Parcel 8
SITE ID # BCP Site No. C241087
Long Island City, New York

REMEDIAL INVESTIGATION REPORT

Prepared for
Queens West Development Corporation
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New York, New York 10017

and

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FLS Project Number: 10011-007-1

Submitted to
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List of Acronyms

ADT	Aquifer Drilling and Testing Inc.
AOC	Area of Concern
AKRF	AKRF Engineers, Inc.
AWQS	Division of Water Technical Operational and Guidance Series (TOGS) 1.1.1 Class GA Ambient Water Quality Standards
BCA	Brownfield Cleanup Agreement
BCP	Brownfield Cleanup Program
BTEX	Benzene, Toluene, Ethylbenzene, and Total Xylenes
CAMP	Community Air Monitoring Program
C & D	Construction and Demolition
CLASS GA	NYSDEC TOGS 1.1.1 Class GA Ambient Water Quality Standards and Guidance Values
cm	Centimeters
CPP	Citizen Participation Plan
COC	Chain-of-Custody
COC	Certificate of Completion
CSOs	Combined Sewer Outfalls
(D)	Deep
DNAPL	Dense Non-Aqueous Phase Liquids
DO	Dissolved Oxygen
DUSR	Data Usability Summary Report
Dup	Duplicate Sample
ERL	Effects Range Low

ERM	Effects Range Medium
ELAP	Environmental Laboratory Accreditation Program
EM	Electromagnetic
ft-ag	feet above grade
ft-bg	feet below grade
FLS	Fleming-Lee Shue, Inc.
GW	Groundwater
GPR	Ground Penetrating Radar
HASP	Health and Safety Plan
HSA	Hollow Stem Auger
J	Estimated Value
LCS	Laboratory Control Sample
LNAPL	Light Non-aqueous Phase Liquid
LOWESS	Locally weighted scatter plot smoothing
LUW	Environ 2008 Lands Under Water Report
MS	Matrix Spike
MS/MSD	Matrix Spike/Matrix Spike Duplicate
OM & M	Operations Monitoring and Maintenance
OSHA	Occupational Safety and Health Association
ORP	Oxidation Reduction Potential
OVM	Organic Vapor Monitor
NAPL	Non-Aqueous Phase Liquid

ND	Non-Detect
NE	Northeast
NYSDEC	New York State Department of Environmental Conservation
NYCDEP	New York City Department of Environmental Protection
NYCDOB	New York City Department of Buildings
NYSDOH	New York State Department of Health
NYSDOH-ELAP	New York State Department of Health Environmental Laboratory Approval Program
NW	Northwest
MEK	Methyl Ethyl Ketone
MW	Monitoring Well
p(50)	50th percentile (median)
p(x)	xth percentile
PAHs	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCE	Tetrachloroethylene
PEL	Permissible Exposure Level
PID	Photoionization Detector
PPBV	Parts Per Billion by Volume
PPMV	Parts Per Million by Volume
QA/QC	Quality Assurance / Quality Control
RAWP	Remedial Action Work Plan
R	Rejected

RI	Remedial Investigation
RIR	Remedial Investigation Report
RL	Analytical Reporting Limit(s)
RSCOs	Recommended Soil Cleanup Objectives
SB	Soil Boring
SCOs	Part 375 Commercial Use Soil Cleanup Objectives
sec	Seconds
SG	Soil Gas
(S)	Shallow
SRI	Supplemental Remedial Investigation
SRIWP	Supplemental Remedial Investigation Work Plan
SU	Standard Units
SVOCs	Semi-Volatile Organic Compounds
SW	Southwest
TAL	Target Analyte List
TAGM 4046	Technical and Administrative Guidance Memorandum 4046
TAGM RSCOs	NYSDEC Technical Assistance Guidance Memorandum 4046 Recommended Soil Cleanup Objectives
TCE	Trichloroethylene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leachate Procedure
TDS	Total Dissolved Solids
TM	Truck Mounted

TOGS	New York State Department of Environmental Conservation Technical and Operational Guidance Series 1.1.1 Water Quality Standards and Guidelines
TP	Test Pit
TPH	Total Petroleum Hydrocarbons
Track 1 – SCOs	NYSDEC Brownfield Cleanup Program Subpart 375-6.8 Track 1 - Unrestricted Use Soil Cleanup Objectives
Track 4 – SCOs	NYSDEC Brownfield Cleanup Program Subpart 375-6.8 Track 4 - Restricted Use Soil Cleanup Objectives
TRC	TRC Engineers, Inc.
U	Below Detection Limit
USGS	United States Geological Survey
USTs	Underground Storage Tanks
QBD	Queens Borough Datum
QWDC	Queens West Development Corporation
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation Recovery Act
µS	Micro siemens
VOCs	Volatile Organic Compounds
Warren Chemical	Warren Chemical Company
1,1,1-TCA	1,1,1 Trichloroethane

1.0 INTRODUCTION

This Remedial Investigation Report (RIR) has been prepared by Arnold F. Fleming, P.E. and Fleming Lee-Shue, Inc. (FLS) for the Queens West Development Corporation (QWDC) tract of land known as Parcel 8 (the Site) within Stage 1 of the Queens West Development (QWD). Parcel 8 is near the East River in the Hunters Point neighborhood of Long Island City, Queens County, New York. The Site fronts the western side of Center Boulevard between 48th Avenue and 47th Road, Gantry Park is to the south and Peninsula Park is to the west, between the Site and the East River. The Site, once home to numerous industrial and commercial operations, is now vacant and belongs to QWDC, a subsidiary of the Urban Development Corporation, d/b/a Empire State Development Corporation. The Site is designated as Block 19, Lot 19 by the New York City Department of Assessment and occupies 0.73 acres (31,799 ft^2). A Site Location Map and Site Layout and Sampling Locations are included as Figures 1 and 2, respectively. A current aerial view of the Site is presented as Figure 3.

Parcel 8 is part of a larger 74-acre shoreline tract of land within the QWD, which extends along the East River from Anable Basin on the north to Newtown Creek on the south (the southern portion of the QWD property is now the locus of New York City's Hunter's Point south development project). The QWD project has been a key step in transforming a large area of New York City's 19th and 20th Century heavy industrial sites into 21st Century communities, because it optimizes use of one of New York City's diminishing resources: land. The development of the Queens West project is fundamental to New York City's future and revitalization of the New York City waterfront.

Parcel 8 is part of this transformation. It is included in the New York State Brownfield Cleanup Program (BCP) as Site No. C241087, subject to a Brownfield Cleanup Agreement (BCA) between Avalon Riverview II, LLC and Avalon Riverview III, LLC (Avalon), as Volunteers, and the New York State Department of Environmental Conservation (NYSDEC) (Index No. W2-1059-05-03). The Site is surrounded by areas in various states of re-development and environmental cleanup. To the east, across Center Boulevard, is Parcel 9, which was contaminated in large part by the same historical operations that affect Parcel 8. Parcel 9 has since been remediated under BCA (Site No. C241049) and received its Certificate of Completion for Restricted Residential use (Track 4) on December 29, 2006.

Future development of Parcel 8 will include the Queensboro Public Library and a park headquarters for the parks associated with the QWD including the existing Gantry Plaza State Park and Peninsula Park.

FLS completed a Remedial Investigation (RI) on Parcel 8 from June 2008 through January 2009. The RI followed an earlier preliminary investigation by AKRF (AKRF, July 2006. *Off-Site Investigation Report,* Queens West Development Parcel 9, Queens, New York, Project Number 10516), under the auspices of Avalon Riverview LLC (Avalon). Based on the findings of the 2006 AKRF *Off-Site Investigation Report* and a site conceptual model that it developed, FLS prepared a Supplemental Remedial Investigation Work Plan (SRIWP) to fill in the data gaps necessary to complete the investigation of Parcel 8. The Department approved the SRIWP on July 8, 2008. The additional information obtained through the Supplemental Remedial Investigation (SRI) will enable Avalon to design and conduct site remediation and Site re-development to proceed. The data collected as part of the SRI will be used together with all historic data to develop the Remedial Action Work Plan (RAWP).

The SRIWP and Stipulations to the environmental investigation for Parcel 8 are presented in Appendix A; Consent and Agreement Documents are presented in (Appendix B). These include the following:

1. Agreement No. D2-0001-00-09/V-00194: Hunters Point (Queens West) Waterfront development Project Parcel 8, Voluntary Cleanup Agreement/Transition to Brownfield Cleanup Program and Addition of New Volunteer, March 29, 2004.
2. Brownfield Cleanup Agreement, Index No. W2-1059-05-03, Site No. C241087. In the Matter of a Remedial Program for the Hunters Point (Queens West Waterfront Development Project, Parcel 8, Queens County, under Article 27, Title 14 of the Environmental Conservation Law by Volunteers Avalon Riverview II LLC and Avalon Riverview III LLC, March 30, 2005.

2.0 SITE DESCRIPTION AND HISTORY

Section 2 presents a description of the Site, its physical condition, investigation history, surrounding land use, and general information on regional and Site geology and hydrology, and summarizes the findings of earlier Site investigations. Where useful, in a few instances, new information from the current investigations has been added to present a more complete description. Otherwise, Section 3 presents all the SRI results.

2.1 Site Description

Parcel 8 is in the Hunters Point section of Queens, New York and is bounded by 47th Road to the north, 48th Avenue and Gantry State Park to the south, Center Boulevard to the east, and Peninsula Park to the west, between the Site and the East River. It occupies 0.73 acres (31,797 ft^2), and is currently surrounded on all sides by a chain-link fence. The Site is designated as Block 19, Lot 21 by the New York City Department of Assessment.

Parcel 8 is a nearly level vacant lot with no structures or other surface features. The area to the north, across 47th Road, is Stage 2 of the QWD. The southern portion of Stage 2 was remediated under Voluntary Cleanup Agreements V00505A and V00505B and redevelopment with residential housing, commercial operations, a park, and utilities is nearly completed. A newly occupied residential building is located in Stage 2 directly north of Parcel 8, across 47th Road. The remediation of the northern portion of Stage 2, conducted pursuant to BCAs V00505C and V00505D, is nearly complete and redevelopment work similar to that of the southern portion of Stage 2 is scheduled to begin soon. The area to the east of Parcel 8, within Stage 1, has been designated Parcel 9 as a part of the QWD and was remediated pursuant to the BCP (BCA No. C241049; Index No. W2-1060-05-03) and received a Certificate of Completion for Restricted Residential Use (Track 4) on December 29, 2006. Construction of a high-rise residential building and townhouses by Avalon on Parcel 9 is complete and the buildings are occupied. To the southeast of Parcel 8 there is a high-rise residential building (Citylights) that also houses P.S. 78, a public elementary school (4809 Center Blvd.), approximately 170 feet southeast of the Site. Peninsula Park and Gantry Plaza State Park border Parcel 8 on the west and south, respectively. The East River lies approximately 300 feet west of Parcel 8. Figure 4 presents the surrounding land use.

2.2 Site History

The site history was developed from several sources including Sanborn maps, historical photograph, previous AKRF and TRC Engineers, Inc. reports, and a detailed history of Long Island City by Vincent Seyfried, 1984, entitled *300 Years of Long Island City 1630 – 1930*. Sanborn maps are included in Appendix C.

2.2.1 Historical Sanborn Maps

The Sanborn Fire Insurance summary included in the July 2008 FLS SRIWP (Appendix A) indicated several past uses that are likely sources of the coal tar/creosote, petroleum, and metals impacts to soil and groundwater. Included in this report is a review of all available Historic Sanborn Insurance Maps from 1898 to 1996. The maps included the following years: 1898, 1915, 1936, 1947, 1950, 1970, 1977, 1979, 1980, 1985, 1986, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995 and 1996. Site history from review of the Sanborn maps appears below.

Year	Comments
1898	**Site:** The Site encompasses portions of Block 19, and is bounded by 6th and 7th Streets, and the block is bounded to the east by Western Ave. The site is occupied by Warren Chemical Company (Warren Chemical), which encompasses the entire Site and extends beyond the current Parcel 8 boundaries. On-site, the Warren Chemical facility includes various structures such as tanks and storage. Warren Chemical occupied the Site for approximately 60 years, from 1855 to 1915 (see below). **Surrounding Properties:** The Site is bounded to the north by 7th Street containing vacant lots and small commercial buildings for N.Y. Mastic Company Work and to the northeast by Cheser Bros Enameled Letters and Signs; to the east by Lawson-Valetine Boiler Works (vacant); to the south by 6th Street and Barber Asphalt Paving, Rail yards and Chase Roberts and Co. Varnish Works; and to the west by the East River. The surrounding properties are predominantly industrial.
1915	**Site:** The Site is vacant. Four structures remain labeled “storage” and all are vacant. Warren Chemical is no longer present on the Site. **Surrounding Properties:** To the north, N.Y. Mastic Company Work and to the south Barber Asphalt Paving are no longer present. Additional industrial development occurred on properties to the north and east of the Site. National Varnish Company occupies a property northeast of the Site and Edward Smith Varnish Works, Blau Gas Company of America Company of America, and Barber Asphalt occupy properties east of the Site. The Rail yards are shown encompassing the entire block south of the Site. The surrounding properties are predominantly industrial.

Year	Comments
1936	**Site:** The Site is occupied by Liquid Carbonic Corp. The buildings associated with the Liquid Carbonic Corp are two large warehouse structures and a smaller storage structure. The surrounding streets have changed names and the Site is now bounded to the north by 47th Rd. (formerly 7th St.), to the south by 48th Ave. (formerly 6th St) and the block bounded to the east by 5th St (formerly Western Ave.) **Surrounding Properties:** The surrounding properties appear generally unchanged from the 1915 Sanborn Map. However, the industrial lot north of the Site is shown occupied by Quimby Corp. and additional factories now occupy properties to the east of the Site. The facilities to the east of the Site are shown as Edward Smith Varnish Works, Harlem Chemical Co., Stanley Barrel Corp., Crest Mfg - Plumber Supplies and Kelly Dry Ginger Ale Corp. The properties south of the Site remain unchanged (Rail yards).
1947	**Site:** The Site appears unchanged from the 1936 Sanborn Map. **Surrounding Properties:** The surrounding properties appear generally unchanged from the 1936 Sanborn Map. However, the properties to the north are shown occupied by Buchman Spark Wheel Mfr., Mfr. of Detergents and Insecticides. The facilities to the east of the Site are shown as Paint and Varnish Works, Chemical Mfg., Refrigeration Equip. Mfr., Crest Mfg - Plumber Supplies and an auto repair shop. The properties south of the Site remain unchanged (Rail yards).
1950	**Site:** The Site appears unchanged from the 1947 Sanborn Map. **Surrounding Properties:** The surrounding properties appear generally unchanged from the 1947 Sanborn Map. The properties to the north are shown as occupied by Buchman Spark Wheel Mfr., Mfr. of Detergents and Insecticides. The facilities to the east of the Site are shown as Paint and Varnish Works, Chemical Mfg., Refrigeration Equip. Mfr., Crest Mfg - Plumber Supplies and an auto repair shop. The properties south of the Site remain unchanged (Rail yards).
1970	**Site:** The Site is occupied by a Metal Storage Warehouse and contains three large warehouse type structures and one smaller storage structure. **Surrounding Properties:** The surrounding properties appear generally unchanged from the 1950 Sanborn Map. The properties to the north are shown as occupied by Buchman Spark Wheel Mfr., Mfr. of Detergents and Insecticides. The facilities to the east of the Site are shown as Hub Paint Works and Adam Metal Supply. The properties south of the Site remain unchanged (Rail yards).
1977	**Site:** The Site appears unchanged from the 1970 Sanborn map and is occupied by a Metal Storage Warehouse. **Surrounding Properties:** The surrounding properties appear vacant to the east with the exception of the immediate eastern adjacent site shown as Charles Offset Co. Inc. The properties to the north are shown as occupied by Buchman Spark Wheel Mfr., Mfr. of Detergents and Insecticides. The properties south of the Site remain unchanged (Rail yards).

Year	Comments
1979	**Site:** The Site appears unchanged from the 1970 Sanborn Map; however, the Site is shown as Hallen Contractors. **Surrounding Properties:** The surrounding properties appear generally unchanged from the 1977 Sanborn Map.
1980-1989	**Site:** The Site appears unchanged from the 1979 Sanborn Map. **Surrounding Properties:** The surrounding properties appear generally unchanged from the 1979 Sanborn Map.
1990-1994	**Site:** The Site appears unchanged from the 1979 Sanborn Map. **Surrounding Properties:** The surrounding properties appear generally unchanged from the 1979 Sanborn Map.
1995-1996	**Site:** The Site appears unchanged from the 1979 Sanborn Map. **Surrounding Properties:** The surrounding properties appear generally unchanged from the 1979 Sanborn Map. Charles Offset Co. Inc. borders the site to the east and the properties to the north are shown as occupied by Buchman Spark Wheel Mfr., Mfr. of Detergents and Insecticides. However, the properties to the south are shown as vacant.

2.2.2 Historical Site Uses and Ownership

Historically, Parcel 8 housed mainly chemical manufacturing and processing operations, although in later years Parcel 8 was used for warehousing and equipment storage. The 1898 Sanborn map, the earliest Sanborn map, shows the Site to have a solid structure belonging to Warren Chemical, a producer of roofing materials, tar paper and asphalt. The structures on the Site at the time include tanks and storage rooms. However, Seyfried 1984 places Warren Chemical Chemical's operations at the Site beginning in 1855. The Site is vacant in the 1915 Sanborn map and the building and structures no longer remain, indicating that Warren Chemical operated on Parcel 8 for approximately 60 years. During Warren Chemical's tenure, pumps, tanks, condensers, dryers, steam stills, and storage areas associated with the rendering of coal tar for production of tar paper and asphalt were shown on Site. Figure 5 shows Parcel 8 when Warren Chemical occupied the Site in the late 1800s-early 1900s (1898 Sanborn map). A historical photograph, Figure 6, shows what is believed to be Parcel 8 during Warren Chemical's tenure in the early 1900s. This photograph, on which the date 1923 appears, shows a large quantity of stacked drums on/abutting Parcel 8. Although the date 1923 appears on the photo, it is believed to have been taken prior to 1907, as the Queensboro Bridge, which was constructed in that year, does not appear in the photo.

The Liquid Carbonic Company, which produced liquefied carbon dioxide for use in soda fountains, occupied the site from the 1930s until the 1950s. In 1970 the Site was occupied by a metal storage warehouse. Hallen Contractors then occupied the Site from the 1970s until the Site was vacated and all structures demolished in 2001 (AKRF 2005). Currently Parcel 8 is an undeveloped, vacant lot enclosed by a chain-linked fence.

2.2.3 Surrounding Historical Land Use

The Hunters Point waterfront area became a major industrial center with chemical processing, manufacturing and petroleum refining operations on or near the Site dating back to the mid 19th Century (Seyfried 1984). According to Sanborn maps dating back to 1898, the area has been populated with industrial and manufacturing facilities from 1898 to 1996. However, as noted by Seyfried 1984, the area was industrialized in the mid-1800s.

According to Sanborn maps dating back to 1898, there were several businesses next to Parcel 8. The N.Y. Mastics Company Works (the Mastics Company) occupied the area to the north (site V00505A of Stage 2 QWDC) from 1898 to 1915. Historical maps do not indicate any significant structures associated with the N.Y. Mastics Company operations. The Barber Asphalt and Paving Company occupied the space to the south of Parcel 8 from 1915 to 1922 and the Long Island Rail yards are shown in this area on the Sanborn maps from 1915 to 1994. According to Seyfried 1984, the Long Island Railway and Rail yard occupied the area adjacent to Parcel 8 since 1861. A description of the work carried out at the time included the “filling in of the docks for the erection of the car houses, engine houses, machine shops and depot.” The historical account describes the fill for the docks as “materials from various places” (Seyfreid 1984). The Sanborn maps indicate Blau Gas Company of America occupied the area to the east (within Parcel 9) from 1915 to 1936. Sanborn maps from 1915 show the western portion of adjacent Parcel 9 with a gas holder, oil tanks, purifying room with gas tanks, stills, air compressor, and fuel oil retorts. Sanborn maps from 1915-1950 show the area to the east within Parcel 9 as occupied by various industrial facilities such as chemical, paint, and varnish manufacturers from 1915-1970.

2.2.4 Historic Fill and Urban Soils

According to Seyfried 1984, the Site and surrounding area occupy land created by filling areas along the East River in the 19th and 20th Centuries (Seyfreid 1984). The Site consists of man-made shoreline constructed of extensive fill, some of which was brought in by barge and consisted of street sweepings and dirt from Manhattan and some of which consisted of leveling small hills in Long Island City in the 19th century (Seyfried 1984).

According to an historical account of the development of Hunters Point, from 1850-1852, 150 acres of waterfront land extending from the junction if Newtown Creek and the East River northwards was filled with sand from a hill on a local farm (Seyfreid 1984). In 1860, two miles of bulkhead and docks were constructed northwards from the Newton Creek and East River junction to 44th Drive (Seyfreid 1984). Also, in the late 1860s, swamps in Hunters Point, an area spanning 1 mile north of Newton Creek to Ravenswood and 1.5 miles east along Newtown Creek were drained and filled. The swamps were filled with sand from a local hill and “cellar earth and street dirt brought in from New York [City] for filling purposes.” (Seyfried 1984). The fill raised the surface elevation and expanded the property out into the East River (AKRF 2005). Evidence of the historic shoreline (cribbing) was observed during the SRI in the form of solid, creosote-preserved wood, at depth in the soil borings along a linear position suggestive of a shoreline structure. Segments of the historical shoreline are shown on Figure 2. In general, Parcel 8 is covered by a layer of historic fill and urban soil from grade to at least 6 ft-bg to 12 ft-bg and deeper in places.

2.3 Geology

2.3.1 Regional Geology

The Site is in northwestern Queens County along the shore of the East River where bedrock lies approximately 20 to 50 ft-bg. Bedrock consists of complexly folded and faulted gneisses and schist that were eroded to a peneplain before deposition of the overlying sediments (Soren 1978).

The Precambrian bedrock, known as the Ravenswood Grandiorite, strikes approximately 50^0 and the surface dips to the southeast at an angle of less than 1 degree (Soren 1978). In northwest Queens, at the Site, bedrock dips to the northwest as it declines more steeply ($<1^0$ to $\sim3^0$ degrees) along the East River before outcropping at Roosevelt Island in the center of the East River. Depth to bedrock is shallow in northwestern Queens and the rock outcrops in a few places or is very close to the surface.

Overlying the bedrock are sediments of varying ages ranging from Cretaceous age, through Pleistocene age, to more recent Holocene time. The older deposits appear more towards central and southeastern Queens, while they are absent in northwestern Queens. Near the Site, only Upper Pleistocene and Holocene deposits underlie the Site (Buxton et al. 1999).

2.3.2 Local Geology

Bedrock near the site is approximately 30 to 40+ ft-bg, but declines steeply towards the southwest corner of the Site as it dives toward the East River, where it dips to approximately 50 to 60+ ft-bg as it leaves the Site (AKRF 2006, TRC Engineers, Inc., 2005).

Overlying the bedrock is a layer of glacial till consisting of compact fine to coarse sand and silt with some gravel, silt, clay, and boulders. It is reportedly up to 30 feet thick in places (AKRF 2006, TRC 2005). Locally, beneath the Site the till surface forms a northwestward trending trough leading to the East River. Immediately east of the Site, in Center Boulevard, the till surface forms a narrow north-northeast trending trough, a localized depression, that is deeper than the till layer on Site.

Atop the till is a layer of alluvial sand consisting of sand and silt up to 17 feet thick (AKRF 2006). Within this stratum are intermittent layers of peat and silt, approximately 10 feet thick, which probably represent the surface of the marsh deposits that were filled in to reclaim land from the East River. Overlying the alluvial sand and silt and peat deposits and extending across the surface of the site is a layer of imported fill approximately 10 to 12 feet thick

(AKRF 2006). The recent investigation found that the fill thickness reached more than 20 feet in a few instances.

2.4 Hydrogeology

Regionally, shallow groundwater has a higher elevation near the east side of Long Island City and Astoria, Queens and groundwater elevations decrease towards the East River and Newtown Creek shorelines (Buxton et al. 1999). Thus, groundwater flows from the regional high to the regional low groundwater discharge areas of the East River and Newtown Creek.

Locally, groundwater flows west across the Site toward the East River. Earlier work shows groundwater flow direction being deflected by subsurface features such as shallow bedrock, subsurface conduit, sheet piles, and heterogeneity of the fill that covers the area (AKRF 2006, TRC 2005). It is expected that Peninsula Park and the inlets north and south of the Peninsula Park influence local flow across the Site by formation of a groundwater divide in Peninsula Park that diverts groundwater radially to each inlet and the East River.

A line of steel sheeting extends along the western boundary of Parcel 9 that was installed during remediation of Parcel 9. This feature does not appear to have any material effect on local groundwater flow direction on Parcel 8.

East River tidal influence on shallow groundwater flow is expected to be negligible, as reflected by the investigation conducted on-Site and discussed in Section 3.0. The Site is far enough from the East River that tidal fluctuations should not have any material effect on the direction or magnitude of groundwater flow.

2.5 Previous Investigations

There were five previous studies associated with Parcel 8 as summarized below. Appendix D contains copies of the reports.

1985 Sampling Program
Roy F. Weston Inc. performed the initial testing of the area in 1985-86 on behalf of the Port Authority’s development plan that was the predecessor of the current development. The results were reported in a memo in which no information on sampling depth or quality assurance/quality control (QA/QC) was presented. Due to inaccessibility to Parcel 8 (then under an active commercial building), no sampling was performed on Parcel 8 and sampling was only completed on the eastern side of Parcel 9. A groundwater sample from well MW-13, located to the west of Parcel 8, was found to contain benzene, toluene, ethylbenzene, and xylene (BTEX), as well as some phenols.

1989 Sampling Program
Soil and groundwater testing was performed across the entire QWD by AKRF in 1989. The results were reported in the Final Environmental Impact Statement, Hunters Point Waterfront

Development, dated 1990. The buildings that occupied the Site area at the time could not be accessed, so no sampling was performed on the Parcel. Soil samples were collected from the open area to the west of Parcel 8 now occupied by the waterfront park (Peninsula Park), and well MW-13, which remained from the 1985 testing program, was re-sampled. No volatile organic compounds (VOCs) and only trace levels of semi-volatile organic compounds (SVOCs) were detected in the groundwater sample collected from MW-13 at that time. Previous sampling on December 19, 1986 identified benzene, ethylbenzene, toluene, PAHs, arsenic, lead, and zinc in groundwater from this well.

1998 Sampling Program

Testing performed by AKRF in 1998 is reported in the *Site Assessment Report, Queens West Development Site, Parcel 8 and 9, Queens, New York* dated June 1998. This additional testing was requested by NYSDEC, which reviewed and approved the remedial investigation work plan. Testing was performed on the open areas of the site and in the western-most warehouse building (4-65 48th Avenue), which is in the area occupied by Parcel 8. No free product was observed in any of the monitoring wells, but groundwater samples from both of the wells installed in the Parcel 9 area (B/MW-8A and B/MW-9A) contained elevated levels of BTEX and naphthalene. A petroleum spill was reported (Spill No. 97-12929) because USTs were expected to be under the inaccessible buildings and were thought to be the source on the elevated BTEX and naphthalene.

2000 Sampling Program

In 2000, when it was possible to gain access to the interiors of the buildings on Parcel 9, the supplemental sampling specified in the AKRF 1998 report was performed following a sampling protocol approved by NYSDEC. No testing was performed on Parcel 8 at that time.

2006 Sampling Program

In July 2006 AKRF completed the investigation of Parcel 9 under the BCP by performing off-site sampling of soils, and groundwater, as described in a report entitled *Off-Site Investigation Report, Queens West Development-Parcel 9* (Parcel 8 is the off-Site portion of Parcel 9.). The investigation included soil borings, groundwater sampling, and fluid level monitoring. Soil borings and monitoring wells extended to the top of the till layer and the investigation focused on the coal tar Dense Non-Aqueous Phase Liquid (DNAPL) atop the till layer. All wells were free of measurable product. Part of the Site was not investigated because of access limitations imposed by a C & D pile that covered the majority of the Site. Off-site soil gas sampling results were also included in this report. This report (included in Appendix D) forms the starting point for the SRIWP, which is the basis for this report.

The July 2006 investigation by AKRF found no free phase Non-Aqueous Phase Liquid (NAPL) in any of the monitoring wells installed on Parcel 8. However, AKRF identified residual NAPL in soil samples predominantly in the saturated zone just atop the low permeability silty clay till layer at approximately 27 to 35 ft-bg. Residual NAPL was also found on top of and within silt/peat lenses at shallower depths. The residual NAPL appeared to follow the topography of the till layer, sloping deeper at the southwest corner of the site. FLS noted in some of the AKRF boring logs that NAPL also appeared above the till layer in SB-9.

Note that the findings presented in Section 3 differ from this preliminary finding. The current investigation found that most of the residual NAPL occurred in the interval above the till layer, generally from the water table to approximately 22 ft-bg.

2008 Periodic Review Report and Annual Certification

AKRF prepared a Periodic Review Report (PRR) to document post-remediation conditions on Parcel 9. The 2008 report contained quarterly groundwater results for wells along Center Boulevard and along 48th Avenue and 47th Road. The report identified elevated concentrations of BTEX and naphthalene in wells MW-8 and MW-2, located upgradient of Parcel 8.

* * * *

A forensic report commissioned by AKRF identified the NAPL as a coal tar-derived material with appreciable naphthalene indicative of limited weathering (*Off-Site Investigation Report, Queens West Development-Parcel 9*). The material is denser than water, a Dense Non-aqueous Phase Liquid (DNAPL).

Benzene, toluene, ethylbenzene, and xylenes (BTEX), petroleum compounds, and chlorinated compounds were detected in relatively low concentrations in the shallow soils above the water table. BTEX levels increased below the water table and exceeded NYSDEC Technical Assistance Guidance Memorandum 4046 (TAGM) Recommended Soil Cleanup Objectives (RSCOs). The highest concentrations correlated with soils containing NAPL. The same pattern occurred for semi-volatile organic compounds (SVOCs), which were predominantly the polycyclic aromatic hydrocarbon (PAH) compounds.

Metals in the fill exceeded Eastern United States Background levels but were typical for fill normally containing slag and coal that frequently comprises the urban fill in New York City. All PCB samples were either non-detect or below TAGM RSCOs. Pesticides in on-site soil samples were all below TAGM RSCOs with the exception of two samples for heptachlor epoxide.

AKRF installed five wells on Parcel 8 or in the sidewalk adjacent to the Site and screened the wells in a range extending from approximately 15 to 30 ft-bg, near the top of the till layer (10-foot-long screens in all wells). Depth to groundwater ranges from approximately 8 to 11 ft-bg.

On-Site volatile organic compounds (VOCs) in groundwater were related to petroleum and coal tar contamination and were above the Division of Water Technical Operational and Guidance Series (TOGS) 1.1.1 Class GA Ambient Water Quality Standards (AWQS). BTEX compounds were highest near the southern portion of the Site and followed the distribution of DNAPL.

Semi-volatile organic compounds (SVOCs) also exceeded the AWQS, with naphthalene exhibiting the highest concentrations of the SVOCs. As with the on-site VOCs, the distribution of SVOCs correlated to the distribution of DNAPL.

AKRF completed a soil gas survey adjacent to Parcel 8 and identified petroleum-related VOCs and low levels of chlorinated compounds near the Site. The AKRF soil gas survey focused on Center Boulevard between 47th Road and 48th Avenue, along the west end of 48th Avenue, and along 47th Road next to Parcel 9.

At the time of the previous investigation, a construction and demolition (C&D) pile occupied the northern and eastern half of the Site and precluded installation of soil borings and monitoring wells in this area. This pile was removed as part of an Interim Remedial Measure (IRM) in the fall of 2008. The area beneath the C&D pile was not investigated during the previous AKRF work, nor were shallow soils less than or equal to 4 ft-bg. The previous AKRF investigation focused on groundwater near the NAPL above the till layer.

2.6 Summary of Soil and Groundwater & Soil Gas Conditions from Prior Studies

The VOC and SVOC results for soil and groundwater sampling from previous investigations in and around Parcel 8 have been compiled and are presented as spider diagrams in Figures 5 and 6, respectively, in the FLS July 2008 SRIWP (Appendix A). Concentrations exceeding the Part 375 BCP Commercial Use (Track 4) Cleanup Criteria (SCOs) for soils and the TOGS GA Ambient Water Quality Standards for groundwater have been highlighted in these figures.

The soil and groundwater information were compiled from the analytical results obtained by AKRF and TRC Engineers, Inc from studies on and around Parcel 8.

2.6.1 Soils

Figure 5 (Appendix A) shows that coal tar-related compounds, such as naphthalene, 2-methylnaphthalene, methylphenol, and BTEX compounds, are the principal contaminants affecting site soils and soils in the surrounding area. Figure 5 (Appendix A) shows that the surrounding area is heavily impacted by coal tar/creosote and petroleum-related compounds, in particular in Center Boulevard and along 47th Road where remediation occurred but where contamination remains at depth and at some locations. Significant concentrations of SVOCs and VOCs also appear in the soils south of Parcel 8.

As reflected in Figure 5 (Appendix A), metals in soils were omitted because concentrations are consistent with typical urban fill. (Section 3 includes metals results for the current investigation.) On the Site, out of 44 soil samples for metals, only one arsenic sample at 7 to 9 ft-bg, measuring 19.5 mg/kg, exceeded the SCO of 16 mg/kg. The only other metal exceeding the SCO was one mercury sample, 2.9 mg/kg, at 5 to 7 ft-bg compared to the criterion of 2.8 mg/kg. All other metals concentrations were below the SCOs.

2.6.2 Groundwater

Figure 6 of the SRIWP (Appendix A) shows groundwater concentrations on Parcel 8 and the surrounding area. Out of 32 off-Site and on-Site samples where benzene was sampled, off-Site benzene concentrations ranged from 1 ug/L to 23,000 ug/L compared to the three on-Site samples that ranged from 990 ug/L to 8,100 ug/L. All but one of the 32 off-Site benzene samples exceeded the TOGS GA benzene AWQS (1 ug/L).

Out of 32 total off-Site and on-Site samples, off-Site toluene was detected in 16 wells and concentrations ranged from ND to 2,100 ug/L compared to on-Site samples that ranged from 4,500 ug/L to 13,000 ug/L. The TOGS GA AWQS for toluene is 5 ug/L.

Out of 32 total off-Site and on-Site samples, off-Site ethylbenzene was detected in 20 samples and concentrations ranged from ND to 3,740 ug/L compared to on-Site samples that ranged from 1.3 ug/L to 1,300 ug/L. The TOGS GA AWQS for ethylbenzene is 5 ug/L.

Out of 32 total off-Site and on-Site samples, off-Site total xylene concentrations were detected in 19 wells and the concentration ranged from ND to 8,960 ug/L compared to three on-Site samples that ranged from ND to 4,700 ug/L. The TOGS GA AWQS for total xylenes is 5 ug/L.

Out of 28 total off-Site and on-Site groundwater samples for SVOCs, off-Site naphthalene concentrations ranged from ND to 19,100 ug/L compared with naphthalene that ranged from 8,300 ug/L to 13,000 ug/L on Site. All of the three Parcel 8 groundwater samples exceeded the TOGS GA AWQS for naphthalene of 10 ug/L.

As reflected by Figure 6, BTEX and naphthalene groundwater concentrations exceeding TOGS AWQS occur both on and off Site and are ubiquitous in the vicinity of the Site. Groundwater for metals was not analyzed in the previous AKRF July 2006 investigation.

2.6.3 Soil Gas

The July 2006 AKRF report presents the results of soil gas sampling completed on Parcel 9 and near Parcel 8. Eighteen soil gas samples were collected around Parcel 9 and the surrounding streets. No soil gas sampling occurred on Parcel 8, but two soil gas sampling points were in the sidewalk bordering Parcel 8 on the eastern side. Two other nearby sample points were opposite the Site in the sidewalk across Center Boulevard.

Petroleum and coal tar-related compounds were prevalent in several of the soil gas samples, with the highest concentrations detected in SG-3, located along the Center Boulevard sidewalk adjacent to Parcel 9 across the street from Parcel 8. Elevated concentrations of tetrachloroethylene (PCE) were detected in one sample, SG-11, but this point is 140 feet southeast of the Site, along 48th Avenue, and is unrelated to the Site. Much lower concentrations of PCE were detected throughout most of the soil gas points in the study area, suggesting that PCE is generally prevalent in the area at low concentrations.

Soil gas concentrations at the two sample points in the sidewalk adjacent to Parcel 8 contained low levels of BTEX compounds, degradation compounds, low levels of chlorinated compounds, and other petroleum-based compounds. Table 4 in the June 1998 AKRF report, *Site Assessment Report, Queens West Development Site, Parcels 8 and 9,* presents the complete results.

2.6.4 Area of Concern

All of Parcel 8 is an area of concern (AOC). The Site is too small (0.73 acres) to identify discrete areas of concern within the Site and impacts to soils occur throughout the entire tract. A schematic presenting an overlay of Site development plans is presented in Section 5, *Contemplated Site Plans.*

3.0 RESULTS

Section 3 presents the results of all phases of sampling under the SRIWP. The sections are presented with the on-Site work first, followed by the off-Site work, except where it made sense to combine the results for comparison (e.g. ambient air). With the exception of the soil gas survey completed by Exploration Technologies Inc., all analytical samples were submitted to Accutest Laboratories of Dayton, New Jersey. Accutest is a New York State Department of Health (NYSDOH) Environmental Laboratory Accreditation Program (ELAP)-approved laboratory. All laboratory analytical back-up is presented in Appendix E.

Table 1 summarizes the samples and analyses completed during the SRI. All soils results are compared to the applicable commercial use cleanup objective (6 New York Codes, Rules and Regulations Part 375-6.8(b)) Restricted Use Commercial Soil Cleanup Objectives (SCOs).

3.1 Exploratory Soil Gas Sampling

Exploration Technologies, Inc. (ETI) of Houston, Texas advanced 74 shallow exploratory soil gas points (different from the soil gas sampling using SUMMA canisters) on an approximate 25 to 30-foot staggered grid throughout Parcel 8 and along the east side of Peninsula Park. The purpose of this exploratory soil gas sampling was to identify likely areas of subsurface NAPL and contaminant mass in order to guide the placement of soil borings for a more targeted future investigation. The soil gas methodology used can accurately locate deep contaminant masses using shallow soil gas measurements. Additional objectives of the shallow soil gas exploratory sampling were to measure methane and hydrogen sulfide concentrations, to assess surface soil gas conditions, and to guide subsurface soil gas sampling using SUMMA canisters. Appendix E contains the complete ETI report along with figures and data tables. Plate 1 in Appendix F shows the exploratory soil gas sampling locations.

ETI’s sampling found “very small concentrations of chlorinated solvents, mainly PCE and 1,1,1-trichloroethane, with only traces of any other measured chlorinated solvents” (ETI 2008), in a pattern that suggests independent spills. PCE concentrations ranged from ND to 0.110 parts per million by volume (ppmv) and 95 percent of the samples measured 0.037 ppmv or less. The highest PCE concentrations centered on locations G-03, G-04 and F-04 (Plate 14 Appendix F). 1,1,1-TCA concentrations ranged from ND to 0.039 ppmv and 75 percent of the samples measured 0.01 ppmv or less. The highest 1,1,1-TCA concentrations centered on location I-03 (Plate 12, Appendix F).

The ETI soil gas survey found concentrations of methane spatially correlated with the heaviest NAPL concentrations identified in the AKRF July 2006 *Off-Site Investigation Report*. The methane appears to be generated from natural decomposition of the NAPL. Except for one elevated methane concentration, the remaining concentrations were very low. Methane and hydrogen sulfide are discussed in more detail in Section 3.11.

The principal finding of this soil gas survey was that the main body of contaminant mass is in the southwest corner of Parcel 8 and extends to the southeast and along the western side of the Site. This finding agrees well with the evidence obtained from the soil borings. Section 3.13 Contaminant Mass Estimates discusses this further.

3.2 Geophysical Survey Results

On July 2, 3, and 7, 2008, NAEVA Geophysics Inc. conducted a geophysical investigation of Parcel 8. The purpose of the investigation was to locate buried structures, USTs, piping, or other subsurface objects associated with former uses of the Site. The geophysical survey identified numerous anomalies that were subsequently investigated during the test pit phase of the investigation.

Methodology

The geophysical survey was performed using an EM-61 electromagnetic (EM) metal-detector, a Geonics EM-31 terrain conductivity meter, a Sensors & Software Noggin SmartCart ground penetrating radar (GPR) system with 250 MHz antenna, a Fisher TW-6 Pipe and Cable Locator (a type of EM metal-detector), a 3M Dynatel 2250 Cable Locator, and a Subsite 950 utility locator. This electromagnetic (EM) survey method can identify anomalies in subsurface conductivity and resistivity caused by the change in the soil characteristics and buried metal objects. The EM-31 measures subsurface conductivity and resistivity through the use of low frequency electromagnetic induction to 18 ft-bg. The GPR's transmitter radiates a short pulse of electromagnetic energy into the ground. When this pulse strikes an interface between layers of material having different electrical properties, a portion of the energy is reflected back to the surface, while the remaining energy continues on to the next interface. The Subsite 950 utility locator and the Dynatel were utilized, both actively and passively, to search for subsurface utilities. Details of the methodologies utilized in these studies are presented in Appendix G, *Results of Geophysical Investigation, Vacant Lot, 47th Road / Center Boulevard, Long Island City, New York.*

Results

A total of 45 anomalies were found and are summarized in Table 2. Figures (Plates 1 thru 6, Appendix G, the NAEVA July 2008 Geophysical Report) display anomaly locations presented in the NAEVA July 2008 Geophysical Report located in Appendix G.

EM-61

The EM-61 bottom coil contour map revealed many significant EM anomalies within the area of investigation that are summarized in Table 2. The two most significant anomalies were located at grid coordinates 20~43E/63~73N (Anomaly 3) and 55~82E/153~160N (Anomaly 13). The follow-up investigation of these anomalies with the TW-6 EM metal-detector indicated high conductivity response, which could have been caused by buried metal or reinforced concrete. GPR data profiles collected over Anomaly 13 showed reflections at a depth of approximately 2 feet. GPR data profiles over Anomaly 3 were inconclusive in determining its source.

Some of the EM-61 anomalies were caused by obvious aboveground cultural features, such as metal pipes, metal beams, screws, and tires, etc. (Anomalies 4, 8, 10, 11, 14, 20, 22, and 23). The EM-61 data also revealed a linear feature (Anomaly 18), which may have been caused by a suspected utility line and/or a possible foundation. The many small metallic anomalies throughout the site were probably caused by the remnants of former structures and/or buried metal scrap.

EM-31

The EM-31 terrain conductivity and in-phase contour maps of the east-west and north-south directions were separately produced and presented as final contour maps (see Plates 3 – 6, Appendix G). The EM-31 contour maps showed a large number of linear features and anomalous areas at the site that are summarized in Table 2. After reviewing the data, the follow-up investigations using the TW-6 and utility-line locators revealed at least four north-south oriented linear features along grid coordinates 30E, 60E, 95E, and 113E and three east-west oriented linear features along grid coordinates 43N, 100N, and 120N.

Five anomalies identified by the EM-31 and/or the TW-6 did not produce a significant response in the EM-61 data: 145~160E/165~178N (Anomaly 33), 115~135E/120~140N (Anomaly 35), 3~10E/101~112N, 7~30E/75~95N, and 52~58E/61~71N. The lack of an EM-61 response suggests these anomalies may be caused by conductive fill material such as ash or slag. Unfortunately, GPR data profiles collected at most of the EM-61/31 anomalies throughout the site were inconclusive in determining their sources.

3.3 Test Pit and Shallow Soil Sampling Results

Thirteen test pits were excavated to depths of 2 to 5 ft-bg throughout the Site. The purpose behind the test pits was to identify and locate physical objects such as tanks, piping, foundations, and to locate gross contamination. Analytical samples were collected in the surficial and shallow soils to assess whether these soils pose an unacceptable risk to the public and to characterize them for disposal or capping.

The test pits were located so as to have at least five on each half of the Site, and were oriented in both random and regular directions so as to offer the best chance in encountering subsurface structures, piping, foundations, and other objects. The specific test pit locations were selected based on the previous exploratory soil gas readings, the geophysical survey, and Sanborn map features such as stills and tanks. The excavations were approximately 4 feet in width and 5 to 7 feet in length with the exceptions of TP-2, TP-5 and TP-6 where larger pits were dug to delineate an object encountered in these test pits. Figure 2 shows the locations of the test pits and Figure 7 is a spider diagram showing soils exceeding the SCOs in the surficial and shallow soils. The excavations were screened using a calibrated organic vapor monitor (OVM) and visual and olfactory observations were recorded in the logs. Photographs and logs of test pit operations are included in Appendices H and I, respectively.

Soils from 10 of the 13 test pits were submitted for laboratory analysis. Five test pits were sampled from the northern half of the Site (TP-1, 2, 3, 4 and 5) and five test pits were sampled from the southern half of the Site (TP-7, 8, 9, 10 and 11). Samples were collected at two horizons, from the surface to 0.25 ft-bg and from the surface to 2 ft-bg. Two duplicates were collected from TP-10, one from each horizon. One discrete sample was taken from TP-5. Two composite samples were collected from the surface to 2 feet, one from the five northern and one from the five southern test pits. All soils results are compared to the applicable Part 375-6.8(b) Restricted Use Commercial Soil Cleanup Objectives [SCOs]).

3.3.1 Shallow Soils – Surface to Two ft-bg

Samples were collected and analyzed for VOCs, SVOCs, metals, pesticides PCBs, and TPH at a frequency of approximately one sample per 100 yd^3 in order to characterize shallow soils (approx. 2,360 yd^3, or the top 2 feet across the Site), for end use and/or disposal. Grab soil samples were collected by removing soil from the sides of the test pits from the two-foot depth interval with a decontaminated steel, stainless steel trowel and homogenized in a decontaminated stainless steel bowl before being placed in sample bottles. VOC samples were collected first and put directly into sample containers without homogenization.

Ten shallow soil grab samples and one duplicate (from TP-10) were taken. In addition, two composite samples, one from each of the five test pits on each half of the Site, were collected and analyzed for the same parameters with the addition of Toxic Characteristic Leachate Procedure (TCLP) Resource Conservation Recovery Act (RCRA) metals plus copper, nickel, and zinc; RCRA characteristics; and paint filter test. The analytical results for shallow soils (0 to 2 ft-bg and surficial soils 0 to 0.25 ft-bg) are presented in Tables 3A and 3B. Six geotechnical samples (porosity, moisture content, density, Atterberg Limits, and grain size) were collected from the shallow soils of TP-1, 2, 3, 4, 7 and 8. Geotechnical results are presented in Section 3.6.

3.3.2 Surficial Soils – Grade to 0.25 ft-bg

Ten grab surficial soil samples soils were collected and analyzed for VOCs, SVOCs, metals, pesticides, and PCBs from surficial soils for characterization using the same procedure described above for shallow soils. A duplicate was taken from TP-10.

Discrete Samples

A discrete soil sample, TP-5D, was collected from test pit TP-5, the test pit with the most pronounced contamination based on visual, olfactory, and OVM observations using the same parameters and procedures for surficial and shallow soils. TP-5 was the only test pit where odors were observed.

Field Observations

Shallow soils in the test pits consisted uniformly of brown coarse sands with C&D of varying types and sizes, mostly bricks, concrete, and pieces of metal. No objects beyond these debris, nor product, staining, or odors, were encountered in TP-1, 4 and 7 through 13. Refusal occurred at a depth of 4 ft-bg due to a heavy concentration of C&D in TP-1 and 4. One former 1,000-gallon fuel oil UST remains on the south side of Parcel 8 next to the wooden barrier. AKRF closed the UST in place by filling with concrete slurry in December 2007. The ancillary piping was removed.

Two 4-inch-diameter steel pipes were encountered running east to west and parallel to one another approximately 5 feet apart in TP-2 (Photo No. 13 to the left of the bucket); the length of the pipes was not determined. The pipes were discovered intact and were not damaged during excavation; no product, staining or odors were observed. The contents of these pipes, if any, remain unknown.

Various concrete structures were encountered in test pits around the Site. A concrete foundation wall was encountered along the west side of TP-3 extending beyond the depth of the test pit, 5 ft-bg. In TP-6 a concrete slab was found approximately 2 ft-bg. The slab was not delineated laterally, as it extended beyond the excavation of the test pit, a total length of 20 feet in a north-south orientation. No product, staining, or odors were encountered in TP-3 and TP-6.

A creosote odor was observed during excavation of TP-5. The soils appeared heavily saturated with creosote and/or coal tar and were delineated laterally to a 10- by 10-foot area. The saturated soils extended to 5 ft-bg. Attempts at deeper excavation met refusal due to debris. The pit contained soil heavily stained with creosote and/or coal tar and measured approximately 10 feet by 10 feet by 5 feet deep. Analytically, sample TP-5D contained no detectable benzene or toluene; naphthalene and 2-methylnaphthalene concentrations were approximately an order of magnitude greater than the ethylbenzene and total xylenes component, indicating that this material was derived from a coal tar/creosote-like source. Deeper sampling near TP-5 occurred with soil boring SB-26 where stained soil occurred at 12.5 ft-bg. Two samples were collected from boring SB-26: one at 9 to 11.5 ft-bg and one at 12 ft-bg. The 9 to 11.5 ft-bg sample had a similar VOC to naphthalene pattern, although not as pronounced.

Organic vapor monitor (OVM) readings in the test pits did not indicate volatile compounds with the exception of TP-5.

Analytical Results

The complete set of test pit sampling analytical results for the surficial soils (0-0.25 ft-bg) and shallow soils (0-2 ft-bg) are presented in Tables 3A and 3B. Figure 7 is a spider diagram showing surficial and shallow soils exceeding the SCOs.

VOCs

No VOCs exceeded the SCOs in either the surficial or shallow soil horizons.

SVOCs

All SVOCs detected at levels exceeding the SCOs are from the PAH class of compounds. PAHs are very common in NYC urban areas and originate from coal, burning of fossil fuels, combustion of organic materials, asphalt, and coal tar. PAHs occur in almost all urban fill.

Multiple PAHs were detected in all samples from both surficial (i.e. the top 3 inches of soil) and shallow soils, with benzo(a)pyrene being the only PAH detected throughout. The PAH compounds exceeding the SCOs strongly correlated between surficial and shallow soils of the same test pit; generally compounds found above those levels in surficial soils were the same as those found in shallow soils. PAH concentrations were often greater in shallow soils than in surficial soils, sometimes by nearly an order of magnitude, as in TP-3. The mean and median concentrations of PAHs were greater in surface soils than surficial soils.

Benzo(a)pyrene, Benzo(b)fluorantherne, dibenzo,a,h,anthracene, and indeno1,2,3,cdpyrene were above their respective SCOs in surficial soils; the remaining PAHs were below the SCOs. The shallow soil sample from TP-5 phenanthrene exhibited the highest overall PAH concentration, 809,000 µg/kg, compared to its SCO of 500,000 ug/kg. This sample also contained the highest number of individual PAH compounds above their respective SCOs in any surficial or shallow soil sample and corresponds to where heavily creosote-stained soil was observed.

PCBs/Pesticides

No pesticides at levels exceeding their SCOs were present in any of the samples. One PCB, aroclor 1260, was detected above the SCO in the surficial sample from TP-11 (0-0.25’) and three shallow samples from TP-9, 10 and 11 (0-2 ft) contained aroclor 1260 above the SCO. The greatest concentrations of aroclor 1260 were found in the shallow soils of TP-10 and 11; 2,150 µg/kg and 3,990 µg/kg respectively. The surficial sample contained less, with a concentration of 1,840 µg/kg.

Metals

The metals arsenic, barium, lead, and mercury were detected at levels exceeding the SCOs. Arsenic above its SCO was detected in samples from 0-2 feet. Mercury was the only metal above its SCO found in surficial soils, in samples from TP-3 and TP-5 at concentrations of 2.9 mg/kg and 4.3 mg/kg, respectively. In shallow soils, arsenic was detected in TP-7 and TP-9 at concentrations of 13.3 mg/kg and 19.1 mg/kg, respectively. Barium, 450 mg/kg, exceeded its SCO in the sample from TP-3. Lead, 1,470 mg/kg, exceeded its SCO in the sample from TP-4. Mercury was above its SCO in shallow soils in samples from TP-7 (0-2’), TP-5D and the composite, TP-1-5, at concentrations of 2.9 mg/kg, 3.8 mg/kg, and 3.4 mg/kg respectively.

TCLP Metals, RCRA Characteristics and Paint Filter Test

The composite samples were analyzed for additional parameters: TCLP metals, RCRA characteristics and paint filter test to determine if the material was hazardous. All results were negative and the soil non hazardous.

3.4 Soil Boring Results

From October 22 through November 10, 2008, FLS advanced 16 soil borings using hollow stem augers (HSA) and 2-foot-long steel split-spoon samplers. Aquifer Drilling and Testing, Inc (ADT) drilled the borings

The soil results discussed in this section are for the soils at a depth greater than two ft-bg. The results in this section include both the results from the current investigation and those collected from the earlier 2006 AKRF off-Site investigation.

Sixteen soil borings (SB-25 through SB-27, SB-29 through SB-38, SB-40, MW-18(D), and MW-22(D)) were installed on Site to depths of approximately 29 to 37 ft-bg, to the compact confining/till layer. Soil samples were collected during soil boring installation in decontaminated split-spoon samplers and noted for lithology, the presence/absence of NAPL, and field screened for VOCs utilizing a calibrated photoionization detector (PID). Soil boring locations are depicted on Figure 2. Figure 8 is a spider diagrams showing soils exceeding the SCOs in the soil borings (FLS and AKRF samples, respectively). Table 4 presents the soil boring analytical results for deeper soils (i.e. > 2 ft-bg).

Two to five grab samples were collected from each soil boring at varying depths for laboratory analyses in order to identify and delineate impacts to the soil and to characterize the overall level of contamination throughout the soil column to the confining layer. This information serves to characterize the Site and supports formulation of an appropriate remediation strategy.

Additionally, three duplicate samples (Duplicate 1 through Duplicate 3) and three field blank samples (Field Blank 1 through Field Blank 3) were collected for quality assurance/quality control (QA/QC) purposes Detailed soil descriptions and analytical sample depths are indicated on the soil boring logs (Appendix I).

Community air monitoring program (CAMP) data collected during SRI activities are included in Appendix M. All CAMP data were within approved limits. A Site survey map is included in Appendix N.

All soils and well development water generated during the SRI water were placed in drums for subsequent disposal.

3.4.1 Stratigraphy Description and Cross Sections

The groundwater system that underlies western Long Island consists of a series of unconsolidated deposits of clay, sand, and gravel of the Late Cretaceous and Pleistocene ages that are underlain by Precambrian bedrock.

Resting on top of these sands and clays and forming the highest elevation is a belt of glacially deposited debris composed of an unsorted, unstratified mixture of boulders, sand, silt, and clay. This debris was deposited in the interval between 75,000 and 17,000 years ago when the area was covered by a massive sheet of glacial ice. In the vicinity of New York, the ice moved in a generally southerly direction, bringing with it detached bedrock, sediment, and soil that it had scoured from more northerly regions.

Sloping gently southeastward from the edge of the terminal moraine in Brooklyn and Queens is an apron of sediment (outwash plain) that slopes very gently toward the Atlantic Ocean. This unit rests on the underlying inclined sedimentary layers, and was formed through the accumulation of sand, silt, and mud deposited by streams carrying away melt waters from the glacial ice. The sharp edge between terminal moraine and outwash plain constitutes the major element of the northeast trend of the contact between the two.

Based on soil boring data collected by AKRF and FLS, the Site contains historic urban fill, consisting of brown medium to coarse sands intermixed with concrete, brick and ash, from ground surface to between approximately 7 and 25 ft-bg followed by brown medium to coarse sands, silts and clays, to between approximately 29 and 35 ft ft-bg, where a heavily consolidated grey silt/till begins. Till lies beneath most of Parcel 8 and typically begins at 28 to 31 ft-bg (Photos 21 & 27). Soil boring logs are included in Appendix I. Tables showing the tabulation of chemical compounds in soil and fill are included in Appendix J.

A lens of silt and silty clay occurs over approximately 85 percent of Parcel 8. The silty layer begins at 15 to 18 ft-bg and ends at 18 to 25 ft-bg. This unit likely acts as separation between an upper surficial groundwater aquifer (approximately 10 to 20 ft-bg) and a lower groundwater surficial aquifer (approximately 20 to 30 ft ft-bg); however, the two aquifers are likely hydraulically connected through discontinuities in the silt/clay layer. These lower and upper water-bearing strata were screened as the shallow and deep wells.

The difference in physical properties between the shallow and deep water-bearing strata is evident in data received by geophysical testing (Section 3.6), analytical testing, hydraulic conductivity testing, and groundwater flow contour development. Visual representations of the lithology are presented on Figure 9, which depicts two cross-sections; one extending from NW to SE onsite (A-A’) and one extending from SW to NE onsite (B-B’); both cross-sections are in the principal direction of groundwater flow.

Of particular importance to DNAPL behavior is the silty clay layer and the increasing bulk density with depth. Bulk density increases from 1.18 g/ml near the water table to 1.57 g/ml near the till layer. This is an increase of nearly 25 percent. The increasing density creates smaller pore sizes that hold water much more tightly and prevent DNAPL from entering the soil pores. There are several instances where DNAPL lays atop medium to coarse sands, unable to penetrate because of the capillary resistance (SB-26, SB-29, SB-31, SB-32, SB-33, SB-34, SB-35, SB-37, SB-40). DNAPL and staining were also observed atop the silty clay lens (Photo Nos. 23, 24 & 25). The increasing soil density, increasing capillary pressure, and fine-textured silty clay lens explain why the main NAPL body and contaminant mass are significantly above the till layer (Photo No. 26).

3.4.2 Analytical Results

VOCs

Soil boring analytical results indicated a sole sample with a benzene concentration exceeding the SCO of 44,000 ug/kg in SB-29 (13-15 ft-bg) at a concentration of 115,000.ug/kg. None of the ethylbenzene or toluene soil samples exceeded their respective SCOs, and only one total xylene sample, QW-SB-15B (16-18’) Dup, 520,000 ug/kg exceeded the SCO of 500,000 ug/kg (AKRF sample). Chlorinated compounds were predominantly ND and in the few instances where they were detected they were all below their respective SCOs.

SVOCs

SVOCs were reported at concentrations in excess of the SCOs in several soil borings at varying depths. The SVOCs reported in excess of the SCOs are members the PAHs, which are often present in historic urban fill and are also components of products such as fuel oils, coal tars, and creosote.

SCO exceedances for PAHs were reported in all samples collected from the 2 to 4 ft bg depth interval, which consists of historic urban fill.

In general, the highest elevated concentrations of PAHs were reported in samples collected from soils exhibiting visual indications of NAPL. In particular, soil samples SB-29 (13-15 ft), SB-29 (19-20 ft), SB-35 (18-20 ft), MW-22 (12-13 ft), MW-22 (17.5-18.5 ft), SB-26 (13-14.5 ft), and SB-26 (19-21ft), which exhibited visual indications of coal tar/creosote, were reported as containing the highest concentrations of PAHs. Soil samples containing elevated concentrations of PAHs largely consisted of medium to coarse sands collected from approximately 12 to 31 ft bg, which is within the saturated zone.

Metals

Below two feet, arsenic exceeded the SCO of 16 mg/kg in four locations: SB40 (2-4’), 17.5 mg/kg; SB35 (2-4’), 17.8 mg/kg; MW22 (12-13’), 24 mg/kg; and QW-SB-7(7-9’), 19.5 mg/kg. Copper exceeded the SCO of 270 mg/kg in one location: SB36 (2-4’), 325 mg/kg. All other toxic metal results were below the SCOs

PCBs

Only one sample location greater than two feet below grade contained PCBs above the SCO of 1,000 ug/kg. Total PCBs in Sample SB31 (2-4') measured 55,100 ug/kg.

Pesticides

All pesticide results below two feet were below the SCOs.

3.5 Geotechnical and Physical Parameter Test Results

Test Pit and Shallow Soil Sampling and Analysis

Thirteen geotechnical samples were collected from shallow soils and deep soils. These samples were analyzed for the following parameters: porosity, moisture content, density, Atterberg Limits, and grain size, which provides additional insight to contaminant behavior and these data are necessary to plan remediation. During test pit excavations, samples were collected from the shallow soils horizon (0-2') in test pits TP-1, 2, 3, 4, 7 and 8. Deep samples were collected during soil boring and monitor well installation from the following monitoring well boring and soil borings: MW-22 (29-31), SB-26 (33-35), SB-29 (21-23), SB-31 (11-15), SB-34 (7-9), SB-36 21-23) and (29-31). Geotechnical results are presented in Table 5. Full laboratory reports and grain size curves are included in Appendix E.

3.6 Free Product

Multiple series of measurements were taken to measure the thickness of DNAPL or LNAPL in monitoring wells. Measurements began in July 2008 when only AKRF Parcel 9 off-site investigation wells existed. As of the time of this report, a total of four series of NAPL measurements were taken from in the monitoring wells (three series included the wells installed as part of this investigation). Other than sheen on the groundwater in some wells, all wells were free of measurable NAPL. This agrees with AKRF's findings of no observable NAPL in any of the Parcel 8 monitoring wells (AKRF July 2006).

Attempts to measure NAPL using an interface probe, steel tape with indicator paste, and a bailer failed to identify any measurable DNAPL or LNAPL. Following the installation of MW-19(D), some NAPL smearing appeared on the measuring tape, but there was no measurable or recoverable NAPL. The staining probably resulted from localized NAPL being released by agitation from the augurs during well installation.

Additional attempts to extract NAPL for physical property measurements made by the laboratory on five soil samples failed to extract any NAPL. The results of these laboratory efforts and the absence of measurable DNAPL or LNAPL indicate that it is unlikely that there is free phase NAPL on Site. This is consistent with the age of the material, the lack of an ongoing source, and the decades of water displacing NAPL from the soil pores. This displacement mechanism causes snap-off and by-pass of the NAPL that result in immobilized droplets in the form of residual NAPL[1] (Wiedemier et al. 1999; Meyer et al. 2005).

Residual NAPL was observed in 12 of the 16 soil borings. It occurred in individual lenses that ranged in thickness from 0.5 feet or less to 14 feet. Overall, residual NAPL thickness ranged from 1 foot to approximately 17 feet. A lens is a discrete bond versus the overall thickness, which is the distance from the top of where NAPL appeared to the last depth where it appeared. Typically, NAPL first appeared near the water table, approximately 9 to 11 ft-bg, and continued to approximately 23 to 25 ft-bg and 27 to 30 ft-bg. Table 6 presents the soil borings and where NAPL was observed. Figure 9 presents the geologic cross sections and distribution of NAPL and NAPL thickness.

3.7 Hydrogeological Descriptions

From October 22 through December 19, 2008 FLS installed 14 monitoring wells on Parcel 8. The shallow wells were installed so as to leave a portion of the screen interval above the water table. Table 7 presents the well installation details. In addition, a stilling well was installed in the East river and pressure transducers were inserted into the stilling well and one deep and one shallow well over one lunar cycle to gauge tidal influences on Parcel 8 groundwater.

Groundwater Hydrology

Groundwater was monitored in two zones: a shallow zone, extending from the water table at approximately 8 to 9 ft-bg to approximately 17 to 19 ft-bg (and in one well, MW-10, to 23 feet), and a deeper zone, from approximately 24 to 36 ft-bg. Synoptic groundwater

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[1] Soil consists of solid soil particles and many small spaces between the particles known as soil pores. In saturated soil, water fills the pores ("pore water") and holds fast in them unless another fluid can push the water out. The smaller the pore, the more strongly the pore water is held, and the harder it is for another fluid, such as NAPL (e.g. gasoline, fuel oil, coal tar), to displace the water. The solid phase also prefers to be filled by water much more than by a NAPL. Even if a NAPL does displace the water and fill the pores, its hold is unsteady. When NAPL first enters a pore it can often flow, i.e., free-phase product. In order for a NAPL to flow, it must be continuous (that is connected without any breaks), and it, plus any water in the pore, must be under positive pressure. Without these two conditions the NAPL cannot move under normal circumstances, i.e., it becomes immobilized in the soil—residual NAPL.

If NAPL occupies the soil pores and the source of the NAPL ceases, then water will eventually make its way back into the pores by displacing the NAPL. As the water seeps in, it causes the once continuous NAPL to break up, or snap off, into small isolated NAPL droplets that are now surrounded by water. Under these conditions the NAPL is now discontinuous and held by capillary, negative, pressure. It has now become an immobile residual. Obvious visual signs of residual NAPL are stained soils and soils with obvious chemical odors; although it should be noted that residual NAPL is often in droplets too small to be seen with the unaided eye.

measurements during high and low tide were collected on January 5, 2009. The measurements are as follows:

Well/Location	Groundwater Elevation (ft-QBD) Low Tide	 High Tide	Difference (ft) HT-LT
MW-7RD	0.65	--	--
MW-9D	-0.20	-0.24	-0.04
MW-10S	0.24	-0.83	-1.07
MW-11D	-0.53	-0.56	-0.03
MW-12D	-0.52	-0.49	0.03
MW-13S	0.06	-0.13	-0.19
MW-14S	0.52	0.53	0.01
MW-15D	-0.53	-0.53	0.00
MW-16S	-0.13	-0.18	-0.05
MW-17S	0.07	0.07	0.00
MW-18D	-0.58	-0.58	0.00
MW-19D	-0.93	-0.92	0.01
MW-20S	-0.31	-0.27	0.04
MW-21S	0.52	0.47	-0.05
MW-22D	-0.60	-0.59	0.01
MW-23S	0.64	0.63	-0.01
SW (Surface)	-3	0.84	3.84

Net groundwater flow in the shallow zone, as expected, is towards the west, as shown on Figure 10. Groundwater appears to mound slightly near the center of Parcel 8 and diverges in its westerly flow, with a portion flowing towards the inlets that border Peninsula Park on the north and south. One component flows northwest toward the Northern Embayment at the end of 47th Road and the other flows southwest towards the Southern Embayment (Figure 10). Groundwater gradients also trend toward the sewer bordering the northern side of Parcel 8 that leads to the 47th Road Outfall. Groundwater in the deeper zone follows the same pattern as the shallow groundwater flow, although there is a greater component of flow towards the northwest and there are local deflections in other directions, but the net deep groundwater flow direction is to the surface water bodies.

The average horizontal hydraulic gradient in the shallow zone is 0.0032 (three measurements) and 0.0035 (three measurements) in the deep zone, which are about the same, but the gradient measurements are more variable in the deeper zone.

The net vertical hydraulic gradient is downward, from the shallow to the deeper groundwater zone, and a downward hydraulic gradient was evident in all eight well pairs measured during both low and high tide measurements. The average vertical gradient measured 0.06. The ratio of horizontal to vertical gradient is slightly less than 20 horizontal to 1 vertical.

Hydraulic conductivity, based on slug tests, in the shallow groundwater zone ranged from 3.0 x 10^{-4} cm/sec (0.85 ft/day or 0.36 Darcies) to 1.7 x 10^{-2} cm/sec (48 ft/day or 20.5 Darcies) and averaged 5.1 x 10^{-3} cm/sec (14.5 ft/day or 6.1 Darcies). Slug test data is provided in Appendix I. In the deep groundwater zone this parameter ranged from 2 x 10^{-4} cm/sec (0.57 ft/day or

0.24 Darcies) to 2.1 x 10^{-3} cm/sec (6 ft/day or 2.5 Darcies) and averaged 8.8 x 10^{-4} cm/sec (2.5 ft/day or 1.1 Darcies). On average, hydraulic conductivity in the shallow groundwater zone was approximately 6 times greater than in the deeper zone.

Seepage velocity, using effective porosities for medium and coarse sands of 0.25 to 0.35 (Wiedemeier et al. 1999), ranged from 2.7 x 10^{-6} cm/sec to 2.2 x 10^{-4} cm/sec and averaged 3.4 x 10^{-5} cm/sec the shallow groundwater zone. In the deeper groundwater zone, seepage velocity ranged from 2.8 x 10^{-6} cm/sec to 2.9 x 10^{-5} cm/sec and averaged 1.1 x 10^{-5} cm/sec.

3.8 Tidal Fluctuation Results

Groundwater in monitoring wells MW-10 (S) and MW-19 (D) and tidal fluctuations in a stilling well in the East River were measured over one lunar cycle (December 9, 2008 to January 13, 2009) to gauge tidal effects on Parcel 8 groundwater. The well pair MW-10(S) and MW-19(D) is approximately 70 to 80 feet from the 47th Road Outfall and the Northern Embayment. Groundwater in MW-10(S) fluctuated 1.9 feet from -0.55 ft (QBD) to +1.33 feet during the monitoring period. Groundwater in MW-19(D) fluctuated 1.75 feet from -1.52 ft to +0.22 ft. In contrast, daily tidal fluctuations were approximately 4.5 to 5 feet and the maximum tidal fluctuation in the East River over the monitoring period was 9.45 feet, from +2.65 ft on December 14, 2008 to -6.80 ft on January 8, 2009. Figure 11 depicts tidal and groundwater fluctuations in the monitoring and stilling wells over the monitoring period

MW-10(S) and MW-19(D) responded identically and appear in sync with each other. The wells lag behind the tide fluctuations by a few hours, going in and out of sync with the tidal fluctuations over the lunar cycle. Where there were very large tidal changes, well levels lag by several days. The tidal fluctuation resulted in changes in groundwater levels in the wells, but groundwater elevations in the shallow well remained approximately 1.2 feet higher than groundwater in the deeper well despite the fluctuation, meaning that, regardless of the fluctuation, there is no change in the net vertical flow direction.

As shown on Figure 10, the horizontal groundwater flow direction is essentially the same regardless of the tidal stage, although the gradient increases during low tide because the tidal change is so much greater than the groundwater seepage velocity. The narrowing of the groundwater contour lines during low tide indicates that the tidal influences are limited to portions of Parcel 8 near the inlets bordering Peninsula Park and that tidal influence decrease sharply (they decrease by an exponential function) with increasing distance from the inlets.

Tidal fluctuation decreases exponentially with increasing distance from a tidal body, so tidal influences would diminish moving toward the center and east side of Parcel 8. On balance, there does not appear any material effect on groundwater flow or movement due to the tide.

3.9 Groundwater Sampling Results

FLS installed 14 monitoring wells: MW-11(D), MW-12(D), MW-13(S), MW-14(S), MW-15(D), MW-16(S), MW-17(S), MW-18(D), MW-19(D), MW-20(S), MW-21(S), MW-22(D), MW-7R(D), and MW-23(S) concurrently with soil boring installations with the exception of MW-14(S) MW-7R(D), and MW-23(S). The wells were installed to characterize both the shallow and deep water-bearing strata and to assess where contaminant impacts were greatest. They were also installed to differentiate between coal tar/creosote impacts and impacts attributable to other sources.

Deep monitoring wells (MW-7R(D), MW-11(D), MW-12(D), MW-15(D), MW-18(D), MW-19(D), and MW-22(D)) were installed to total depths of approximately 29 to 36 ft-bg and were constructed with 10 feet of two-inch-diameter, 0.020-inch slotted stainless steel well screen threaded to stainless steel riser to approximately three feet above grade. Shallow monitoring wells MW-13(S), MW-14(S), MW-16(S), MW-17(S), MW-20(S), MW-21(S), and MW-23(S) were installed to total depths of approximately 19 ft-bg and were constructed with ten feet of two-inch diameter, 0.020-inch slotted PVC well screen threaded to PVC riser to approximately 3 ft-ag. All monitoring wells were constructed with an approximate 12 foot Morie #2 sand filter pack, a two-foot bentonite seal, neat Portland cement to surface, were completed with an expandable well-plug and a locking steel riser box, and were developed until purge water was relatively clear.

Monitoring well locations are depicted on Figure 2 and monitoring well construction diagrams are included in Appendix I. Laboratory back-up documents are included in Appendix E. Tables 8A and 8B present the groundwater sampling results and Figure 12 is a spider diagram showing groundwater exceeding TOGS 1.1.1 Class GA standards. All well development water generated during the SRI water were placed in drums for subsequent disposal.

On November 19 through 21 and 23 through 25, 2008, FLS sampled the monitoring wells. Prior to sampling each groundwater monitoring well, a calibrated MiniRAE 2000 OVM equipped with a (PID was utilized to measure possible VOCs within the well casing and each groundwater monitoring well was purged according to protocol described in the approved SRIWP. Eighteen groundwater samples MW-2(D), MW-7R(D), MW-8(D), MW-9(D), MW-10(S), MW-11 (D) MW-12 (D), MW-13 (S), MW-14 (S), MW-15 (D), MW-16 (S), MW-17 (S), MW-18 (D), MW-19 (D), MW-20 (S), MW-21 (S), MW-22 (D), and MW-23 (S), a duplicate sample (DUP1) of MW-11 (D) and a field blank (FIELD BLANK), were collected.

3.9.1 Groundwater Geochemical Parameters

Groundwater Geochemistry

Several basic field parameter measurements were collected to characterize the groundwater geochemistry. The pH ranged from 6.9 SU to 8.1, but most of the groundwater pH values were between 6.9 and 7.4, meaning groundwater is predominately neutral to very slightly alkaline. This pH range is optimal for biodegradation (Wiedemeier et al. 1999). Conductivity measurements ranged 0.1 µS/cm to 0.86 µS/cm. Conductivity measurements were widely scattered with most measurements falling between 0.2 µS/cm and 0.27 µS/cm. These values are within the range of low conductive groundwater.

Dissolved oxygen (DO) ranged from 0 mg/L to 5.9 mg/L (5.9 is probably a spurious value), but the majority of the DO measurements measured 0 mg/L to 0.2 mg/L. All but one DO measurement was below 1 mg/L, meaning that oxygen is essentially depleted. The off-Site wells MW-2(D) and MW-8(D) had DO levels of 0 mg/L and 0.2 mg/L, respectively. The DO levels are comparable to other sites contaminated with BTEX and related compounds (Wiedemeier et al. 1999). BTEX and related compounds, such as PAHs, appear in numerous types of contamination including coal tar, creosote, gasoline, fuel oil, diesel fuel, and heating oil.

Oxidation Reduction Potential (ORP) is a measure of electron activity and the tendency of capacity of the groundwater to accept or transfer electrons (Wiedemeier et al. 1999). ORP measurements ranged from -109 millivolts (mV) to -369 mV, with most measurements falling between approximately -180 mV to -300 mV. This means that groundwater is in a reducing state and that biodegradation of the contamination is underway by naturally occurring microbes. This condition is most likely from biodegradation of the organic matter in the soil from natural organic material and organic contamination in the form of petroleum compounds and coal tar-like material. The off-Site wells MW-2(D) and MW-8(D) had ORP measurements of -297 mV and -246 mV, respectively, suggesting widespread organic contamination load throughout the general area. The ORP levels are comparable to other sites contaminated with BTEX and related compounds.

A number of basic groundwater analyses were also collected to characterize the groundwater geochemistry: iron, chloride, sulfate, nitrate, alkalinity, and methane.

Iron

Iron concentrations ranged from approximately 0.2 mg/L to 19.1 mg/L. Overall, dissolved iron trended slightly higher in the groundwater from approximately 18 to 28 ft-bg. These concentrations are within the range for other sites impacted by BTEX and related organic compounds (Wiedemeier et al. 1999). This also indicates that anaerobic biodegradation is taking place that is releasing iron. The highest, elevated, iron concentrations were at FLS MW-20(S), 19.1 mg/L and FLS MW-14(S), 7.8 mg/L.

Some portion of the iron stems from turbidity in the sample and two samples were filtered in the laboratory to measure this effect. In samples MW8 and MW2, the unfiltered/filtered samples measured 0.397/ND mg/L and 1.04/0.23 mg/L, respectively.

Nitrate

Nitrate was all ND except for one sample, which indicates that anaerobic degradation is occurring.

Sulfate

Sulfate concentrations ranged from ND to 848 mg/L with most of the results falling between approximately 90 mg/L and 440 mg/L. Sulfate concentrations trend highest in the groundwater interval between 18 and 25 ft-bg. The lower sulfate concentrations in the deeper zone suggest that sulfate is being used in biodegradation to a moderate degree. Sulfate concentrations on Parcel 8 are notably greater than in the off-Site, upgradient wells, MW-2(D) and MW-8(D), indicating off-Site contaminant sources exist that are depleting sulfate. Otherwise, there was no discernable spatial pattern in the sulfate concentrations.

Methane

Methane concentrations ranged from approximately 0.071 mg/L to 2.1 mg/L. Methane concentrations increase slightly with depth where the mean concentration in shallow wells is approximately 0.7 mg/L (n[2] = 8) compared to the mean concentration in the deep wells where the mean methane concentration is 1.2 mg/L (n = 12). Methane was detected in the two off-Site, upgradient wells, MW-8(D) and MW-2(D). The concentrations are comparable to sites contaminated with BTEX and related contamination. Methane is an indication of organic contamination in the subsurface undergoing anaerobic degradation.

Alkalinity

Alkalinity is a measure of the amount of inorganic carbon in the groundwater. One source of inorganic carbon is CO_2 produced from aerobic and anaerobic respiration of BTEX and related contamination. Alkalinity in Parcel 8 groundwater ranged from 398 mg/L to 1,410 mg/L. Alkalinity concentrations of approximately 1,000 mg/L or greater correlate reasonably well with the CO_2 plume (Plate 9, Appendix F). The off-Site wells MW-2(D) and MW-8(D) had alkalinity levels of 1,020 mg/L and 1,010 mg/L, respectively, indicating off-Site contaminant sources exist that are degrading and contributing to alkalinity. The alkalinity from biodegradation of the mass of BTEX and related organic contamination probably accounts for the slightly alkaline pH in much of the groundwater.

Sodium, Chloride, and TDS

Chloride ranges from 27 mg/L to 2,350 mg/L and sodium ranged from 23.7 mg/l to 1,370 mg/L. Both elements increase in concentration with increasing depth. This indicates that the deeper water is more saline, which is consistent with instrument salinity measurements that

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[2] n refers to the number of samples used in the summary statistic.

show salinity generally highest in the deeper wells, although there is overlap in the lower salinity levels. The two highest salinity measurements were at the well pair MW-10(S) and MW-19(D) closest to the 47th Road Outfall. TDS also follows the same general pattern with the higher TDS concentrations in the deeper intervals closer to the East River and nearer the west side of Parcel 8.

3.9.2 VOCs, SVOCs, and Metals in Groundwater

This subsection presents the results of analytical testing for VOCs, SVOCs, and metals. Figure 11 is a spider diagram for the groundwater sampling results. Figure 13 depicts BTEX and naphthalene in groundwater along with isocontours. Tables 8A and 8B present the results. Two groundwater samples, from MW-2(D) and MW-8(D) were filtered in the laboratory to compare filtered and unfiltered samples.

VOCs in Groundwater

The TOGS GA criterion for benzene is 1 ug/L and 5 ug/L individually for toluene, ethylbenzene, and total xylenes. Benzene, toluene, ethylbenzene, and total xylenes exceeded the TOGS GA criteria in all wells, with the exception of MW10 on the northwest corner of Parcel 8 and MW20 in the northwest quadrant of Parcel 8 (Figure 10), where benzene was below detection levels,. In most cased these VOCs exceeded the TOGS criteria by one to three orders of magnitude. Table 8B summarizes the concentrations sorted on benzene.

The highest benzene concentrations on Parcel 8 were in well cluster MW-16(S)/MW 9(D) where benzene measured 5,050 ug/L and 1,210 ug/L, respectively, and in well cluster MW-14(S)/MW-22(D), where benzene measured 3,720 ug/L and 1,020 ug/L, respectively. The benzene concentrations trend northeast-southwest from the center of Parcel 8 to the southwest corner of the Site. Elsewhere, benzene concentrations drop off by approximately one to two orders of magnitude. Benzene concentrations are lowest along the northern border of Parcel 8, a finding consistent with the AKRF 2006 *Off-Site Investigation Report.*

Benzene concentrations in the upgradient, off-site wells (MW-2(D) and MW-8(D)) measured 496 ug/L and 20 ug/L, respectively. These concentrations are substantially lower than the highest benzene detections on Parcel 8. For perspective, it should be noted that two other wells (not included in the current investigation) were sampled during the AKRF 2006 Off-Site Investigation. Well MW-3, located in an upgradient/sidegradient position at the southeast corner of Center Boulevard and 48th Avenue, and MW-6, located just outside the southeast corner of Parcel 8, measured 6,300 ug/L and 3,000 ug/L, respectively.

BTEX concentrations in groundwater ranged from 1 ug/L to 24,120 ug/L. The middle 50 percent of the results lie within approximately 1,240 ug/L and 4,330 ug/L. The three highest measurements appear in samples MW-16(S), 21,220 ug/L; MW-9(D), 21,610 ug/L; and MW 14(S), 24,120 ug/L, all of which are in the middle and southwest corner of Parcel 8. (MW-9 and MW-16(S) is a nested pair.) The two off-Site, upgradient wells, MW-2(D) and MW-8(D) also contained BTEX in concentrations of 1,946 ug/L and 563 ug/L, respectively.

Figure 14, based on the bottom well screen depth, presents the BTEX concentrations in groundwater with respect to depth. The most elevated concentrations trend northeast to southwest across Parcel 8 with the highest BTEX concentrations falling roughly between 18 and 24 ft-bg. BTEX concentrations from approximately 2,000 ug/L to 4,000 ug/L extend to near the top of the till layer. Spatially, the northeast-southwest pattern of concentration correlates reasonably well with the C5+ plume identified in the soil gas survey, (Plate 8, Appendix F) and correlates quite well with the CO_2 plume (Plate 9, Appendix F), meaning that the most elevated BTEX groundwater concentrations agree well with where soil gas measurements place the principal contaminant mass body

MTBE Parcel 8 concentrations ranged from ND to 36 ug/L, but 11 out of 15 Parcel 8 groundwater samples registered ND. MTBE was ND in all shallow wells. In the deeper wells MTBE measured approximately 18 ug/L in MW12(D) and 37 ug/L in MW11(D). Both wells are on the eastern side of Parcel 8 near Center Boulevard. MTBE in upgradient, off-Site wells measured approximately 1 ug/L in MW-8(D) and 28 ug/L in MW-2(D). Styrene, detected at low concentrations in the AKRF 2006 Off-Site Investigation, was ND in all samples.

Methylene chloride, detected at low concentrations in the AKRF 2006 Off-Site Investigation, was ND in all samples. All other chlorinated VOC concentrations were below detection limits in all Parcel 8 wells. (An exception is chloromethane, which was detected in MW-17(S), 0.76 ug/L. There is no TOGS criterion for this compound.)

SVOCs

The SVOCs detected are essentially all PAHs and phenol. Acenaphthene concentrations ranged from 1 ug/L to 405 ug/L with a median concentration of 227 ug/L. Acenaphthene exceeded the TOGS GA criterion of 20 ug/L in all samples except in MW10. Benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(g,h,i)perylene were below detection limits in most wells, but exceeded their collective TOGS GA criterion of 0.002 ug/L in four wells where their concentrations ranged from 1.9 ug/L to 27 ug/L. All of the detections of these compounds at concentrations greater than 1 ug/L occurred in four shallow wells: MW14(S), MW16(S), MW20(S), and MW23(S).

Chrysene and benzo(a) anthracene and exceeded their collective TOGS GA criterion of 0.002 ug/L in six and eight wells, respectively, where their concentrations ranged from 0.41 ug/L to 27.3 ug/L. All of the concentrations of these compounds greater than 1 ug/L occurred in shallow wells: MW14(S), MW16(S), MW20(S), MW23(S), MW-17(S), and MW-21(S). The exception was with the exception of benzo(a) anthracene in MW-15 (D) and MW-19 (D) where it measured 0.14 ug/L and 0.44 ug/L, respectively.

Naphthalene concentrations ranged from ND to 17,300 ug/L in MW-11 (D). Naphthalene was below detection limits in four wells, MW-23 (S), MW-15 (D), MW-8 (D), off-Site, and MW-

12 (D). The concentrations greater than 5,000 ug/L occurred in an hour glass-shaped pattern in wells near the middle, northwest, southwest, and southeast corners of the Site. The average naphthalene concentrations were approximately 1.6 times greater in the deeper wells (average of 10.1 mg/L) than the shallow wells (6.5 mg/L).

Metals

Arsenic

Arsenic concentrations in wells on Parcel 8 ranged from ND to 21.5 ug/L which are all below the TOGS 1.1.1 AGWS criterion of 25 ug/L. Immediately off-Site, in MW-8(D), arsenic concentrations measured 160 ug/L and 164 ug/L in the unfiltered and filtered samples, respectively. This suggests that there is an off-Site source of arsenic that is in the dissolved form; possibly due to the reducing conditions that predominate near the Site. With the exception of MW-16(S), which is near an elevated shallow soil arsenic level, all other wells on Site where arsenic is above 10 ug/L are close to the eastern part of Parcel 8 near Center Boulevard. This suggests possible on-Site migration. Arsenic is a by-product of coal ash, which in turn is a by-product of burning coal (Alloway 1995; New York Times Dec.25, 2008). It is likely prevalent throughout the area, due to the former LIRR rail yard that occupied the area and widespread us of coal as an industrial fuel prior to the use of oil.

Lead

Lead exceeded the TOGS criterion of 25 ug/L in two samples: MW-20(S), 27.9 ug/L and MW-14(S), 66 ug/L. Both sample locations correspond to where reducing conditions elevated dissolved iron compared to other wells.

Mercury

Mercury was ND in all wells except for MW-14(S) where it measured 1.1 ug/L compared to the TOGS criterion of 0.7 ug/L. This location corresponds to where iron and lead are elevated due to reducing conditions.

Chromium

All chromium concentrations were below the TOGS GA criterion of 50 ug/L. The duplicate sample for MW-11(D) was greater than the criterion but is considered spurious because it so much higher than the sample and all the other samples from the Site. Most chromium results were ND and the two locations where it was detected correspond to where iron and lead were elevated in MW-14(S) and MW-20(S). Both filtered and unfiltered sample measured ND for chromium.

Manganese

Manganese concentrations ranged from approximately 89 ug/L to 2,160 ug/L. Manganese exceeded the TOGS criterion of 300 ug/L in a few wells and the highest concentration occurred at MW-14(S) where other metals were elevated due to reducing conditions. Manganese was elevated also at MW-20(S), the other location with elevated concentrations of other metals. Off-Site well MW-8(D) also had manganese concentrations slightly exceeding 300 ug/L. Both the filtered and unfiltered samples had very similar concentrations indicating that dissolved manganese occurs in groundwater. Manganese is another metal that acts as an electron acceptor during anaerobic degradation. Consequently it is presumed that the levels detected as the Site are primarily the result of being mobilized by reducing conditions at the Site and do not indicate an on-Site source.

The remaining toxic metals were either all ND or below the TOGS GA criteria. Where detected, they were often found at MW-14(S) and MW-20(S).

3.9.3 Groundwater Plume Analysis

This section examines the chemical composition of groundwater samples as a method to identify the contamination source. BTEX and SVOC compounds occur in both coal tar/creosote and petroleum-based compounds, but the proportion of the compounds differs dramatically, so that the source can be determined from the relative proportion of each compound and the overall signature of all the compounds together. The ratios of selected compounds can be compared to known standards to type the contamination.

Identification of the source of groundwater plumes was an objective of the investigation. Using the multivariate analysis procedure described in *Multivariate Analysis to Improve Understanding of NAPL Pollutant Sources* by S. E. Powers, J. F. Villaume and J. A. Ripp (Powers et al. 1997), the relative concentrations of BTEX compounds and naphthalene were plotted in order to compare the proportion of each compound in a groundwater sample, which enables identification of the likely source of the groundwater contamination when compared to representative signatures of coal tar, creosote, diesel, and gasoline.

FLS prepared multivariate star plots that compare the relative proportions of toluene, benzene, naphthalene, and the sum of ethylbenzene and xylenes (EB+xylenes) according to the procedure by Powers et al. (1997). The compound concentrations were normalized by dividing the compound concentration in each well by the total of BTEX plus naphthalene in the subject well. For non-detects FLS used one-half the lowest detection limit for each compound. Figure 15 shows the multivariate plots of contamination types.

Using this approach, nearly all of the groundwater samples from both the shallow and deep wells indicate that groundwater is impacted by either creosote or coal tar. The plots are quite distinct for these compounds in most locations, given the much greater proportion of naphthalene. Eight of the 16 on-Site wells show a distinct creosote signature and three samples near the southwest corner of the Site exhibit a signature indicative of a lighter coal tar. Soil samples from these locations and nearby soil borings indicate NAPL droplets, product, and/or a "coal tar-like odor" (AKRF 2006). These locations also correspond to the portion of the site with the greatest mass of contamination.

The higher proportion of toluene in MW-16 (S) and its deeper sister well MW-9(D) and in MW-14(S) indicate a possible different source. These wells are near the former still, storage, and processing area, so it is possible that historic spills of unprocessed feedstock have resulted in the different signatures. These signatures are similar to examples provided by Powers et al. for a carbureted water gas (a lighter coal tar-like compound).

All told, the analysis using the Powers methodology agrees well with the results of the *Queens West Parcel 9 Environmental Forensic Report* by META Environmental, Inc. 2005 (Appendix E of the 2006 AKRF Report, Appendix D) that used ratio plots from its in-house library to type the DNAPL found in a deep soil sample (SB-15, 28-30 ft-bg) on Parcel 8. The META report stated that "there were no indications of other petroleum products or non-tar material in any of the samples" (there were two samples collected from a soil boring in Center Boulevard). META identified the sample as "formed from manufactured gas plants utilizing coal carbonization processes, as well as coke oven tars, creosotes and some other coal tar products."

Three samples, MW-8(D) (off-Site) and couplet MW-23(S)/MW-12(D), have a higher proportion of toluene, which may indicate a diesel/fuel oil component. These locations are next to Center Boulevard, where it is possible that diesel could be a contributing factor in combination with coal tar/creosote. Even if diesel fuel contributes to the groundwater plume, its proportion appears negligible compared to that of coal tar/creosote. The proportion of xylenes plus ethylbenzene decreases in most samples moving in the downgradient northwest direction from Center Boulevard. Another sample from deep well MW-7R(D) has a signature similar to that of gasoline and there was no detectable naphthalene. This is consistent with the soil gas survey for this location, which showed evidence of a gasoline spill.

On balance, the groundwater plume appears almost solely influenced by creosote/coal tar and any petroleum impact is dwarfed by coal tar/creosote impacts. This finding is also consistent with the contaminant source identified by the diagnostic ratios plotted on Figure 22.

3.10 Surface Water Sampling Results

FLS collected three surface water samples for VOCs, SVOCs, metals, pesticides, and PCBs: one sample from the outfall in 47th Road, a second from the northern embayment, and the third from the southern embayment (Figure 2). Surface water samples were collected to assess whether Parcel 8 has adversely impacted the East River and as a basis for comparison between groundwater and surface water. Table 9 presents the surface water sampling results. Laboratory back up is included in Appendix E.

It is difficult to assess whether groundwater from Parcel 8 is adversely affecting surface water because the volume of water flowing through the East River dwarfs the groundwater volume flowing into the East River from the relatively small discharge area afforded by Parcel 8. The open channel flow rate of the East River is also many orders of magnitude greater than groundwater flow, so any contribution by Parcel 8 would be diluted beyond measurement. For example, flow rate in the East River is approximately 2×10^2 cm/sec (Environ 2008) compared with a Site groundwater seepage velocity on the order of 1×10^{-4} cm/sec and 1×10^{-5} cm/sec, a difference of 6 and 7 orders of magnitude. Considering this vast difference, it is not meaningful to make direct comparisons between Site groundwater and impacts to the East River because of the vast differences in flow rate and volume. Direct comparisons between Site groundwater and the East River are further confounded because of the many other non-point contamination sources entering the river.

On the other hand, it is possible to make meaningful comparisons and inferences using nearby features that connect Parcel 8 and the East River. For this reason, FLS collected one sample from the 47th Road Outfall during a period of low base flow. Since the outfall flows alongside the entire northern side of Parcel 8, this feature apparently receives at least some groundwater flow from Parcel 8 as shown on the shallow groundwater flow figure (Figure 10) and some inferences can be made about the Parcel 8 contribution. The outfall invert is -1.00 feet QBD at the outlet and 0.0 feet QBD at Center Boulevard (NYCDEP 1999). Both shallow and deep groundwater elevations exceed these elevations (Figure 11).

Figure 16 compares the sodium and calcium levels in surface and groundwater from Parcel 8. The figure shows clearly that water from the 47th Road Outfall is very similar to groundwater from Parcel 8. A Piper diagram analysis (not presented) of several samples using the major cations and anions yields a similar result. For these reasons, plus the groundwater flow contours, it is possible to infer that some portion of Parcel 8 groundwater is reaching the sewer line before reaching the surface water, and that the presence or absence of chemical compounds in the sewer says something about potential Parcel 8 impacts to surface water.

For example, acetone was detected in the 47th Road Outfall, but was below detection levels in all Parcel 8 wells. Benzene, while detected in several on-Site wells was ND in the outfall sample despite detection in all the wells along the northern boundary of Parcel 8. The same pattern holds for toluene, ethylbenzene, and total xylenes. Since these compounds are the most soluble components, and groundwater flows toward the sewer line, the inference is that groundwater from Parcel 8 is not having a material adverse impact on local surface water.

These results are consistent with the findings of the Environ International Corp., April 2008. *Supplemental Investigation Report for Lands Under Water, Queens West Development Stage 2 Site, Long Island City, New York.* NYSDEC Voluntary Cleanup Program, Site Number V00505C, Operable Unit 2 report, which addressed the site on the other side of the same sewer line. The *Lands Under Water Report* also concluded that “Given the multiple lines of evidence, the sampling data do not provide evidence of contamination in surface water or sediments in the East River from the Site [QWDC Stage 2] that would warrant further action.”

3.11 Shallow Soil Gas (SUMMA Canister) Sampling

Beginning on September 2, 2008, 11 SUMMA canisters were used to measure VOCs plus naphthalene in Parcel 8 shallow soil gas using USEPA Method TO-15. Shallow soil gas sampling was conducted to assess whether shallow soil contains unacceptable levels of contaminants and to assess the potential for soil gas to enter a structure. The SUMMA canisters were calibrated for a 30-minute monitoring period and were deployed in three sub-areas on Parcel 8 that were selected based on the results of the exploratory sampling by ETI. Within these sub-areas SUMMA canisters were deployed at randomly selected locations. One duplicate sample was collected at location H06S. The soil gas probes were inserted approximately two to four ft-bg, the tip retracted to expose the sampling screen, and the borehole sealed with bentonite to prevent ambient air leaks from the surface before collecting the samples. A helium tracer was used to test three locations for leakage. All three tests reported zero leakage.

Figure 2 identifies the sample locations and Table 10A presents the analytical results. Table 10B presents summary statistics for selected VOCs. Table 11 compares shallow soil gas concentrations to NYSDOH indoor air quality guidelines and to OSHA PELs. Results are in parts per billion by volume (ppbv).

The soil gas concentrations are predominantly ND to low. Benzene concentrations ranged from ND to a maximum concentration of 37.4 ppbv. Benzene was ND in 2 out of 11 samples. The median concentration measured 2.7 ppbv and the mean 8.5 ppbv. These concentrations are much lower, less than 1 percent, than the OSHA Permissible Exposure Level (PEL) of 1,000 ppbv.

Toluene concentrations ranged from ND to a maximum concentration of 21.2 ppbv. Toluene was detected in 10 out of 11 samples. The median concentration measured 3.8 ppbv and the mean 5.5 ppbv. These concentrations are much lower, less than 0.1 percent, than the OSHA PEL of 200,000 ppbv.

Naphthalene, despite occurring at elevated concentrations at depth, in both soils and groundwater, was barely detectable in the shallow soil gas. Naphthalene was detected in 2 out of 11 samples. The maximum naphthalene concentration was 3 ppbv.

The New York State Department of Health (NYSDOH) has indoor air guidelines for three compounds (methylene chloride, tetrachloroethylene, and trichloroethene) measured in the sub-slab soil gas. PCE concentrations ranged from 1.1 ppbv to a maximum concentration of 31.9 ppbv. PCE was detected in all 11 samples. The median concentration measured 6.4 ppbv and the mean 8.5 ppbv. These concentrations are much lower, less than 0.1 percent, than the OSHA PEL of 100,000 ppbv. All but two samples, I01S (16.1 ppbv) and F04S (31.9 ppbv), were below the NYSDOH PCE indoor air guideline of 14.7 ppbv. PCE was below detection limits in all 18 groundwater monitoring wells sampled as part of the Parcel 8 investigation.

TCE concentrations ranged from ND to a maximum concentration of 5.4 ppbv. TCE was detected in 2 out of 11 samples. The median concentration measured ND and the mean 0.59 ppbv. These concentrations are much lower, less than 0.1 percent, than the OSHA PEL of 10,000 ppbv. The two detections, G04S (5.4 ppbv) and H02S (1.1 ppbv), were modestly above the NYSDOH trichloroethene indoor air guideline of 1 ppbv. TCE was below detection limits in all 18 monitoring wells sampled as part of the Parcel 8 investigation.

Methylene chloride concentrations ranged from ND to a maximum concentration of 4 ppbv. It was detected in only 1 out of 11 samples. This concentration is much lower, less than 0.1 percent, than the OSHA PEL of 25,000 ppbv. The sole detection, G04S (4 ppbv), is well below the NYSDOH methylene chloride indoor air guideline of 17.7 ppbv (Table 11). Methylene chloride was below detection limits in all 18 monitoring wells sampled as part of the Parcel 8 investigation.

Employing both the OSHA PELs and the NYSDOH guidelines in the *Soil Vapor/Indoor Air Matrix 1,* and *Table 3.1, Air Guideline Values* found in NYSDOH's document entitled *Final Guidance for Evaluating Soil Gas Intrusion in the State of New York,* October 2006, the shallow soil gas concentrations are well below the magnitude requiring any further action.

Comparison of Shallow Soil Gas with Ambient Air

Table 12 compares total VOCs in ambient air and shallow soil gas. As expected, shallow soil gas concentrations are mostly higher than those detected in the on-Site and surrounding area ambient air, typically by an order of magnitude. A notable exception is sample TRCAA (708 ppbv), collected approximately one block east of the Site, where the total VOCs in background ambient air concentration exceed all but three on-site shallow soil gas total VOC concentrations. VOCs in background air probably exceed the shallow soil gas concentrations as a result of vehicular emissions and commercial operations in the area.

Table 12 shows that Parcel 8 ambient air total VOC concentrations are an order of magnitude lower than the Parcel 8 total VOC soil gas concentrations. Table 13 compares the ratio of benzene to total xylenes between soil gas and ambient air. The ratios differ by an order-of-magnitude or more indicating that the proportion of benzene to total xylenes is much different in the shallow soil gas than in the ambient air. The implication of the different ratios is that Parcel 8 is not adversely affecting ambient air and that ambient air measurements are not able to detect off-gassing from Parcel 8.

Methane and Hydrogen Sulfide

ETI collected 74 soil gas measurements (Section 3.1) for methane on Parcel 8 and along the border with Peninsula Park using a soil probe and ETI's methodology. Methane concentrations ranged from 0.8 parts per million by volume (ppmv) to a maximum of 10,197 ppmv (20% of the methane Lower Explosive Limit (LEL). The median value measured 3.9 ppmv and the mean 171 ppmv. Ninety-five percent of all methane concentrations measured 431 ppmv (0.9 % LEL) or less. Seventy measurements out of 74 measured approximately 95 ppmv or less. These concentrations represent very low levels of methane and do not appear to be of concern.

ETI collected 74 soil gas measurements for hydrogen sulfide using a soil probe and field instrument. Hydrogen sulfide concentrations ranged from ND to a maximum of 0.059 ppmv. The median value measured ND and the mean 0.0015 ppmv. Sixty measurements out of 74 measured ND. Hydrogen sulfide does not appear to be a concern.

3.12 Ambient Air

Five SUMMA canisters were deployed for VOCs plus naphthalene measurement using USEPA Method TO-15 to evaluate ambient air on the Site and in the surrounding area. The ambient air SUMMA canisters were deployed to measure background air quality for comparison to the Site. Two SUMMA canisters were deployed on Site, one placed in Peninsula Park, one at the intersection of 47th Road and 5th Street, and one at the corner of 48th Road and Center Boulevard. Two additional SUMMA canisters were later deployed during test pitting, one on the upwind side of Parcel 8 and one on the downwind side. The upwind canister has been treated as background air and the downwind canister treated as an on-Site air sample. In addition, results from the background ambient air samples collected by TRC Engineers, Inc. during remediation of Stage 2 (sites V00505C and V00505C) were also incorporated into the background air analysis.

The SUMMA canisters were calibrated for an 8-hour monitoring period. Table 14 identifies the samples and locations and Table 15 presents the results. Tables 16A and 16B present summary statistics for selected VOCs for Parcel 8 and off-Site locations, respectively. One qualification in the comparisons of Parcel 8 and off-Site air is the limited number of on-Site air samples (3).

The results show that overall ambient air quality on Parcel 8 is the same as or marginally better than ambient air quality in the surrounding area. This is probably due to Parcel 8 being an open space near parks and open water, removed from areas with traffic and commercial activity and exposed to breezes from the East River.

3.13 Contamination Mass Estimates

FLS prepared an order-of-magnitude contaminant mass estimate using the sum of VOCs and SVOCs as an indicator of the total contaminant mass. The estimate was developed to identify the areas and depths containing the bulk of the contaminant mass. Identifying the three-dimensional distribution of contaminant mass will serve to focus the remedial effort, target remediation most effectively and assess whether treatment could occur *in situ*, without exposing the community to odors, soil, noise and dust.

Samples from both the current FLS study and the earlier AKRF investigation were used for the estimate. The sum of VOCs and SVOCs was used because the compound list measures only a portion of the total mass.

The method employed for obtaining the mass estimates was developed by Gallagher et al. 1995, as described in Wiedemeier et al. 1999. The method uses soil concentration data, bulk density data, and soil concentration isocontours by depth intervals to develop the contaminant mass estimate. The approach was modified slightly to focus on the contaminant mass in soil only as the dissolved constituents represent a small fraction of the total mass. Calculations are included in Appendix K. A simple straight-line decreasing contour methodology was used to construct the contours. Average concentration values for the respective depth intervals were used to develop the estimate. Because the range of concentration levels is large, with a few very high values, the combination of straight-line contouring and using the average concentrations resulted in a conservative estimate that biases the estimate on the high side.

The total contaminant mass estimate is on the order of 100,000 pounds on Parcel 8 (defined by the area within the Lot lines and from surrounding grade to within the till layer at approximately 30 ft-bg). Assuming the waste has a coal tar-like/creosote density of 1.05 grams/cm^3 (8.76 pounds/gallon), this yields a spill volume estimate of roughly 11,500 gallons of product. Since the facility utilizing coal tar operated from 1855 to around 1915, a period of approximately 60 years, this translates into an annual spillage rate of just under 200 gallons/year, or about 4 drums per year, or slightly over one tanker truck's worth over the operational life of the facility. In most facilities of this type, leaks and spills were routine. Pipelines often broke or were breached due to differential settling, and trenches often were excavated to channel or dispose of material during the course of normal operations. All told, this seems like a reasonable number considering the operational life span, NAPL in numerous soil borings, groundwater concentrations, and soil gas results.

Out of 104 total mass samples, the proportion of SVOCs to VOCs is 0.99 in 90 percent of the samples, meaning that of the 100,000 pounds, approximately 1,000 pounds are VOCs and the remaining 99,000 pounds are SVOCs. Twenty-two samples had a VOCs fraction that measured 0.1 or greater, and all but one of these samples was below the water table. Where VOCs exceeded a fraction of 0.1 of the total mass, the proportion of VOCs generally increased with depth. Spatially, these VOC samples occurred predominantly on the northern side of Parcel 8 and near the eastern and southern Site perimeter. For Parcel 8, SVOCs comprise nearly all of the contaminant mass.

The distribution of the bulk of total contaminant mass, from near the top of the capillary fringe, 6 ft-bg, to 22 ft-bg, correlates well spatially with the methane and C5+ plots (BTEX-related compounds) from the ETI soil gas survey (Plates 2 and 8 in Appendix E), which show most of the NAPL body in the southwest corner and extending to the southeast and along the western side of Parcel 8.

Incorporating the soil boring observations and soil sample results, the greatest concentration of contaminant mass is in a band extending from the southeast corner of Parcel 8 to the northwest corner of the Site and encompassing the western side of the parcel. All told, this covers approximately 60 percent of the Site area and coincides with locations with the greatest density of historic stills, storage and processing units (refer to Figure 5, historical use). As shown in Figures 17 and 18, the contaminant mass contours prepared from the analytical results correlate well with the methane and C5+ soil gas plots. This yields a high level of confidence that the principal NAPL body has been accurately identified. The soil gas and mass contours figures agree quite well, although there appear to be separate gasoline-related areas on the east near Center Boulevard and trailing to the southwest corner (where there was a known diesel spill).

With respect to depth, approximately 3 percent (Figure 19) of the contaminant mass, 3,000 pounds, is in the upper 6 feet of soil. The total contaminant mass increases markedly at 6 ft-bg, coinciding with the approximate top of the capillary fringe, and continues to increase steeply to 20 ft-bg, before leveling off at 22 to 24 ft-bg so that approximately 90 percent (86 percent more precisely) of the total contaminant mass, approximately 86,000 pounds, occurs between 6 and 22 ft-bg, a 16-foot smear zone interval. This finding is consistent with the behavior of coal tar NAPL, which because of its low relative density and high affinity for adhering to soil tends to spread out over a broader area compared to denser NAPLs such as PCE (Pankow and Cherry 1996). The remaining 11 percent of the contaminant mass is between 22 feet and 36 ft-bg (no change from 22 to 24 feet). Figure 18 shows the distribution of contaminant mass with depth.

Figure 19 shows the single greatest amount of contaminant mass in the 14-foot depth interval (6 to 22 ft-bg). The contaminant mass decreases below this interval to near zero at 24 ft-bg, before a slight increase just above the till layer, which begins at approximately 28 to 31 ft-bg in most instances. Figure 18 illustrates another key finding with implications for remediation: the depth intervals with the greatest contaminant mass do not necessarily coincide exactly with the depths exhibiting the highest total mass concentrations. This is because a few high concentrations can skew the estimates, but more importantly, high concentrations by themselves do not reflect the actual extent of contamination. The two greatest total mass concentrations on Figure 18 (top graph) are from one sample location in the same boring (sample and duplicate sample); however, the spatial extent of these concentrations is limited by the numerous lower concentrations from other samples in the same depth interval and therefore the peak concentrations have a very limited extent.

3.14 Sediment Sampling and Analysis

During July 2008, three cores were advanced 10 feet into the sediment below the river bottom in the inlet bordering Peninsula Park on the south side. The cores were sampled according to the protocol in the Parcel 8 *Supplemental Remedial Investigation Work Plan* (SRIWP), July 2008. Figure 2 shows the sample locations. The sampling locations lie in what is referred to as the “Southern Embayment” for the purpose of comparison with nearby areas mentioned in the Environ 2008 *Lands Under Water Report* submitted under the Voluntary Cleanup Agreement for Stage 2 QWDC. The results of the July 2008 sediment sampling complement the data analyzed in the *Lands Under Water Report*. Historically, the Southern Embayment received discharge from a now abandoned 12-inch-diameter combined sewer (NYCDEP Utility Plan, Drawing UP-1, August 10, 1999).

Three samples were collected from each core and analyzed for TCL VOCs, SVOCs, TAL metals, pesticides, PCBs, and TPHs. One duplicate (Dup) sample was collected, yielding a total of 10 sediment samples. Samples from each of the three locations are as follows:

Location 1	Location 2	Location 3
SS1(0-2’)	SS2(0-2’)	SS3(0-2’)
SS1(2-4’)	SS2(2-4’)	SS3(2-4’)
SS1(8-10’)	SS2(8-10’)	SS3(8-10’)
SS1(8-10’)Dup	--	--

The three sediment cores consisted of black sands, organic silt, and silt throughout the entire 10-foot column. The cores were free of petroleum and/or chemical odors and free of visible NAPL or staining. The only exception was a slight petroleum odor only in sample SS1 (0-2’) in Location 1. Samples from each of the three locations are as follows:

Results

Table 17 presents the complete set of sediment sampling analytical results. Tables 18A through 22A present the results of sampling organized by selected sample parameters and sample depth. They present the analytical parameters with detected concentrations or parameters of particular interest. Parameters not having any bearing on the interpretation are similarly omitted from the tables, except for the PCB results, which have been included because of the small number of compounds (aroclors). Tables 18B through 22B present statistical summaries of the total Parcel 8 sediment data set. Duplicate samples have been included in the statistical summaries as have the non-detects.

Because many of these parameters have a wide concentration range, the median, or p50, yields a more representative picture of the overall concentration and a measure from which to compare concentrations. The mean has also been included for comparison.[3]

The *Lands Under Water Report* summarized the results by surface sediment, 0 – 2 feet, and subsurface sediment, greater than 2 feet. This breakdown has been followed with the emphasis on the 0- to 2-foot interval.

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[3] The mean has been included because it is commonly used. For the sediment data, much of which is skewed right (i.e. distribution of data is asymmetrical, with the higher values, right tail, being much longer than the lower values, left tail), it is better to use a 5-point analysis with percentiles (min, p25, p50, p75, max), with the median, p50, being particularly useful, as this yields a “reasonably complete description of center and spread,” and a data distribution is more informative than one summary number (D. S. Moore and G.P. McCabe, 2003. *Introduction to the Practice of Statistics,* 4th Edition).

VOCs

Table 18A presents the sediment sample VOC content for those samples with appreciable concentrations or where the parameter is of particular interest because of toxicity (e.g. benzene). In the case of VOCs, the parameters excluded from Table 18A were below detection levels. Table 18B provides a statistical summary of the data.

Table 18A shows that VOCs are a very minor component of the sediment. Most VOCs are below detection levels and even the parameters with measurable concentrations have scattered results at comparatively low concentrations.

The exceptions are acetone and carbon disulfide. These occur in almost all samples. Both are common solvents used in painting, cleaning, and manufacturing. They are most abundant at Location 1 in samples SS-1 (0-2') and SS1 (2-4') where they occur in association with MEK, toluene, ethylbenzene, and xylenes, suggesting that their source is from waste mixed solvents. Location 1 is furthest from the shoreline and Parcel 8. Note that acetone and carbon disulfide were not detected in any of the Parcel 8 monitoring wells. Acetone was detected in the sample from the 47th Road Outfall. Acetone is also commonly used in laboratories.

SVOCs

Table 19A presents key SVOCs. Table 19B provides a statistical summary of the data. The compounds not shown are all undetected except for carbozole, indeno(cd-123)pyrene and di-n-butylphthalate. Nearly all of the detected compounds represent the PAH class of compounds. PAHs are very common in urban areas. They originate from coal, burning of fossil fuels, combustion of organic materials, asphalt, and coal tar. PAHs occur in almost all urban fill. Storm sewer and combined sewer outfalls (CSOs) are a known, well-documented continuing urban source of PAHs.

PAHs were detected in all samples and the concentrations in Table 19A range from ND to 136,000 ug/kg. The highest PAH concentrations appear in samples SS1 (0-2') and SS1 (2-4') in Location 1, where their concentrations range from one to three orders of magnitude greater than the remaining samples. PAH concentrations are greatest in Sample SS1 (2-4').

Despite a few very high concentrations in the upper sample in Location 1 (Sample SS-1), most of the PAH concentrations in the Southern Embayment are low to moderate. For example, naphthalene, while ranging from 38 ug/kg to 136,000 ug/kg, has a median (p50) value of 137 ug/kg. The middle fifty percent of the naphthalene concentrations are spread over a range of 187 ug/kg. Seventy-five percent of the naphthalene results are below 250 ug/kg. Stem plots give a quick picture of the shape of data distribution using the actual numerical values in the graph (Moore & McCabe 2003). The stem plot below shows the distribution of naphthalene concentrations: mostly low with a much smaller number of elevated values[4].

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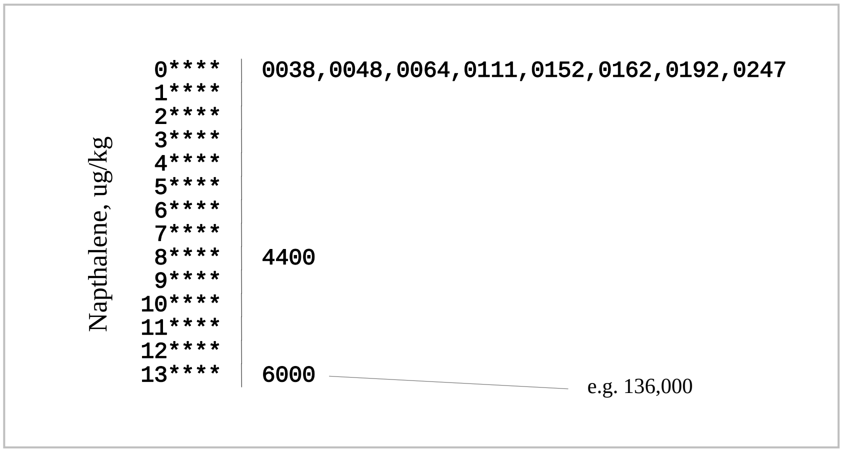
[4] The stem plot for naphthalene is representative of the distribution of VOCs and SVOCs, where there are a large number of small and moderate results and a much smaller number of high concentrations.



```
 0****  | 0038,0048,0064,0111,0152,0162,0192,0247
 1****  |
 2****  |
 3****  |
 4****  |
 5****  |
 6****  |
 7****  |
 8****  | 4400
 9****  |
10****  |
11****  |
12****  |
13****  | 6000
```

A similar distribution is seen for most SVOCs. For instance, another PAH, benzo(a)pyrene, ranges from 521 ug/kg to 20,400 ug/kg. The p50 is 1,190 and the middle 50 percent of the data are spread over a range of 1,204 ug/kg. Seventy-five percent of the benzo(a)pyrene results are below 2,010 ug/kg.

Similarly, phenanthrene ranges from 484 ug/kg to 149,000 ug/kg. The median is 980 ug/kg and the middle 50 percent of the data are spread over a range of 1,541 ug/kg. Seventy-five percent of the phenanthrene results are below 2,240 ug/kg.

In all the PAH compounds, the most elevated concentrations are in samples SS1 (0-2') and SS1 (2-4') from Location 1; but overall, across all locations, PAH concentrations are generally higher in the 0 – 2-foot interval than below 2 feet. This is probably the result of continuous PAH loading from the many combined sewer outfalls along the East River.

Pesticides

Tables 20A and 20B present a summary of the pesticides detected and a statistical summary. Dieldrin, 4,4' DDD, 4,4' DDE, and 4,4' DDT were the most commonly detected pesticides. Concentrations were generally low, ranging from approximately 9 ug/kg to 87 ug/kg. As with VOCs and SVOCs, samples SS1 (0-2') and SS1 (2-4') have concentrations that are predominantly higher than in the other samples. Pesticides appear in greater concentrations at depths below 2 feet.

PCBs

Tables 21A and 21B present the PCB results and statistical summary. PCBs were below detection levels in 4 out of 7 aroclors, but were detected at comparatively low levels in all samples. Total PCBs measured up to 1.54 mg/kg in the 0- to 2-foot interval and generally occurred at slightly greater concentrations below 2 feet. The highest total PCB concentration measures 2.1 mg/kg in the 2- to 4-foot interval.

Metals

Tables 22A and 22B present the metals results and statistical summary. Individual metals exhibit a comparatively small spread over their respective concentration ranges. Copper and lead exhibited the largest spread, 384 mg/kg and 369 mg/kg, respectively, but even this is a relatively small range.

Metals concentrations are greater below 2 feet except for mercury. The narrow concentration range suggests mixing by sediment transport. Median values (p50) for selected metals show the trend.

Comparison of Parcel 8 Sediment to Background, Inlet Outfall Basin Sediment, and Parcel 8 Upland Soil

In this section the Parcel 8 sediment sampling results are compared to the same categories as in the *Lands Under Water Report.* As in the *Lands Under Water Report*, the results are compared for the 0- 2-foot interval, by groups: Southern Embayment sediments, background sediments, inlet outfall basins (CSOs), sediments adjacent to the QWDC Stage 2 site, and Parcel 8 soils. The same *Lands Under Water Report* samples were used in this analysis. Figure 20 shows selected metals and PAHs compared to the concentrations in the other groups. In general, the findings from the Parcel 8 sediment sampling are very similar to those in the *Lands Under Water Report*.

Figure 20 shows the median concentrations of arsenic, chromium, copper, nickel, and vanadium in the Southern Embayment sediments are elevated, compared to sediments in all other groups. The upper range of these metals exceeds the upper range for all other groups except for nickel and vanadium. Sediments from the Inlet Outfall Basins (CSOs) have median concentrations of these metals elevated compared to the remaining groups. The two groups with the highest median metals concentrations and range of concentration are at or near outfalls that receive runoff from the surrounding area. This is consistent with the findings of the *Lands Under Water Report* and adds additional evidence supporting those findings.

Median concentrations for lead and zinc are greatest in the samples from the Inlet Outfall Basins followed by Southern Embayment sediments. Mercury, cadmium, and silver (not shown) exhibit a similar pattern. The median concentrations in the Southern Embayment sediments are greater than the median concentrations of the corresponding metals in Parcel 8 soils.

Most metals concentrations in the Southern Embayment sediments are significantly higher than in the corresponding metals concentrations measured in Parcel 8 surface soil (0 – 0.25 feet) and shallow soil (0 – 2 feet) samples collected during test pit sampling. For example, silver was ND in 25 soil samples on Parcel 8, while silver had a maximum concentration of 11 mg/kg in the upper two feet of sediment.

Cadmium, while ND in 20 out of 25 Parcel 8 surface and shallow soil samples, reached a maximum on-Site concentration of 1.5 mg/kg compared with a sediment maximum of 8.5 mg/kg. Mercury exhibited the same pattern, measuring a maximum of 4.3 mg/kg on Parcel 8 compared with a sediment maximum of 10.4 mg/kg. Arsenic, chromium, and copper exhibited the same pattern, all of which indicates that Parcel 8 is not the principal source of metals in sediment.

Figure 20 shows that the median (p50) of selected PAH concentrations in Southern Embayment are somewhat lower compared to the median concentration in other categories, including Parcel 8 and the background samples. The overall spread of PAHs, i.e., the range of PAH concentrations, in Southern Embayment are well within the range observed for the other categories and there are no noteworthy differences between the groups.

Based on these comparisons, it does not appear that Parcel 8 has adversely contributed to contaminant levels in the Southern Embayment sediments. The concentrations of metals are appreciably greater in Southern Embayment sediments than in Parcel 8 soils and the concentrations of PAHs in the Southern Embayment are comparable, although modestly lower, compared to sediments in the general area.

Median concentrations of PAHs in the upper two feet of soil on Parcel 8 are modestly higher than in Southern Embayment sediments, but PAHs in the sediment have larger concentrations over the range of concentrations. Several Parcel 8 PAHs have a few concentrations that are much greater than in the sediment.

Application of forensic methodology identifies the sources of the PAHs. Yunker et al. 2002 employed PAH ratios to identify the sources of PAHs. In the Figure 21, PAH ratios from both soils and sediment were plotted and compared to the sources identified by Yunker. Figure 22 clearly shows that PAHs (all samples, not just the upper two feet) in the sediment derive mostly from petroleum and petroleum combustion, while those in soil originate predominately from combustion of coal or wood.

This evidence points to CSOs and regional historical activity as the principal source of PAHs in shallow sediment.

For pesticides, Dieldrin, was detected in 1 out of 25 Parcel 8 surface and shallow soil samples at a concentration of 7.3 ug/kg. The concentration of Dieldrin in the upper two feet of sediment is two or more times greater than in Parcel 8 soils. Therefore, it seems highly unlikely that Parcel 8 is the source of this compound.

4’4’ DDE was detected in 3 out of 25 Parcel 8 surface and shallow soil samples at a maximum concentration of 29.8 ug/kg. The concentration of 4’4’ DDE in the upper two feet of sediment reached 40.3 ug/kg. Therefore, it seems highly unlikely that Parcel 8 is the source of this compound.

4’4’ DDD was not detected in 25 Parcel 8 surface and shallow soil samples. The concentrations in the upper two feet of sediment reached 19.4 ug/kg. Therefore, it seems highly unlikely that Parcel 8 is the source of this compound.

The PCB aroclor 1242 was not detected in 25 test pit soil samples from the surface to 2 feet on Parcel 8, but was detected at 822 ug/kg in the sediment samples. Aroclor 1254 was detected in 4 out of 25 samples on Parcel 8 at a maximum concentration of 363 ug/kg, but was detected in the sediment samples at a maximum concentration of 467 ug/kg, making it unlikely that Parcel 8 is a source.

Aroclor 1260 was detected on Parcel 8 in the shallow test pit soils with a maximum concentration of 3,330 ug/kg (and in soil boring SB31, 2-4’ at 55,100 ug/k), which is higher than the maximum PCB concentration in the upper two feet of sediment of 575 ug/kg. But as the scatter plot in Figure 22 shows, there is a distinct difference and trend in the relationship between land-based PCBs (soil) and PCBs found in sediment (all sediment samples with detectable aroclors were used in the plot). Out of 25 Parcel 8 surface and shallow soil samples collected for PCBs, the four locations where both aroclors 1254 and 1260 were detected cluster predominately near the bottom and lower left, while the corresponding aroclors found in sediment cluster predominately toward the top and upper right. (There were insufficient detections among the other aroclors to plot.) The land-based aroclors exhibit a strong linear trend with very little variation, while the aroclors in sediment are much more widely dispersed, have a much larger level of variation, and show a much greater magnitude of concentration. The weight of evidence of these patterns indicates that the PCBs in Site soil and off-Site sediment are from different sources.

Fish and Wildlife Assessment

This Fish and Wildlife Assessment compares the concentrations and distribution patterns of selected chemical parameters to assess potential impacts to fish, other marine biota, and wildlife. The assessment presents tables summarizing the concentrations of various chemical parameters in the 0- to 2-foot sediment interval compared to the Effects Range Low (ERL) and Effects Range Medium (ERM) screening criteria presented in the New York State Department of Environmental Conservation, Division of Fish, Wildlife, and Marine Resources document entitled *Technical Guidance for Screening Contaminated Sediments* 1999.

The *Lands Under Water Report* (Environ 2008) (Appendix L) found that “In general, constituent concentrations in surface sediment samples were determined not to pose an ecological concern or were determined not to be elevated, relative to background and regional concentrations.” The *Lands Under Water Report* also concluded that “Given the multiple lines of evidence, the sampling data do not provide evidence of contamination in surface water or sediments in the East River from the Site [QWDC Stage 2] that would warrant further action.” The report’s analysis and conclusions were accepted without any further requirements in the Department’s December 4, 2008 letter *Re: Lands Under Water Queens Development Site Stage 2,* to Mr. Charles S. Warren Chemical, Esq., Kramer Levin Naftalis & Frankel, LLP

(Appendix L). In a letter dated January 26, 2009, to TRC Companies, NYSDEC stated that no further action is required for the Lands Under Water (Appendix L).

The same QWDC Stage 2 findings apply to the sediments in the Southern Embayment that borders the location evaluated in the LUW report, and that also received discharges from a former CSO. This fish and wildlife assessment reached conclusions similar to those of the *Lands Under Water Report*; in general, constituent concentrations in surface sediment samples were found not to pose an ecological concern or were determined not to be elevated, relative to background and regional concentrations. This assessment also concluded that given the multiple lines of evidence, the sampling data do not provide evidence of contamination in surface water or sediments in the East River from the Site.

A comparison of the sediment concentrations the ERL and ERM is presented below.

VOCs

VOCs in the 0- to 2-foot interval were mostly below detection levels. There are no ERL and ERM criteria for VOCs.

SVOCs

Table 23 compares SVOC concentrations to the ERL and ERM criteria. Nearly all of the median concentrations for the SVOCs in Table 23 lie between the ERL and ERM criteria.

Metals

Table 24 presents the metals results for the upper two feet of sediment. The median for arsenic, cadmium, and chromium lies between the ERL and ERM. The median concentration for mercury and silver both exceed the ERL and ERM. The remaining metals in Table 24 are below the ERL.

Pesticides

Table 24 presents the pesticide results for the upper two feet of sediment. Except for Dieldrin, where the median exceeds the ERM, the median concentrations for all other pesticides in Table 25 are below the ERM.

PCBs

Table 26 presents the PCB results for the upper two feet of sediment. The median concentration for aroclor 1254 exceeds the ERM. The median for the remaining two aroclors is ND.

3.15 Data Validation

New Environmental Horizons, Inc. (NEH), performed a third-party data review of one soil and one groundwater laboratory data report (Accutest job numbers JA4857 and JA6100, respectively), in support of the Supplemental Remedial Investigation of the Queens West Development, Parcel 8, Long Island City, New York. NEH followed guidance in the New York State Department of Environmental Conservation, Draft DER-10, *Technical Guidance for Site Investigation and Remediation*, Appendix 2B, December, 2002 to prepare the Data Usability Summary Report (NYSDUSR) for each of the two sets of data. DUSR worksheets, additional data qualifiers, and QA/QC tables are included in Appendix E.

NEH reviewed the following quality control (QC) summary information provided in the data reports, where applicable, to evaluate the accuracy, precision, and sensitivity of the results.

- Assessment measures of Accuracy: preparation and analytical holding times, surrogate recoveries, laboratory control sample (LCS) recoveries, matrix spike (MS) recoveries, internal standard recoveries, and initial and continuing calibration characteristics
- Assessment measures of Precision: matrix spike/matrix spike duplicate (MS/MSD) precision, field duplicate precision, dual column precision for pesticides and PCBs, and serial dilutions for metals
- Assessment measures of Sensitivity: reporting limits (RLs) of ND data were evaluated to determine if they were below the applicable action levels for all compounds/analytes in each matrix

For the soil data set JA4857, 15 soils for a project-specific list of Volatile Organic Compounds (VOCs), 14 soils for Target Analyte List (TAL) Metals and Superfund Target Compound List (TCL) Semivolatile Organic Compounds (SVOCs), and 4 soils for Pesticides and Polychlorinated Biphenyl (PCBs) were reviewed and a NYSDUSR was generated by NEH. The following QC issues were found (further details are included in Table 2 and Section III of the NYSDUSR).

- Three results were rejected (R) in sample SB-36(11-13) for cis-1,3-dichloropropene, styrene, and trans-1,3-dichloropropene due to severe quality control exceedances. These results are unusable for project decisions.
- Accuracy for antimony, calcium, chromium, copper, iron, lead, nickel, potassium, sodium, and zinc was compromised in all soils due to low MS recoveries and/or serial dilution issues. Qualified data (J and UJ) are considered usable with a potential low bias.
- Accuracy and precision were compromised in the MS/MSD analysis of sample SB-36(11-13) for most of the VOC results. Qualified data (J and UJ) are considered usable with indeterminate bias.
- Precision was unacceptable for 5 SVOCs (acenaphthene, carbazole, dibenzofuran, fluorene, and phenanthrene) and PCB Aroclor 1260 in the FD pair, SB-30(2-4) and

DUPLICATE 2, and for the pesticide 4,4'-DDT in two other soil samples. Qualified data (J and UJ) are considered usable with the caution that they may be imprecise or non-representative of site locations.

- Accuracy was compromised for 40 SVOCs and VOCs due to low surrogate recoveries, low internal standard recoveries, and/or reporting of results at a level below the calibration range. Qualified results (J and UJ) are considered usable with either low or indeterminate bias.
- Sensitivity for the soil results was considered acceptable because all non-detects for TAL Metals, VOCs, SVOCs, Pesticides, and PCBs were reported at levels less than the Soil Cleanup Objectives (SCOs) included in 6 NYCRR Part 375, Table 375-6.8(b): Restricted Use Soil Cleanup Objectives, Protection of Public Health – Commercial (December 2006).

The groundwater data set, JA6100, contained 6 field samples that were evaluated for TAL Metals, VOCs, and SVOCs. The following QC issues were found (further details are included in Table 2 and Section III of the NYSDUSR).

- Accuracy for selenium and vanadium in all samples and arsenic in two samples was compromised due to low recoveries of a calibration standard. Qualified data (J and UJ) are considered usable with a potential low.
- Precision was compromised for chromium, iron, and nickel in the FD pair, MW-11 (D) and DUP1. Qualified data (J and UJ) are considered usable with the caution that they may be imprecise or non-representative of the site location.
- Accuracy was compromised for two VOCs and two SVOCs in three samples due to reporting at a level below the calibration range. Qualified data (J) are considered usable with indeterminate bias.
- Sensitivity of groundwater TAL Metals was considered acceptable for all non-detect results except for aluminum, antimony, and thallium, compared to the NYS Ambient Water Quality Standards and Guidance Values – Water Class “GA” (TOGS GA AWQS) included in the Division of Water Technical and Operational Guidance Series (TOGS 1.1.1), *Ambient Water Quality Standards And Guidance Values and Groundwater Effluent Limitations* (June 1998 with 2000 Addenda).
- Sensitivity of groundwater VOC results was considered acceptable for all non-detects based on RLs less than or equal to the TOGS GA AWQS except for 1,2-dichloroethane, cis-1,3-dichloropropene, and trans-1,3-dichloropropene in all samples plus many additional non-detect results for the following 23 VOCs: acetone, 2-butanone, carbon tetrachloride, chlorobenzene, chloroethane, chloroform, chloromethane, 1,1-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,2-dichloroethene (total), 1,1,2,2-tetrachloroethane, tetrachloroethene, 1,1,1-trichloroethane, trichloroethene, bromoform, 1,2-dichloropropane, styrene, 1,1,2-

trichloroethane, vinyl chloride, bromomethane and methylene chloride (due to dilutions used for analysis in the affected groundwater samples).

- Sensitivity of groundwater SVOC results was considered acceptable for all non-detects compared to the TOGS GA AWQS with the exceptions of the following 23 SVOCs: 2,4,5-trichlorophenol 2,4,6-trichlorophenol, 2,4-dimethylphenol, 2,4-dichlorophenol, 2,4-dinitrophenol, 2-chlorophenol, 2-methylphenol, 2-nitrophenol, 3&4-methylphenol, 4,6-dinitro-o-cresol, 4-chloro-3-methylphenol, 4-nitrophenol, benzo(b)fluoranthene, benzo(k)fluoranthene, bis(2-chloroethyl)ether, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, indeno(1,2,3-cd)pyrene, nitrobenzene, pentachlorophenol and phenol in all samples; and benzo(a)anthracene in all samples except one.

The soil NYSDUSR indicates that all but three results are usable; however, accuracy and precision were compromised due to possible sample heterogeneity, which may also affect the representativeness of these soil data to the sample locations for Metals, VOC, SVOC, Pesticides, and PCBs. Sensitivity of the soil data was acceptable. The groundwater NYSDUSR indicates that all results are usable; accuracy and precision was acceptable for the VOC and SVOC results but was compromised for several Metals. Sensitivity of the groundwater data was not acceptable for several Metals and for many VOCs and SVOCs. Non-detect results with RLs that are greater than the TOGS GA AWQS may not be usable for project objectives; therefore, the data users will need to evaluate these results on a case-by-case basis for project decisions.

In short, the results of the data validation indicate that the results are suitable for Site characterization and remediation purposes.

3.16 Deviations from Work Plan

There were four deviations to the work plan. First, regarding well development, the wells were developed until as turbidity free as possible, but pH, conductivity, and turbidity measurements were not collected during development because of equipment malfunction. As a result, stabilization of water quality parameters during well development could not be assessed. Second, wells MW-2 and MW-8 were sampled in lieu of wells that were paved over or covered by parked cars during sampling (wells TRC-MW-3 and AKRF well MW-1). Third, MW-7R(D) was installed because well MW-7(D) was paved over; and four, the SRIWP stated that soil and groundwater data were to be validated at a rate of five percent for each matrix. Because the data were validated by examining the results from one sample delivery group for soils and one sample delivery group for groundwater, the data were validated at a rate of approximately 17 percent for soils and approximately 35 percent for groundwater.

3.17 Qualitative Human Health Exposure Assessment

The following exposure assessment follows the guidelines of Appendix 3B of the *Draft DER-10 Technical Guidance for Site Investigation and Remediation* (NYSDEC 2002). NYSDEC and NYSDOH consider an exposure pathway complete and exposure possible when all five of the following criteria exist. If any of the criterion does not exist, then there is no exposure pathway. The exposure criteria are as follows:

1. Contaminant source
2. Contaminant release and transport mechanism
3. Point of exposure
4. Route of exposure
5. Receptor population

This qualitative exposure assessment is for the Site in its current state. It was prepared under the assumption that a separate Health & Safety Plan along with monitoring would support workers during remediation and construction; a separate exposure assessment would accompany a Remedial Action Work Plan; and an OM & M plan would specify requirements for maintenance and utility workers following remediation.

Soil Gas

As described in Section 3.13, there is no complete exposure pathway for soil gas to the surface. Concentrations of soil gas were below detection limits at the surface of Parcel 8, and the air over Parcel 8 reflects background ambient air quality. Exposure to the public or trespassers is incomplete because there is no transport and release mechanism and because there is a negligible source of soil gas.

Surface Soil (0 – 0.25 feet)

All PCB samples, except for one location modestly over the Restricted Residential SCO, were well below this criterion. All metals results except for some mercury and most zinc samples were below the Unrestricted Residential SCOs and all BTEX results except for one total xylene result were below the Commercial SCOs. Most PAH compounds in surface soil did exceed Part 375 Restricted Residential, but are below the Commercial Use SCOs.

The surface soil samples contained a low level source of mercury, zinc, and PAHs. The point of exposure is the surrounding area (park, sidewalk, street).   The route of exposure is inhalation and dermal contact via fugitive dust. The Site is nearly level and slightly depressed from the surrounding area, so erosion of surface soils to the surrounding area is not a concern. Additionally, the Site will be stabilized, providing additional protection against dust.

The potential release and transport mechanisms are wind and airborne transport during dry periods. The surface of Parcel 8 is mostly covered with gravel, compact based material, and vegetation, but there are some bare areas. The bare soil is mostly hard-packed and does not easily yield dust; nevertheless, Parcel 8 is on the East River and this is a windy area. Overall, there is a slight, intermittent level of exposure to PAHs and some metals from surface soils.

Subsurface Soil

Subsurface soils, those greater than 0.25 ft-bg, contain metals, one area of elevated PCBs, VOCs, and ubiquitous PAHs that exceed the Commercial Use SCOs. Under current Site conditions, these compounds are beneath the surface and isolated from contact with the public and trespassers because of the overlying soil, gravel, and hard-packed base material. Other than excavation, there is no release mechanism for exposure, so this is an incomplete exposure pathway.

Surface Water

There is no surface water on Site and groundwater discharges to surface water are within background levels (Sections 3.11 and 3.12).

Groundwater

Groundwater concentrations of BTEX, SVOCs, and some metals exceed the TOGS GA criteria. Depth to groundwater is approximately 7 to 10 ft-bg and there are no supply wells in the contaminated area (NYCDEP 2009). The area is served by a public water supply that receives its water via aqueducts from upstate reservoirs. Drinking water is monitored regularly at local sampling points (NYCDEP 2009).

Significant Receptors in Surrounding Area

A review of area with a 0.5 mile radius of the site revealed both environmental and human health receptors. A map provided by *TRC Operable Units Three and Four Remedial Investigation Report, August 2006* was used for reference and updated following area surveys conducted on November 1, 2008 and February 3, 2009. The environmental receptors in the vicinity are the park adjacent to Parcel 8 and the East River. A review of the New York City Department of Environmental Protection (NYCDEP), indicate that the one groundwater well operating in Queens is not in the vicinity of Parcel 8.

The human health receptors in the area are schools, a daycare center, parks and residences. There are two schools and a daycare center within the 0.5 mile radius including an elementary school (PS 78) and a daycare (Little Ones) located approximately 300 ft southeast of Parcel 8 in a multi-family building. Multi-family buildings surround the site to the north, east and southeast. The area further east includes park, residential and commercial development. Industrial and manufacturing developments are located northeast and southeast of Parcel 8. A map including the surrounding land uses and sensitive receptors in included as Figure 4.

4.0 SITE CONCEPTUAL MODEL

This section presents a revised conceptual model explaining the effect of history, stratigraphy, hydrogeology, and soil physical properties on the distribution of contaminants. The original conceptual model in the SRIWP was prepared based on the data available in the AKRF Parcel 9 Off-Site Investigation Report. The conceptual model identified data gaps that were used to develop the SRIWP and direct the SRI.

Now that the SRI has been completed, the new information has been incorporated into this revised conceptual model. The revised model focuses on the next step, Site remediation. The revised conceptual model is as follows:

Warren Chemical Chemical began producing roofing materials from the distillation of coal tar on Parcel 8 in 1855, and according to the historical information presented, operated on Site for approximately 60 years. Records indicate that the bulk of the main processing and storage operations were on the southwest and western side of Parcel 8 (Figure 5). These operations included stills, pumps, condensers, storage bins, and dryers. These features form the footprint for the main operations. The surrounding area was heavily industrialized and bears the signature of heavy coal use for many decades.

Based on this information and field observations and analytical results, it appears that coal tar/creosote leaked from Site operational areas and began moving downward. The contaminant distribution suggests that the release history was one of more or less continuous small-scale leaks to the subsurface above the water table from processing units and piping, or possibly shallow trenches. The bulk of the SVOC contamination coincides quite well with the footprint of the main operational area.

The Site coal tar/creosote contamination migrated downward and encountered increasing resistance near the capillary fringe due to water in the soil pores. The capillary resistance retarded migration of the DNAPL and caused it to smear over soil from the water table to approximately 22 ft-bg. Migration was also retarded by a silty clay layer that covers most of the site beginning at approximately 15 ft-bg and increasing bulk density with depth, which resulted in greater capillary resistance to DNAPL migration. Capillary resistance prevented DNAPL downward migration even where the silty clay stratum was absent. The end result is that most of the contaminant mass is in the span from the capillary fringe to 22 ft-bg beneath the former main operational footprint occurring on the Site. Some DNAPL did reach the till layer at approximately 30 ft-bg, but this is a much smaller amount than in the overlying strata. This is a key difference from the original conceptual model where it was postulated that most DNAPL migrated downward and accumulated on the till. The till/bedrock topography does not appear to play the expected role in contaminant migration.

Filling of the Site following Warren Chemical's operations, trench disposal, leaking subsurface piping, movement and reworking of soil, and subsequent facility construction and operation probably account for why the coal tar/creosote is not pervasive on the surface.

All of the DNAPL is residual—no free-phase DNAP was found. Numerous attempts to gauge DNAPL accumulation in wells failed to identify measurable NAPL. The DNAPL source ceased nearly a century ago, and re-entry of water into the pores occupied by DNAPL has resulted in snap-off and by-pass that caused the DNAPL to form discontinuous blobs locked in place by capillary forces. Visible NAPL occurred in soil borings throughout Parcel 8, mainly in sandy lenses, but the bulk of the contaminant mass, the contaminant source, is near the former operational foot print on the southwest and west central part of Parcel 8. This area also corresponds to where NAPL thickness is greatest. The DNAPL originating from Parcel 8 seems to have remained where it was released, not migrating horizontally in any significant quantity in any particular direction. AKRF (2006) reported an extensive area of NAPL upgradient of Parcel 8 under Center Boulevard. This appears to be a separate source from the DNAPL on Parcel 8.

There is a downward component of groundwater flow and groundwater flows to the west, as expected, but it diverges with a component flowing toward the 47th Road Outfall and a component flowing toward the Southern Embayment. Tidal influences, while measurable, do not appear to influence groundwater flow in a way that would affect contaminant transport.

Dissolved BTEX concentrations are prevalent throughout the Site in both shallow and deep wells, but BTEX concentrations are on average 1.5 times greater in the shallow wells. The highest BTEX concentrations are in groundwater in the southwest side of Parcel 8, corresponding to the area of the thickest DNAPL smearing and the Site operational footprint. Dissolved naphthalene concentrations are slightly higher in the deeper wells and naphthalene is highest along a line running northeast to southwest across Parcel 8, with the highest concentrations predominantly on the southwest and western side of Parcel 8.

The dissolved concentrations of benzene, the most mobile VOC, do not indicate a plume moving off-Site to the northwest in the direction of groundwater flow in the shallow zone, although it is difficult to evaluate this on the southwest side because the Site boundary is close to the higher concentrations. Dissolved benzene in the deeper groundwater zone appears to move toward the northwest, as there is a decreasing concentration gradient along this direction. Benzene was not detected in any surface water sample, however.

Soils on Parcel 8 are impacted by PAHs from the surface to depth. The shallow surface soils contain some debris and PAHs from a combination of waste and the fill that was brought in to raise the land for development. The surface soil also contains a few scattered areas of metals and PCB contamination. Subsequent to Warren Chemical Chemical, Site occupants left scattered small-scale solvent spills that do not impact groundwater or result in elevated soil gas concentrations.

5.0 CONTEMPLATED SITE PLANS

Site development plans at the time of this report are not yet finalized. However, the contemplated use of the Parcel 8 is as a two-story slab-on-grade public library with a proposed floor plan of either 18,000 ft^2 (Option A) or 30,000 ft^2 (Option B), or approximately 50 percent or 90 percent of the Site area, respectively (Figure 23). The building will also house a park ranger station. In either case the library would front along Center Boulevard. In the case of Option A the western side of Parcel 8 would remain open as an extension of Peninsula Park. The sketches for Option A show the conceptual building footprints and layout.

6.0 SUMMARY

Parcel 8 has been heavily impacted by former manufacturing operations and historical fill. Creosote and coal tar-like materials are the principal contaminants. There is also a large NAPL body of similar material bordering the Site along Center Boulevard. The principal finding is that the contaminant mass, containing mainly SVOCs, occupies the interval from the water table to approximately 22 ft-bg over the southwest portion of Parcel 8. This comprises the source area. The NAPL within this area and over the remainder of Parcel 8 is immobile and occurs as a residual only. The data from the investigation to date suggests that NAPL from historical releases has remained mainly in place. The source area correlates very well with the highest density of historical coal tar storage and processing areas. Although soils contain many PAHs, out of more than 100 samples, only one soil sample exceeded the SCO for benzene. None of the ethylbenzene or toluene soil samples exceeded their respective SCOs and only one total xylene sample exceeded its SCO. Chlorinated compounds were predominantly ND, and in the few instances where they were detected they were all below their respective SCOs.

Groundwater is impacted by this contamination and contains elevated levels of BTEX compounds. Dissolved BTEX concentrations are greatest near the southwest portion of Parcel 8. The dissolved concentrations drop off markedly with increasing distance from the source area, and testing was unable to identify BTEX entering surface water. Therefore, based on the results to date, it is not expected that the contamination in the on-Site groundwater has a material adverse effect off the Site. Impacted groundwater upgradient of the Site 8 is flowing onto Parcel 8 from Center Boulevard.

Surface soils contain a few scattered locations where PCBs and metals exceed the Part 375 Commercial SCOs. PAHs exceed the Commercial SCOs over most of the shallow soils.

A few isolated and scattered solvent spills appear to have occurred on Parcel 8. The quantities and age are such that they do not yield concentrations of soil gas that pose an unacceptable risk. Concentrations of other VOCs and SVOCs in soil gas also are low enough that they do not pose an unacceptable risk.

Sediments in the water surrounding Peninsula Park do not appear impacted by soils on Parcel 8, nor were adverse impacts to surface water from Parcel 8 observed. These findings are consistent with the *Lands Under Water Report* prepared by Environ Corp., 2008, for the site bordering Parcel 8 on the north.

There is a considerable amount of concrete and miscellaneous debris in the shallow soils. While inert, it will need to be removed for construction.

In its current condition, Parcel 8 does not pose an adverse threat to public health, although there is a very limited risk of exposure to surface soils.

7.0 REFERENCES

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FIGURES

TABLES

APPENDICES
A - O