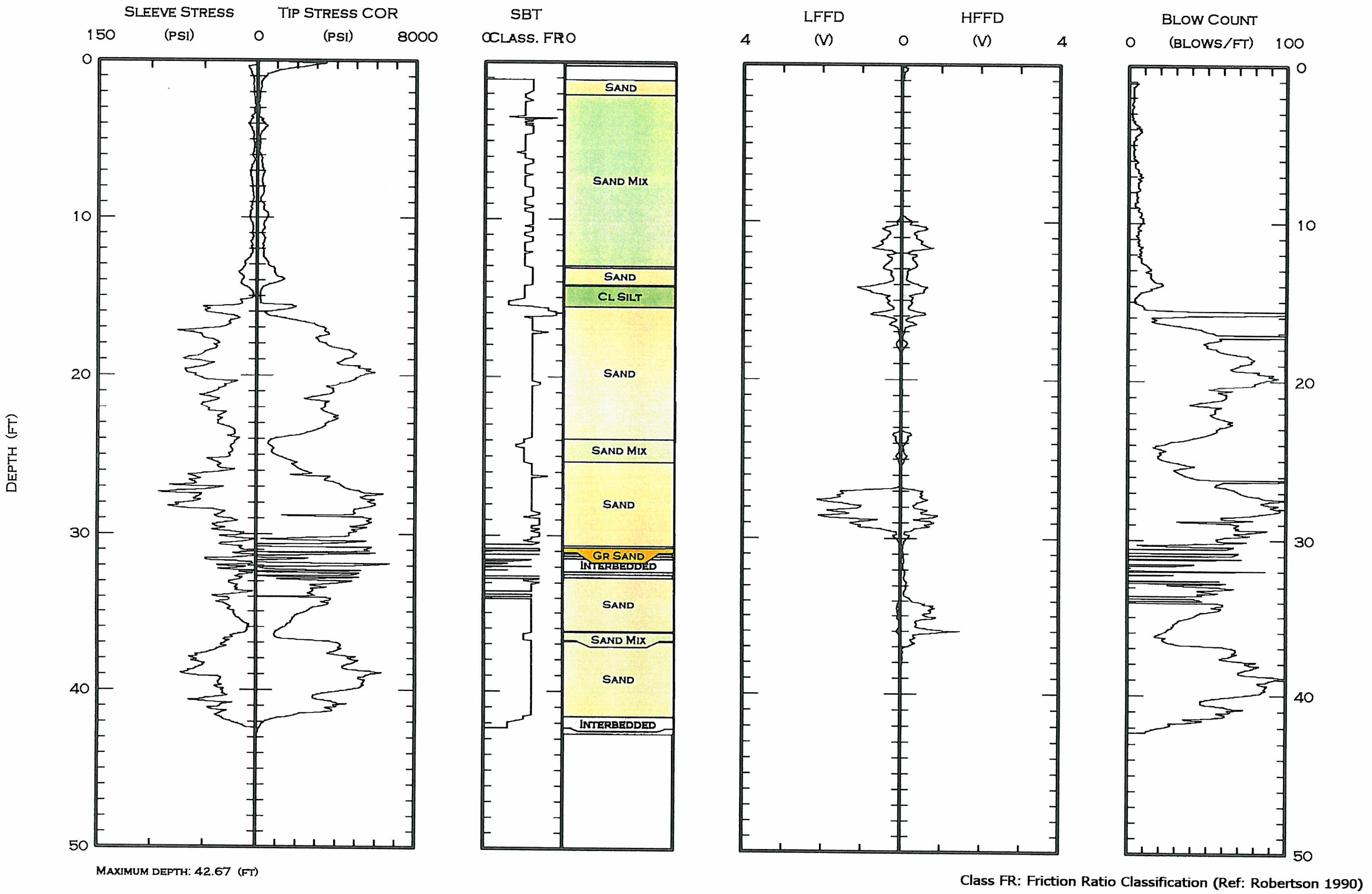
Test ID: CPT-14
File: z30g0001c.ecp

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 29/Aug/2000
Test ID: CPT-15
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 42.67 (FT)

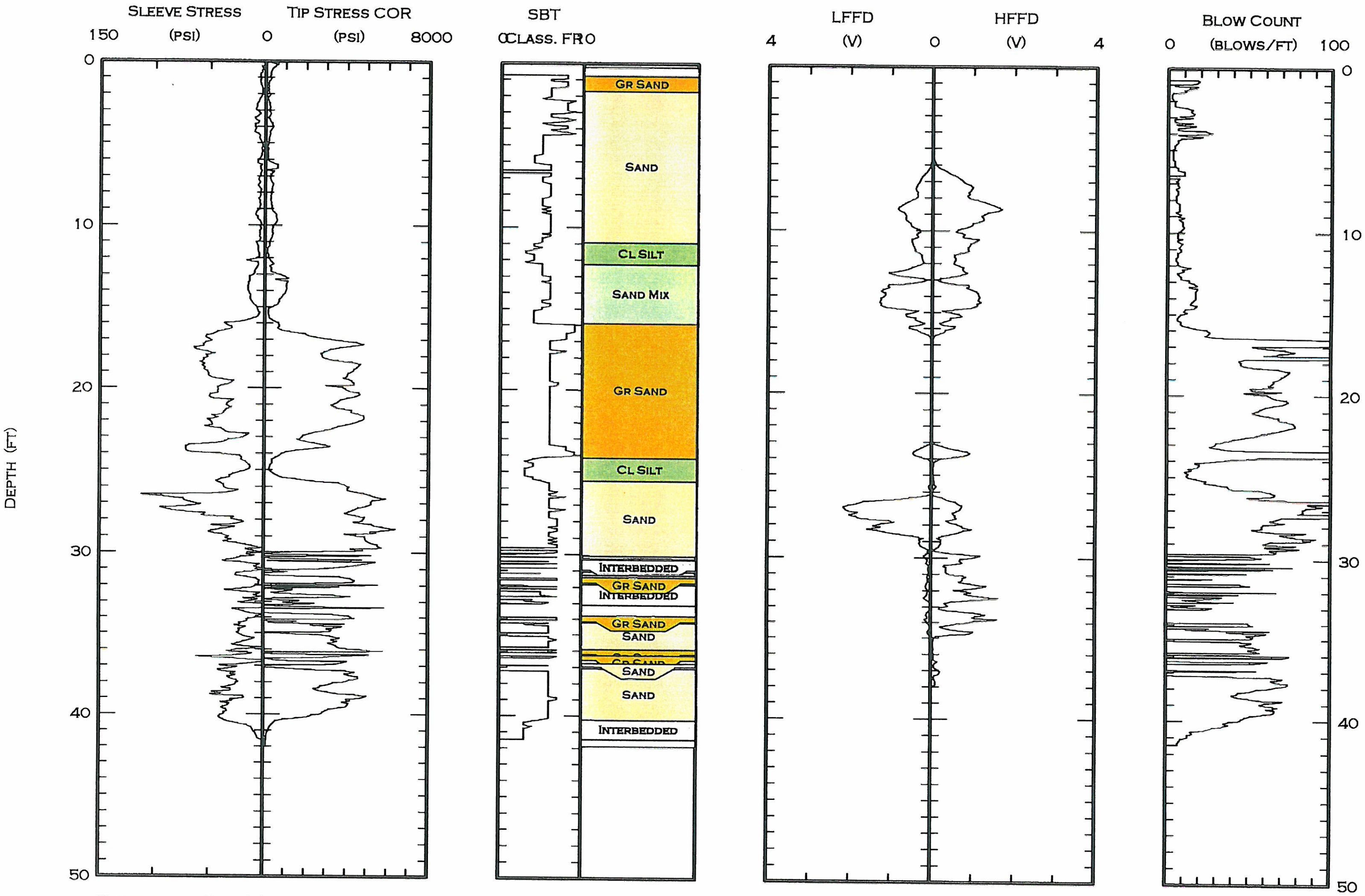
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

TEST ID: CPT-15
FILE: z29g0007c.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:
Client: Sun
Site: Sunnoco Belmont Refinery

Date: 29/Aug/2000
Test ID: CPT-16
Project: PhlSun



Maximum depth: 41.91 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

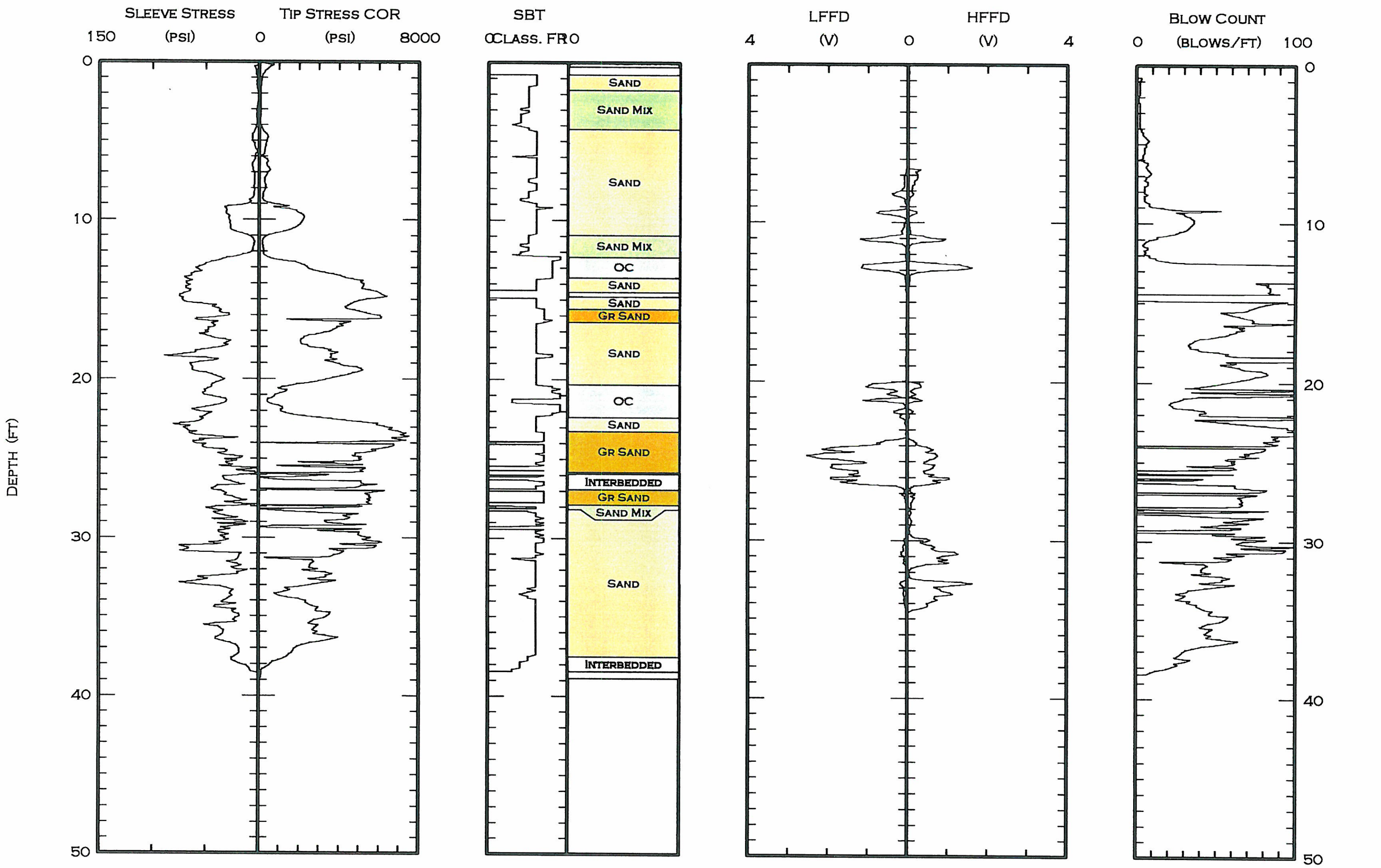
Test ID: CPT-16
File: z29g0009c.ecp

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 29/Aug/2000
Test ID: CPT-17
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 38.88 (FT)

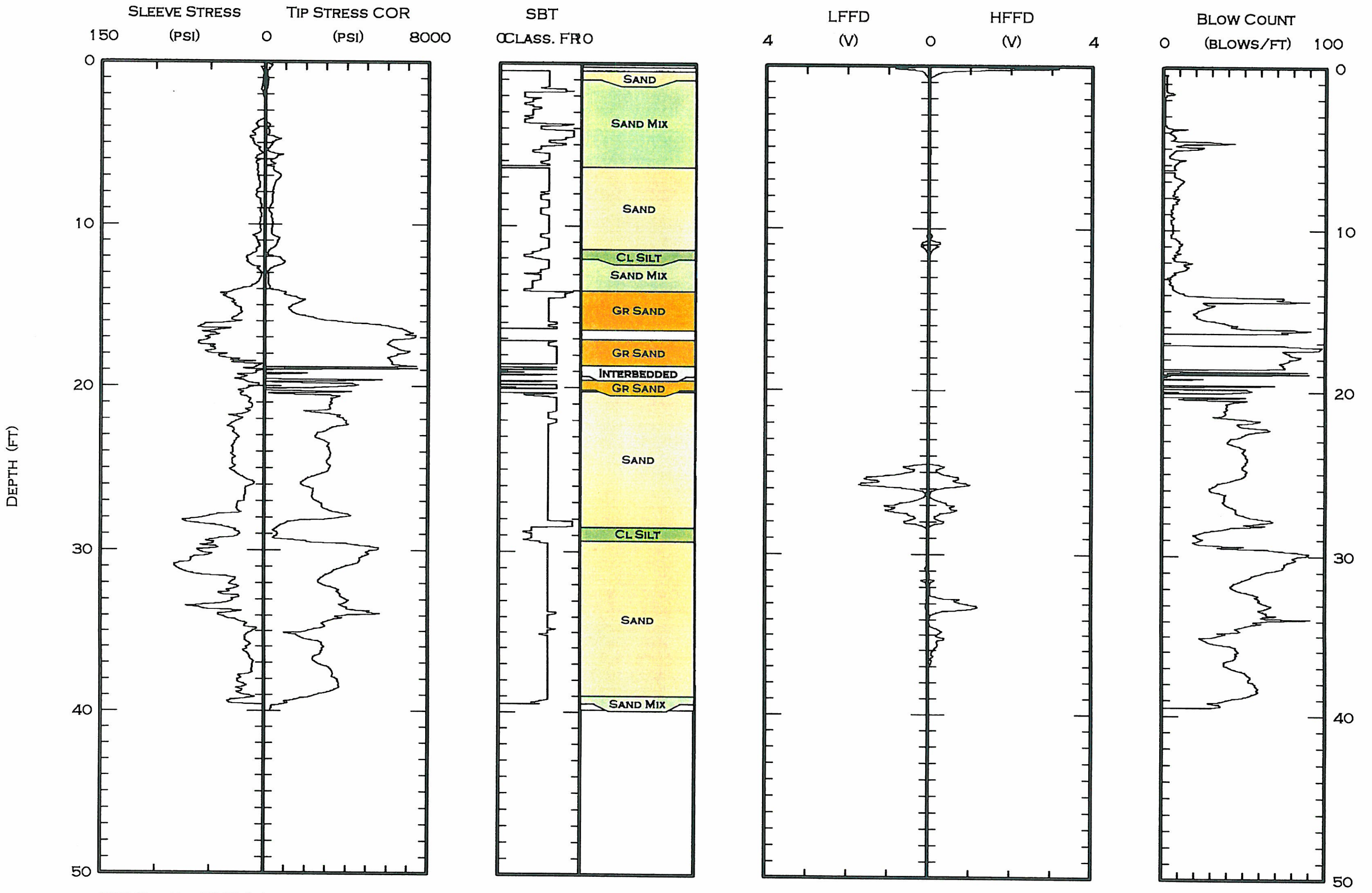
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

TEST ID: CPT-17
FILE: Z29G0015C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:
Client: Sun
Site: Sunnoco Belmont Refinery

Date: 29/Aug/2000
Test ID: CPT-18
Project: PhlSun



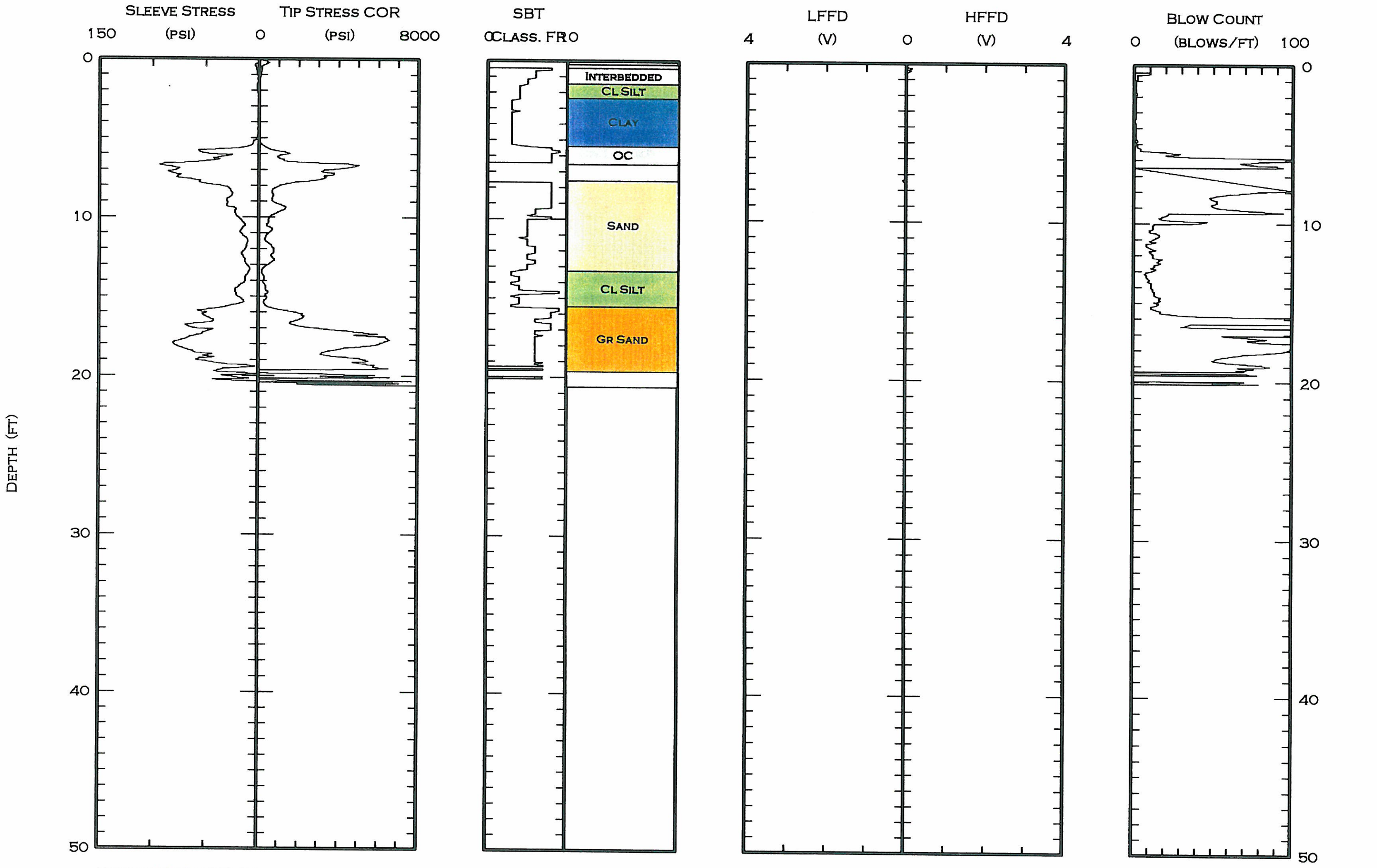
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-18
File: z29g0006c.ecp

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:
Client: Sun
Site: Sunnoco Belmont Refinery

Date: 29/Aug/2000
Test ID: CPT-19
Project: PhlSun



Maximum depth: 20.61 (ft)

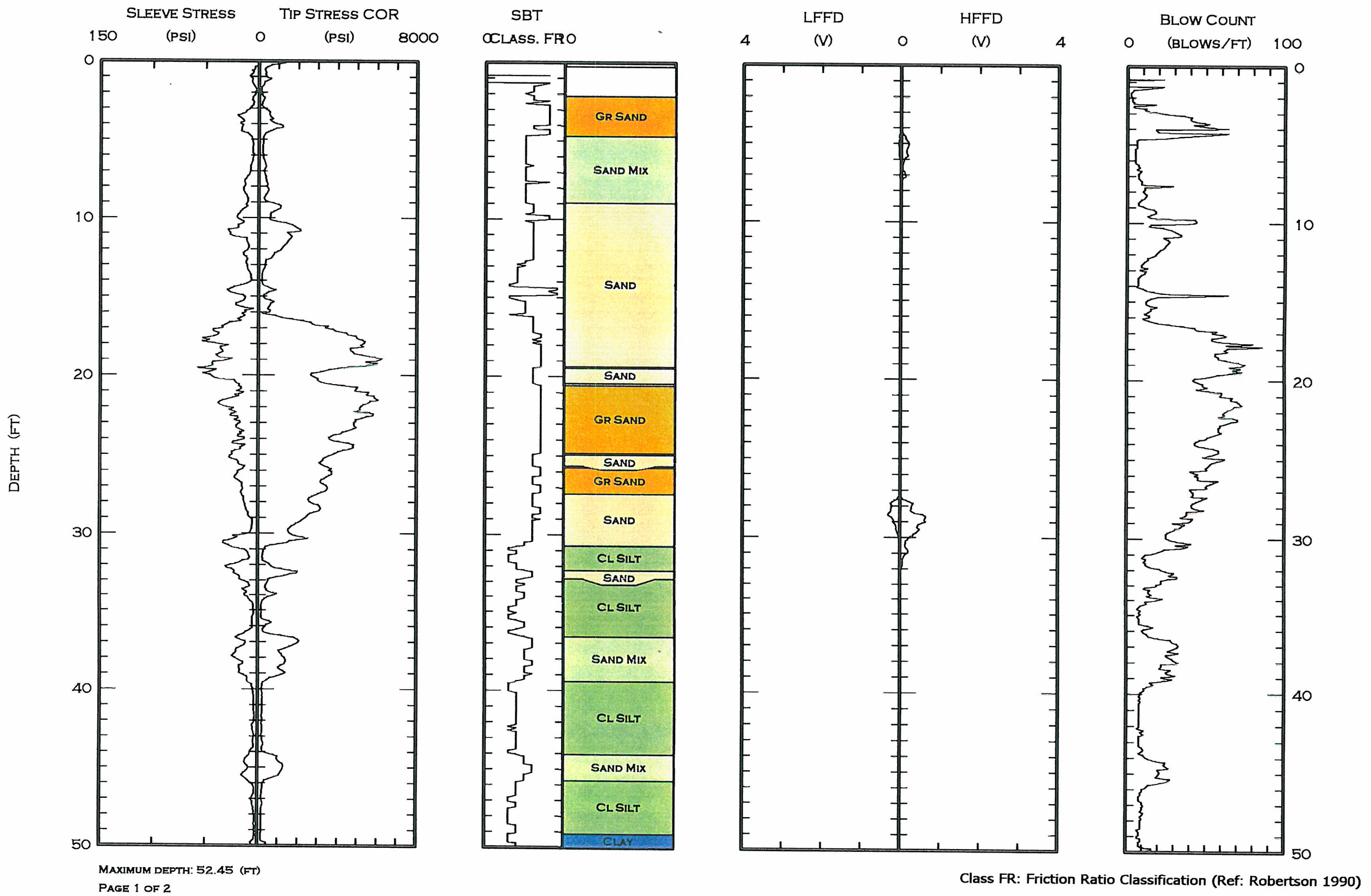
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-19
File: Z29G0011C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:
Client: Sun
Site: Sunnoco Belmont Refinery

Date: 30/Aug/2000
Test ID: CPT-20
Project: PhlSun



MAXIMUM DEPTH: 52.45 (FT)
PAGE 1 OF 2

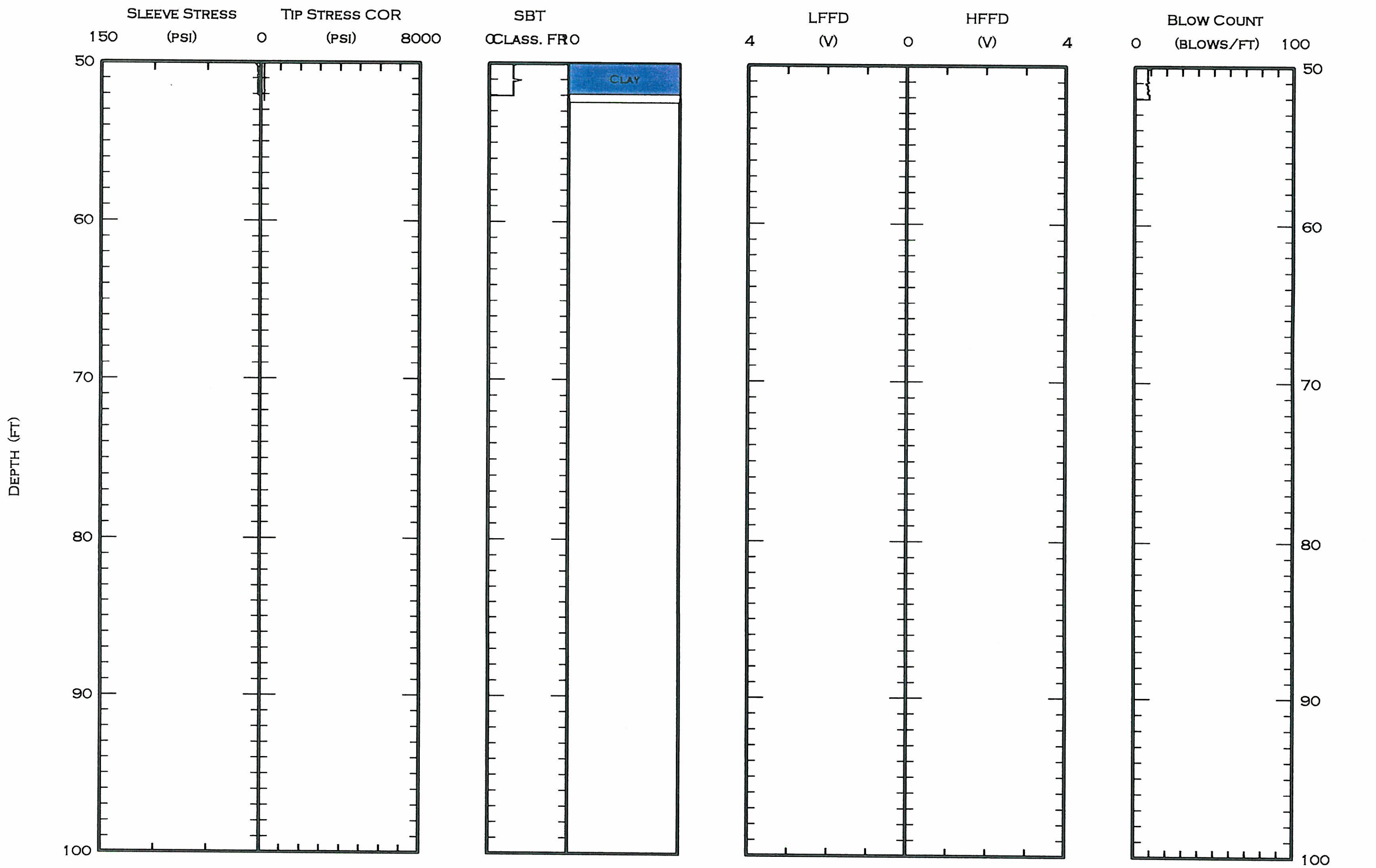
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

TEST ID: CPT-20
FILE: Z30G0005C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:
Client: Sun
Site: Sunnoco Belmont Refinery

Date: 30/Aug/2000
Test ID: CPT-20
Project: PhlSun



Maximum depth: 52.45 (ft)
Page 2 of 2

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

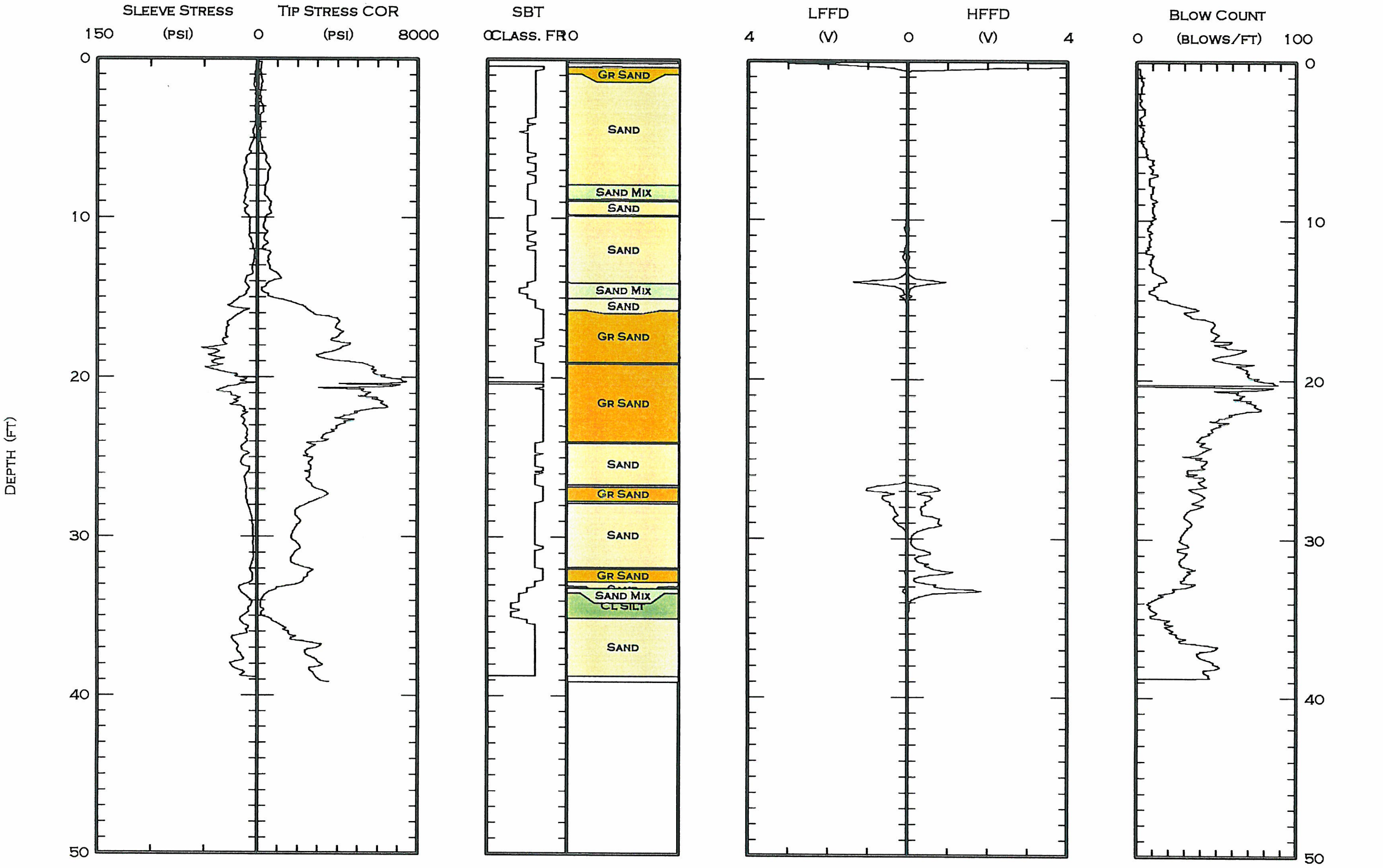
Test ID: CPT-20
File: z30g0005c.ecp

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 30/Aug/2000
Test ID: CPT-21
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 39.13 (FT)

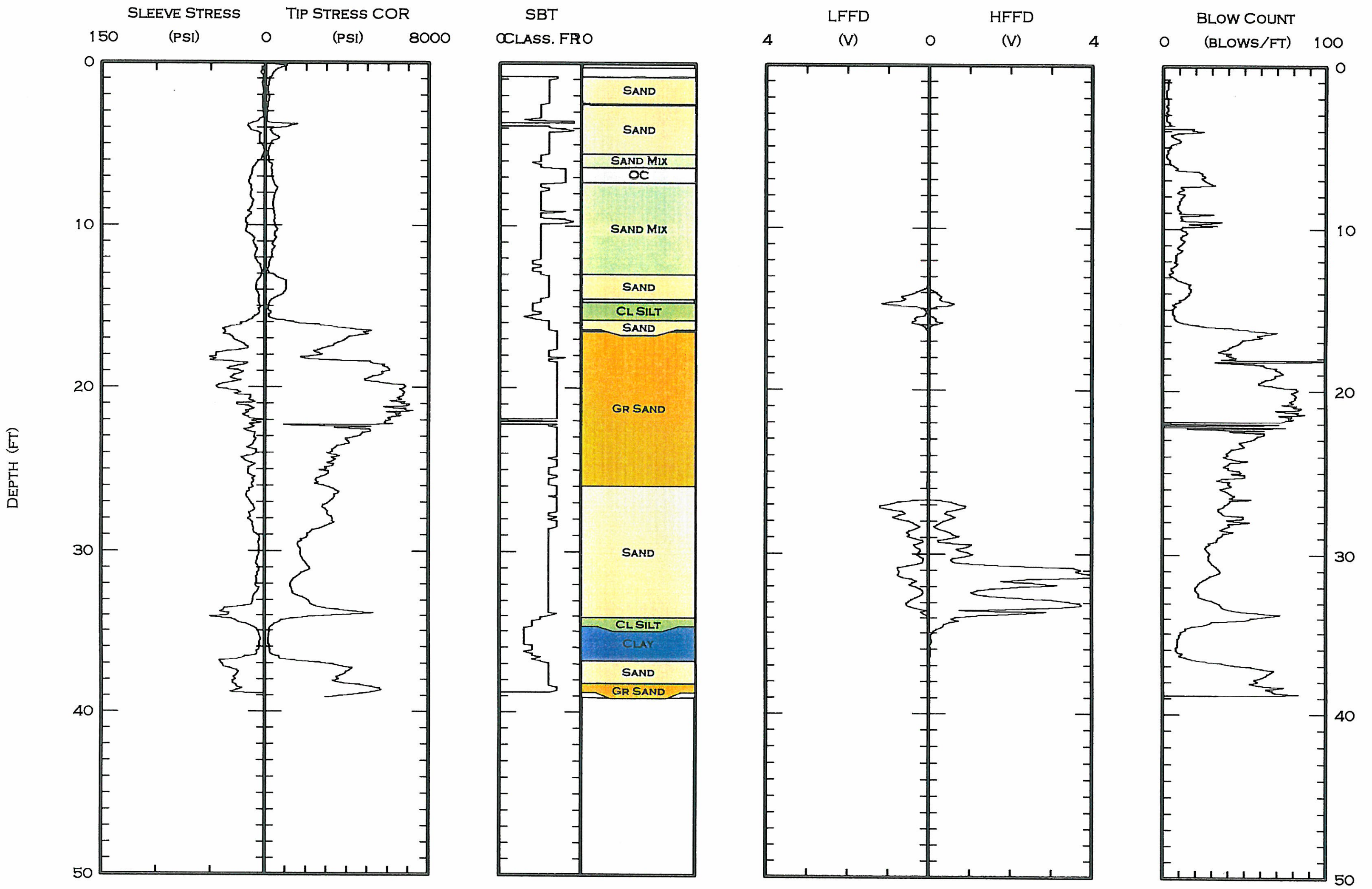
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

TEST ID: CPT21
FILE: Z30G0004C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:
Client: Sun
Site: Sunnoco Belmont Refinery

Date: 30/Aug/2000
Test ID: CPT-22
Project: PhlSun



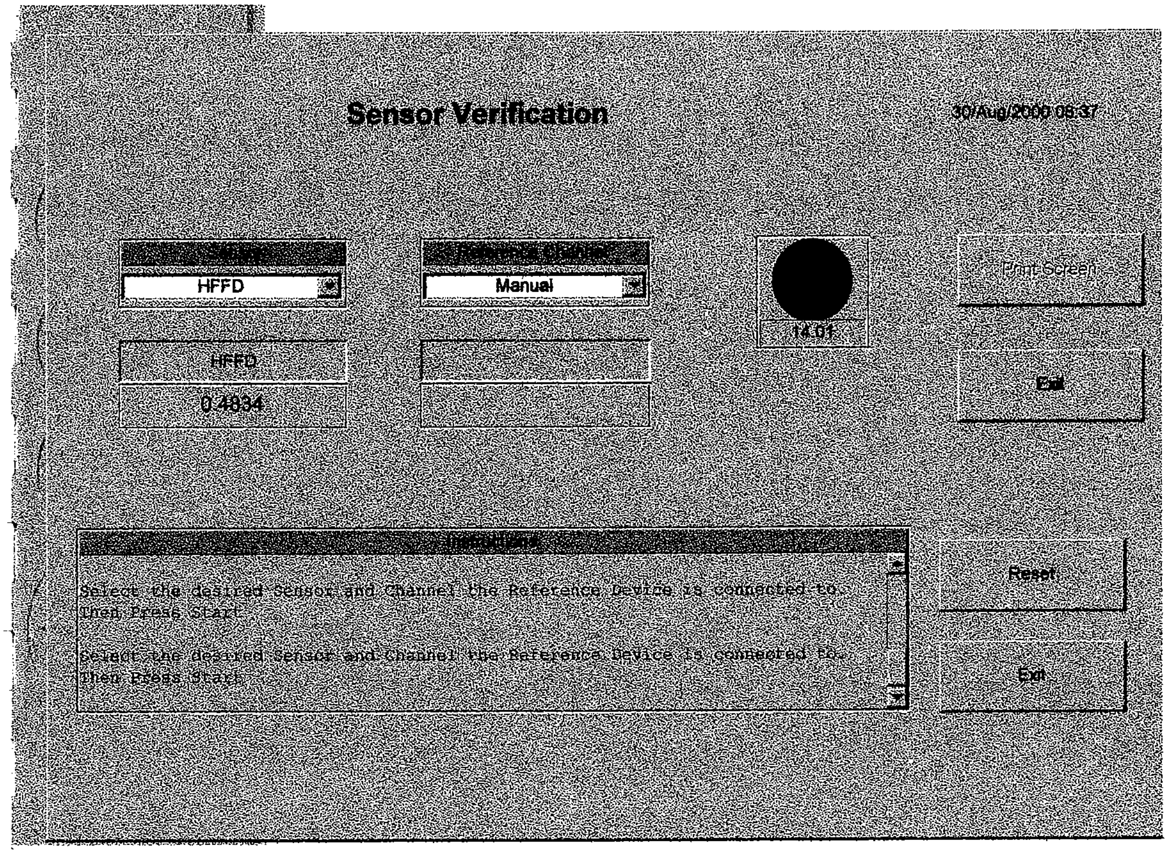
Maximum depth: 39.13 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-22
File: z30g0003c.ecp

APPENDIX B

SITE CALIBRATION DATA
(CPT/FFD MODULE)



Sensor Verification

30/Aug/2000 08:37

HFFD

Manual

14.01

HFFD

0.4834

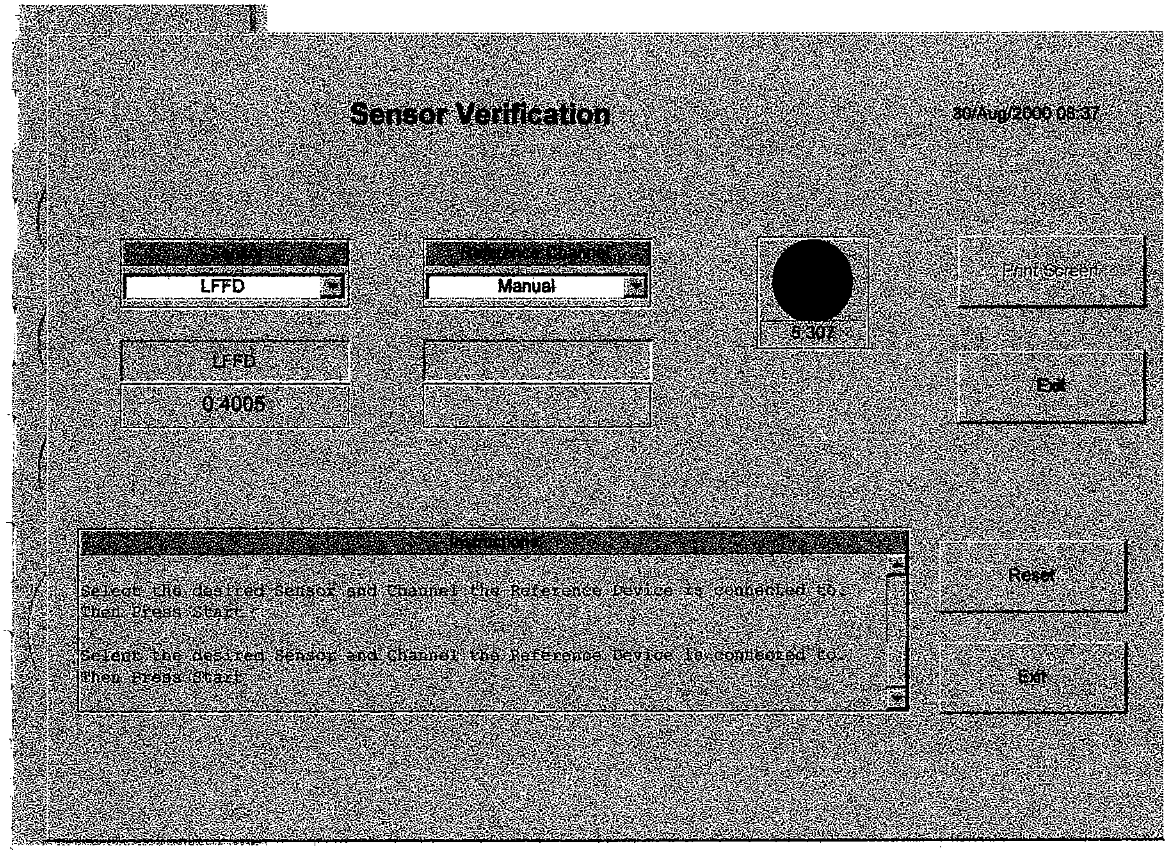
Instructions

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Vertek CalibrationCard
#2

3



Sensor Verification

30/Aug/2000 08:37

Sensor: LFFD

Reference Channel: Manual

LFFD

0.4005

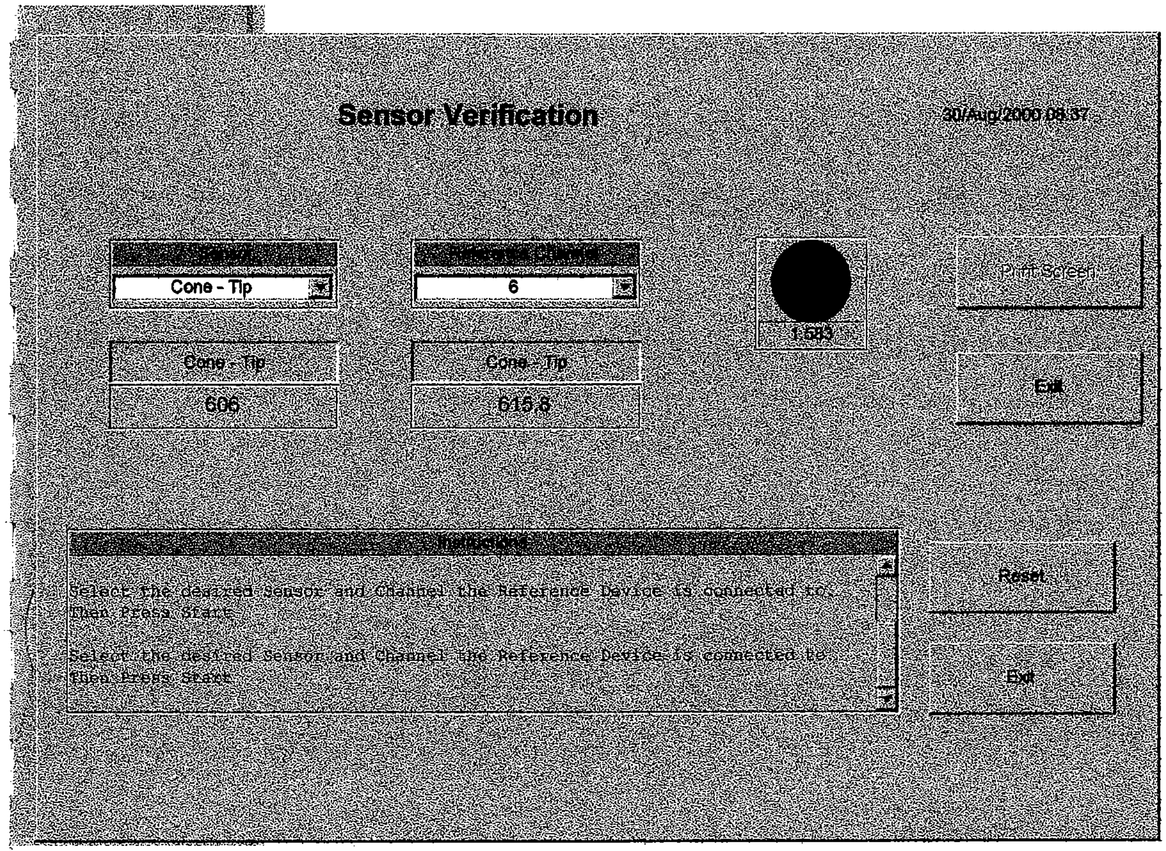
5.307

Instructions

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start.

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start.

Vertek CALIBRATION CARD
#2



Sensor: Cone - Tip

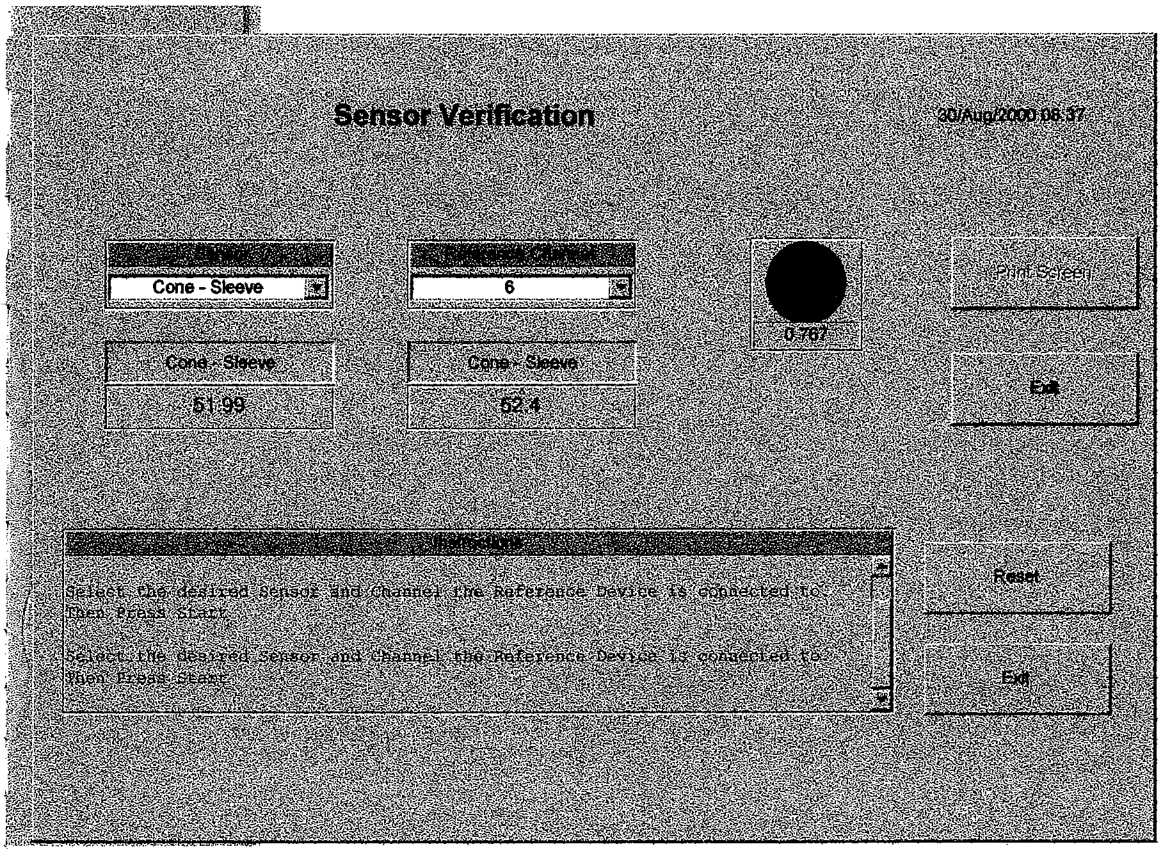
Reference Channel: 6

Cone - Tip	Cone - Tip
606	615.8

1.583

```
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start
```



Sensor: Cone - Sleeve

Reference Channel: 6

Cone - Sleeve 51.99

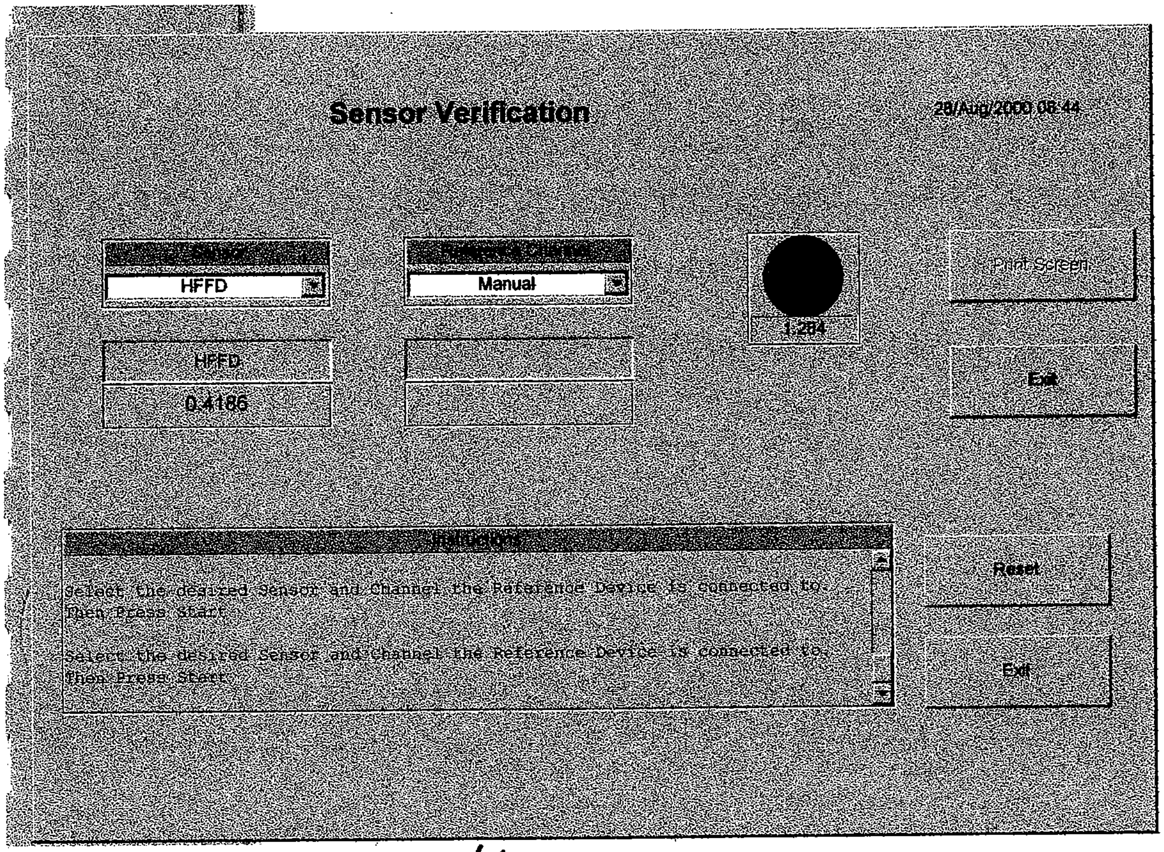
Cone - Sleeve 52.4

Instructions

Select the desired Sensor and Channel the Reference Device is connected to
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to
Then Press Start

Mon 28/Aug/2000 09:05:42



Sensor Verification

28/Aug/2000 08:44

Sensor: HFFD

Reference Channel: Manual

HFFD

0.4186

1.284

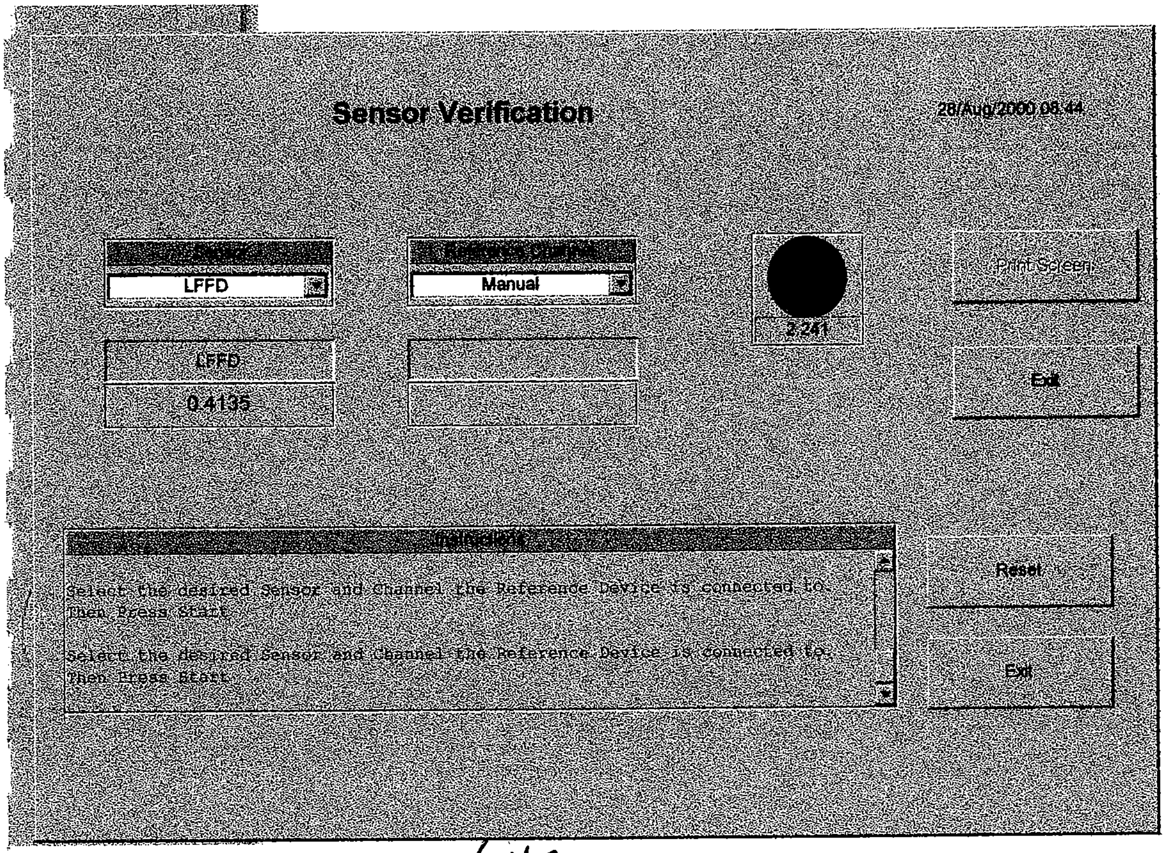
Instructions

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Vertek card #2

Mon 28/Aug/2000 09:04:32



Sensor Verification

28/Aug/2000 08:44

Sensor: LFFD

Reference Channel: Manual

2.241

LFFD

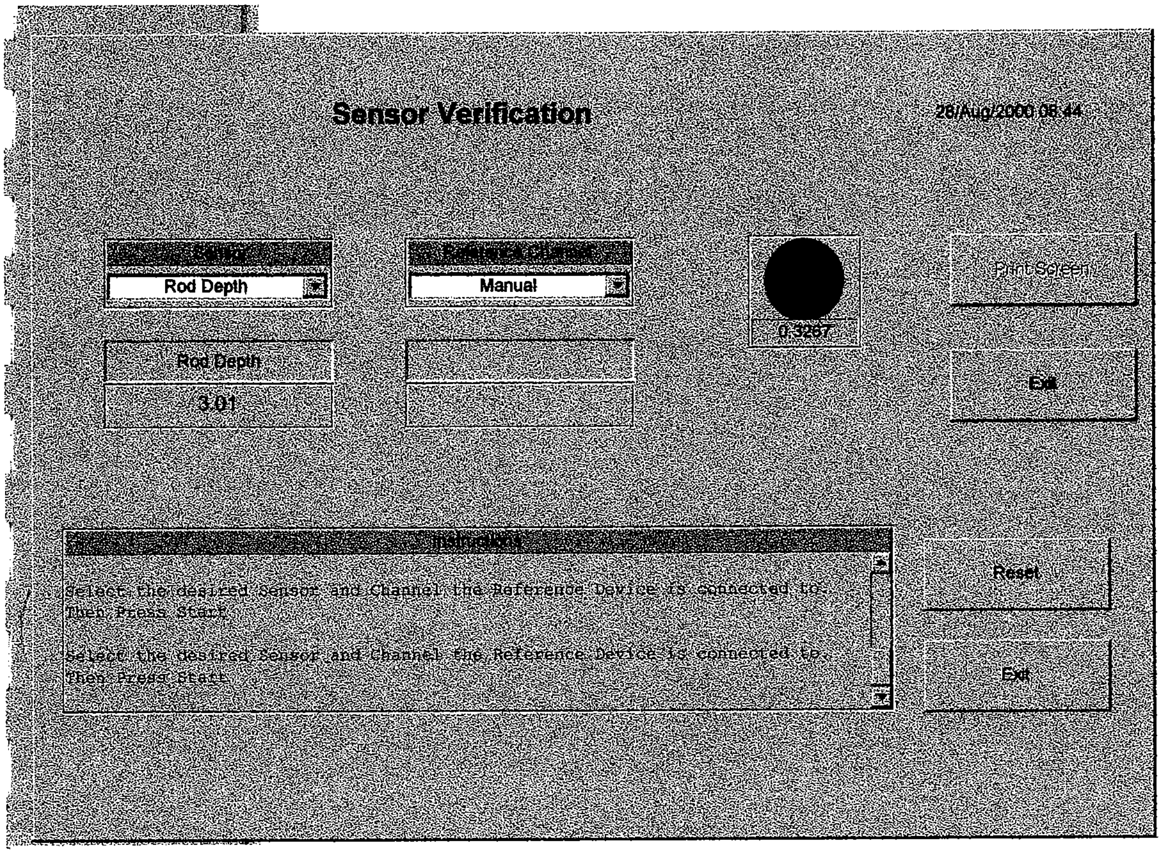
0.4135

Instructions

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

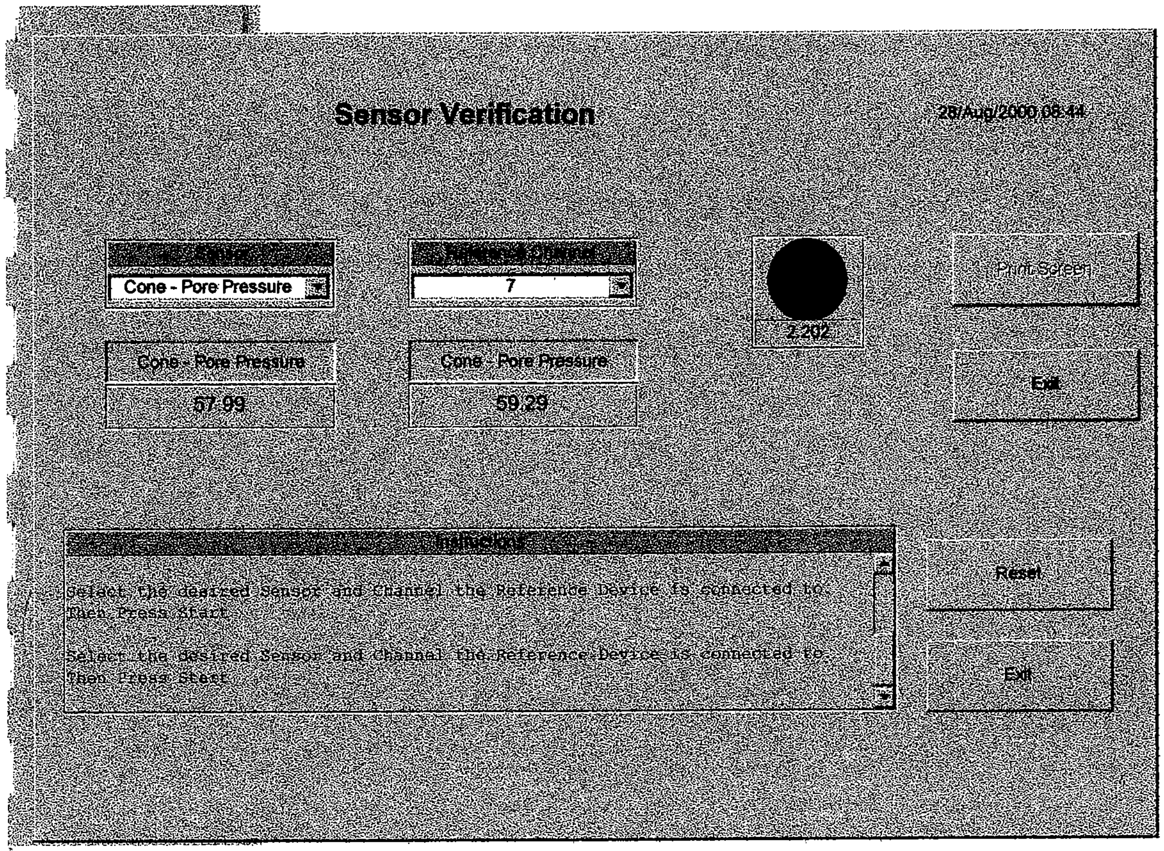
Vertek Card #2



Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Mon 28/Aug/2000 08:58:32



Sensor Verification

28/Aug/2000 08:44

Sensor: Cone - Pore Pressure

Reference Channel: 7

●

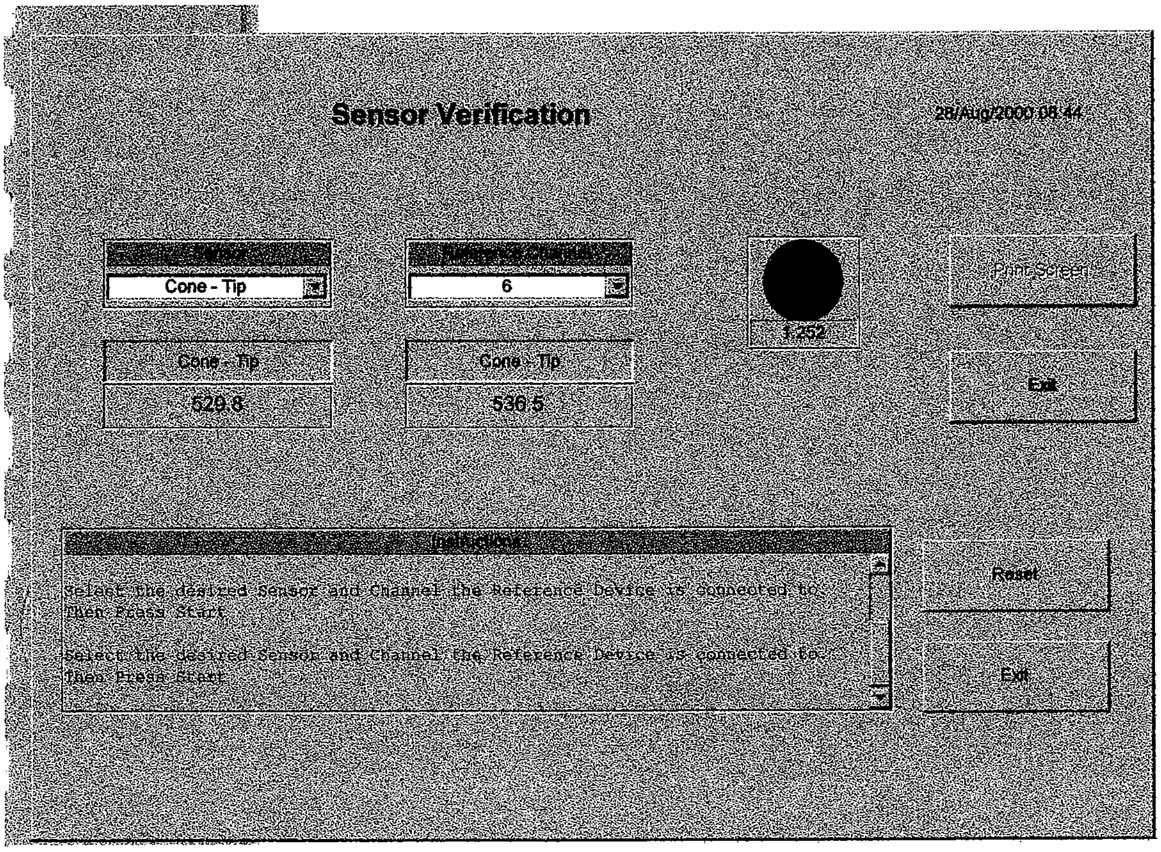
2.202

Cone - Pore Pressure	Cone - Pore Pressure
57.99	59.29

Instructions

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start



Sensor Verification

28/Aug/2000 08:44

Sensor: Cone - Tip

Reference Channel: 6

1.252

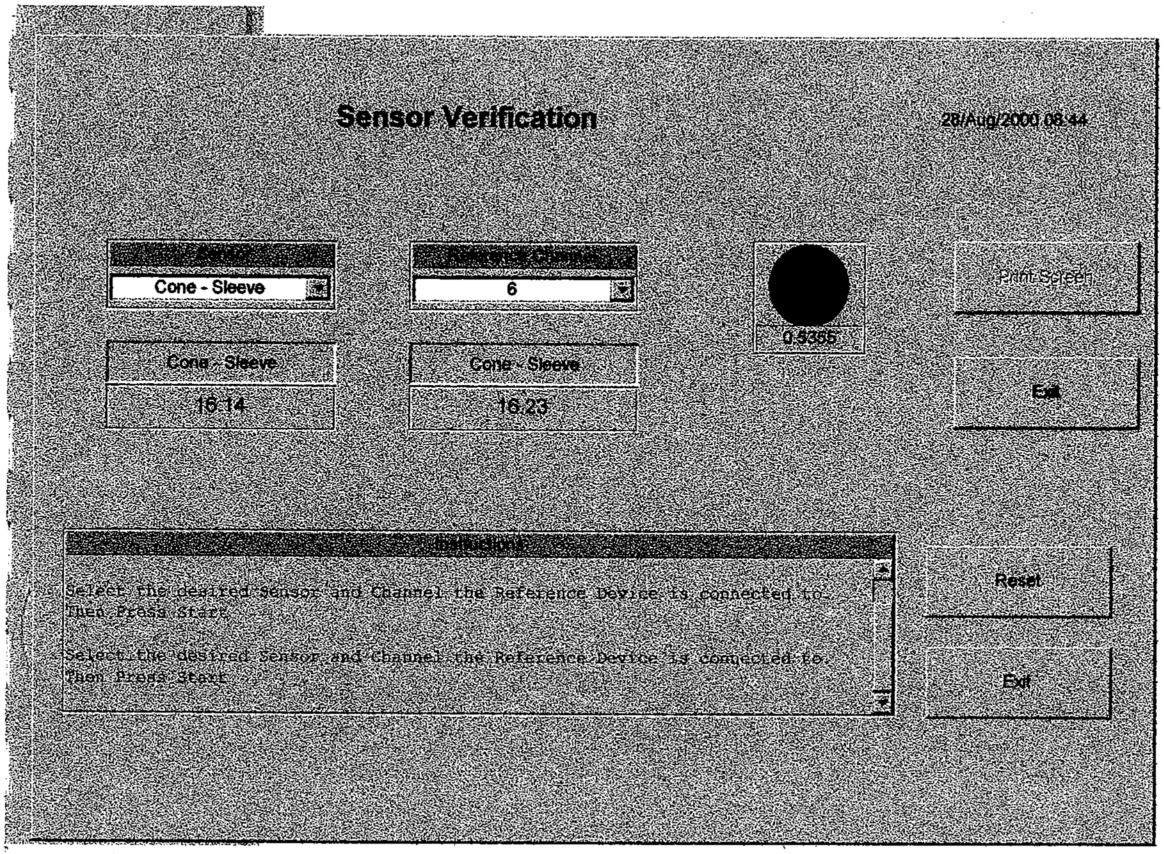
Cone - Tip
529.8

Cone - Tip
536.5

Instructions

Select the desired Sensor and Channel the Reference Device is connected to
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to
Then Press Start



Sensor: Cone - Sleeve

Reference Channel: 6

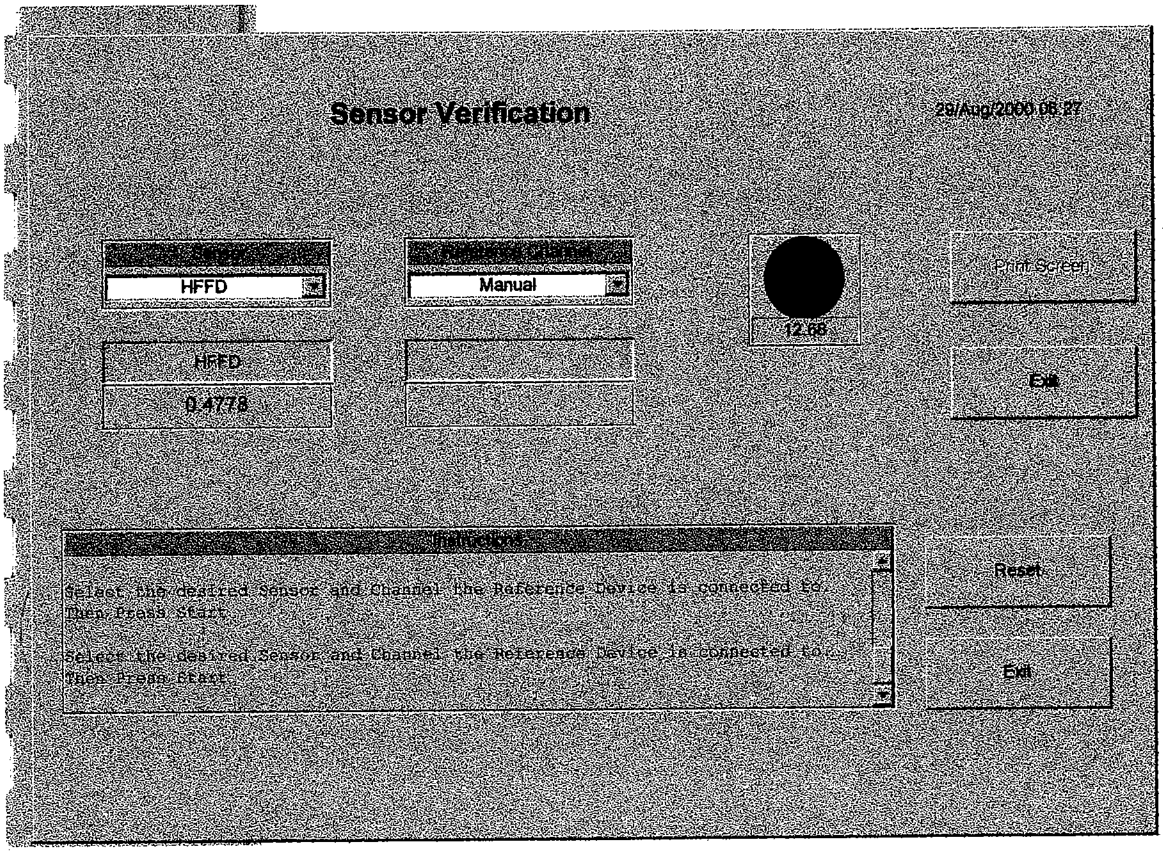
0.5355

Cone - Sleeve	Cone - Sleeve
16.14	16.23

Instructions

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start



Sensor Verification

29/Aug/2000 08:27

Sensor: HFFD

Reference Channel: Manual

HFFD

0.4778

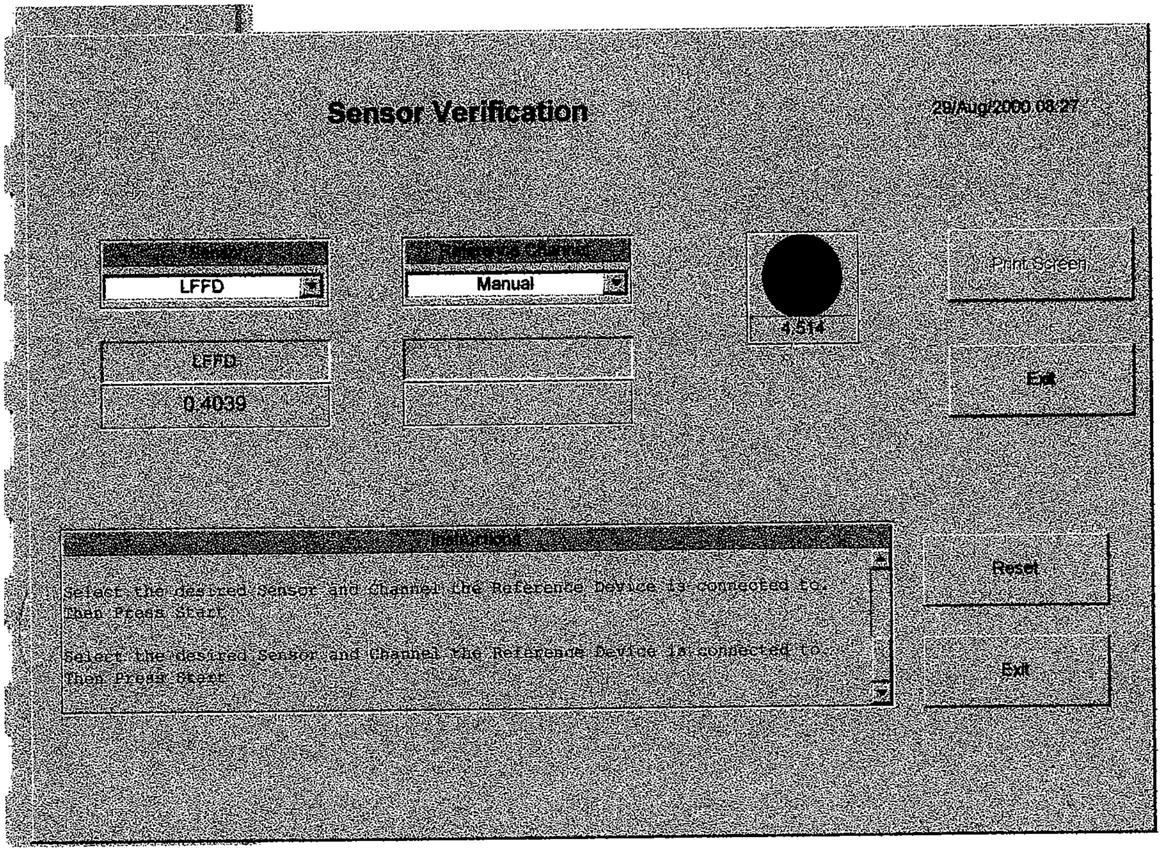
12.68

Instructions

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Tue 29/Aug/2000 08:51:01



Sensor Verification

29/Aug/2000 08:27

Reference Channel

LFFD

Manual

LFFD

0.4039

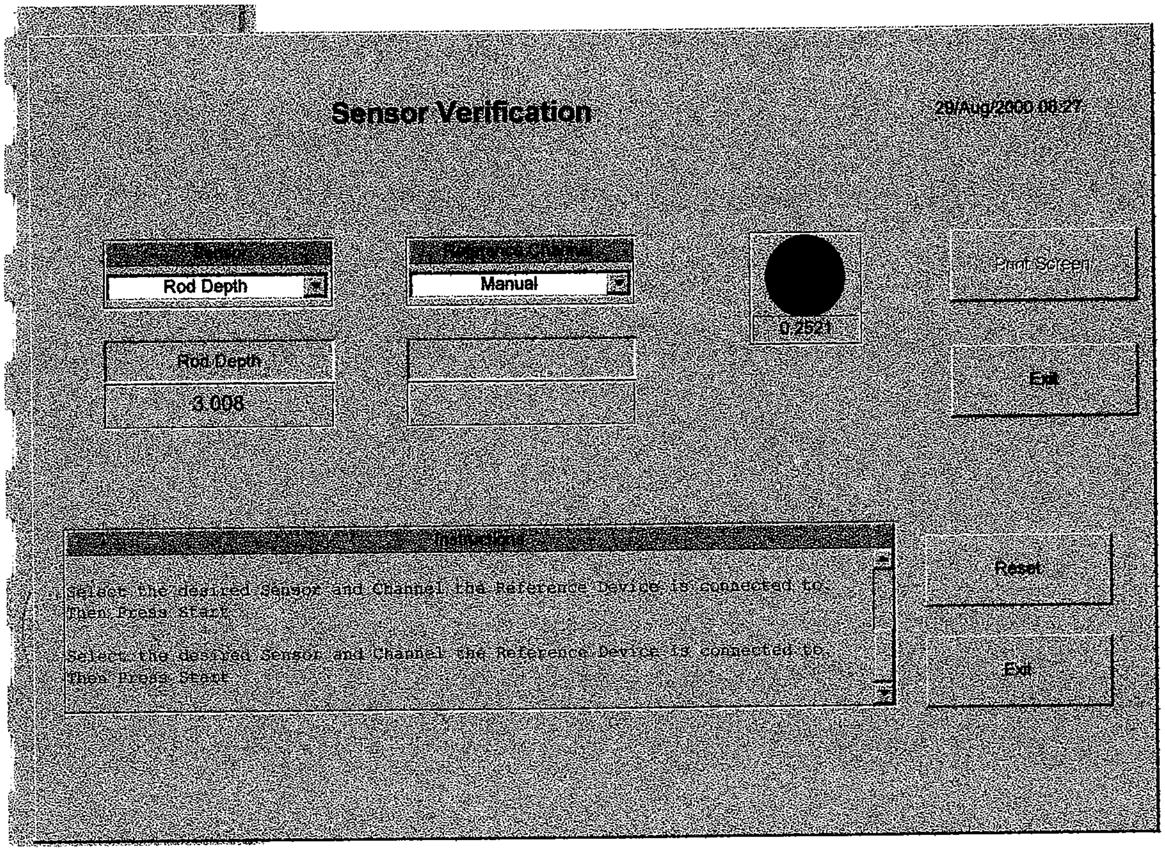
4.514

Instructions

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Tue 29/Aug/2000 08:47:31



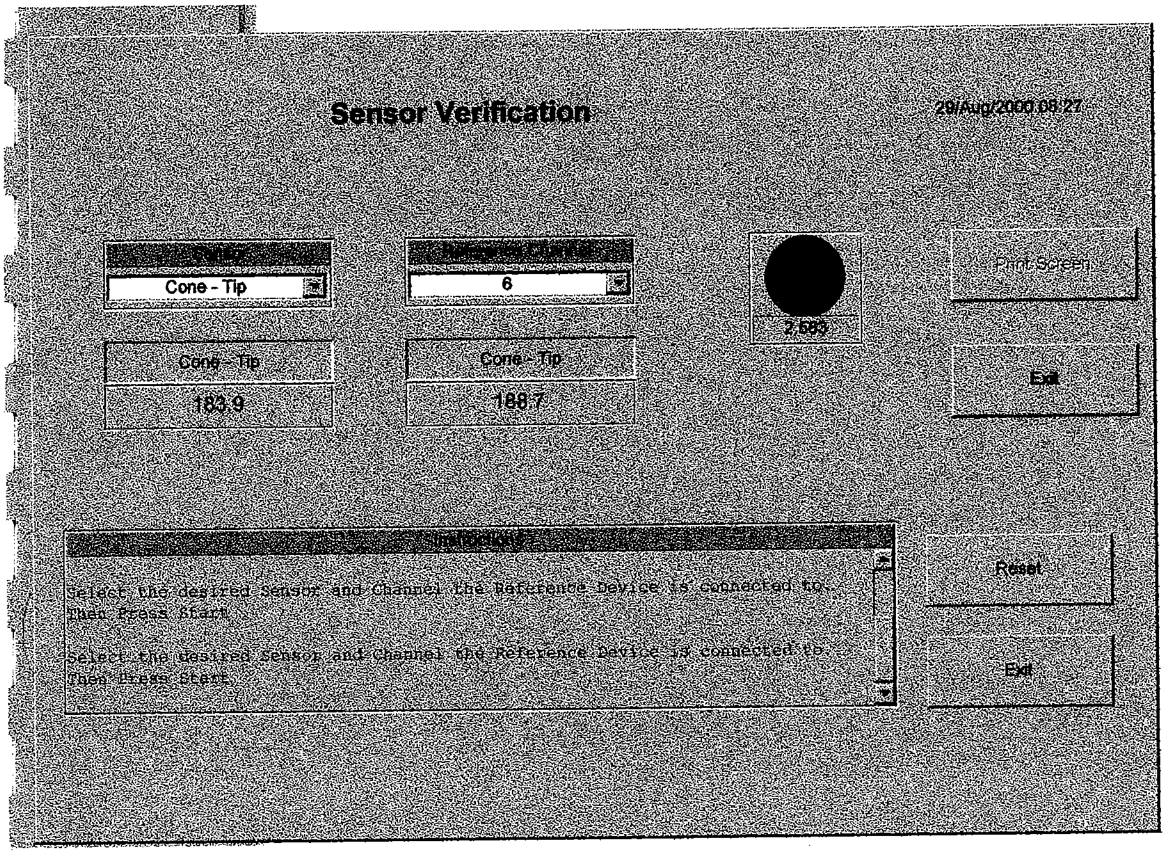
Sensor: Rod Depth

Reference Channel: Manual

Select the desired Sensor and Channel the Reference Device is connected to
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to
Then Press Start

Tue 29/Aug/2000 08:41:29



Sensor Verification

29/Aug/2000 08:27

Sensor: Cone - Tip

Reference Channel: 6

2.583

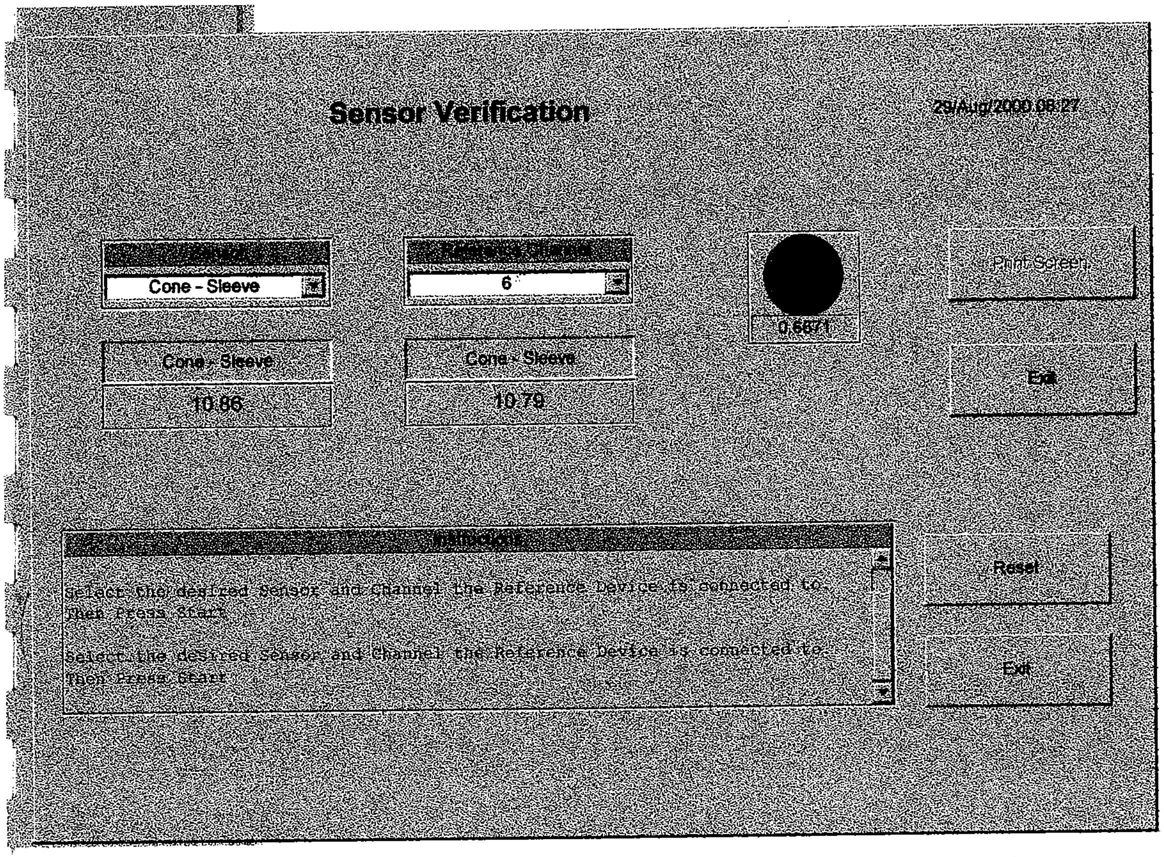
Cone - Tip	Cone - Tip
183.9	188.7

Instructions

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Tue 29/Aug/2000 08:30:52



```
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start

Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start
```

APPENDIX III
API LNAPL TRANSMISSIVITY WORKBOOKS

Light Non-aqueous Phase Liquid (LNAPL) Site Conceptual Model (LCSM)
Area of Interest 1

PHILADELPHIA REFINERY COMPLEX
PHILADELPHIA, PENNSYLVANIA
PHILADELPHIA REFINERY OPERATIONS,
A SERIES OF EVERGREEN RESOURCES GROUP, LLC
3144 PASSYUNK AVENUE, PHILADELPHIA, PENNSYLVANIA

Well Designation:	CSX-MW-5	Beckett and Lyverse (2002)
Date:		

Ground Surface Elev (ft msl)	0.0	Enter These Data
Top of Casing Elev (ft msl)	0.0	
Well Casing Radius, r_c (ft):	0.083	r_{e1}
Well Radius, r_w (ft):	0.344	
LNAPL Specific Yield, S_y:	0.175	
LNAPL Density Ratio, ρ_r:	0.793	
Top of Screen (ft bgs):	10.0	
Bottom of Screen (ft bgs):	60.0	
LNAPL Baildown Vol. (gal.):	0.1	
Effective Radius, r_{e3} (ft):	0.163	Calculated Parameters
Effective Radius, r_{e2} (ft):	0.100	
Initial Casing LNAPL Vol. (gal.):	0.10	
Initial Filter LNAPL Vol. (gal.):	0.29	

Drawdown Adjustment (ft)
0.075

Enter Data Here

	Time (min)	DTP (ft btoc)	DTW (ft btoc)	DTP (ft bgs)
Initial Fluid Levels:	0	47.26	47.89	47.26
Enter Test Data:	0.1	47.50	47.64	47.50
	0.5	47.48	47.68	47.48
	1.5	47.43	47.65	47.43
	7.5	47.39	47.62	47.39
	9.5	47.37	47.62	47.37
	11.5	47.36	47.62	47.36
	13.5	47.36	47.64	47.36
	20.5	47.35	47.64	47.35
	26.5	47.34	47.64	47.34
	36.5	47.34	47.65	47.34
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A

Generalized Bouwer and Rice (1976)

Well Designation:	CSX-MW-5
Date:	

$$T_n = \frac{r_e^{\,2}\ln(R/r_e)\ln(s_n(t_1)/s_n(t))}{2(-J)(t-t_1)}$$

Enter early time cut-off for least-squares model fit

Time_{cut}	10

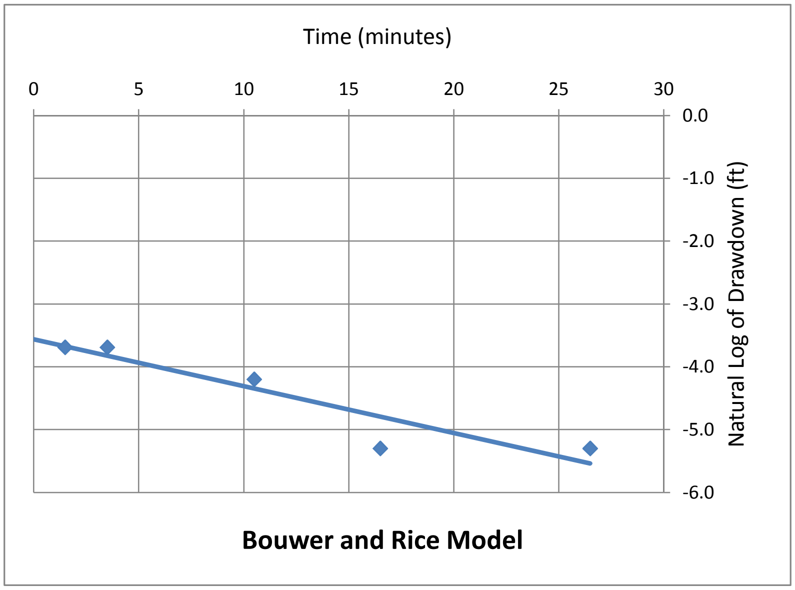
<- Enter or change value here

Model Results: T_n (ft^2/d) = 1.60 +/- 0.36 ft^2/d

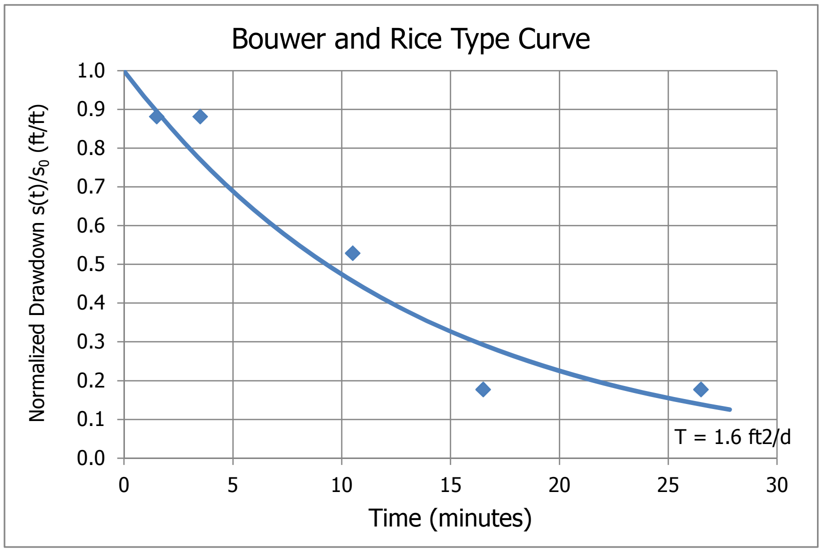
L_e/r_e 3.9
C 0.95
R/r_e 2.58

J-Ratio -0.839

Coef. Of Variation 0.23



C coefficient calculated from Eq. 6.5(c) of Butler, The Design, Performance, and Analysis of Slug Tests, CRC Press, 2000.



Cooper and Jacob (1946)

Well Designation:	CSX-MW-5
Date:	

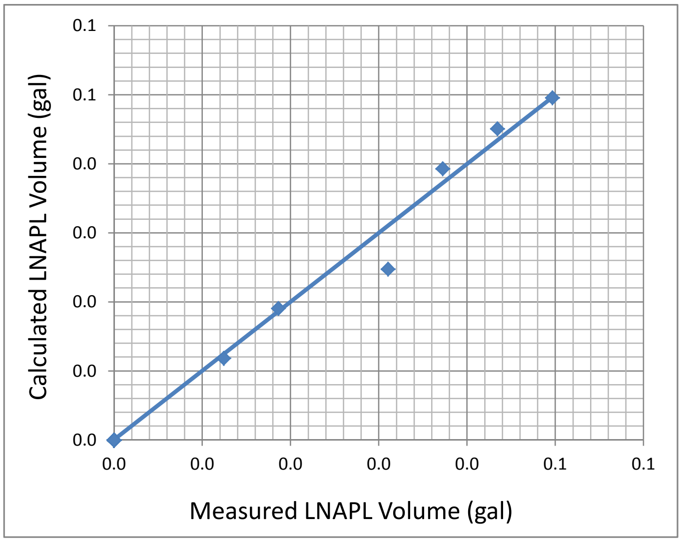
$$V_n(t_i) = \sum_{j}^{i} \frac{4\pi T_n s_j}{\ln\left(\frac{2.25 T_n t_j}{r_e^{2} S_n}\right)} \Delta t_j$$

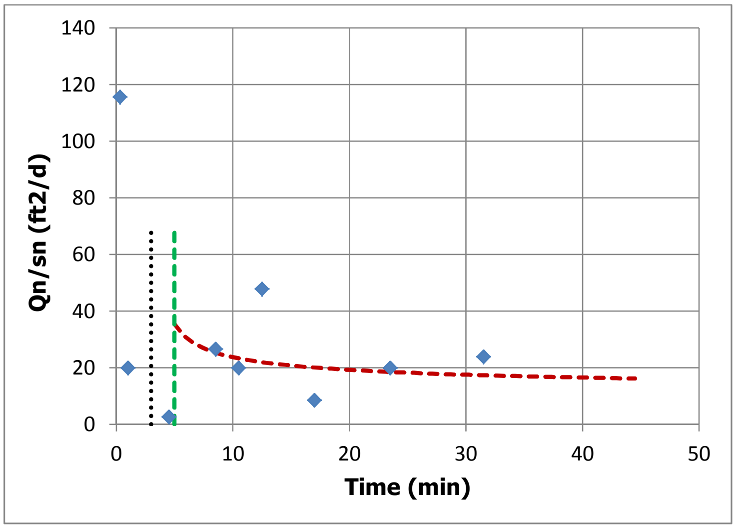
Enter early time cut-off for least-squares model fit

Time_{cut} (min):	5	<- Enter or change values here
Time Adjustment (min):	3	
Trial S_n:	d	<-- Enter d for default or enter S_n value
Root-Mean-Square Error:	0.007	<-- Minimize this using "Solver"
	0.067	<-- Working S_n
Trial T_n (ft^2/d):	7.139	<-- By changing T_n through "Solver"

Add constraint $T_n > 0.00001$

Model Result: T_n (ft^2/d) = **7.14**





Height

70

Cooper, Bredehoeft and Papadopulos (1967)

Well Designation:	CSX-MW-5
Date:	

Enter early time cut-off for least-squares model fit

Time_{cut} (min):	3	<- Enter or change values here
Initial Drawdown s_n (ft):	0.08	

Trial S_n: d <-- Enter d for default

Root-Mean-Square Error: 0.212 <-- Minimize this using "Solver"

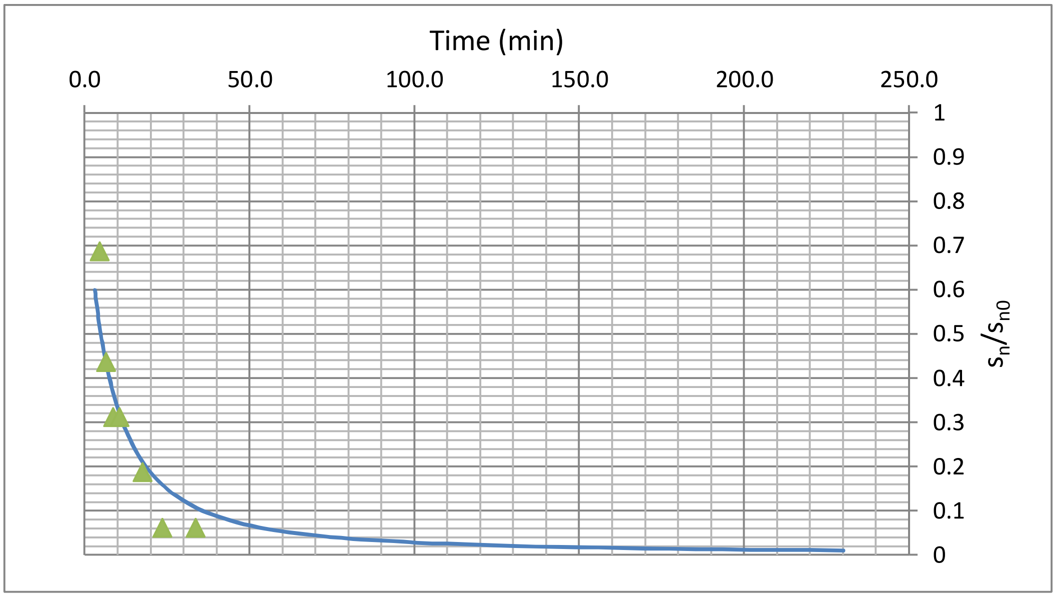
Trial T_n (ft^2/d): 4.933 <-- By changing T_n through "Solver"

0.056 <-- Working S_n

Add constraint Tn > 0.00001

Model Result: T_n (ft^2/d) = **4.93**

T_{min}	3
T_{max}	230



J-Ratio
-0.839

Well Designation:	S-50	Beckett and Lyverse (2002)
Date:		

Ground Surface Elev (ft msl)	0.0	Enter These Data	**Drawdown Adjustment (ft)**
Top of Casing Elev (ft msl)	0.0		
Well Casing Radius, r_c (ft):	0.083	r_{e1}	0
Well Radius, r_w (ft):	0.344		
LNAPL Specific Yield, S_y:	0.175		
LNAPL Density Ratio, ρ_r:	0.751		
Top of Screen (ft bgs):	10.0		
Bottom of Screen (ft bgs):	30.0		
LNAPL Baildown Vol. (gal.):	0.8		
Effective Radius, r_{e3} (ft):	0.163	Calculated Parameters	
Effective Radius, r_{e2} (ft):	0.105		
Initial Casing LNAPL Vol. (gal.):	0.17		
Initial Filter LNAPL Vol. (gal.):	0.47		

Enter Data Here

	Time (min)	DTP (ft btoc)	DTW (ft btoc)	DTP (ft bgs)
Initial Fluid Levels:	0	24.68	25.71	24.68
Enter Test Data:	0.1	25.09	25.29	25.09
	0.5	25.04	25.27	25.04
	1.0	24.99	25.25	24.99
	7.0	24.81	25.11	24.81
	11.0	24.79	25.11	24.79
	25.0	24.76	25.13	24.76
	28.0	24.75	25.13	24.75
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A

Generalized Bouwer and Rice (1976)

Well Designation:	S-50
Date:	

$$T_n = \frac{r_e^{\ 2}\ln(R/r_e)\ln(s_n(t_1)/s_n(t))}{2(-J)(t-t_1)}$$

Enter early time cut-off for least-squares model fit

Time_{cut}	5

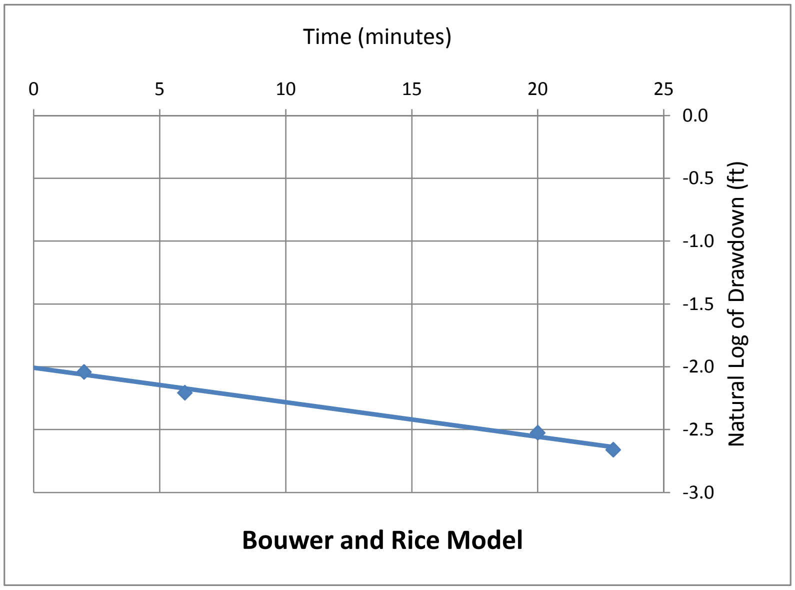
<- Enter or change value here

Model Results: T_n (ft^2/d) = 0.87 +/- 0.07 ft^2/d

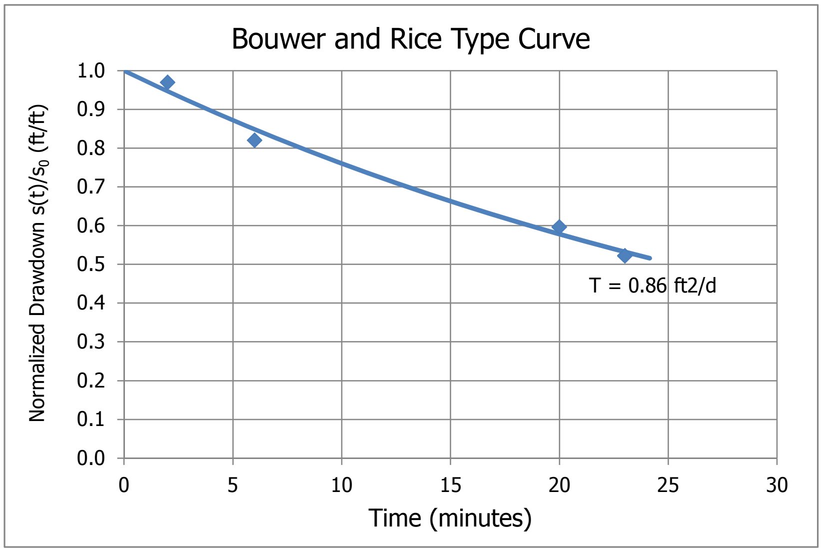
L_e/r_e
6.3
C
1.05
R/r_e
3.72

J-Ratio
-0.789

Coef. Of Variation
0.08



C coefficient calculated from Eq. 6.5(c) of Butler, The Design, Performance, and Analysis of Slug Tests, CRC Press, 2000.



Cooper and Jacob (1946)

Well Designation:	S-50
Date:	

$$V_n(t_i) = \sum_{j}^{i} \frac{4\pi T_n s_j}{\ln\left(\frac{2.25\, T_n t_j}{r_e^{\,2} S_n}\right)} \Delta t_j$$

Enter early time cut-off for least-squares model fit

Time$_{cut}$ (min): 5 <- Enter or change values here

Time Adjustment (min): 3

Trial S_n: d <-- **Enter d for default or enter S_n value**

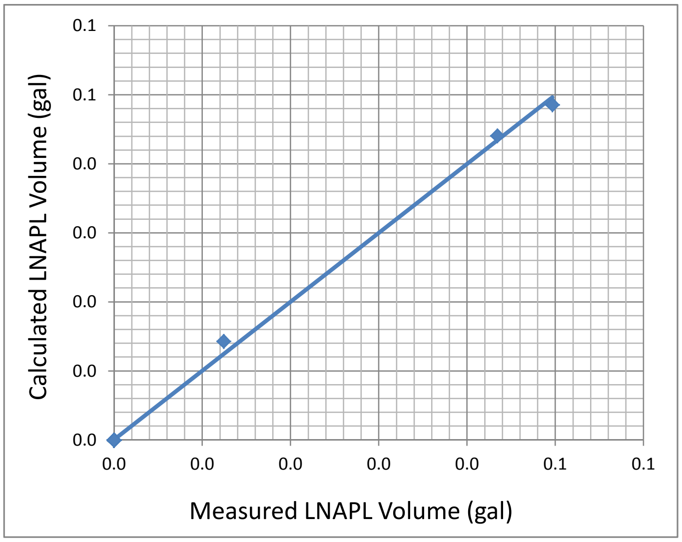
Root-Mean-Square Error: 0.002 <-- **Minimize this using "Solver"**

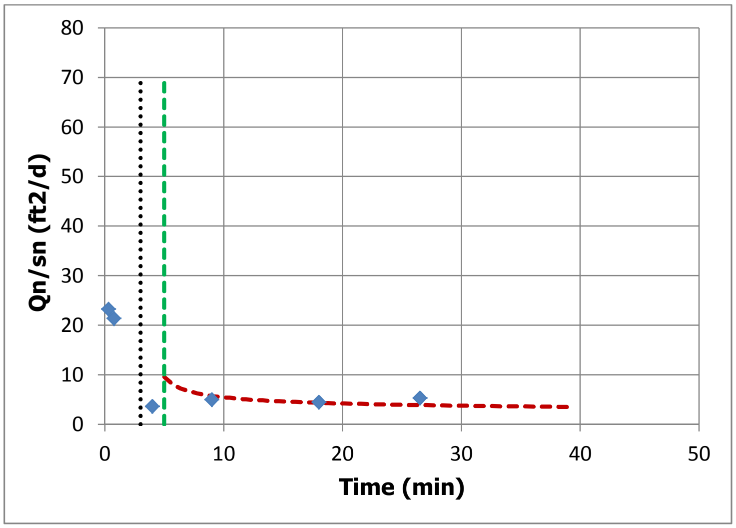
0.028 <-- **Working S_n**

Trial T_n (ft^2/d): 1.263 <-- **By changing T_n through "Solver"**

Add constraint $T_n > 0.00001$

Model Result: T_n (ft^2/d) = **1.26**





Height

70

Well Designation:	S-98	Beckett and Lyverse (2002)
Date:		

Ground Surface Elev (ft msl)	0.0	Enter These Data
Top of Casing Elev (ft msl)	0.0	
Well Casing Radius, r_c (ft):	0.167	r_{e1}
Well Radius, r_w (ft):	0.500	
LNAPL Specific Yield, S_y:	0.175	
LNAPL Density Ratio, ρ_r:	0.797	
Top of Screen (ft bgs):	10.0	
Bottom of Screen (ft bgs):	30.0	
LNAPL Baildown Vol. (gal.):	3.0	
Effective Radius, r_{e3} (ft):	0.258	Calculated Parameters
Effective Radius, r_{e2} (ft):	0.237	
Initial Casing LNAPL Vol. (gal.):	0.40	
Initial Filter LNAPL Vol. (gal.):	0.57	

Drawdown Adjustment (ft)
0.02

Enter Data Here

	Time (min)	DTP (ft btoc)	DTW (ft btoc)	DTP (ft bgs)
Initial Fluid Levels:	0	25.26	25.88	25.26
Enter Test Data:	0.1	25.42	25.48	25.42
	1.0	25.41	25.50	25.41
	2.0	25.40	25.52	25.40
	3.0	25.39	25.55	25.39
	4.0	25.38	25.58	25.38
	5.0	25.36	25.61	25.36
	6.0	25.35	25.64	25.35
	7.0	25.34	25.66	25.34
	8.0	25.34	25.68	25.34
	9.0	25.33	25.70	25.33
	10.0	25.33	25.71	25.33
	11.0	25.32	25.73	25.32
	12.0	25.32	25.74	25.32
	14.0	25.31	25.75	25.31
	15.0	25.3	25.76	25.30
	17.0	25.3	25.78	25.30
	19.0	25.3	25.79	25.30
	21.5	25.29	25.80	25.29
	24.0	25.29	25.81	25.29
	27.0	25.29	25.82	25.29
				#N/A
				#N/A

Generalized Bouwer and Rice (1976)

Well Designation:	S-98
Date:	

$$T_n = \frac{r_e^{\,2} \ln\left(R/r_e\right)\ln\left(s_n\left(t_1\right)/s_n\left(t\right)\right)}{2\left(-J\right)\left(t-t_1\right)}$$

L_e/r_e
2.4
C
0.89
R/r_e
1.85

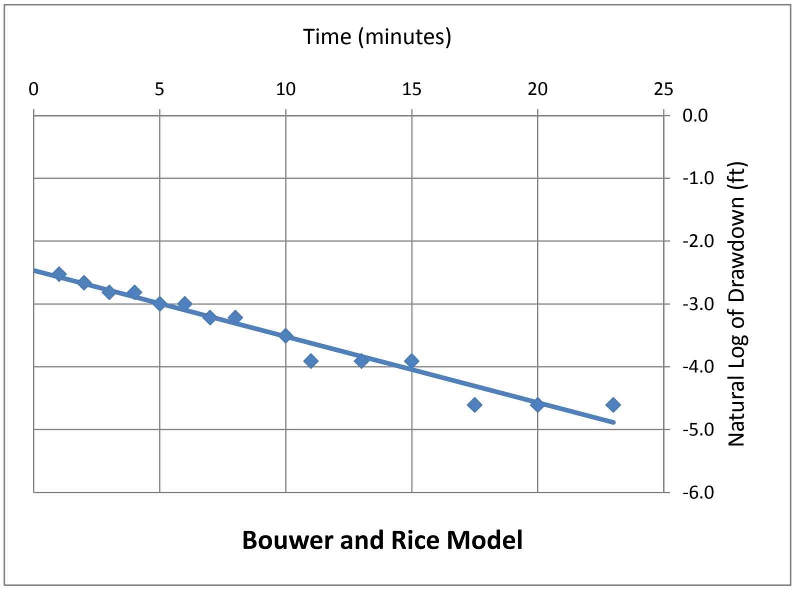
Enter early time cut-off for least-squares model fit

Time_{cut} | 4 | <- Enter or change value here

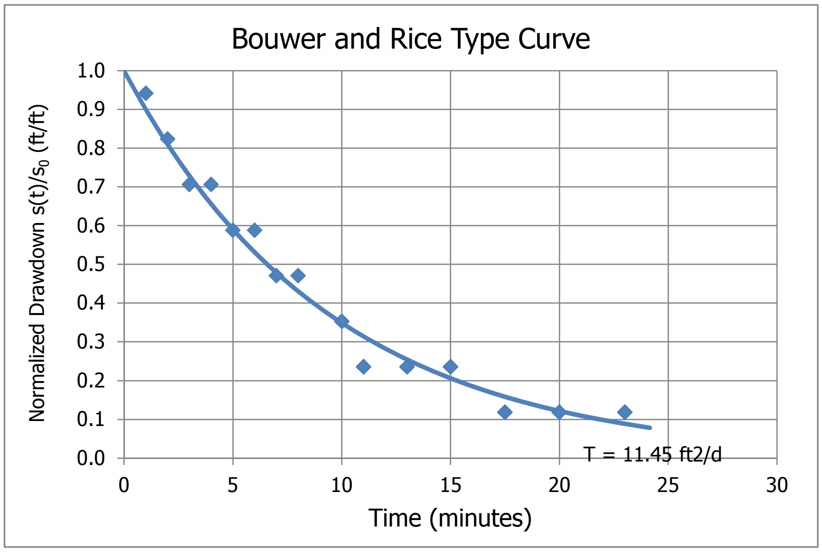
Model Results: T_n (ft^2/d) = 11.46 +/- 0.66 ft^2/d

J-Ratio
-0.271

Coef. Of Variation
0.06



C coefficient calculated from Eq. 6.5(c) of Butler, The Design, Performance, and Analysis of Slug Tests, CRC Press, 2000.



Cooper and Jacob (1946)

Well Designation:	S-98
Date:	

$$V_n(t_i) = \sum_{j}^{i} \frac{4\pi T_n s_j}{\ln\left(\frac{2.25\, T_n t_j}{r_e^{\,2} S_n}\right)} \Delta t_j$$

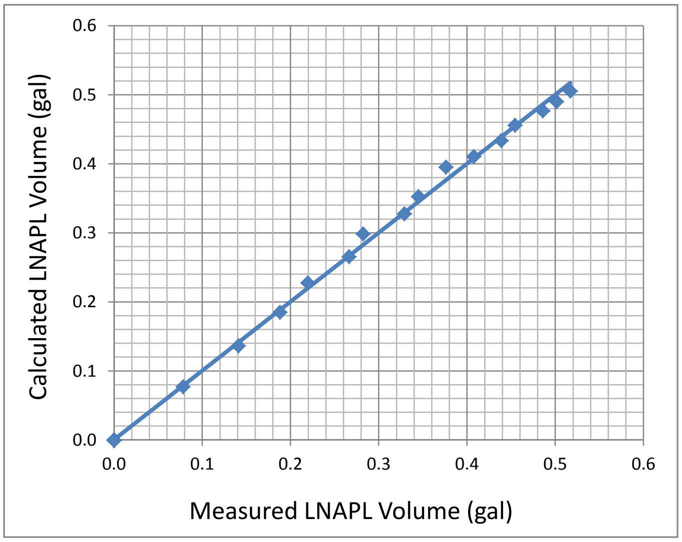
Enter early time cut-off for least-squares model fit

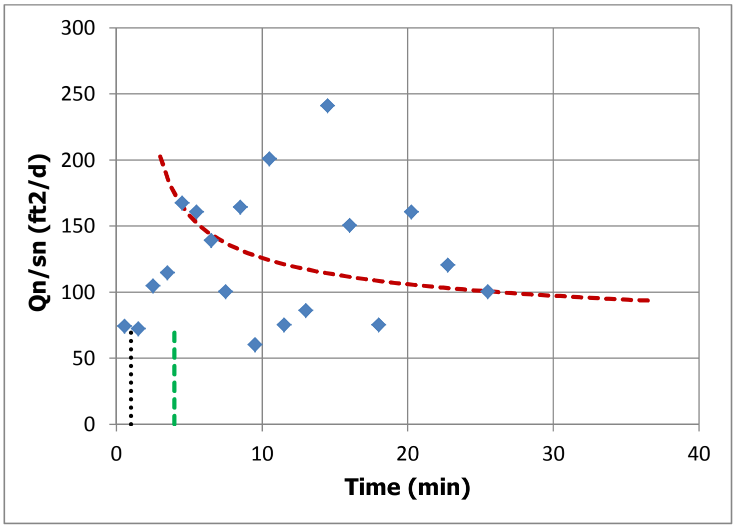
Time_{cut} (min):	4	<- Enter or change values here
Time Adjustment (min):	1	

Trial S_n:	d	<-- Enter d for default or enter S_n value
Root-Mean-Square Error:	0.035	<-- Minimize this using "Solver"
	0.158	<-- Working S_n
Trial T_n (ft^2/d):	39.791	<-- By changing T_n through "Solver"

Add constraint T_n > 0.00001

Model Result: T_n (ft^2/d) = **39.79**





Height

70

Cooper, Bredehoeft and Papadopulos (1967)

Well Designation:	S-98
Date:	

Enter early time cut-off for least-squares model fit

Time_{cut} (min):	5	<- Enter or change values here
Initial Drawdown s_n (ft):	0.08	

Trial S_n: d <-- Enter d for default

Root-Mean-Square Error: 0.348 <-- Minimize this using "Solver"

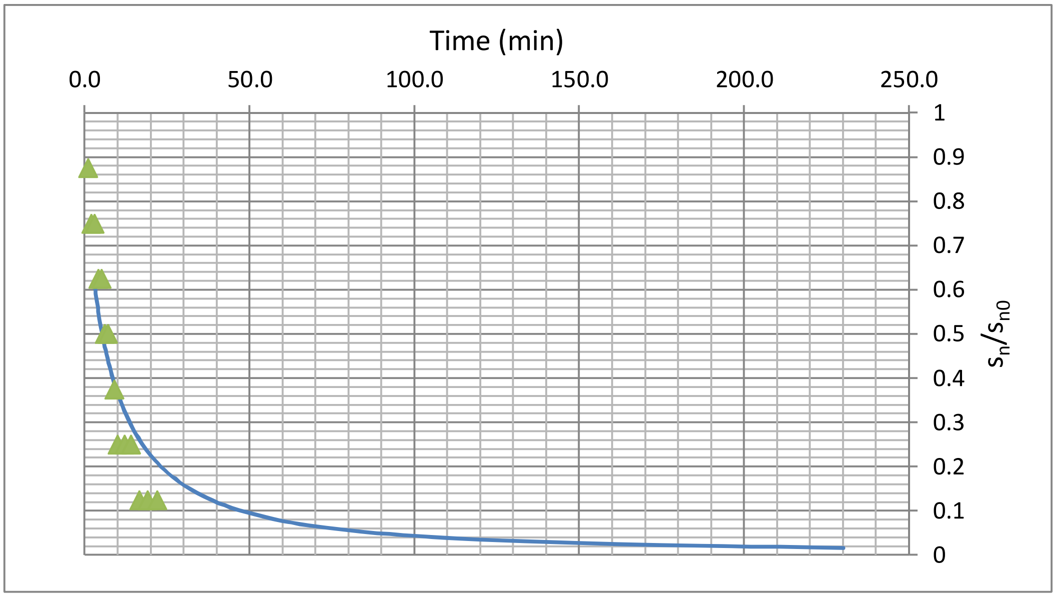
Trial T_n (ft^2/d): 25.237 <-- By changing T_n through "Solver"

0.126 <-- Working S_n

Add constraint Tn > 0.00001

Model Result: T_n (ft^2/d) = **25.24**

T_{min}	3
T_{max}	230



J-Ratio
-0.271

Well Designation:	S-100	Beckett and Lyverse (2002)
Date:		

Ground Surface Elev (ft msl)	0.0	Enter These Data
Top of Casing Elev (ft msl)	0.0	
Well Casing Radius, r_c (ft):	0.167	r_{e1}
Well Radius, r_w (ft):	0.500	
LNAPL Specific Yield, S_y:	0.175	
LNAPL Density Ratio, ρ_r:	0.793	
Top of Screen (ft bgs):	10.0	
Bottom of Screen (ft bgs):	30.0	
LNAPL Baildown Vol. (gal.):	2.0	
Effective Radius, r_{e3} (ft):	0.258	Calculated Parameters
Effective Radius, r_{e2} (ft):	0.202	
Initial Casing LNAPL Vol. (gal.):	0.40	
Initial Filter LNAPL Vol. (gal.):	0.56	

Drawdown Adjustment (ft)
0.1

Enter Data Here

	Time (min)	DTP (ft btoc)	DTW (ft btoc)	DTP (ft bgs)
Initial Fluid Levels:	0	24.49	25.1	24.49
Enter Test Data:	0.1	24.71	24.85	24.71
	1.2	24.65	24.85	24.65
	2.0	24.63	24.84	24.63
	4.0	24.62	24.84	24.62
	5.0	24.61	24.85	24.61
	5.9	24.60	24.85	24.60
	12.0	24.59	24.85	24.59
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A
				#N/A

Generalized Bouwer and Rice (1976)

Well Designation:	S-100
Date:	

$$T_n = \frac{r_e^{\ 2} \ln\left(R/r_e\right)\ln\left(s_n\left(t_1\right)/s_n\left(t\right)\right)}{2\left(-J\right)\left(t-t_1\right)}$$

Enter early time cut-off for least-squares model fit

Time_{cut}	4.5

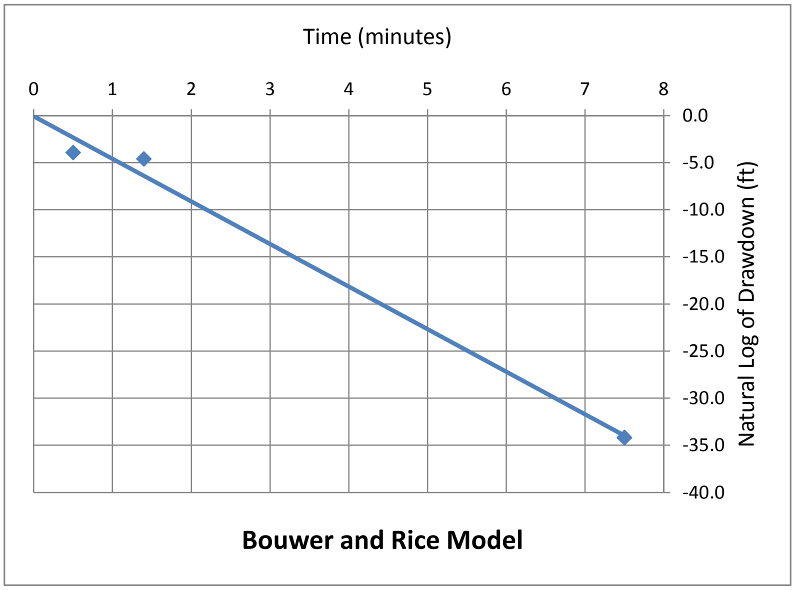
<- Enter or change value here

Model Results: T_n (ft^2/d) = 196.55 +/- 19.40 ft^2/d

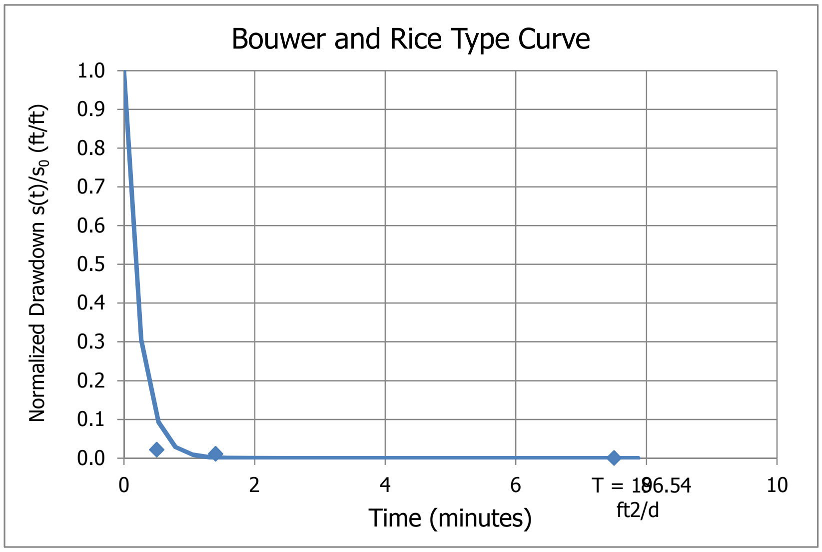
L_e/r_e 2.4
C 0.89
R/r_e 1.83

J-Ratio -0.667

Coef. Of Variation 0.10



C coefficient calculated from Eq. 6.5(c) of Butler, The Design, Performance, and Analysis of Slug Tests, CRC Press, 2000.



Cooper and Jacob (1946)

Well Designation:	S-100
Date:	

$$V_n(t_i) = \sum_j^i \frac{4\pi T_n s_j}{\ln\left(\frac{2.25 T_n t_j}{r_e^2 S_n}\right)} \Delta t_j$$

Enter early time cut-off for least-squares model fit

Time_{cut} (min):	4.5	<- Enter or change values here
Time Adjustment (min):	2.7	

Trial S_n: d <-- Enter d for default or enter S_n value

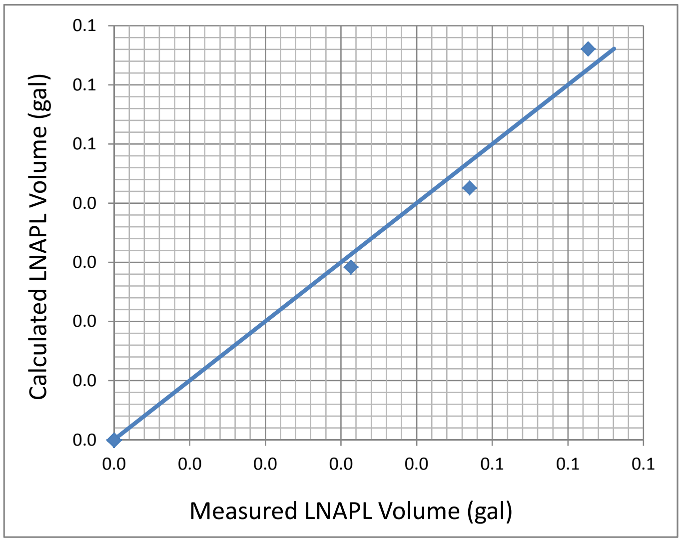
Root-Mean-Square Error: 0.006 <-- Minimize this using "Solver"

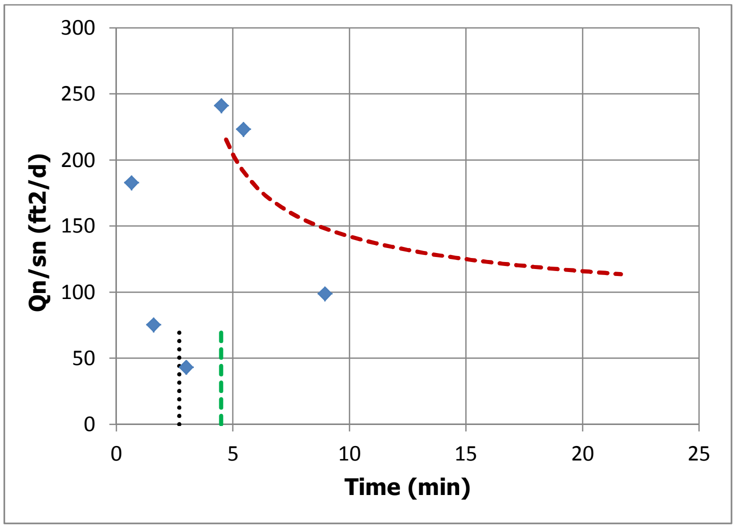
0.164 <-- Working S_n

Trial T_n (ft^2/d): 43.000 <-- By changing T_n through "Solver"

Add constraint $T_n > 0.00001$

Model Result: T_n (ft^2/d) = **43.00**





Height

70

Cooper, Bredehoeft and Papadopulos (1967)

Well Designation:	S-100
Date:	

Enter early time cut-off for least-squares model fit

Time$_{cut}$ (min):	0	<- Enter or change values here
Initial Drawdown s_n (ft):	0.1	

Trial S_n: d <-- **Enter d for default**

Root-Mean-Square Error: 0.411 <-- **Minimize this using "Solver"**

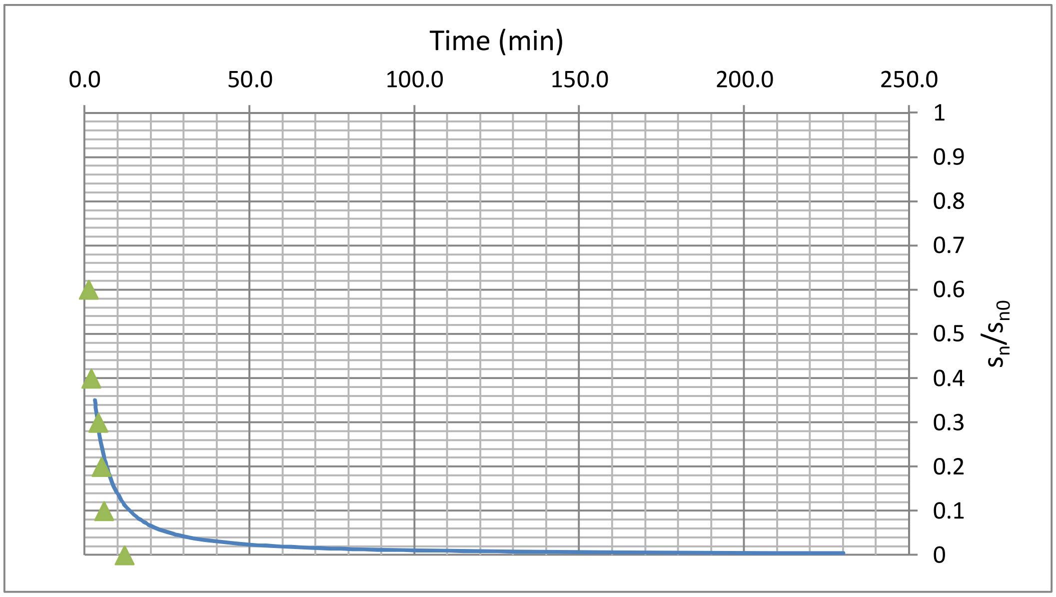
Trial T_n (ft^2/d): 34.443 <-- **By changing T_n through "Solver"**

0.147 <-- **Working S_n**

Add constraint Tn > 0.00001

Model Result: T_n (ft^2/d) = **34.44**

T_{min}	3
T_{max}	230



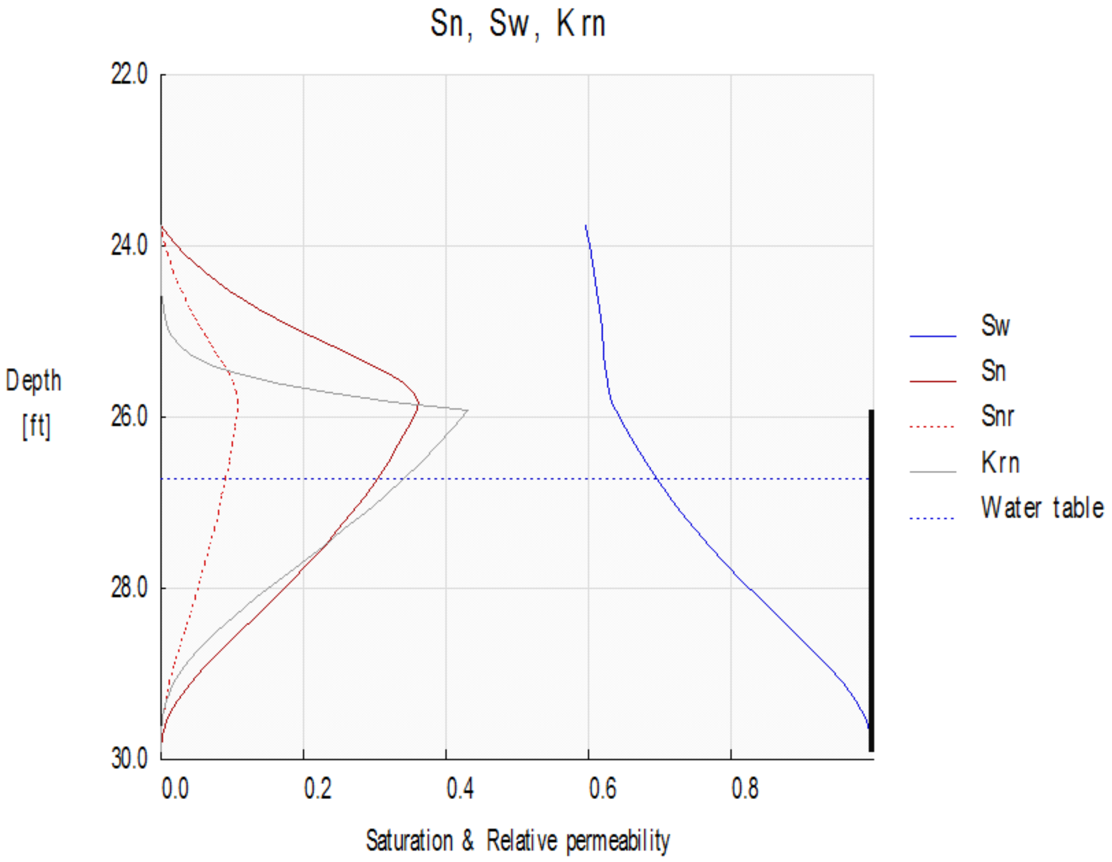
J-Ratio
-0.667

APPENDIX IV
API LDRM: SATURATION PROFILE GRAPHS

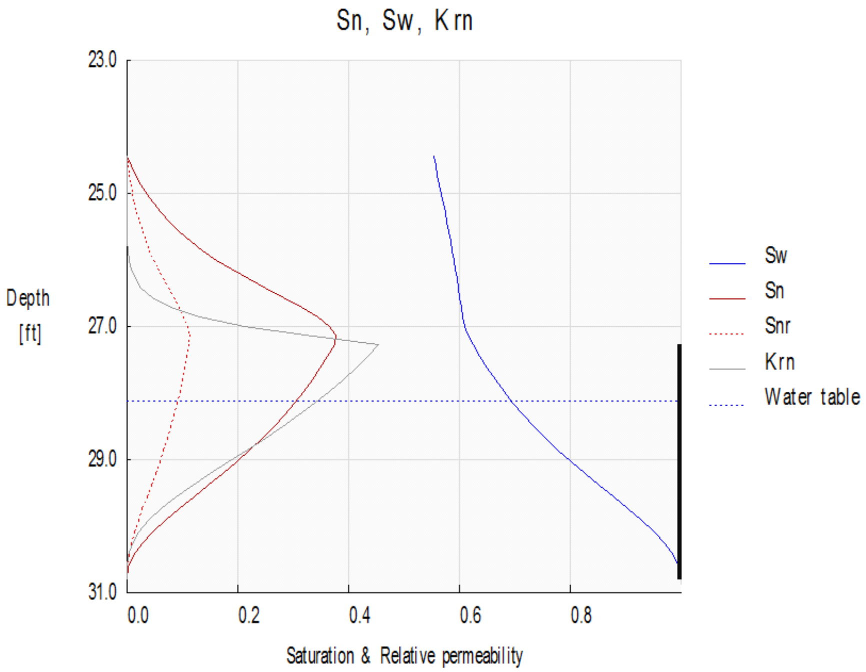
Light Non-aqueous Phase Liquid (LNAPL) Site Conceptual Model (LCSM)
Area of Interest 1
PHILADELPHIA REFINERY COMPLEX
PHILADELPHIA, PENNSYLVANIA
PHILADELPHIA REFINERY OPERATIONS,
A SERIES OF EVERGREEN RESOURCES GROUP, LLC
3144 PASSYUNK AVENUE, PHILADELPHIA, PENNSYLVANIA

Light Non-Aqueous Phase Liquid
Conceptual Site Model
Appendix IV
API LDRM: Saturation Profile Graphs

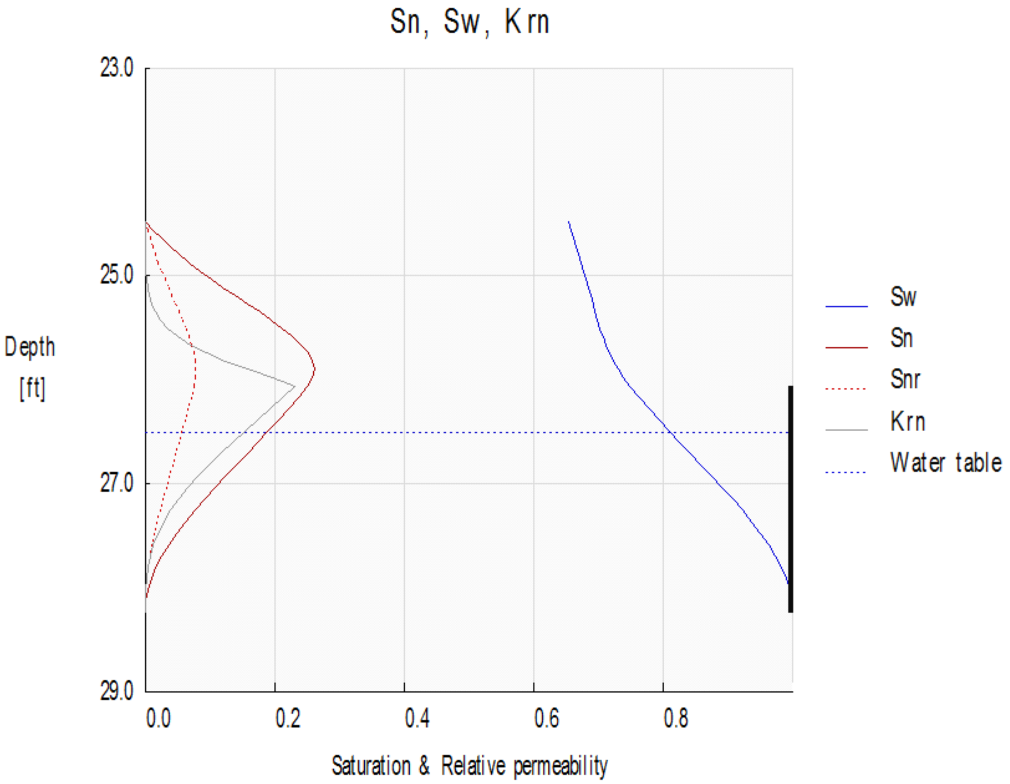
RW-4



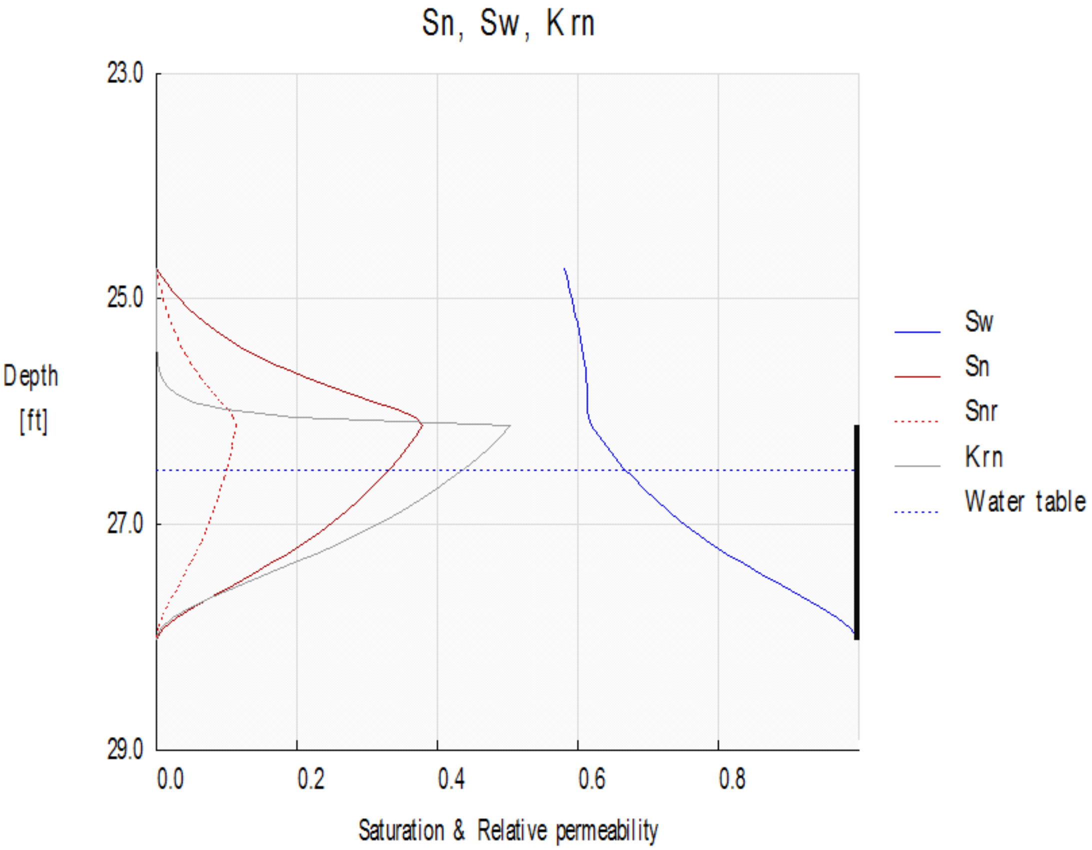
RW-23


Sn, Sw, Krn
Depth [ft]
23.0
25.0
27.0
29.0
31.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

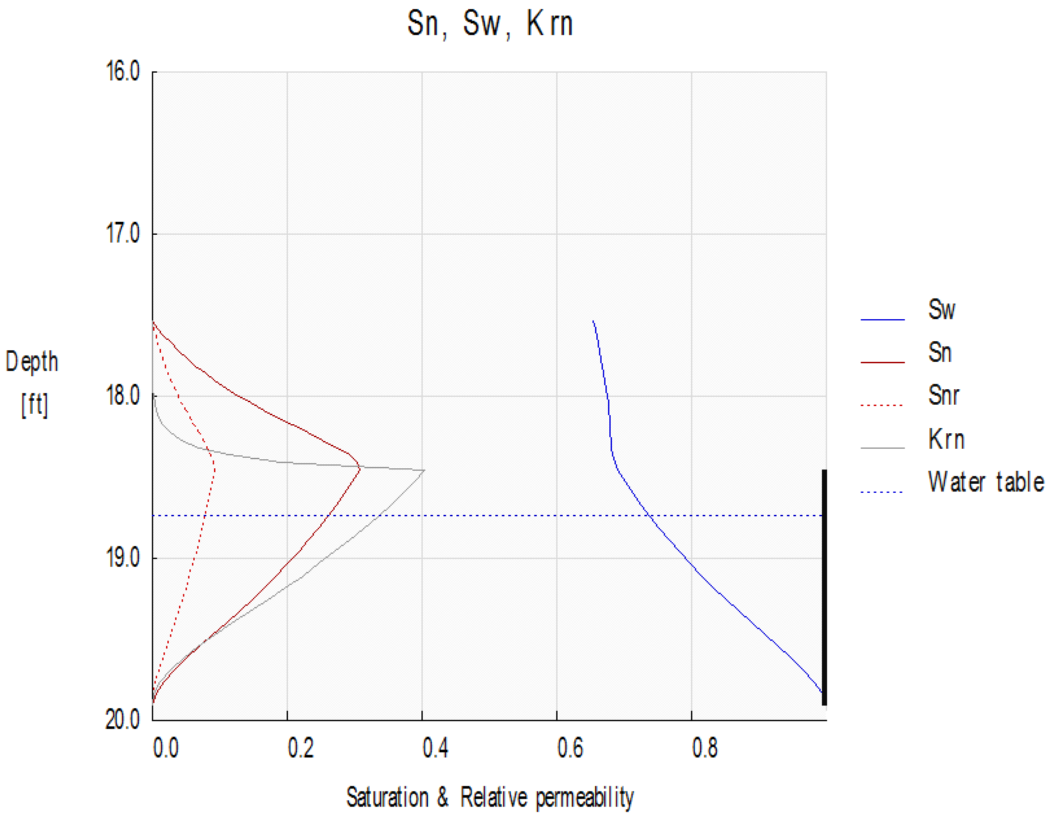
MW-29


Sn, Sw, Krn
23.0
25.0
27.0
29.0
Depth
[ft]
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

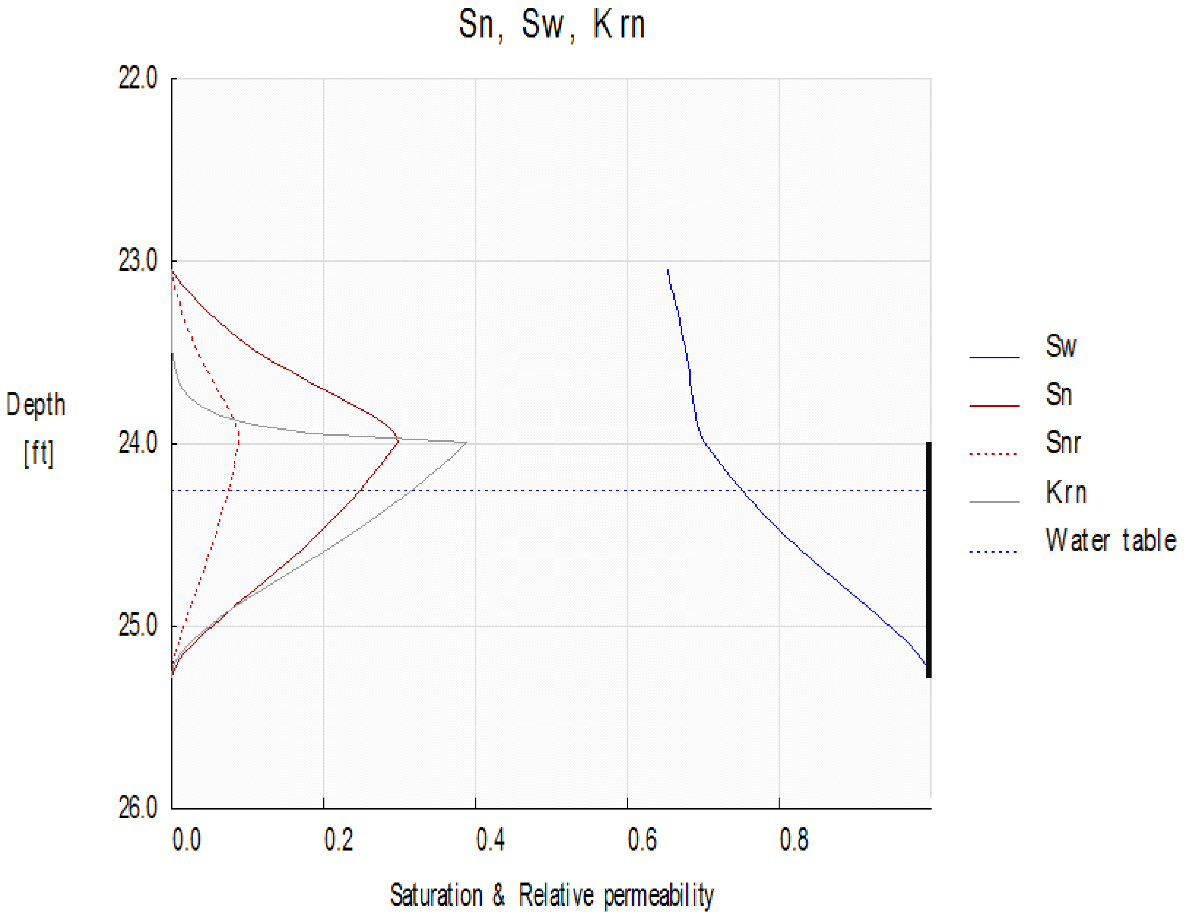
S-198


Sn, Sw, Krn
23.0
25.0
27.0
29.0
Depth
[ft]
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

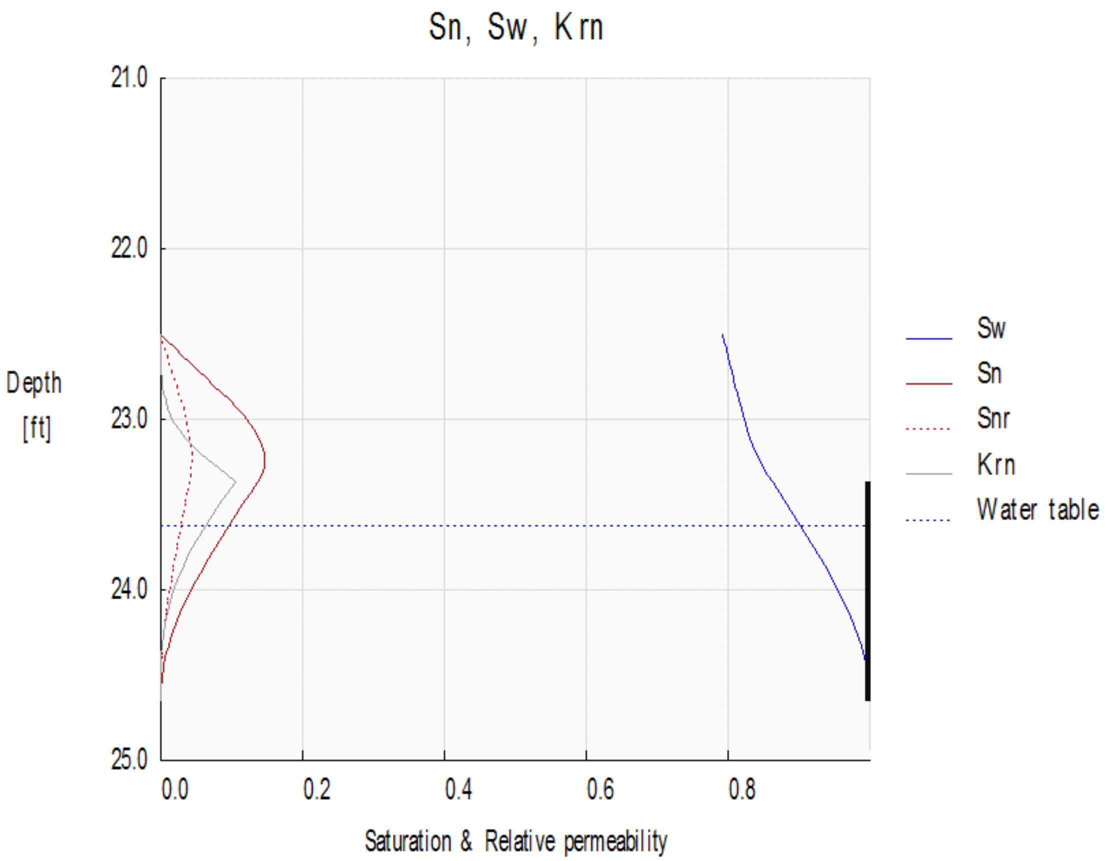
S-205


Sn, Sw, Krn
Depth
[ft]
16.0
17.0
18.0
19.0
20.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

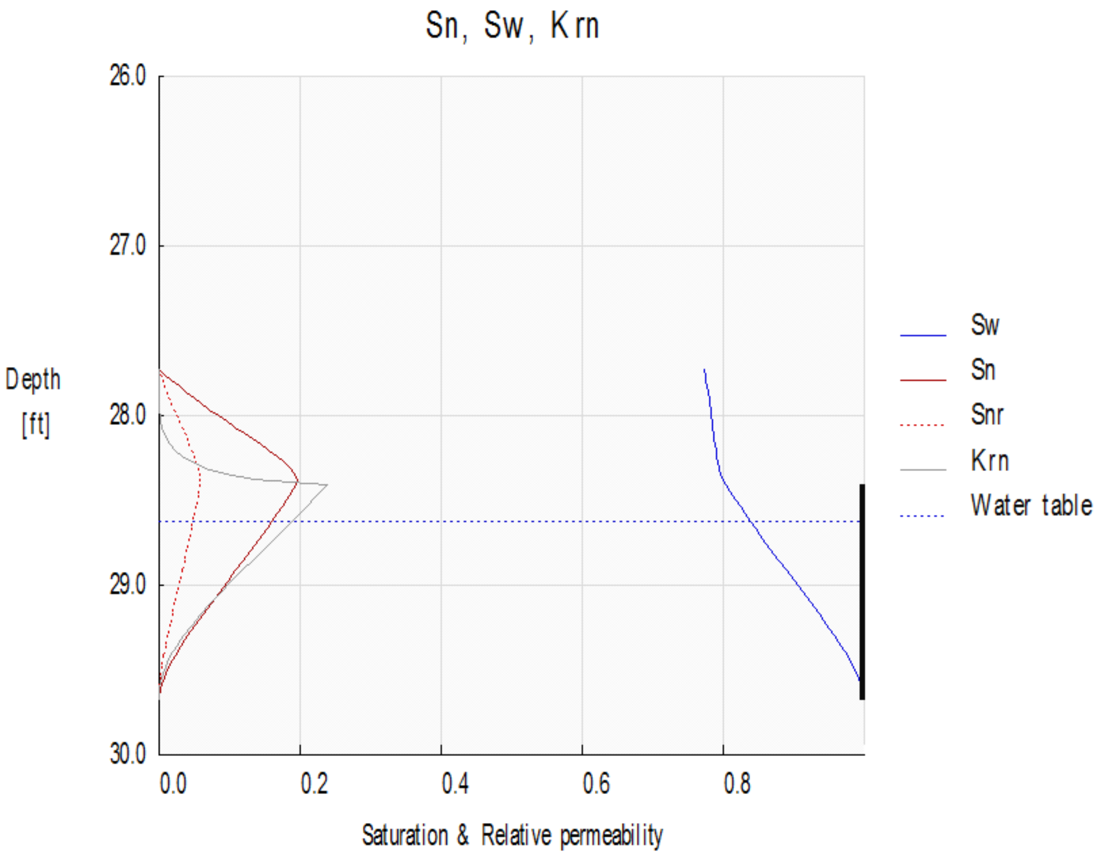
S-100


Sn, Sw, Krn
Depth
[ft]
22.0
23.0
24.0
25.0
26.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

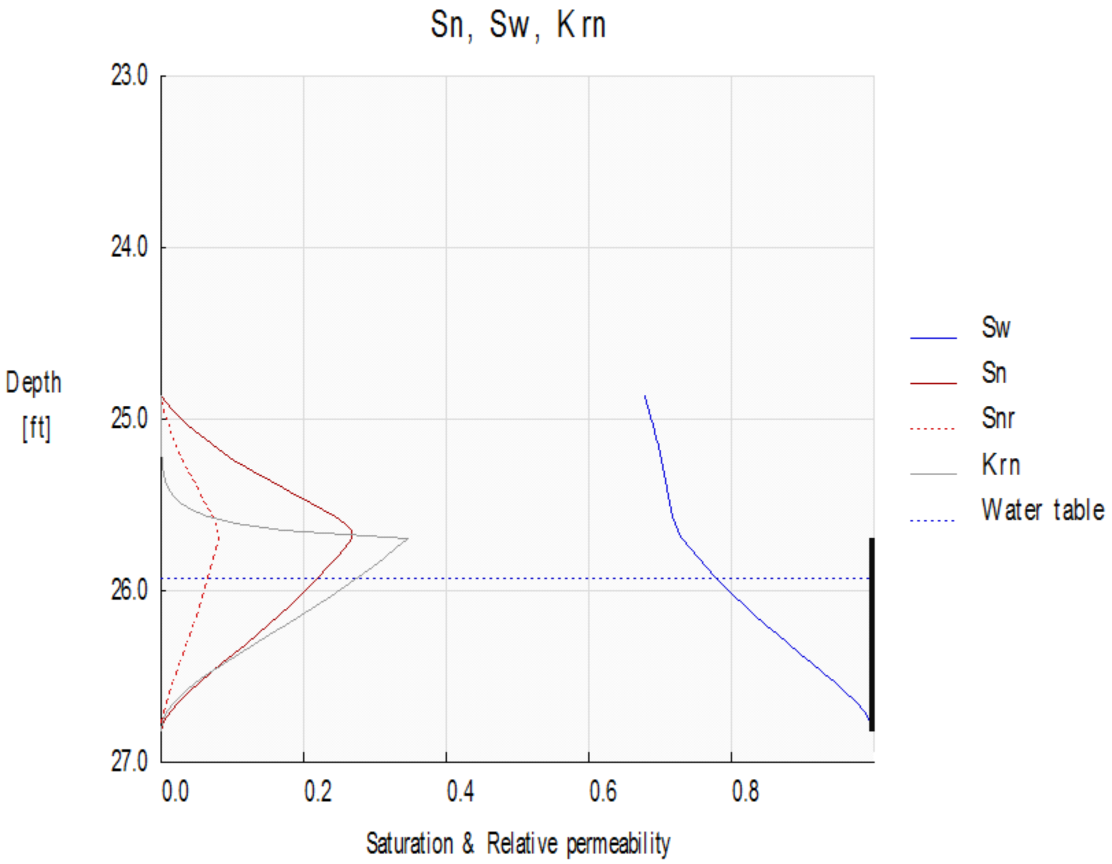
MW-26


Sn, Sw, Krn
Depth
[ft]
21.0
22.0
23.0
24.0
25.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

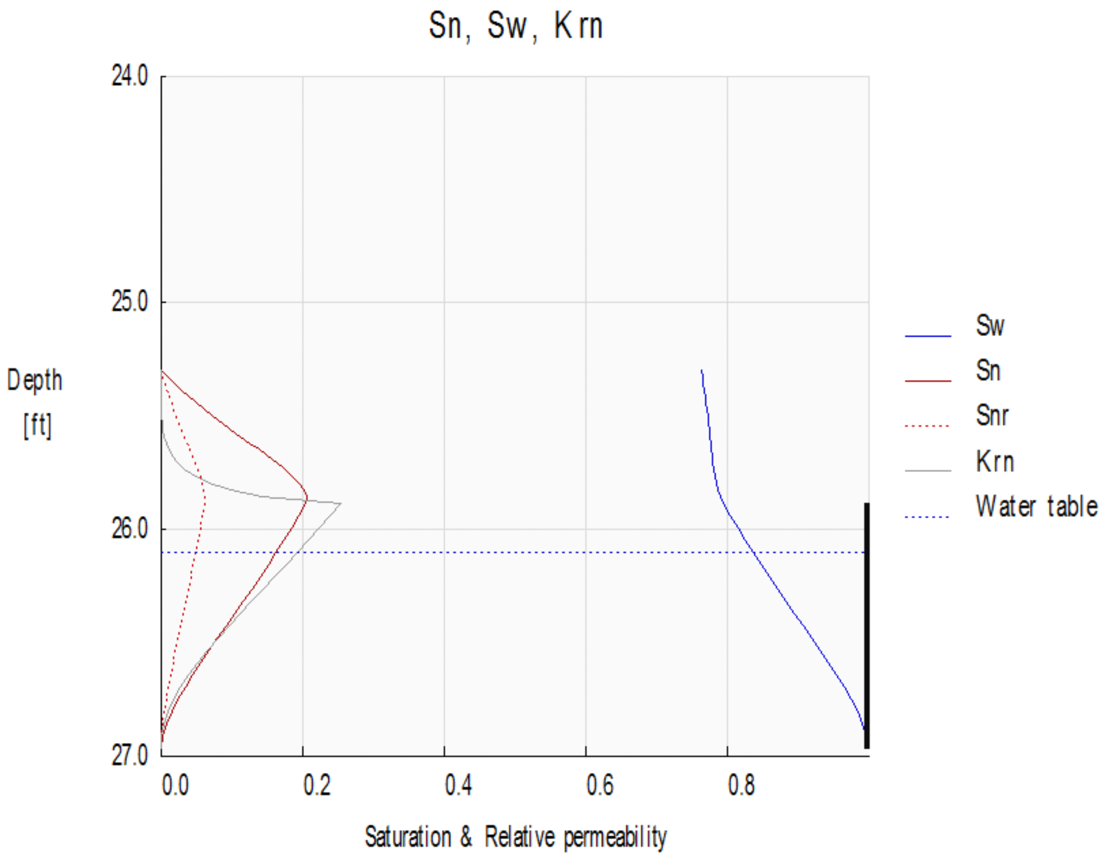
S-203


Sn, Sw, Krn
Depth
[ft]
26.0
27.0
28.0
29.0
30.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

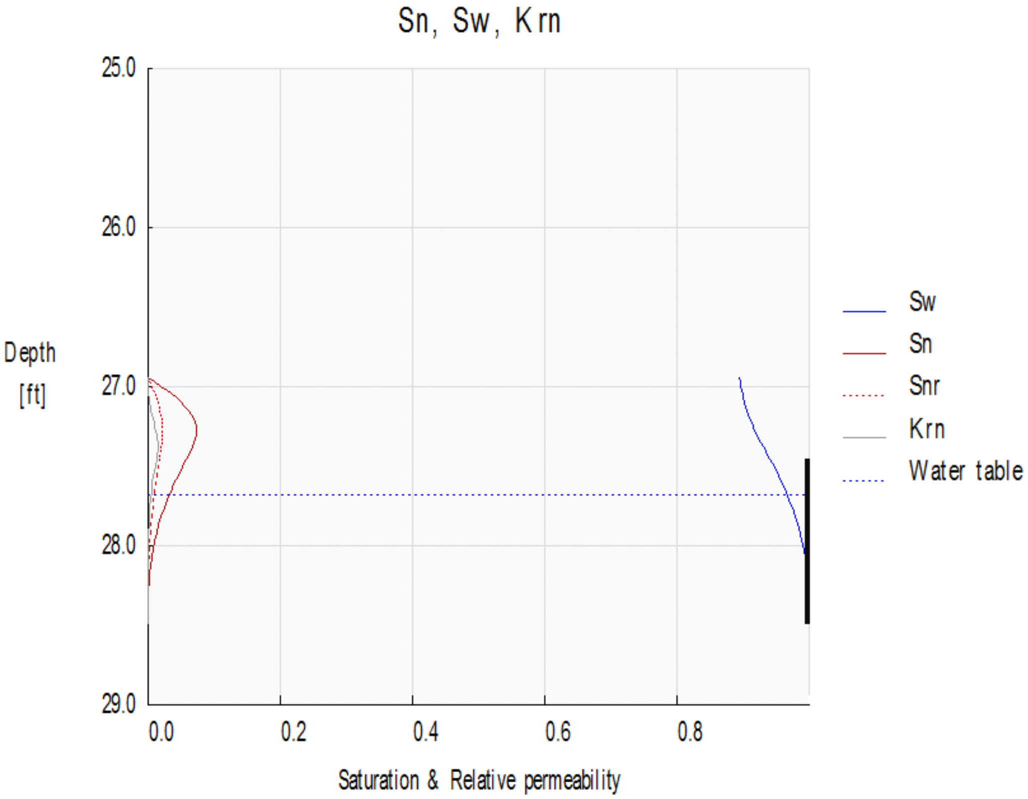
S-199


Sn, Sw, Krn
Depth [ft]
23.0
24.0
25.0
26.0
27.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

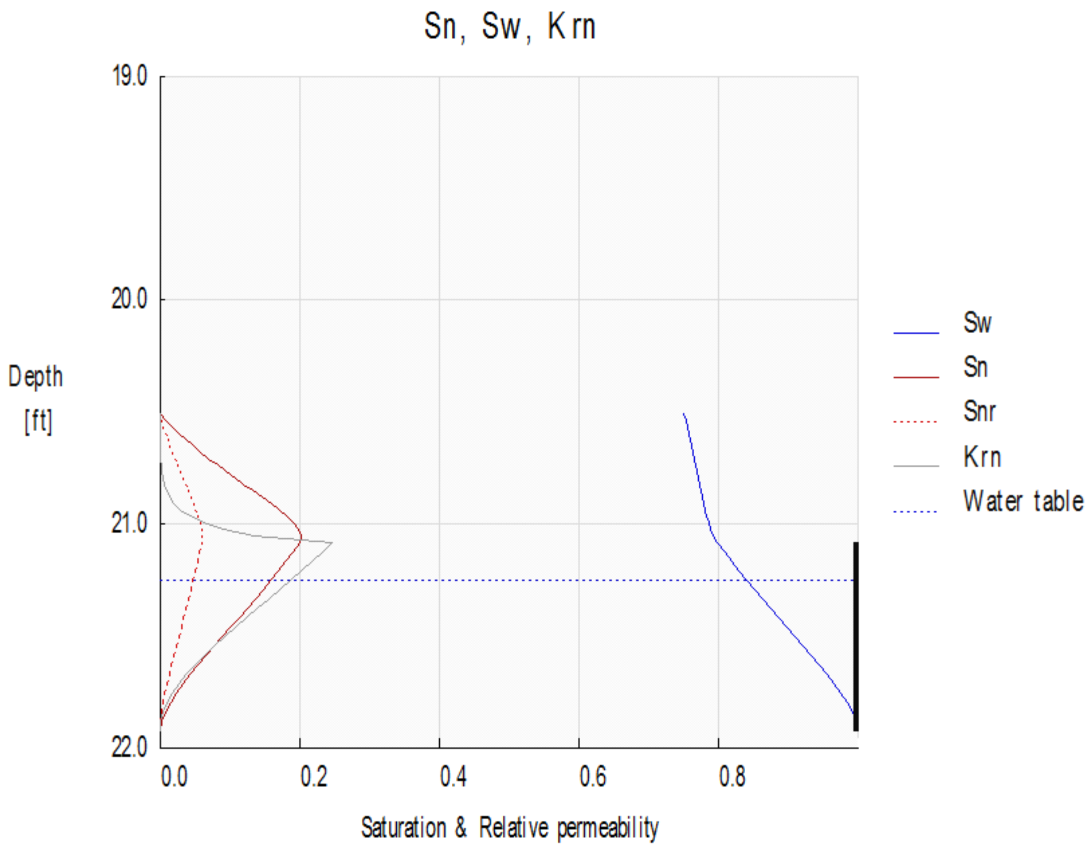
S-189


Sn, Sw, Krn
24.0
25.0
26.0
27.0
Depth
[ft]
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

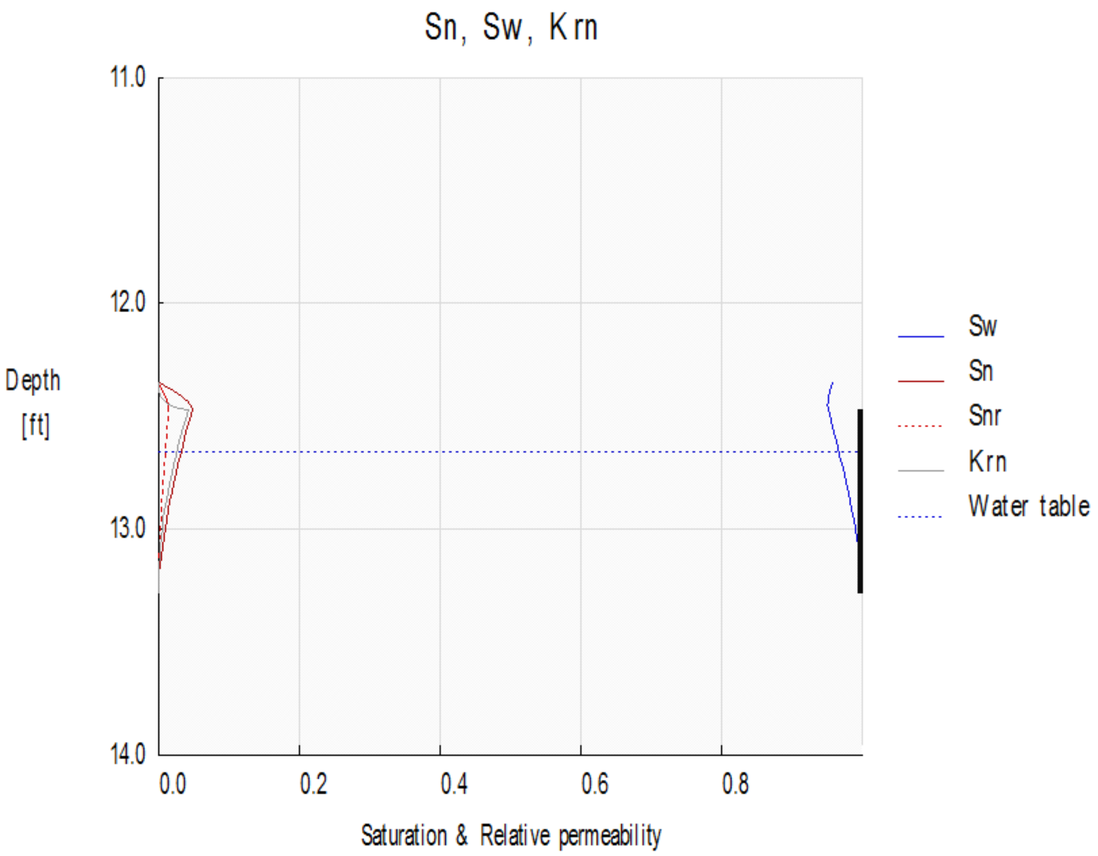
S-76


Sn, Sw, Krn
Depth
[ft]
25.0
26.0
27.0
28.0
29.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

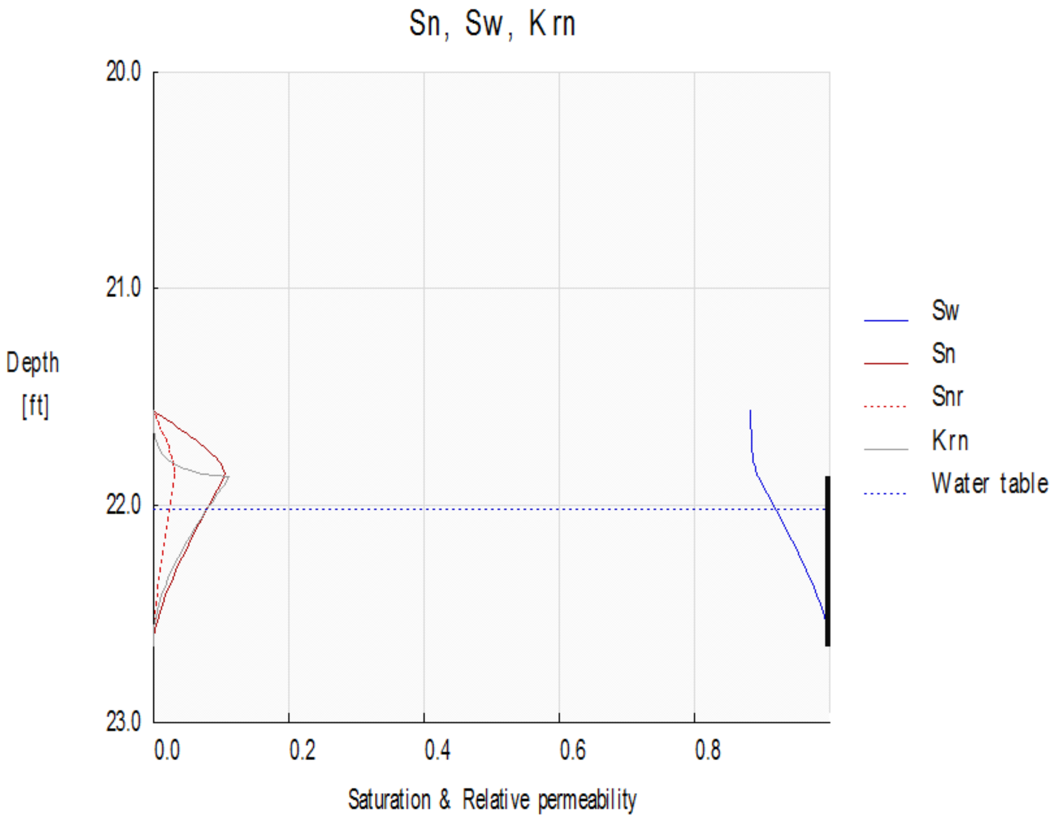
S-277


Sn, Sw, Krn
Depth
[ft]
19.0
20.0
21.0
22.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

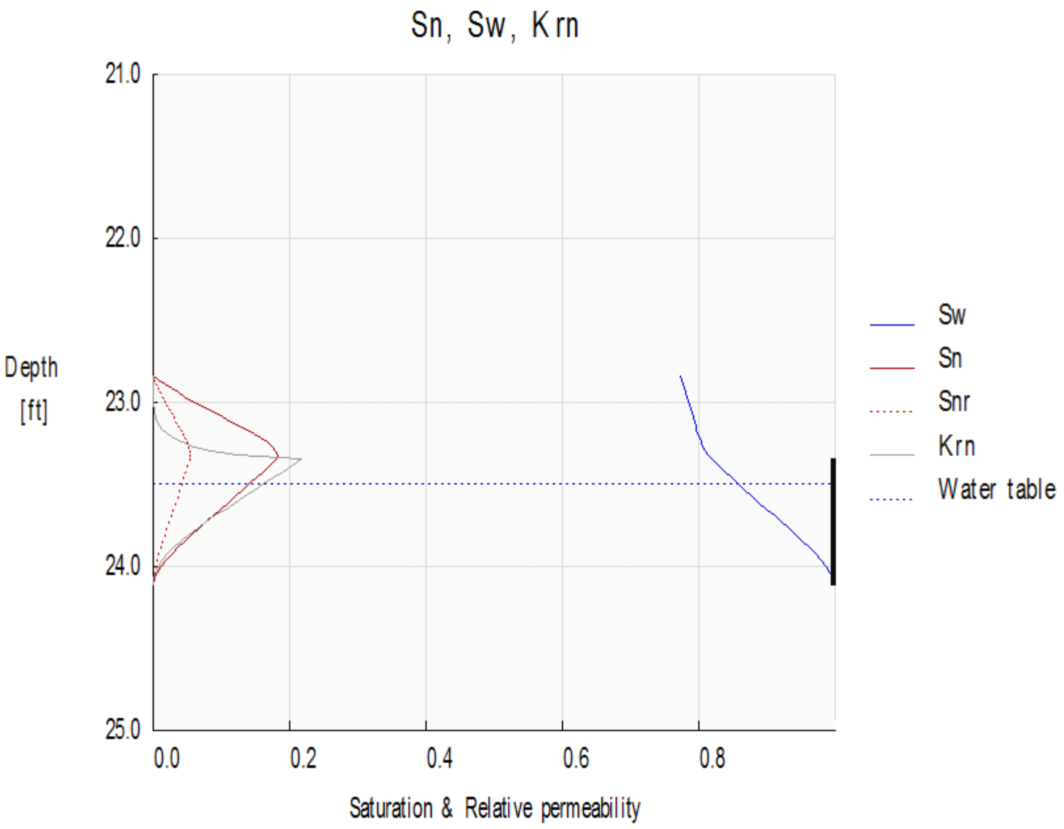
S-77


Sn, Sw, Krn
11.0
12.0
13.0
14.0
Depth
[ft]
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

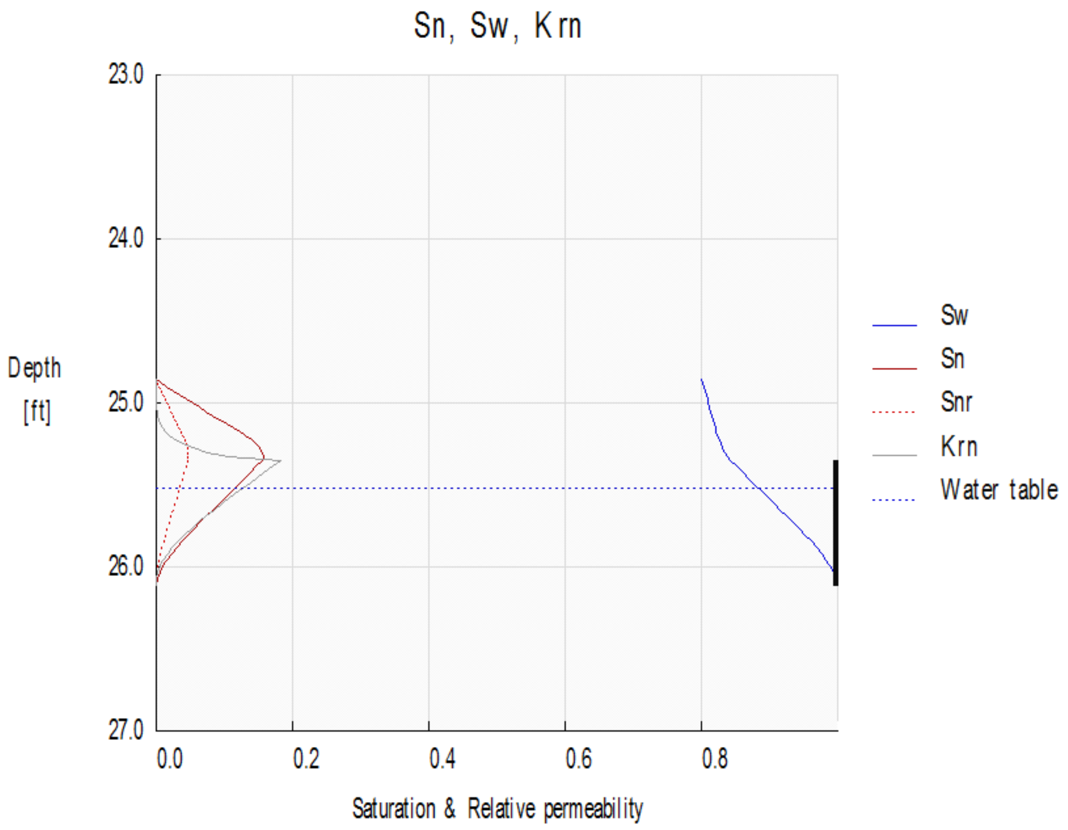
S-276


Sn, Sw, Krn
Depth
[ft]
20.0
21.0
22.0
23.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

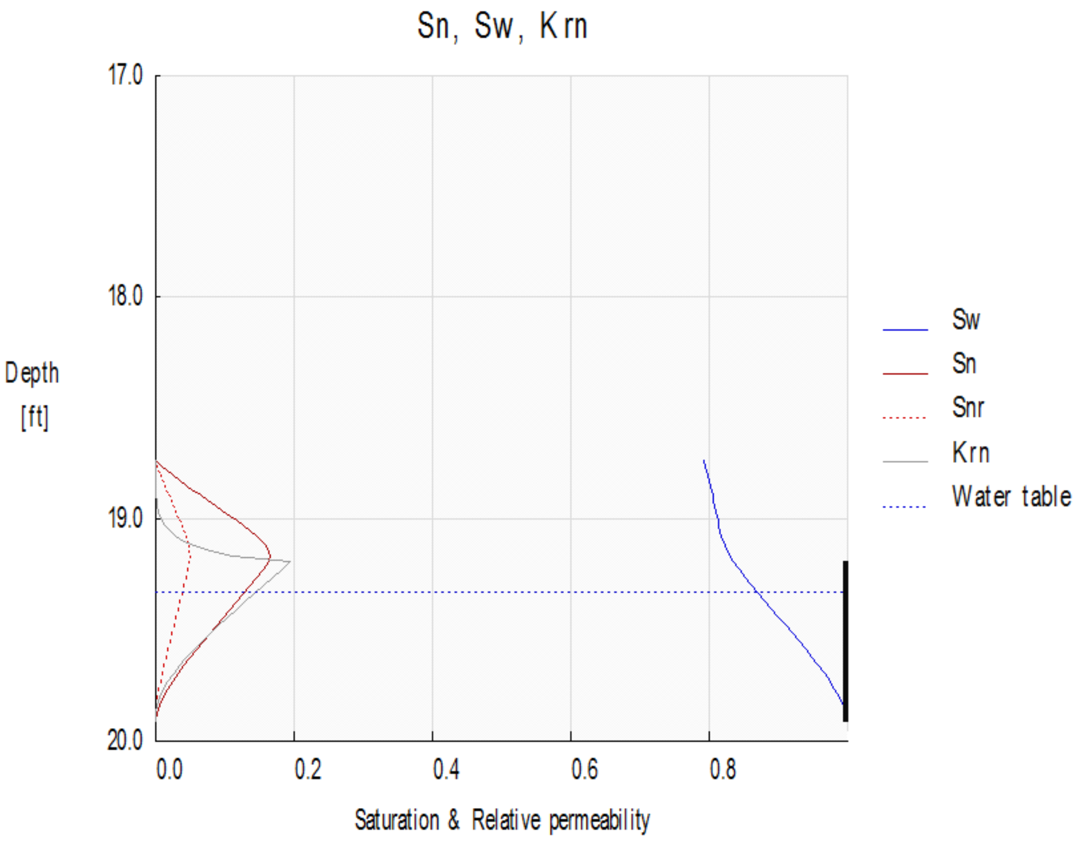
S-201


Sn, Sw, Krn
Depth
[ft]
21.0
22.0
23.0
24.0
25.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

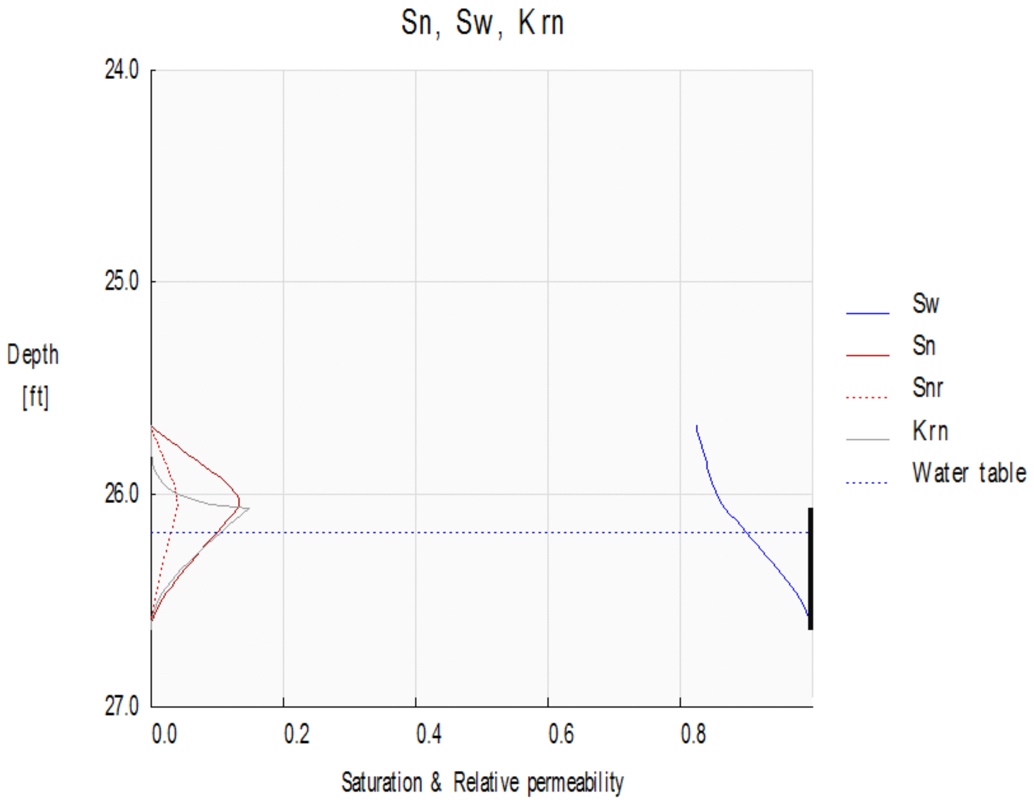
RW-25


Sn, Sw, Krn
Depth [ft]
23.0
24.0
25.0
26.0
27.0
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

S-83


Sn, Sw, Krn
17.0
18.0
19.0
20.0
Depth
[ft]
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

PZ-404


Sn, Sw, Krn
24.0
25.0
26.0
27.0
Depth
[ft]
0.0
0.2
0.4
0.6
0.8
Saturation & Relative permeability
Sw
Sn
Snr
Krn
Water table

APPENDIX F
REMEDIATION SYSTEMS SUMMARY

Remedial Investigation Report
Area of Interest 1
Philadelphia Refinery Complex
Philadelphia, Pennsylvania
Philadelphia Refinery Operations,
a series of Evergreen Resources Group, LLC
3144 Passyunk Avenue, Philadelphia, Pennsylvania

Appendix F
Remediation System Summary
AOI 1 Remedial Investigation Report
Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC

1.0 26th Street Sewer Area (26th Street North)

1.1 SYSTEM DESCRIPTION

The 26th Street Sewer Area remediation system is a total fluids recovery system that was designed to provide hydraulic containment of subsurface petroleum hydrocarbon impacts identified along the Philadelphia Refinery Complex's (the facility) No. 1 Tank Farm border with 26th Street. The system is operated and maintained by Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC (Evergreen) on property presently under the ownership of Philadelphia Energy Solutions Refining and Marketing LLC (PES). Presently, the operational system consists of a network of 15 recovery wells that extract total fluids utilizing pneumatic pumps and convey pumped fluids through a common discharge line to the facility's process sewer. The well network includes the following recovery wells: RW-400, RW-402, S-180, S-181, S-182, S-183, S-184, S-185, S-186, S-187, S-188, S-189, S-190, S-191, and S-192.

A Kaeser SK26 rotary screw air compressor is utilized to facilitate pneumatic pumping of total fluids from each recovery well. A common air line passes from the compressor through an isolation valve, a moisture separator, and a pressure-regulating valve prior to supplying compressed air to the recovery wells. The common air line then separates to power each system well. There are isolation valves installed on the air lines running from the common line to the individual well pumps. The discharge line from the pumps passes through a check valve and isolation valve before entering a common discharge line. The pump discharge lines and common discharge line were originally above ground. As will be described in additional detail in Section 1.2, the lines were reinstalled below ground surface during system modifications performed in 2015.

The common discharge line for all of the wells travels above ground for approximately 2,900 feet before discharging into the facility's process sewer. The common line is a 4-inch (formerly 3-inch) diameter high-density polyethylene (HDPE) line that is reduced to a 1.5-inch diameter line to pass through a flowmeter/totalizer. The line is then returned to a 4-inch (formerly 3-inch) diameter line. The nearby Belmont Terminal Remediation System discharge line joins to the 26th Street North system discharge line approximately 867 feet from the most distal well on the 26th Street system.

1.2 SYSTEM MODIFICATIONS

The 26th Street Sewer Area system was modified/rehabilitated in 2015 in an attempt to increase its overall effectiveness. During February 2015, all of the 4-inch diameter recovery wells (S-180, S-

181, S-182, S-183, S-184, S-185, S-186, S-187, S-188, S-189, S-190, S-191, and S-192) were over-drilled and replaced with 6-inch diameter recovery wells. As existing recovery wells RW-400 and RW-406 were originally installed as 6-inch diameter wells, all system recovery wells are currently 6-inch diameter.

Prior to modification, operation of the 26th Street North system was commonly interrupted by freezing conditions and the system was shut down during winter months. To maintain maximum year-round system runtime, a 4-inch HDPE discharge line was installed in a trench approximately 42-inches below grade from recovery wells S-180 to S-188. In order to provide freeze protection for recovery wells S-189, S-190, S-191, and S-192 [within the secondary containment of aboveground storage tank (AST) 26], the discharge line was extended under the north and south containment walls. Within the AST 26 area, a trench containing the discharge line was constructed at a similar depth to that previously described. Due to the significant distance to the discharge point, it was not feasible to trench in or heat trace the remaining portion of the discharge line. In addition, a 1¼-inch HDPE air supply header was installed in the above-referenced trench at approximately 32-inches below grade.

Within each system recovery well, a QED Environmental Systems Model AP-4 AutoPump was installed to recover groundwater and light non-aqueous phase liquid (LNAPL). Each well pump contains a liquid level control and will discharge independently in accordance with the rate of recharge to the individual wells. A 1¼-inch HDPE lateral air line runs from the air supply header to each well vault and is furthermore reduced to a 3/8-inch flex hose at the pump. Each recovery well contains a 1-inch all-purpose rubber hose that is tied into a 2-inch line which leads to the main discharge line.

The upgraded/rehabilitated 26th Street Sewer Area system was restarted on October 12, 2015.

1.3 OPERATIONAL HISTORY

The original 26th Street Sewer area recovery system was installed in 1995 and consisted of the RW-400 series recovery wells. The original series consisted of RW-400 though RW-405 with RW-406 added to the system in 2000. Note that RW-400 is located on the current Belmont Terminal property. The system was originally equipped with a dual pump system. Between 2003 and 2006, 14 wells (S-179 through S-192) were installed along the 26th Street facility boundary and 9 wells (S-193 through S-197 and S-265 through S-268) were installed on the CSX property with the intention of possibly converting them to recovery wells. All of the wells, with the exception of onsite well S-179 and the offsite wells, were later incorporated into the 26th Street recovery system and many of the RW-400 series wells were no longer pumped. The system has generally been operated seasonally since its inception, with exceptions for periodic maintenance and upgrades. Prior to 2015 and as described above, the discharge lines for the 26th Street system were above ground surface and did not allow for continuous system operation through the winter months. With the 2015 modifications, it is intended that this system be operational year-round. Since its inception, the 26th Street Sewer System system has recovered approximately 64.5 million gallons of groundwater and approximately 57,500 gallons of LNAPL (through March 2016).

2.0 S-50 Area (26th Street South)

2.1 SYSTEM DESCRIPTION

Between January and March 2009, the 26th Street South Oxygen Injection System was installed and consisted of the construction of 54 nested injection well points, utilizing 27 augered boreholes. The goal of the system was to provide a biologically active barrier in this area to mitigate the potential offsite migration of dissolved-phase contaminants through the water-table aquifer. By design, each borehole was to contain one, 1-inch diameter shallow and one, 1-inch diameter deep injection well point. The nested configuration was utilized due to aquifer heterogeneity, the relatively thick interval of petroleum impacted soil in the subsurface, and the presence of clay layers which may inhibit the movement of oxygen to the impacted zones. Shallow injection points were installed at depth interval from approximately 25.0 to 33.5 feet below grade, and deep injection points were installed at depth interval from approximately 29.0 to 41.0 feet below grade, each with two feet of slotted screen.

The injection wells are located along two transects, one which lies basically north-south parallel to 26th Street and one that runs perpendicular to the first and intersects it about mid-way. The wells are spaced approximately 15 feet apart based on the calculated approximate radius of influence of the proposed oxygen injection system. The north-south 26th Street transect includes 42 injection points, beginning with IW-01S and IW-01D (north end) and extending approximately 300 feet to wells IW-21S and IW-21D (south end). The second transect includes wells IW-22S and IW-22D (east end) through wells IW-27S and IW-27D (west end). These wells were later renamed MW-1-O2 through MW-27-O2.

Upon completion of well installation activities, a trench was excavated to connect all injection well points to a remediation trailer. HDPE tubing was utilized in individual runs to connect each of the well points to the trailer. Four ‘banks’ of wells were established and set to inject into multiple wells at a time so that oxygen was pulsed into the aquifer. Bank 1 included wells IW-01D through IW-07D, Bank 2 included wells IW-08D through IW-14D, Bank 3 included wells IW-15D through IW-21D, and Bank 4 included wells IW-22D through IW-27D. Each bank was set to deliver 8 minutes of oxygen injection at 50 minute intervals (a total of 6 injections per day). This pulsing of the system was to aid in transfer of oxygen from the vapor to dissolved phase, and the low flow rate was to allow for maximum dissolved oxygen (DO) saturation without causing contaminant volatilization.

The system was initially set up to only inject within the deep well points (except at MW-1-O2 where there was a blockage in the deep point); however, due to lower than projected target DO concentrations in surrounding monitoring wells, the system was adjusted on November 18, 2009 to inject into the shallow points so that oxygen injection was being performed closer to the monitoring well screen intervals. Injection wells MW-17-O2, MW-18-O2, and MW-19-O2 remained as deep injection points due to the deeper well screen construction of nearby monitoring well S-232. On April 6, 2012, oxygen injection at MW-18-O2 was switched from the deep point to the shallow point due to a blockage in the deep point. On January 14, 2010, injection at MW-25-O2 was switched back to the deep point due to loss of pressure in the shallow point.

2.2 OPERATIONAL HISTORY

Operation of the 26th Street South Oxygen Injection System was initiated on March 25, 2009. Since that time, system operation was commonly affected by the silting/fouling of well points. To rehabilitate the wells, one well development event using an air lift was conducted on April 30, 2009 to reduce pressures in select wells and to increase air flow. During this effort, the flow to well IW-01D could not be reestablished; therefore, injection at this point was switched to the shallow well IW-01S. The system was again shut down from November 13 to November 18, 2009 due to road paving activities within the vicinity of the system. During that time, as noted above, injection was switched from deep to shallow points at all locations with the exception of IW-17-O2, IW-18-O2, and IW-19-O2.

The system was down due to a low oxygen pressure alarm on May 31, 2011. On June 4, preventative maintenance was performed on the compressor, and the system was restarted.

On September 11, 2012, October 17, 2012, November 27, 2012, and December 31, 2012, the system was down on arrival due to an issue with the air dryer. On each occasion, the system was reset and restarted upon departure.

On January 17, 2013, the compressor was down due to an overload alarm. The air dryer was manually bypassed due to continued issues. The system was down on February 27, 2013 due to a water leak in the air tank. Due to the amount of issues with the air dryer, the system was shut off from March 14, 2013 to May 30, 2013 at which time a new air dryer was installed. On June 17, 2013, the system was down due to a frozen air dryer. The system was subsequently restarted on June 21, 2013. Due to reoccurring issues with the air dryer, a new unit was installed in July 2013.

On August 22, 2014, the 26th Street South Oxygen Injection System was permanently shut down due to the ongoing observation of LNAPL in the vicinity of the system.

3.0 Packer Avenue and 26th Street Sewers (Point Breeze) Ventilation System and Biofilter

The 26th Street and Packer Avenue Sewers Ventilation System and Biofilter was constructed pursuant to a Consent Order and Agreement between Sunoco, Defense Personnel Support Center (DPSC) (currently referred to as the Defense Supply Center Philadelphia), and the PADEP. The PADEP asked Sunoco and the DPSC in a letter dated April 8, 1997 to develop and implement a plan "to control or abate the accumulation of petroleum hydrocarbon vapors in the sewer and to monitor the sewer to assess the effectiveness of abatement." As such, the system was designed to ventilate/extract petroleum hydrocarbon vapors from the Packer Avenue/Pollock Street and 26th Street Intercepting Sewers, and remove volatile organic compounds (VOCs) from the effluent air stream by sorption and biological degradation via passage through a humidifier (when needed) and treatment beds containing biofilter media. Treated air is monitored and discharged to the atmosphere.

3.1 BIOFILTER SYSTEM DESCRIPTION

Originally, the Packer Avenue and 26th Street influent air streams were monitored by pressure and temperature indicators located on the inlet ductwork, outside of the system building. The air flow from each sewer was also monitored by a MT86 Multipoint Mass Flow Meter. Currently, these parameters are monitored manually.

The inlet of each blower is protected by a moisture separator/filter. Differential pressure gauges monitor the pressure drop through each moisture separator/filter. Three Buffalo Forge Howden Fan Company blowers (14,000 cubic feet per minute (CFM)) were installed. Two of the blowers operate continuously to extract VOCs from the Packer Avenue and 26th Street sewers, and the third blower is a stand-by unit. Inlet and outlet dampening valves allow for the adjustment of the air flow to a desired rate.

The influent air stream is monitored by two temperature gauges before and after the steam operated heating coil (used to heat the air stream in the winter months). Before entering the treatment beds, the influent air stream is humidified by a steam supplied humidipack, as needed. The humidipack is controlled by a Vaisala humidity monitor that indicates the relative humidity. The moisture element is set to keep the moisture close to 100 percent.

From the humidification system, the influent air stream flows to an air distribution manifold that feeds a system of laterals which extend into the bottom of each treatment bed (a total of four biomass treatment beds). Each treatment bed is approximately 73 feet long by 39 feet wide by 4 feet deep and is designed to up flow petroleum hydrocarbon vapors through an 11,388 cubic foot (422 cubic yard) compost bed for filtration and subsequent biodegradation.

Each treatment bed is lined on the bottom with a plastic liner and pitched to enhance the collection of leachate in a sump. Any leachate returns to the drain manhole. The laterals are embedded in gravel which prevents plugging of the holes in the laterals and helps to distribute the air flow evenly below the biofilter media. Geotextile fabric is placed over the gravel to preclude the movement of fine material from composting in the gravel layer. Four feet of compost media is placed above the geotextile with the edges tapered to grade. The compost media supports aerobic microbes that may degrade petroleum hydrocarbons. After passing through the biofilter media, the treated air is discharged to the atmosphere.

3.2 OPERATIONAL HISTORY

Operation of the sewer odor treatment unit was initiated in March 1998. A drip irrigation system was installed on June 18, 2010 to aid in retention of moisture in the treatment beds. At that time, Cell 3 and Cell 4 were shut off as they were not needed for vapor treatment. The system was shut off on September 30, 2015 for upgrades.

APPENDIX G
DATA USABILITY ASSESSMENT

Remedial Investigation Report
Area of Interest 1
Philadelphia Refinery Complex
Philadelphia, Pennsylvania
Philadelphia Refinery Operations,
a series of Evergreen Resources Group, LLC
3144 Passyunk Avenue, Philadelphia, Pennsylvania

Technical Memorandum

To: Jennifer Menges, Project Manager
From: Patrick Vaughan, Senior Scientist

File: Philadelphia Refinery Complex, Area of Interest 1
Date: February 29, 2016

Reference: Data Usability Assessment – Pace Analytical Laboratory Sample Data Group 30108988

This memorandum presents the findings of analytical data validation and usability assessment of the data generated from the analysis of six soil samples collected on December 2-3, 2013 by Stantec Consulting Services Inc. (Stantec) at the Philadelphia Refinery Complex Site. The data review was performed according to the quality assurance and quality control parameters set by the project laboratory and the following guidance documents.

- USEPA, 2014, National Functional Guidelines for Inorganic Superfund Data Review, EPA-540-R-013-001, August 2014.
- USEPA, 2014, National Functional Guidelines for Organic Superfund Data Review, EPA-540-R-014-002, August 2014.
- Stantec, 2015, Evergreen Data Usability – Data Updates, Standard Operating Procedures, Draft, May 31, 2015.

The samples were analyzed at the Pace Analytical Laboratory in Greensburg, Pennsylvania for volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), and metals using the analytical methods listed below.

- VOCs by SW-846 Method 8260B
- SVOCs by SW-846 Method 8270 SIM
- Metals by SW-846 Methods 6010C and 7471

Validation Overview

The following table summarizes the laboratory and client sample identification numbers, sample collection dates, and analytical parameters subject to review.

SDG	Lab Sample ID	Sample Date	Client Sample ID	Analytical Parameters
30108988	30108988001	12/2/2013	S-388_0-2'_120213	VOCs, SVOCs, Metals
30108988	30108988002	12/2/2013	S-389_0-2'_120213	VOCs, SVOCs, Metals
30108988	30108988003	12/2/2013	S-390_0-2'_120213	VOCs, SVOCs, Metals
30108988	30108988004	12/3/2013	S-391_0-2'_120313	VOCs, SVOCs, Metals
30108988	30108988005	12/3/2013	S-392_0-2'_120313	VOCs, SVOCs, Metals
30108988	30108988006	12/3/2013	S-388_19-20'_120313	VOCs, SVOCs, Metals

The sample results were subject to a data review that includes an evaluation of the following parameters: laboratory raw data and finished data packages; chain-of-custody records; sample holding time, temperature, and sample preservation; blank data (method, trip, and equipment); calibration data; chromatograms; laboratory control sample/laboratory control sample duplicate recovery; matrix spike/matrix spike duplicate recovery; surrogate recovery; and overall data assessment.

The data qualifiers applied to the data are defined below.

J	The result is an estimated quantity with "+" indicating a high bias and "-"indicating a low bias. The associated numerical value is the approximate concentration of the analyte in the sample.

Major Exceptions to Data Acceptance Criteria

Major exceptions include those that significantly impact data quality and require the rejection of results. No major exceptions were identified.

Minor Exceptions to Data Acceptance Criteria

Minor exceptions effect data quality but do not result in unusable data. The section below describes the minor exceptions that were identified.

EDB by EPA SW-846 Method 8011

EDB analysis by Method 8011 was requested on the chain-of-custody form but analyzed by the laboratory using Method 8260B.

VOCs by EPA SW-846 8260B

Positive volatile results for benzene and toluene were flagged as "J +"estimated (biased high) in sample S-388 0-2' 120213 because 1 of 3 surrogate recoveries was above control limits in the sample.

Positive volatile results for 1,3,5-trimethylbenzene were flagged as "J" estimated in samples S-391 0-2' 120313, S-392 0-2' 120313, and S-388 19-20' 120313 because the percent difference (%D) for 1,3,5-trimethylbenzene was above the allowable maximum in the associated continuing calibration.

SVOCs by SW-846 Method 8270C

Positive semi-volatile results for 10 target compounds were flagged as "J+" estimated (biased high) in sample S-390 0-2' 120213 because 1 of 2 surrogate recoveries was above control limits in the sample.

Positive semi-volatile results for 9 target compounds were flagged as "J+" estimated (biased high) in sample S-388 19-20' 120313 because 1 of 2 surrogate recoveries was above control limits in the sample.

Positive semi-volatile results for 10 target compounds were flagged as "J+" estimated (biased high) in sample S-392 0-2' 120313 because 2 of 2 surrogate recoveries were above control limits in the sample.

All data are considered usable with estimated (J or J+) data but are associated with a higher level of quantitative uncertainty.

Metals Analysis by SW-846 Method 6010C and 7471

No deficiencies were noted.

Data Usability Assessment

All data are considered usable with the specific exceptions and qualifications noted above.

Completeness of the data set is 100% (defined as the percentage of analytical results that are considered to be valid).

Technical Memorandum

To:	Jennifer Menges, Project Manager	From:	Patrick Vaughan, Senior Scientist
File:	Philadelphia Refinery Complex, Area of Interest 1	Date:	February 29, 2016

Reference: Data Usability Assessment – Pace Analytical Laboratory Sample Data Group 30148426

This memorandum presents the findings of analytical data validation and usability assessment of the data generated from the analysis of eight soil samples collected on May 15, 2015 by Aquaterra at the Philadelphia Refinery Complex Site. The data review was performed according to the quality assurance and quality control parameters set by the project laboratory and the following guidance documents.

- USEPA, 2014, National Functional Guidelines for Inorganic Superfund Data Review, EPA-540-R-013-001, August 2014.
- USEPA, 2014, National Functional Guidelines for Organic Superfund Data Review, EPA-540-R-014-002, August 2014.
- Stantec, 2015, Evergreen Data Usability – Data Updates, Standard Operating Procedures, Draft, May 31, 2015.

The samples were analyzed at the Pace Analytical Laboratory in Greensburg, Pennsylvania for volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), and metals using the analytical methods listed below.

- VOCs by SW-846 Method 8260B
- Gasoline and diesel range organics by SW-846 Method 8015B
- SVOCs by SW-846 Method 8270C SIM
- Metals by SW-846 Methods 6010B and 7471A

Validation Overview

The following table summarizes the laboratory and client sample identification numbers, sample collection dates, and analytical parameters subject to review.

SDG	Lab Sample ID	Sample Date	Client Sample ID	Analytical Parameters
30148426	30148426001	5/15/2015	AOI1_BH-14-001_0-2_051515	Metals
30148426	30148426002	5/15/2015	AOI1_BH-14-001_2-4_051515	Metals
30148426	30148426003	5/15/2015	AOI1_BH-14-001_4-6_051515	Metals
30148426	30148426004	5/15/2015	AOI1_BH-14-002_0-2_051515	Metals
30148426	30148426005	5/15/2015	AOI1_BH-14-002_2-4_051515	VOCs, SVOCs, Metals
30148426	30148426006	5/15/2015	AOI1_BH-14-002_4-6_051515	Metals
30148426	30148426007	5/15/2015	AOI1_BH-14-035_12-14_051515	Metals
30148426	30148426008	5/15/2015	AOI1_BH-14-035_14-16_051515	Metals

The sample results were subject to a data review that includes but is not limited to an evaluation of the following parameters: laboratory raw data and finished data packages; chain-of-custody records; sample holding time, temperature, and sample preservation; blank data (method, trip, and equipment); calibration data; chromatograms; laboratory control sample/laboratory control sample duplicate recovery; matrix spike/matrix spike duplicate recovery; surrogate recovery; and overall data assessment.

The data qualifiers applied to the data are defined below.

J	The result is an estimated quantity with "+" indicating a high bias and "-"indicating a low bias. The associated numerical value is the approximate concentration of the analyte in the sample.

Major Exceptions to Data Acceptance Criteria

Major exceptions include those that significantly impact data quality and require the rejection of results. No major exceptions were identified.

Minor Exceptions to Data Acceptance Criteria

Minor exceptions effect data quality but do not result in unusable data. The section below describes the minor exceptions that were identified.

DRO by Method 8015B:

Positive DRO results for TPH (C10-C28) and TPH (C28-C40) were flagged as "J+ "(estimated, biased high) in sample AOI1 BH-14-002 2-4 051515 because the surrogate recovery was above control limits in the sample.

SVOC Analysis by Method 8270C SIM

Positive benzo(a)pyrene, benzo(b)fluoranthene, and benzo (g,h,i) perylene results were flagged as "J+"(estimated, biased high) in sample AOI1 BH-14-035_14-16_051515 because the internal standard response was below control limits.

Metals Analysis by SW-846 Method 6010C and 7471A

No deficiencies were noted.

Comments

All data are considered usable with the specific exceptions and qualifications noted above.

Completeness of the data set is 100% (defined as the percentage of analytical results that are considered to be valid).

Technical Memorandum

To: Jennifer Menges, Project Manager
From: Patrick Vaughan, Senior Scientist

File: Philadelphia Refinery Complex,
Area of interest 1
Date: March 2, 2016

Reference: Data Usability Assessment – Accutest Laboratories Sample Data Group JB67747

This memorandum presents the findings of analytical data validation and usability assessment of the data generated from the analysis of 12 groundwater samples, one field blank and one trip blank collected on May 21-23, 2014 by Stantec Consulting Services Inc. (Stantec) at the Philadelphia Refinery Complex site. The data review was performed according to the quality assurance and quality control parameters set by the project laboratory and the following guidance documents.

- USEPA, 2014, National Functional Guidelines for Inorganic Superfund Data Review, EPA-540-R-013-001, August 2014.
- USEPA, 2014, National Functional Guidelines for Organic Superfund Data Review, EPA-540-R-014-002, August 2014.
- Stantec, 2015, Evergreen Data Usability – Data Updates, Standard Operating Procedures, Draft, May 31, 2015.

The samples were analyzed at Accutest Laboratories in Dayton, New Jersey for volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), and metals using the analytical methods listed below.

- VOCs by SW-846 Method 8260B
- VOCs by SW-846 Method 8011
- SVOCs by SW-846 Method 8270D SIM
- Metals by SW-846 Methods 6010C

Validation Overview

The following table summarizes the laboratory and client sample identification numbers, sample collection dates, and analytical parameters subject to review.

SDG	Lab Sample ID	Sample Date	Client Sample ID	Analytical Parameters
JB67747	**JB67747-1**	5/23/2014	S-192	VOCs, SVOCs, Metals
JB67747	**JB67747-2**	5/23/2014	S-41	VOCs, SVOCs, Metals
JB67747	**JB67747-3**	5/23/2014	S-272	VOCs, SVOCs, Metals
JB67747	**JB67747-4**	5/23/2014	S-95	VOCs, SVOCs, Metals
JB67747	**JB67747-5**	5/23/2014	S-85	VOCs, SVOCs, Metals
JB67747	**JB67747-6**	5/23/2014	S-46	VOCs, SVOCs, Metals

SDG	Lab Sample ID	Sample Date	Client Sample ID	Analytical Parameters
JB67747	**JB67747-7**	5/23/2014	S-164	VOCs, SVOCs, Metals
JB67747	**JB67747-8**	5/23/2014	RW-404	VOCs, SVOCs, Metals
JB67747	**JB67747-9**	5/23/2014	S-188	VOCs, SVOCs, Metals
JB67747	**JB67747-10**	5/23/2014	FB_05232014	VOCs, SVOCs, Metals
JB67747	**JB67747-11**	5/23/2014	S-51	VOCs, SVOCs, Metals
JB67747	**JB67747-12**	5/21/2014	S-80D	VOCs, SVOCs, Metals
JB67747	**JB67747-13**	5/21/2014	S-394	VOCs, SVOCs, Metals
JB67747	**JB67747-14**	5/23/2014	TRIP BLANK	VOCs

The sample results were subject to a data review that includes but is not limited to an evaluation of the following parameters: laboratory raw data and finished data packages; chain-of-custody records; sample holding time, temperature, and sample preservation; blank data (method, trip, and equipment); calibration data; chromatograms; laboratory control sample/laboratory control sample duplicate recovery; matrix spike/matrix spike duplicate recovery; surrogate recovery; and overall data assessment.

The data qualifiers applied to the data are defined below.

J	The result is an estimated quantity with "+" indicating a high bias and "-"indicating a low bias. The associated numerical value is the approximate concentration of the analyte in the sample.

Major Exceptions to Data Acceptance Criteria

Major exceptions include those that significantly impact data quality and require the rejection of results. No major exceptions were identified.

Minor Exceptions to Data Acceptance Criteria

Minor exceptions effect data quality but do not result in unusable data. The section below describes the minor exceptions that were identified.

VOCs by SW-846 Method 8260B

The not detected volatile results for 1,2-dichloroethane were flagged as "J" (estimated) in all 12 ground water samples, the field blank, and the trip blank because the percent difference (%D) for 1,2-dichloroethane were above the allowable maximum in the associated continuing calibrations.

Metals by SW-846 Method 6010C

No deficiencies were noted.

Comments

All data are considered usable with the specific exceptions and qualifications noted above.

Completeness of the data set is 100% (defined as the percentage of analytical results that are considered to be valid).

Technical Memorandum

To:	Jennifer Menges, Project Manager	From:	Patrick Vaughan, Senior Scientist
File:	Philadelphia Refinery Complex, Area of Interest1	Date:	February 29, 2016

Reference: **Data Usability Assessment – Accutest Laboratories Sample Data Group JB84215**

This memorandum presents the findings of analytical data validation and usability assessment of the data generated from the analysis of 22 groundwater samples and 1 trip blank sample collected on December 15, 2014 by Stantec Consulting Services Inc. (Stantec) at the Philadelphia Refinery Complex Site. The data review was performed according to the quality assurance and quality control parameters set by the project laboratory and the following guidance documents.

- USEPA, 2014, National Functional Guidelines for Inorganic Superfund Data Review, EPA-540-R-013-001, August 2014.
- USEPA, 2014, National Functional Guidelines for Organic Superfund Data Review, EPA-540-R-014-002, August 2014.
- Stantec, 2015, Evergreen Data Usability – Data Updates, Standard Operating Procedures, Draft, May 31, 2015.

The samples were analyzed at the Accutest Laboratories in Dayton, New Jersey for volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), and metals using the analytical methods listed below.

- VOCs by SW-846 Method 8260B
- VOCs (EDB) by SW-846 Method 8011
- SVOCs by SW-846 Method 8270D SIM
- Metals by SW-846 Methods 6010C

Validation Overview

The following table summarizes the laboratory and client sample identification numbers, sample collection dates, and analytical parameters subject to review.

SDG	Lab Sample ID	Sample Date	Client Sample ID	Analytical Parameters
JB84215	JB84215-1	12/15/2014	S-193-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-2	12/15/2014	S-98-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-3	12/15/2014	RW-21-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-4	12/15/2014	S-395-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-5	12/15/2014	RW-30-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-6	12/15/2014	RW-29-20141215	VOCs, SVOCs, Metals

SDG	Lab Sample ID	Sample Date	Client Sample ID	Analytical Parameters
JB84215	JB84215-7	12/15/2014	S-330-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-8	12/15/2014	S-331-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-9	12/15/2014	S-202-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-10	12/15/2014	S-200-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-11	12/15/2014	S-271-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-12	12/15/2014	S-187-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-13	12/15/2014	S-275-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-14	12/15/2014	S-182-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-15	12/15/2014	S-332-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-16	12/15/2014	TB-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-17	12/15/2014	S-269-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-18	12/15/2014	S-50-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-19	12/15/2014	S-44-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-20	12/15/2014	S-227-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-21	12/15/2014	S-259-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-22	12/15/2014	S-258-20141215	VOCs, SVOCs, Metals
JB84215	JB84215-23	12/15/2014	S-79P-20141215	VOCs, SVOCs, Metals

The sample results were subject to a data review that includes, but is not limited to, an evaluation of the following parameters: laboratory raw data and finished data packages; chain-of-custody records; sample holding time, temperature, and sample preservation; blank data (method, trip, and equipment); calibration data; chromatograms; laboratory control sample/laboratory control sample duplicate recovery; matrix spike/matrix spike duplicate recovery; surrogate recovery; and overall data assessment.

The data qualifiers applied to the data are defined below.

J	The result is an estimated quantity with "+" indicating a high bias and "-"indicating a low bias. The associated numerical value is the approximate concentration of the analyte in the sample.
R	The data are unusable. Sample results are rejected due to serious deficiencies in meeting quality control criteria. The analyte may or may not be present in the sample.

Major Exceptions to Data Acceptance Criteria

Major exceptions include those that significantly impact data quality and require the rejection of results. The following major exceptions were identified.

<u>SVOCs by SW-846 Method 8270D SIM</u>

Not detected results are flagged unusable, rejected (R) in the following 6 samples because 1 of 3 surrogate recoveries was below control limits, and below 10% recovery: S-193-20141215, S-271-20141215, RW-30-20141215, S-182-20141215, S-202-20141215, S-227-20141215.

Minor Exceptions to Data Acceptance Criteria

Minor exceptions effect data quality but do not result in unusable data. The section below describes the minor exceptions that were identified.

VOCs by SW-846 Method 8260B

No exceptions were noted.

SVOCs by SW-846 Method 8270D SIM

The not detected semi-volatile results for benzo(a)anthracene were flagged as "J" estimated in samples S-395-20141215, S-187-20141215, S-269-20141215, S-50-2014125, and S-44-20141215 because the percent difference (%D) for benzo(a)anthracene was above the allowable maximum in the associated continuing calibration.

The positive semi-volatile results for target compounds were flagged as "J-" estimated, (biased low) and not detected results flagged "J" estimates in samples S-330-20141215,S-275- 20141215, and S-79P-20141215 because 1 of 3 surrogate recoveries was below control limits, but not below 10% in the samples.

The positive semi-volatile results for target compounds were flagged as "J-"estimated, (biased low) in the following samples because 1 of 3 surrogate recoveries was below control limits, but not below 10% in the samples: S-193-20141215, S-271-20141215, RW-30-20141215, S-182-20141215, S-202-20141215, S-227-20141215 (not detected results were flagged rejected (R) as described in the previous section).

Metals Analysis by SW-846 Method 6010C

No exceptions were noted.

Comments

All data are considered usable with the specific exceptions and qualifications noted above.

Completeness of the data set is 74% (defined as the percentage of analytical results that are considered to be valid).

Technical Memorandum

To:	Jennifer Menges, Project Manager	From:	Patrick Vaughan, Senior Scientist
File:	Philadelphia Refinery Complex, Area of Interest 1	Date:	March 2, 2016

Reference: Data Usability Assessment – Accutest Laboratories Sample Data Group JB98826

This memorandum presents the findings of analytical data validation and usability assessment of the data generated from the analysis of two groundwater samples, one field duplicate sample and one trip blank collected on July 9, 2015 by Stantec Consulting Services Inc. (Stantec) at the Philadelphia Refinery Complex Site. The data review was performed according to the quality assurance and quality control parameters set by the project laboratory and the following guidance documents.

- USEPA, 2014, National Functional Guidelines for Inorganic Superfund Data Review, EPA-540-R-013-001, August 2014.
- USEPA, 2014, National Functional Guidelines for Organic Superfund Data Review, EPA-540-R-014-002, August 2014.
- Stantec, 2015, Evergreen Data Usability – Data Updates, Standard Operating Procedures, Draft, May 31, 2015.

The samples were analyzed at the Pace Analytical Laboratory in Greensburg, Pennsylvania for volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), and metals using the analytical methods listed below.

- VOCs by SW-846 Method 8260C
- VOCs (EDB) by SW-846 Method 8011
- SVOCs by SW-846 Method 8270D SIM
- Metals by SW-846 Methods 6010C

Validation Overview

The following table summarizes the laboratory and client sample identification numbers, sample collection dates, and analytical parameters subject to review.

SDG	Lab Sample ID	Sample Date	Client Sample ID	Analytical Parameters
JB98826	JB98826-1	7/9/2015	TB-20150709	VOCs
JB98826	JB98826-2	7/9/2015	S-418-20150709	VOCs, SVOCs, Metals
JB98826	JB98826-3	7/9/2015	S-418-20150709 DUP	VOCs, SVOCs, Metals
JB98826	JB98826-4	7/9/2015	S-419-20150709	VOCs, SVOCs, Metals

The sample results were subject to a data review that includes, but is not limited to, an evaluation of the following parameters: laboratory raw data and finished data packages; chain-of-custody records; sample holding time, temperature, and sample preservation; blank data (method, trip, and equipment); calibration data; chromatograms; laboratory control sample/laboratory control sample duplicate recovery; matrix spike/matrix spike duplicate recovery; surrogate recovery; and overall data assessment.

The data qualifiers applied to the data are defined below.

J	The result is an estimated quantity with "+" indicating a high bias and "-"indicating a low bias. The associated numerical value is the approximate concentration of the analyte in the sample.
R	The data are unusable. The sample results are rejected due to serious deficiencies meeting quality control criteria. The analyte may or may not be present in the sample.

Major Exceptions to Data Acceptance Criteria

Major exceptions include those that significantly impact data quality and require the rejection of results. The following exceptions were identified.

SVOCs by SW-846 Method 8270D

Not detected semi-volatile results in samples S-418- 20150709 DUP and S-419-20150709 are flagged "R" unusable, rejected because 1 of 3 surrogate recoveries was below control limits and below 10% in the samples.

Minor Exceptions to Data Acceptance Criteria

Minor exceptions effect data quality but do not result in unusable data. The section below describes the minor exceptions that were identified.

SVOCs by SW-846 Method 8270D

The positive semi-volatile results for target compounds in samples S-418- 20150709 DUP and S-419-20150709 were flagged as "J-" (estimated, biased low) because 1 of 3 surrogate recoveries was below control limits and below 10% in the samples.

Metals Analysis by SW-846 Method 6010C

No deficiencies were noted.

Comments

All data are considered usable with the specific exceptions and qualifications noted above.

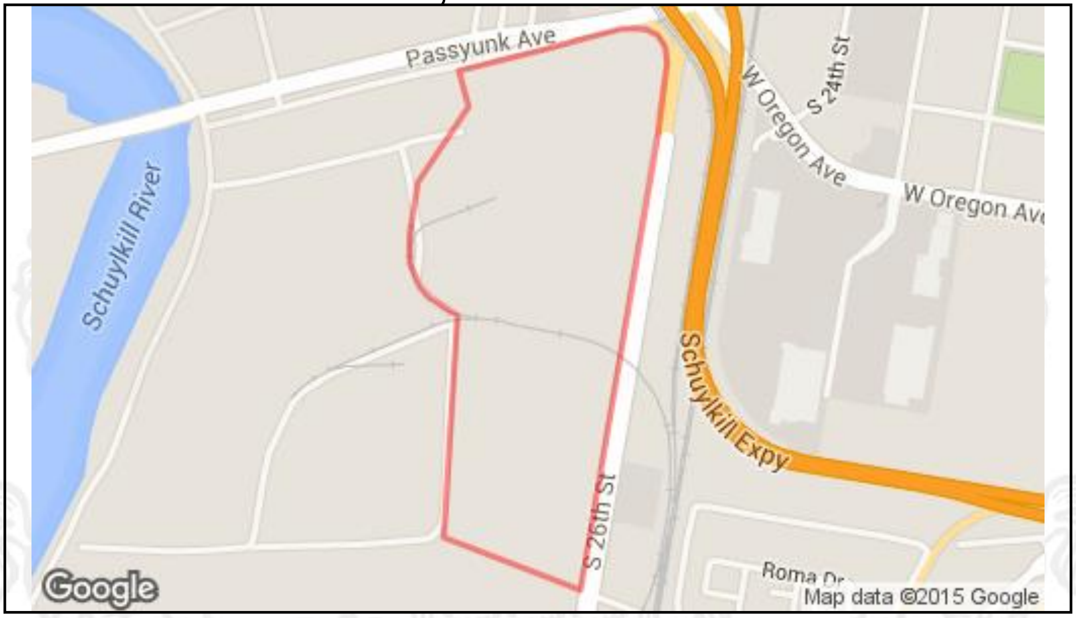
Completeness of the data set is 95% (defined as the percentage of analytical results that are considered to be valid).

APPENDIX H
ECOLOGICAL ASSESSMENT DOCUMENTATION

Remedial Investigation Report
Area of Interest 1
Philadelphia Refinery Complex
Philadelphia, Pennsylvania
Philadelphia Refinery Operations,
a series of Evergreen Resources Group, LLC
3144 Passyunk Avenue, Philadelphia, Pennsylvania

1. PROJECT INFORMATION

Project Name: **PHL AOI-1**
Date of review: **12/7/2015 1:16:10 PM**
Project Category: **Hazardous Waste Clean-up, Site Remediation, and Reclamation,Spill (e.g., oil, chemical)**
Project Area: **78.0** acres
County: **Philadelphia** Township/Municipality: **Philadelphia**
Quadrangle Name: **PHILADELPHIA** ~ ZIP Code: **19145**
Decimal Degrees: **39.918613 N, -75.192095 W**
Degrees Minutes Seconds: **39° 55' 7" N, -75° 11' 31.5" W**



2. SEARCH RESULTS

Agency	Results	Response
PA Game Commission	No Known Impact	No Further Review Required
PA Department of Conservation and Natural Resources	**Potential Impact**	**FURTHER REVIEW IS REQUIRED, See Agency Response**
PA Fish and Boat Commission	No Known Impact	No Further Review Required
U.S. Fish and Wildlife Service	No Known Impact	No Further Review Required

As summarized above, Pennsylvania Natural Diversity Inventory (PNDI) records indicate there may be potential impacts to threatened and endangered and/or special concern species and resources within the project area. If the response above indicates "No Further Review Required" no additional communication with the respective agency is required. If the response is "Further Review Required" or "See Agency Response," refer to the appropriate agency comments below. Please see the DEP Information Section of this receipt if a PA Department of Environmental Protection Permit is required.

RESPONSE TO QUESTION(S) ASKED

Q1: "Accurately describe what is known about wetland presence in the project area or on the land parcel by selecting ONE of the following. ""Project"" includes all features of the project (including buildings, roads, utility lines, outfall and intake structures, wells, stormwater retention/detention basins, parking lots, driveways, lawns, etc.), as well as all associated impacts (e.g., temporary staging areas, work areas, temporary road crossings, areas subject to grading or clearing, etc.). Include all areas that will be permanently or temporarily affected -- either directly or indirectly -- by any type of disturbance (e.g., land clearing, grading, tree removal, flooding, etc.). Land parcel = the lot(s) on which some type of project(s) or activity(s) are proposed to occur ."
Your answer is: **"2. The project area (or land parcel) has not been investigated by someone qualified to identify and delineate wetlands, or it is currently unknown if the project or project activities will affect wetlands."**

Q2: Aquatic habitat (stream, river, lake, pond, etc.) is located on or adjacent to the subject property and project activities (including discharge) may occur within 300 feet of these habitats
Your answer is: **2. No**

3. AGENCY COMMENTS

Regardless of whether a DEP permit is necessary for this proposed project, any potential impacts to threatened and endangered species and/or special concern species and resources must be resolved with the appropriate jurisdictional agency. In some cases, a permit or authorization from the jurisdictional agency may be needed if adverse impacts to these species and habitats cannot be avoided.

These agency determinations and responses are **valid for two years** (from the date of the review), and are based on the project information that was provided, including the exact project location; the project type, description, and features; and any responses to questions that were generated during this search. If any of the following change: 1) project location, 2) project size or configuration, 3) project type, or 4) responses to the questions that were asked during the online review, the results of this review are not valid, and the review must be searched again via the PNDI Environmental Review Tool and resubmitted to the jurisdictional agencies. The PNDI tool is a primary screening tool, and a desktop review may reveal more or fewer impacts than what is listed on this PNDI receipt. The jursidictional agencies **strongly advise against** conducting surveys for the species listed on the receipt prior to consultation with the agencies.

PA Game Commission

RESPONSE: No Impact is anticipated to threatened and endangered species and/or special concern species and resources.

PA Department of Conservation and Natural Resources

RESPONSE: Further review of this project is necessary to resolve the potential impacts(s). Please send project information to this agency for review (see WHAT TO SEND).

DCNR Species: (Note: The PNDI tool is a primary screening tool, and a desktop review may reveal more or fewer species than what is listed below. After desktop review, if a botanical survey is required by DCNR, we recommend the DCNR Botanical Survey Protocols, available here: http://www.gis.dcnr.state.pa.us/hgis-er/PNDI_DCNR.aspx.)
Scientific Name: Echinochloa walteri
Common Name: Walter's Barnyard-grass
Current Status: Endangered

Proposed Status: Endangered

PA Fish and Boat Commission

RESPONSE: No Impact is anticipated to threatened and endangered species and/or special concern species and resources.

U.S. Fish and Wildlife Service

RESPONSE: No impacts to **federally** listed or proposed species are anticipated. Therefore, no further consultation/coordination under the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.* is required. Because no take of federally listed species is anticipated, none is authorized. This response does not reflect potential Fish and Wildlife Service concerns under the Fish and Wildlife Coordination Act or other authorities.

* Special Concern Species or Resource - Plant or animal species classified as rare, tentatively undetermined or candidate as well as other taxa of conservation concern, significant natural communities, special concern populations (plants or animals) and unique geologic features.
** Sensitive Species - Species identified by the jurisdictinal agency as collectible, having economic value, or being susceptible to decline as a result of visitation.

WHAT TO SEND TO JURISDICTIONAL AGENCIES

If project information was requested by one or more of the agencies above, send the following information to the agency(s) seeking this information (see AGENCY CONTACT INFORMATION).

Check-list of *Minimum* Materials to be submitted:

____**SIGNED** copy of this Project Environmental Review Receipt
____Project narrative with a description of the overall project, the work to be performed, current physical characteristics of the site and acreage to be impacted.
____Project location information (name of USGS Quadrangle, Township/Municipality, and County)
____USGS 7.5-minute Quadrangle with project boundary clearly indicated, and quad name on the map

The inclusion of the following information may expedite the review process.
____A basic site plan(particularly showing the relationship of the project to the physical features such as wetlands, streams, ponds, rock outcrops, etc.)
____Color photos keyed to the basic site plan (i.e. showing on the site plan where and in what direction each photo was taken and the date of the photos)
____Information about the presence and location of wetlands in the project area, and how this was determined (e.g., by a qualified wetlands biologist), if wetlands are present in the project area, provide project plans showing the location of all project features, as well as wetlands and streams

4. DEP INFORMATION

The Pa Department of Environmental Protection (DEP) requires that a signed copy of this receipt, along with any required documentation from jurisdictional agencies concerning resolution of potential impacts, be submitted with applications for permits requiring PNDI review. For cases where a "Potential Impact" to threatened and endangered species has been identified before the application has been submitted to DEP, the application should not be submitted until the impact has been resolved. For cases where "Potential Impact" to special concern species and resources has been identified before the application has been submitted, the application should be submitted to DEP along with the PNDI receipt. The PNDI Receipt should also be submitted to the appropriate agency according to directions on the PNDI Receipt. DEP and the jurisdictional agency will work together to resolve the potential impact(s). See the DEP PNDI policy at http://www.naturalheritage.state.pa.us.

5. ADDITIONAL INFORMATION

The PNDI environmental review website is a **preliminary** screening tool. There are often delays in updating species status classifications. Because the proposed status represents the best available information regarding the conservation status of the species, state jurisdictional agency staff give the proposed statuses at least the same consideration as the current legal status. If surveys or further information reveal that a threatened and endangered and/or special concern species and resources exist in your project area, contact the appropriate jurisdictional agency/agencies immediately to identify and resolve any impacts.

For a list of species known to occur in the county where your project is located, please see the species lists by county found on the PA Natural Heritage Program (PNHP) home page (www.naturalheritage.state.pa.us). Also note that the PNDI Environmental Review Tool only contains information about species occurrences that have actually been reported to the PNHP.

6. AGENCY CONTACT INFORMATION

PA Department of Conservation and Natural Resources

Bureau of Forestry, Ecological Services Section
400 Market Street, PO Box 8552, Harrisburg, PA. 17105-8552
Fax:(717) 772-0271

U.S. Fish and Wildlife Service

Pennsylvania Field Office
110 Radnor Rd; Suite 101, State College, PA 16801
NO Faxes Please.

PA Fish and Boat Commission

Division of Environmental Services
450 Robinson Lane, Bellefonte, PA. 16823-7437
NO Faxes Please

PA Game Commission

Bureau of Wildlife Habitat Management
Division of Environmental Planning and Habitat Protection
2001 Elmerton Avenue, Harrisburg, PA. 17110-9797
Fax:(717) 787-6957

7. PROJECT CONTACT INFORMATION

Name: Andrew Klingbeil
Company/Business Name: Stantec Consulting Services, Inc.
Address: 1060 Andrew Drive, Suite 140
City, State, Zip: West Chester, PA 19380
Phone:(610) 840-2525 Fax:(610) 840-2501
Email: andrew.klingbeil@stantec.com

8. CERTIFICATION

I certify that ALL of the project information contained in this receipt (including project location, project size/configuration, project type, answers to questions) is true, accurate and complete. In addition, if the project type, location, size or configuration changes, or if the answers to any questions that were asked during this online review change, I agree to re-do the online environmental review.

applicant/project proponent signature

12-7-15
date

Stantec

December 8, 2015

PA Department of Conservation and Natural Resources
Bureau of Forestry, Ecological Services Section
400 Market Street
P.O. Box 8552
Harrisburg, PA, 17105-8552

Reference: Potential PNDI Conflict
Philadelphia Refinery Complex – AOI 1
PNDI Search ID: 20151207541539
City of Philadelphia, Philadelphia County, Pennsylvania

Dear Sir/Madam,

Stantec Consulting Services, Inc. (Stantec) is currently preparing Site Characterization Reports (SCRs) on behalf of Philadelphia Energy Solutions Refining and Marketing LLC (PES) and Philadelphia Refinery Operations, a series of Evergreen Resources Group, LLC (Evergreen) for select aboveground storage tanks located in the PES Philadelphia Refinery Complex (facility), located at 3144 Passyunk Avenue in the City of Philadelphia, Philadelphia County, Pennsylvania (**Figure 1**) in response to tank-related incidents. Additionally, the facility, including the adjacent Belmont Terminal owned by Sunoco Partners Marketing and Terminals, L.P., is part of the One Cleanup Program which provides a mechanism for properties participating in the Pennsylvania Land Recycling Program to also satisfy the requirements of the Environmental Protection Agency (EPA) Corrective Measures program. As a part of this program, Stantec is currently preparing a combined Site Characterization Report/Remedial Investigation Report (SCR/RIR) to establish the current conditions of the facility and investigate environmental impacts resulting from historical refining/petroleum storage operations within Area of Interest 1 (AOI 1).

The storage tank Corrective Action Process (CAP) regulations in 25 PA Code Chapter 245, Subchapter D, specifically §245.310(a)(28) and §245.310(b)(4), and the Land Recycling Program regulations in 25 PA Code Chapter 250, specifically §250.311 and §250.402, require an evaluation of ecological receptors at the facility. According to the Pennsylvania Natural Diversity Inventory (PNDI) Environmental Review Tool search (PNDI Search ID: 20151207541539), potential impacts may exist within the facility under the jurisdiction of the State of Pennsylvania Department of Conservation and Natural Resources (PADCNR). The search identified Walter's Barnyard-grass (Echinochloa walteri) as an endangered species of concern within the general project area. A copy of the PNDI Project Environmental Review Receipt is attached.

The facility is located on industrial property with access restricted by fencing and security measures. AOI 1 is bordered by Passyunk Avenue to the north, 26th Street to the east, Hartranft Street to the south, and by additional PES-owned industrial property (AOI 2) to the west. AOI 1

Reference: Potential PNDI Conflict
Philadelphia Refinery Complex – AOI 1
PNDI Search ID: 20151207541539
City of Philadelphia, Philadelphia County, Pennsylvania

encompasses approximately 80 acres and is located approximately 1,500 feet to the east of the Schuylkill River. AOI 1 consists of an active fuel terminal (Belmont Terminal) and aboveground storage tank farms (Nos. 1 and 2 Tank Farms). An aerial photograph depicting site features is included as **Figure 2**. The current and intended future uses of AOI 1 are non-residential.

We request a determination from the PADCNR as to whether or not projects at this facility could affect Walter's Barnyard-grass, identified by the PNDI Environmental Project Review to be an endangered species of concern in the area under PADCNR jurisdiction. If you have questions on the enclosed material or require any additional information to make your determination, please feel free to contact me at (610) 840-2525.

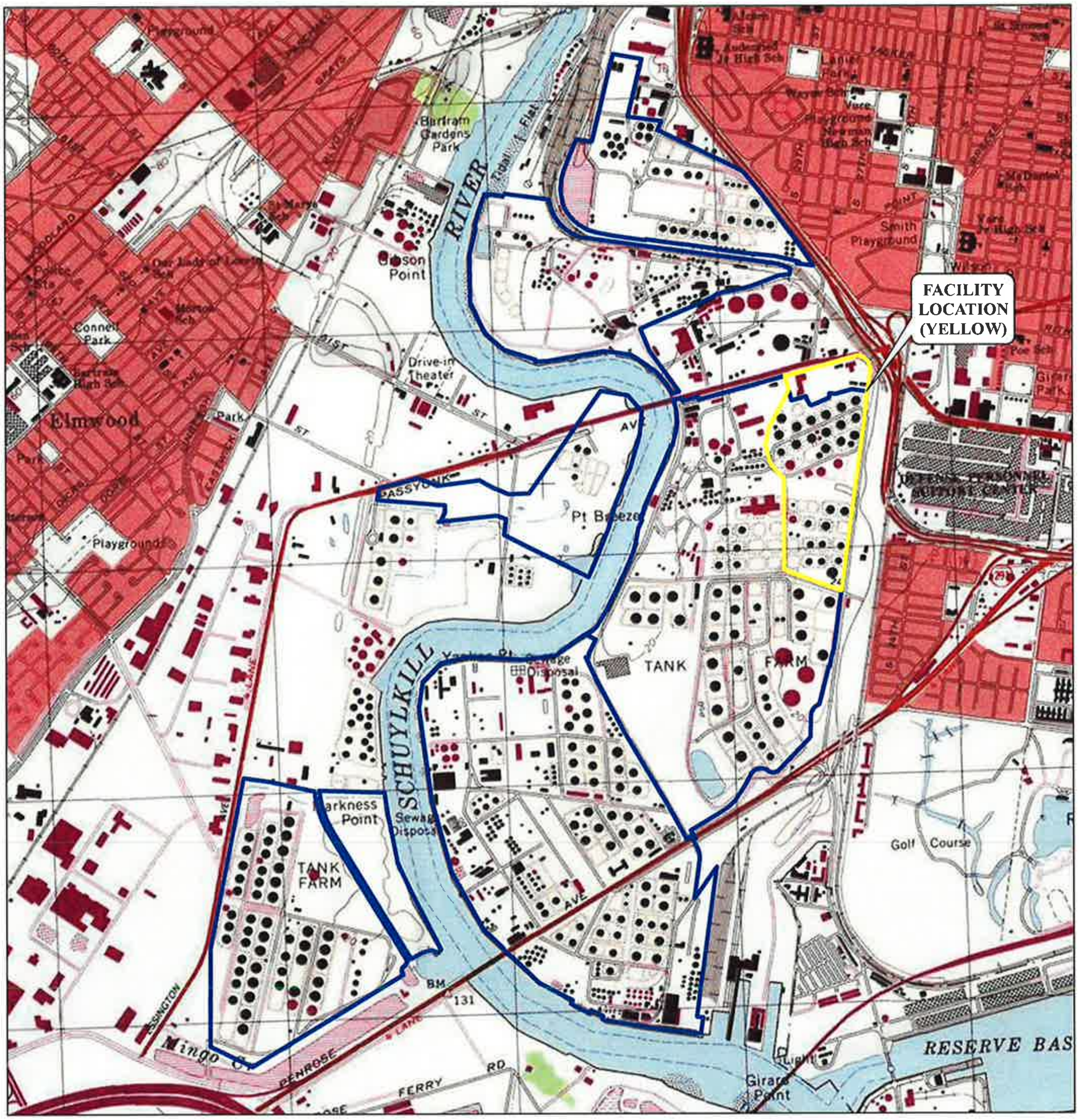
Regards,

Stantec Consulting Services, Inc.

Andrew D. Klingbeil, P.G.
Geologic Project Specialist
Phone: 610-840-2525
Fax: 610-840-2501
andrew.klingbeil@stantec.com

Attachment: PNDI Project Environmental Review Receipt
Figure 1 – Site Location Map
Figure 2 – Site Plan

c. Stantec Project File
Evergreen Project File



LEGEND

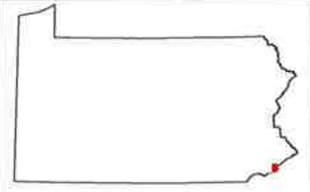
🟨 AOI 1 AND BELMONT TERMINAL

🟦 PHILADELPHIA REFINERY COMPLEX

0 750 1,500 3,000 4,500 Feet

1:26,400 (at original document size of 8.5x11)

N



PHILADELPHIA, PA-NJ
USGS 7.5" TOPOGRAPHIC QUADRANGLE

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Source: Stantec, Evergreen Resources Management
3. Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed

Stantec

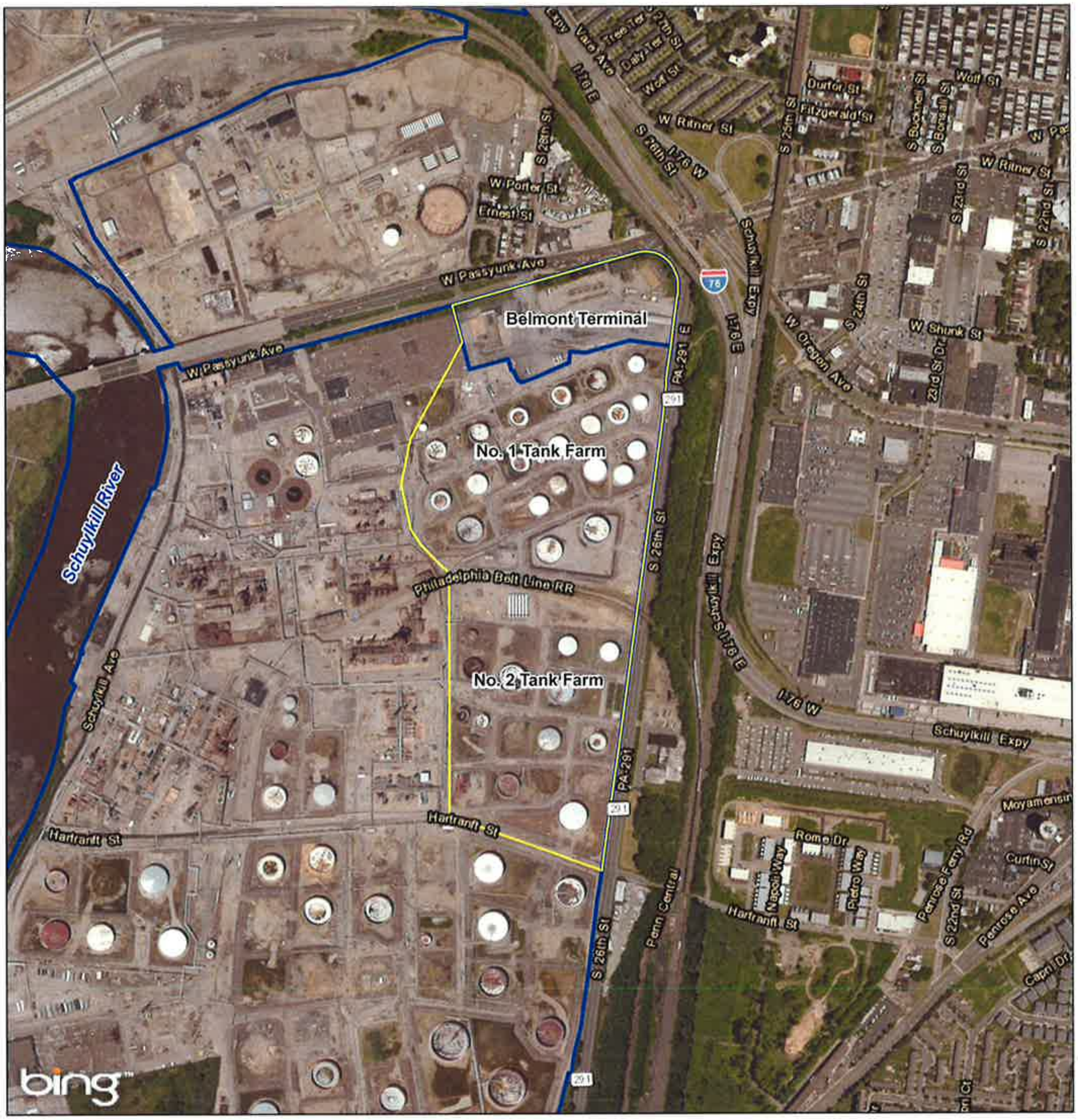
Project Location
City of Philadelphia,
Pennsylvania

213402434
Prepared by ADK on 12/7/2015
Technical Review by JKD on 12/8/2015
Independent Review by DD on 12/11/2015

Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Figure No.
1

Title
AOI 1 - SITE LOCATION MAP



LEGEND

- AOI 1 AND BELMONT TERMINAL
- PHILADELPHIA REFINERY COMPLEX

0 250 500 1,000 1,500 Feet

1:10,000 (at original document size of 8.5x11)

N

Stantec

Notes

1. Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
2. Source: Stantec, Evergreen Resources Management
3. Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo.

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

Project Location
City of Philadelphia,
Pennsylvania

213402434
Prepared by ADK on 12/7/2015
Technical Review by JKD on 12/8/2015
Independent Review by DD on 12/11/2015

Client/Project
EVERGREEN RESOURCES MANAGEMENT OPERATIONS LLC
PHILADELPHIA REFINERY
3144 PASSYUNK AVENUE
PHILADELPHIA, PA 19145

Figure No.
2

Title
AOI 1 - SITE PLAN

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

BUREAU OF FORESTRY

December 31, 2015 **PNDI Number: 20151207541539**

Andrew Klingbeil
Stantec Consulting Services, Inc.
1060 Andrew Drive, Suite 140
West Chester, PA 19380
Email: andrew.klingbeil@stantec.com (hard copy will not follow)

Re: PHL AOI-1
Philadelphia Township, Philadelphia County, PA

Dear Andrew Klingbeil,

Thank you for the submission of the Pennsylvania Natural Diversity Inventory (PNDI) Environmental Review Receipt Number **20151207541539** for review. PA Department of Conservation and Natural Resources screened this project for potential impacts to species and resources under DCNR's responsibility, which includes plants, terrestrial invertebrates, natural communities, and geologic features only.

No Impact Anticipated

PNDI records indicate species or resources under DCNR's jurisdiction are located in the vicinity of the project. However, based on the information you submitted concerning the nature of the project, the immediate location, and our detailed resource information, DCNR has determined that no impact is likely. No further coordination with our agency is needed for this project.

This response represents the most up-to-date review of the PNDI data files and is valid for two (2) years only. If project plans change or more information on listed or proposed species becomes available, our determination may be reconsidered. Should the proposed work continue beyond the period covered by this letter, please resubmit the project to this agency as an "Update" (including an updated PNDI receipt, project narrative and accurate map). As a reminder, this finding applies to potential impacts under DCNR's jurisdiction only. Visit the PNHP website for directions on contacting the Commonwealth's other resource agencies for environmental review.

Should you have any questions or concerns, please contact Jaci Braund, Ecological Information Specialist, by phone (717-214-3813) or via email (c-jbraund@pa.gov).

Sincerely

Greg Podniesinski

Greg Podniesinski, Section Chief
Natural Heritage Section

APPENDIX I
COPIES OF REFERENCED CONSULTANT REPORTS (CD-ROM)

Remedial Investigation Report
Area of Interest 1
Philadelphia Refinery Complex
Philadelphia, Pennsylvania
Philadelphia Refinery Operations,
a series of Evergreen Resources Group, LLC
3144 Passyunk Avenue, Philadelphia, Pennsylvania